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This book is dedicated to my wife, Emily, for her unwavering support through all the years of my training. To my fellow neurosurgery residents; remember they can always make it a little harder, but they cannot stop the clock.
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It is an honor for me to christen this book by Dr. Ross Puffer for the ABNS written (primary) examination. For nearly two decades, I have been an enthusiastic teacher for multiple written and oral neurosurgical board preparation courses in neurosurgery. This book is the end product of a casual comment to Ross approximately 1 year ago—that there was a void for a contemporary neurosurgical review book addressing the seven sections of the exam (neuroanatomy, neurosciences, neuropathology, neuroimaging, clinical neurology, neurosurgery, critical care/fundamental clinical skills), and core competencies. Both the comprehensive nature and the quick turnaround time of this book are testaments to Dr. Puffer’s innate talents.

I have known and admired Ross for 10 years: first as a medical school student and more recently as a neurosurgical resident at the Mayo Clinic, an institution where his parents have been on staff—his father, a family physician, and his mother, a radiologist. Ross has been an exemplary student and resident, demonstrating his ability to absorb, process, and apply a large amount of information with ease. He has consistently scored in the 99th percentile on standardized examinations (including the targeted ABNS primary examination). His clinical performance demonstrates his evidence-based approach to patients and compassionate care. His knowledge of the literature combined with his organizational skills have helped him become a prolific researcher, answering clinically relevant questions during his abundant “free time.” Equally as impressive has been his ability to educate and mentor, and serve as a role model. He knows how to simplify complex concepts into smaller morsels that can be digested.

In short, this Q & A review book and question bank will be a great resource not only for residents preparing for this important primary examination, but also for learners at all levels throughout their careers as practicing neurosurgeons.

Robert J. Spinner, MD
Preface

Those who train in medicine these days understand that to complete training (medical school, residency, and fellowship), one must become a professional test taker. At every level, there are one or more standardized tests that act as gateways to residency programs, training, and board certification. On occasion, trainees joke that if only patients could present as a multiple choice question, the practice of medicine would be much easier. My personal experience navigating these tests has involved completing practice questions before each test, sometimes thousands of practice questions. Practice questions allow the student to closely simulate the examination experience, and often serve as a powerful identifier of areas in need of further study.

This book was created from a set of questions I wrote while studying for the American Board of Neurological Surgery (ABNS) primary written examination in 2017. Some questions are available currently to students, but residents can benefit from a larger bank of practice questions to study from. The field is rapidly advancing, and the material and format of the ABNS primary examination is changing constantly. Exam preparation materials should evolve along with the test and the field of neurosurgery in general. Many references and texts are now accessible online, and on the go. While this question book is in print, the entirety of the question bank will also be available online with simulated test software, to allow the learner to closely mimic the test experience, as well as take advantage of direct reference links and high-quality images. The question bank consists of 1,575 questions, 1,200 of which are designed for general study, as well as a stand-alone, 375-question practice examination with 120 images taken from the Thieme image library. The practice examination contains the exact number of questions as the current examination, and they are categorized into the same subjects as listed on the ABNS primary examination website. The main question bank contains 1,200 questions, 264 images from the Thieme image library, and is divided into the same subjects as the primary examination itself.

My hope is that making these questions available to residents studying for the ABNS primary examination will help improve the number of available practice questions, as well as provide a set of questions relevant to the current examination. The online version of these questions should be welcomed by residents who are used to standardized examination preparation via online question banks, as is standard for these tests in medical school. I would like to thank Thieme for their help in the production of these questions, as well as providing the production of an online test taking software system that will allow residents to simulate the examination environment better than I was able to with currently available resources.

Ross C. Puffer, MD
I Questions
1 Neurosurgery

1. You are evaluating an 82-year-old man who takes 325 mg of aspirin daily for coronary artery disease. He presented to the emergency department with a headache and sleepiness. CT is shown below. What is the most likely diagnosis? Use the following figure to answer questions 1 through 5:

A. Epidural hematoma
B. Subdural hematoma
C. Intraparenchymal hematoma
D. Traumatic subarachnoid hemorrhage

2. You are evaluating an 82-year-old man who takes 325 mg of aspirin daily for coronary artery disease. He presented to the emergency department with a headache and sleepiness. Refer to CT shown in Question 1. How long has this bleed likely been present?
A. 1 to 3 days
B. 4 days to 2 weeks
C. 2 weeks to 3 months
D. > 3 months

3. You are evaluating an 82-year-old man with a history of a mechanical aortic valve. He presented to the emergency department with a headache and sleepiness. His GCS is 13 (E3, V4, M6). Refer to CT shown in Question 1. What is the next best step?
A. Intubate
B. Bedside burr hole evacuation
C. Start levetiracetam
D. Check INR

4. You are evaluating an 82-year-old man with a history of a mechanical aortic valve. He presented to the emergency department with a headache and sleepiness. His GCS is 13 (E3, V4, M6). Refer to CT shown in Question 1. You decide to intervene. What procedure would you recommend?
A. EVD insertion
B. Burr hole evacuation
C. Decompressive hemicraniotomy/ectomy
D. Posterior fossa decompression

5. You are evaluating an 82-year-old man with a history of a mechanical aortic valve. He presented to the emergency department with a headache but is otherwise neurologically intact with a GCS of 15. What would you recommend?
A. EVD insertion
B. Admission/observation
C. Decompressive hemicraniotomy/ectomy
D. Discharge home from ED with 1 month follow-up head CT
6. You see a 40-year-old man who was out drinking with friends and was involved in a car accident as an unrestrained passenger. He is sleepy in the trauma bay and his head CT is demonstrated below. What is the most likely diagnosis?

Use the following figure to answer questions 6 to 8 and 10:

A. Chronic subdural hematoma
B. Acute subdural hematoma
C. Epidural hematoma
D. Traumatic subarachnoid hemorrhage

7. You see a 40-year-old man who was out drinking with friends and was involved in a car accident as an unrestrained passenger. He is sleepy in the trauma bay and his head CT is demonstrated in Question 6. The injured vessel in this setting enters the skull through what foramen?

A. Foramen ovale
B. Foramen rotundum
C. Foramen spinosum
D. Foramen lacerum

8. You see a 40-year-old man who was out drinking with friends and was involved in a car accident as an unrestrained passenger. He is sleepy in the trauma bay and his head CT is demonstrated in Question 6. What is the next best step?

A. EVD placement
B. Observation
C. Operative evacuation
D. Bedside burr hole drainage

9. You see a 40-year-old man who was involved in a car accident as an unrestrained passenger. He is awake and responsive in the trauma bay (GCS 15) and his head CT is demonstrated below. What is the next best step?

A. EVD placement
B. Observation/rescan
C. Operative evacuation
D. Bedside burr hole drainage

10. You see a 40-year-old man who was involved in a car accident as an unrestrained passenger. He initially lost consciousness but EMTs reported that he woke up and was talking to them through transport. When you see him in the trauma bay he is no longer responding verbally and opens his eyes only to deep central stimulation. His head CT is demonstrated in Question 6. What is the next best step?

A. EVD placement
B. Observation/rescan
C. Operative evacuation
D. Intubate
11. You are evaluating a 55-year-old woman who was involved in a car accident where she hit her head and she thinks she lost consciousness. On CT scan you see small hyperdensities in both frontal lobes concerning for small intraparenchymal hemorrhages. She has a GCS of 15. What should you recommend in your consult note?
A. Discharge home  
B. Rescan in 6 hours  
C. Rescan now  
D. Start levetiracetam

12. You are evaluating an 82-year-old man who takes 325 mg of aspirin daily for coronary artery disease. He presented to the emergency department with a headache and sleepiness. MRI is shown below. How long has this bleed likely been present?
A. 1 day  
B. 3 days  
C. 1 week  
D. > 3 weeks

13. You are evaluating an 82-year-old man who takes 325 mg of aspirin daily for coronary artery disease. He presented to the emergency department with a headache and sleepiness. CT is shown below. What procedure would you recommend?
A. EVD placement  
B. Burr hole evacuation  
C. Decompressive hemicraniotomy/ectomy  
D. Posterior fossa decompression

14. You are seeing a 78-year-old man in your office who underwent drainage of a large, right-sided chronic subdural hematoma approximately 40 days ago. He has evidence of a residual subdural fluid collection. Approximately how many patients will still have a fluid collection after subdural drainage at 40 days?
A. 3%  
B. 15%  
C. 35%  
D. 60%  
E. 90%

15. When evaluating patients with gunshot wounds to the head, bullet trajectory is important for prognostication. What trajectory has been found to be uniformly fatal in the civilian population?
A. Bifrontal trajectory  
B. Holohemispheric trajectory  
C. Biventricular trajectory  
D. Transverse cerebellar trajectory

16. You are asked to evaluate a 65-year-old patient who was discharged from the hospital 1 week ago after undergoing decompression of a right-sided subdural hematoma. She has noticed some clear drainage from her incision and has had a persistent, severe headache all day. Head CT is demonstrated below. What is the diagnosis?
Use the following figure to answer questions 16 and 17:

A. Subdural hematoma  
B. Epidural hematoma  
C. Tension pneumocephalus  
D. Subdural empyema
17. You are asked to evaluate a 65-year-old patient who was discharged from the hospital 1 week ago after undergoing decompression of a right-sided subdural hematoma. She has noticed some clear drainage from her incision and has had a persistent, severe headache all day. She prefers to keep her eyes closed and responds with one-word answers only. Head CT is demonstrated in Question 16. What is the next best step?
A. Decompression
B. Lumbar drain
C. Discharge home
D. 100% FiO₂ via nonrebreather

18. You have been asked to act as the sideline physician for a local high school football game. One of the players takes a big hit and appears to initially walk to the wrong sideline. When you evaluate him he says that he doesn’t remember the previous play. Should he be allowed to go back into the game?
A. Yes
B. No

19. What is the normal range of intracranial pressure in adults (mm Hg)?
A. 1 to 4
B. 5 to 9
C. 10 to 15
D. 16 to 20

20. How is cerebral perfusion pressure calculated?
A. CPP = CMRO₂ + ICP
B. CPP = SBP − ICP
C. CPP = MAP − ICP
D. CPP = CBF − ICP

21. A 33-year-old man is attempting to perform BMX tricks on a bicycle and is not wearing a helmet. He goes over the handlebars and hits his head on a concrete surface. He loses consciousness at the scene but regains consciousness in the trauma bay and is GCS 15. CT is shown below. What is the next best step?

22. What is the most common type of temporal bone fracture?
A. Longitudinal
B. Transverse
C. Anterior
D. Lateral

23. What type of temporal bone fracture is associated with VII nerve injury?
A. Longitudinal
B. Transverse
C. Anterior
D. Lateral
24. You are seeing a patient in the trauma bay who was involved in a motor vehicle accident leading to a skull base fracture that appears to be a transverse temporal bone fracture. There is blood coming from the EAC and significant bruising around the ear/mastoid tip. On exam the patient is GCS 15, but has House-Brackmann grade VI left facial nerve function. What is the next best step?
A. Immediate surgical decompression
B. IV antibiotics
C. Start steroids
D. Repeat head CT

25. You are seeing a patient in the trauma bay who was involved in a motor vehicle accident leading to a skull base fracture that appears to be a transverse fracture of the clivus. All of the following should be performed except?
A. CBC/Electrolyte panel
B. NG tube insertion
C. CT angiogram head and neck
D. Cervical spine CT

26. What type of Lefort facial fracture has a high incidence of associated brain injury?
A. Type I
B. Type II
C. Type III
D. Type IV

27. You are asked to see a 6-month-old infant who sustained a skull fracture after his older brother accidentally pulled down the flat screen TV that landed on the infant’s head. CT scan is demonstrated below. The child is neurologically intact with no focal deficits. How would you manage this fracture?
A. Operative elevation
B. Observation
28. You are asked to see a 6-month-old infant who sustained a skull fracture after his older brother accidentally pulled down the flat screen TV that landed on the infant's head. Follow-up CT scan is demonstrated below. What is the diagnosis?

*Use the following figure to answer questions 28 and 29:*

- A. Growing skull fracture
- B. Arachnoid cyst
- C. Intraparenchymal hemorrhage
- D. Normal bone healing

29. You are asked to see a 6-month-old infant who sustained a skull fracture after his older brother accidentally pulled down the flat screen TV that landed on the infant's head. Follow-up CT scan is demonstrated in Question 28. What is the next best step?

- A. Observation
- B. Percutaneous drainage
- C. Cranioplasty
- D. Circumferential craniotomy and dural repair

30. You are asked to see a 6-month-old infant who is being worked up for suspected non-accidental trauma. What is the most common intracranial manifestation of non-accidental trauma?

- A. Diffuse axonal injury
- B. Bilateral subdural hematomas
- C. Intraparenchymal hemorrhage
- D. Epidural hematoma

31. What is the most common reason for retinal hemorrhages on fundoscopy in an infant?

- A. Nonaccidental trauma
- B. Benign subdural effusion in infants
- C. Acute high altitude sickness
- D. Acute ICP increase

32. You are seeing a 25-year-old man who was involved in a car accident where he hit his head on the windshield and lost consciousness. What marker has been shown to be associated with acute traumatic brain injury?

- A. PTEN
- B. GFAP
- C. Amyloid precursor protein
- D. Tau protein

33. You have been following a 55-year-old man with severe traumatic brain injury and depressed GCS for the last 48 hours. A bolt was placed, and over the last 6 hours ICP has been elevated to 30 despite aggressive medical management. According to the DECRA trial, what is the best next step?

- A. Continued medical management
- B. Withdrawal of care
- C. Decompressive hemicraniectomy
- D. Posterior fossa decompression

34. You are performing a decompressive hemicraniectomy for a patient with evidence of impending herniation. What is the most important aspect of the craniectomy to decrease the risk of uncal herniation?

- A. AP diameter > 12 cm
- B. Drilling to the edge of the sagittal sinus
- C. Drilling to the floor of the middle fossa
- D. Intraoperative EVD placement

35. Which of these options is not a part of Cushing's triad (signs of acute increased intracranial pressure)?

- A. Hypotension
- B. Hypertension
- C. Bradycardia
- D. Irregular respirations
36. You are seeing a patient in the trauma bay with evidence of acute increased ICP who has subsequently been intubated. You are taking the patient to the OR for decompression. In order to temporize the situation, you sit up the patient’s head of bed and tell the anesthesiologist to hyperventilate in order to decrease intracranial pressure. How long will this technique work?
   A. ~ 1 minute
   B. ~ 30 minutes
   C. ~ 12 hours
   D. ~ 24 hours
   E. ~ 48 hours

37. You are seeing a patient in the trauma bay with evidence of acute increased ICP who has subsequently been intubated. You are taking the patient to the OR for decompression. In order to temporize the situation, you sit up the patient’s head of bed and tell the anesthesiologist to hyperventilate in order to decrease intracranial pressure. What is the target PaCO₂ you are aiming for?
   A. 16 to 20 mm Hg
   B. 21 to 25 mm Hg
   C. 26 to 30 mm Hg
   D. 31 to 35 mm Hg
   E. 36 to 40 mm Hg

38. You are medically managing a patient with persistent increased intracranial pressure using scheduled mannitol, 0.5 g/kg Q6H. You are appropriately checking serum osmolality during this treatment. What serum osmolality measurement would make you stop giving mannitol?
   A. 306
   B. 312
   C. 318
   D. 324

39. You have been emergently consulted by neurology in a patient with a subarachnoid hemorrhage who has evidence of acute hydrocephalus and you feel that an EVD is warranted. What is a good approximation of where you should perform your bedside burr hole?
   A. 8 cm back from the nasion, mid-pupillary line
   B. 11 cm back from the nasion, mid-pupillary line
   C. 14 cm back from the nasion, mid-pupillary line
   D. 3 cm up from the pinna, 3 cm posterior

40. You are taking care of a patient with persistently elevated intracranial pressure despite mannitol administration. You decide to utilize hypertonic saline, but the patient currently only has a peripheral IV. What is the highest concentration of hypertonic saline you can safely give through a peripheral IV?
   A. 1.5%
   B. 3%
   C. 7%
   D. 23.4%

41. What is the approximate volume of CSF within the ventricular system at any given time?
   A. 100 mL
   B. 150 mL
   C. 200 mL
   D. 250 mL

42. You see a patient in the trauma bay that opens his eyes to painful stimulation, localizes to that painful stimulation, and mutters incomprehensible words. What is the GCS?
   A. 8
   B. 10
   C. 12
   D. 14
   E. 15

43. You see a patient in the trauma bay that was intubated during transport for airway concerns, does not open his eyes to painful stimulation, and externally rotates/extends both upper extremities during that painful stimulation. What is the GCS?
   A. 4t
   B. 6t
   C. 8t
   D. 3t
   E. 14t

44. You are managing the care of a patient who has elevated ICP, hydrocephalus, and has had an EVD placed. Your staff wants you to move the EVD to 10 mm Hg, but the EVD catheter only has markings for cm H₂O. What should you set the EVD height to?
   A. 8.7 cm H₂O
   B. 17.4 cm H₂O
   C. 13.6 cm H₂O
   D. 21.4 cm H₂O
Questions

45. What type of ICP waves are associated with elevations of ICP > 50 mm Hg for 5 to 20 minutes accompanied by elevations in mean arterial pressure?
   A. Lundberg A waves
   B. Lundberg B waves
   C. Lundberg C waves
   D. Lundberg D waves
   E. Lundberg E waves

46. Which peak of the ICP waveform gives you information about the compliance of the ventricular system?
   A. P1
   B. P2
   C. P3
   D. P4
   E. P5

47. In patients with elevated ICP, what should be the goal cerebral perfusion pressure?
   A. > 20
   B. > 50
   C. > 100
   D. > 150
   E. > 200

48. In a patient with elevated ICP (25 mm Hg) in the setting of severe traumatic brain injury, what should be the goal mean arterial pressure?
   A. 45
   B. 85
   C. 115
   D. 145
   E. 165

49. You are asked to evaluate a patient in the trauma bay that is unresponsive. He is intubated, does not open his eyes, and exhibits no movement of the upper or lower extremities even to deep painful stimulation of the nail bed. What is the GCS?
   A. 0
   B. 3
   C. 6
   D. 9
   E. 12

50. What medical therapy is thought to provide the maximum drop in CMRO$_2$ and CBF in patients with severely increased ICP in the setting of trauma?
   A. Mannitol
   B. Hypertonic saline
   C. Propofol
   D. Pentobarbital
   E. Ketamine

51. You are evaluating a 33-year-old man who experienced a first-time seizure; subsequent MRI was performed and is demonstrated below. If you decided to operate on this patient, what operative adjunct would be useful in this case?

Use the following figure to answer questions 51 and 52:

   A. Motor mapping
   B. Diffusion tensor imaging
   C. Awake language mapping
   D. Somatosensory evoked potentials
   E. EMG
52. You are evaluating a 33-year-old man who experienced a first-time seizure; subsequent MRI was performed and is demonstrated in Question 51. What further imaging study might be helpful in this case?
A. PET scan
B. Diffusion tensor imaging
C. Functional MRI
D. Perfusion MRI
E. Perfusion C

53. You are evaluating a 45-year-old man who experienced a first-time seizure; subsequent MRI was performed and is demonstrated below. What would be useful during surgical resection of this mass?

Use the following figure to answer question 53:

![MRI images](image)

A. Motor mapping
B. Awake language mapping
C. Somatosensory evoked potentials
D. EMG

54. You are operating on a 55-year-old man with a low-grade astrocytoma of the posterior frontal lobe and you are utilizing motor mapping to identify the motor structures. What monitoring finding alerts you to the location of the motor strip?
A. Doubling of signal amplitude
B. Signal dampening
C. Phase reversal
D. Phase doubling

55. You are operating on a 55-year-old man with a low-grade astrocytoma of the posterior frontal lobe and you are utilizing motor mapping to identify the motor structures. Intraoperative recordings are demonstrated below. What electrode is located on the motor strip in this image?

![Intraoperative recordings](image)

A. 2
B. 3
C. 4
D. 5
E. 6
1 Questions

56. What is the most common tumor of the central nervous system?
   A. Meningioma
   B. Metastases
   C. Glioblastoma
   D. Lymphoma
   E. Low-grade glioma

57. What is the most common metastatic tumor to the brain?
   A. Lymphoma
   B. Lung
   C. Colorectal
   D. Melanoma
   E. Renal

58. What is the most common metastatic tumor to the brain in females?
   A. Melanoma
   B. Lung
   C. Colorectal
   D. Breast
   E. Renal

59. A 66-year-old woman presents to your clinic with a first-time seizure and an MRI was performed which is demonstrated below. What is the next best step?

   A. Total spine MRI
   B. CT chest, abdomen, and pelvis
   C. Gamma knife
   D. Whole brain radiation

60. Which of these metastatic tumor types has a higher risk of presenting with hemorrhage?
   A. Lymphoma
   B. Renal cell carcinoma
   C. Squamous cell lung carcinoma
   D. Ductal carcinoma in situ
   E. Colon adenocarcinoma

61. Which of these metastatic lesions is considered radiosensitive?
   A. Multiple myeloma
   B. Thyroid
   C. Malignant melanoma
   D. Renal cell carcinoma

62. Which of these metastatic lesions is considered highly resistant to radiation?
   A. Multiple myeloma
   B. Breast cancer
   C. Small cell lung cancer
   D. Renal cell carcinoma

63. What Karnofsky performance status score is a patient considered able to care for himself or herself without assistance?
   A. 70
   B. 80
   C. 90
   D. 100
   E. 110

64. You are evaluating a patient with a single, right frontal brain metastasis with no known primary who has a KPS of 100. What should you offer the patient?
   A. Surgical resection
   B. Gamma knife
   C. Observation
   D. Biopsy

65. Primary CNS melanoma commonly arises from melanocytes located where?
   A. Pachymeninges
   B. Leptomeninges
   C. Virchow-Robin spaces
   D. Pia mater
66. What percentage of incidentally discovered meningiomas will exhibit no growth over 3-year follow-up?
   A. 10%
   B. 33%
   C. 66%
   D. 90%
   E. 100%

67. Where do meningiomas arise from?
   A. Oligodendrocytes
   B. Arachnoid cap cells
   C. Pachymeninges
   D. Pia mater

68. What is the overall incidence of meningiomas?
   A. ~ 1 to 3%
   B. ~ 8 to 10%
   C. ~ 13 to 15%
   D. ~ 18 to 20%
   E. ~ 21 to 23%

69. What is the most common location for a meningioma?
   A. Sphenoid wing
   B. Parasagittal
   C. Convexity
   D. Planum sphenoidale
   E. Petrous apex

70. Foster-Kennedy syndrome classically was caused by what tumor?
   A. Medulloblastoma
   B. Frontal glioblastoma
   C. Olfactory groove meningioma
   D. Clival chordoma

71. What is the most common type of WHO grade II astrocytoma?
   A. Anaplastic
   B. Gemistocytic
   C. Protoplasmic
   D. Fibrillary

72. What is considered the principal treatment for low-grade gliomas?
   A. Observation
   B. XRT alone
   C. Chemotherapy + XRT
   D. Surgical resection

73. In patients with subtotally resected low-grade gliomas, early radiotherapy (54 Gy) has been associated with what results?
   A. No difference in progression-free survival
   B. 2-year increase in progression-free survival
   C. 5-year increase in progression-free survival
   D. 8-year increase in progression-free survival

74. In patients with gross total resection of a low-grade glioma, early radiotherapy (54 Gy) has been associated with what results?
   A. No difference in progression-free survival
   B. 2-year increase in progression-free survival
   C. 5-year increase in progression-free survival
   D. 8-year increase in progression-free survival

75. In patients with glioblastoma, what percentage of resection has been associated with increased overall survival?
   A. > 50%
   B. > 70%
   C. > 85%
   D. > 95%
   E. > 97%

76. The classic Stupp regimen of chemoradiation following glioblastoma resection consists of what?
   A. 60 Gy XRT + PCV chemotherapy
   B. 25 Gy XRT + temozolomide chemotherapy
   C. 25 Gy XRT + PCV chemotherapy
   D. 60 Gy XRT + temozolomide chemotherapy

77. Giving 60 Gy XRT and temozolomide chemotherapy (Stupp) after resection of a glioblastoma is associated with a median overall survival of how many months?
   A. 11.5 months
   B. 14.6 months
   C. 12.1 months
   D. 18.3 months
   E. 20.7 months
78. MGMT promoter methylation in glioblastoma is associated with what median survival benefit compared to non-methylated tumors after utilization of the Stupp regimen of chemoradiation?
   A. 6.3 months
   B. 10.8 months
   C. 23.4 months
   D. 35.5 months
   E. 40.2 months

79. What is the main side effect of temozolomide chemotherapy?
   A. Peripheral neuropathy
   B. Myelosuppression
   C. Cardiomyopathy
   D. Leukocytosis
   E. Seizures

80. You are seeing a 55-year-old patient back in follow-up 3 months after a gross total resection of a glioblastoma of the right frontal lobe. She has undergone 60 Gy XRT and TMZ chemotherapy. Her tumor demonstrated MGMT promoter methylation. On her MRI there is evidence of a contrast enhancing nodule in the resection cavity. What is the likely cause of this finding?
   A. Postoperative blood products
   B. Tumor recurrence
   C. Pseudoprogression
   D. Ischemic stroke

81. You are seeing a patient with recurrent glioblastoma who is currently undergoing treatment with bevacizumab (Avastin). All of the following are side effects of bevacizumab except?
   A. Hypertension
   B. Arterial thromboembolism
   C. Hemorrhage
   D. Myelosuppression

82. Approximately 75% of pilocytic astrocytomas present in what age group?
   A. 1 to 20 years
   B. 21 to 40 years
   C. 41 to 60 years
   D. 61 to 80 years
   E. 81 to 100 years

83. What is the preferred postoperative treatment regimen for incompletely resected pilocytic astrocytomas in the pediatric population?
   A. Observation
   B. Early XRT
   C. Temozolomide chemotherapy
   D. Gamma knife

84. Collins’ law suggests that a pediatric patient with pilocytic astrocytomas can be considered cured if no recurrence happens in what time interval?
   A. 5 years
   B. 10 years
   C. Patient’s age at diagnosis + 5 years
   D. Patient’s age at diagnosis + 9 months

85. A 16-year-old boy with a known history of NF-1 presents with painless proptosis. What is the most likely diagnosis?
   A. Sphenoid wing meningioma
   B. Optic glioma
   C. Thyrotoxicosis
   D. Orbital neurofibroma

86. A 12-year-old girl presents with headache, nausea/vomiting, and diplopia. MRI is demonstrated below. What management should you recommend to the parents?

   a
   b

   A. Surgical resection
   B. Biopsy
   C. Chemotherapy
   D. Observation
   E. Radiation
87. Pleomorphic xanthoastrocytomas often present where?
A. Frontal lobe  
B. Temporal lobe  
C. Brainstem  
D. Cerebellum  
E. Occipital lobe

88. You perform a subtotal resection of a tumor confirmed to be an oligodendroglioma based on final pathology. What is the recommended postoperative treatment?
A. 60 Gy XRT + temozolomide chemotherapy  
B. 60 Gy XRT + PCV chemotherapy  
C. PCV chemotherapy alone  
D. Temozolomide chemotherapy alone

89. You are evaluating a 33-year-old woman with what appears to be an ependymoma on MRI. If she were to present with a cranial nerve deficit, what deficit would you expect to see?
A. Visual loss  
B. Medial rectus palsy  
C. Facial weakness  
D. Tongue weakness

90. You are evaluating a 33-year-old woman with what appears to be an ependymoma on MRI of the brain. What other imaging should be performed?
A. Whole body PET CT  
B. CT chest/abdomen/pelvis  
C. MRI spinal axis  
D. Technetium bone scan

91. You resect an ependymoma of the fourth ventricle in a 33-year-old woman. MRI of the spinal axis does not demonstrate any evidence of drop metastases. What postoperative treatment would you recommend?
A. XRT + temozolomide chemotherapy  
B. XRT + PCV chemotherapy  
C. XRT alone  
D. Temozolomide alone

92. What tumor type is often found attached to the septum pellucidum?
A. Glioblastoma  
B. Central neurocytoma  
C. Intraventricular meningioma  
D. Intraventricular lymphoma  
E. Pleomorphic xanthoastrocytoma

93. Gelastic seizures are often seen with a mass located where?
A. Frontal lobe  
B. Mesial temporal lobe  
C. Third ventricle  
D. Anterior temporal pole  
E. Fourth ventricle

94. You have just resected a dysembryoplastic neuroepithelial tumor of the anterior temporal pole in a 22-year-old man with intractable epilepsy. Postoperative imaging suggests gross total resection. What do you recommend for postoperative management?
A. XRT + temozolomide chemotherapy  
B. XRT alone  
C. Temozolomide chemotherapy alone  
D. Observation

95. During surgery for a paragangioma, manipulation of the tumor can lead to what intraoperative complication?
A. Cardiac arrhythmia  
B. Life-threatening hemorrhage  
C. Seizure  
D. Stroke

96. Which of the following is the most common type of paragangioma?
A. Glomus tympanicum  
B. Glomus jugulare  
C. Glomus intravagale  
D. Carotid body tumor
I Questions

97. Neuroblastomas arise from what element of the nervous system?
   A. Sympathetic ganglion
   B. Peripheral nerve
   C. Dorsal root ganglion
   D. Free nerve endings

98. You are seeing a patient with a pineal region tumor. CSF markers are ordered and demonstrated below. What is the most likely diagnosis?
   B-HCG (+), AFP (−), PLAP (−)
   A. Germinoma
   B. Choriocarcinoma
   C. Embryonal carcinoma
   D. Mature teratoma

99. You are seeing a patient with a pineal region tumor. CSF markers are ordered and demonstrated below. What is the most likely diagnosis?
   B-HCG (+), AFP (−), PLAP (+)
   A. Germinoma
   B. Choriocarcinoma
   C. Embryonal carcinoma
   D. Mature teratoma

100. You are seeing a patient with a pineal region tumor. CSF markers are ordered and demonstrated below. What is the most likely diagnosis?
    B-HCG (−), AFP (−), PLAP (−)
    A. Germinoma
    B. Choriocarcinoma
    C. Embryonal carcinoma
    D. Mature teratoma

101. You are seeing a patient with a pineal region tumor. CSF markers are ordered and demonstrated below. What is the most likely diagnosis?
    B-HCG (−), AFP (+), PLAP (−)
    A. Germinoma
    B. Choriocarcinoma
    C. Embryonal carcinoma
    D. Mature teratoma

102. Patients with vestibular schwannomas are most likely to present with which of the symptoms listed below?
    A. Facial weakness
    B. Facial numbness
    C. Taste changes
    D. Otalgia

103. What is the most common presentation of a vestibular schwannoma?
    A. Facial weakness
    B. Facial numbness
    C. Taste changes
    D. Hearing loss

104. You see a 34-year-old woman with an asymptomatically discovered 1.3-cm vestibular schwannoma. Her hearing tests demonstrate intact hearing. What is the next best step?
    A. Surgical resection
    B. Stereotactic radiosurgery
    C. Observation
    D. Chemotherapy

105. What direction is the facial nerve most often displaced by a vestibular schwannoma?
    A. Anterior
    B. Posterior
    C. Superior
    D. Inferior
    E. Lateral

106. What percentage of hemangioblastomas occur as part of von Hippel-Lindau disease?
    A. 20%
    B. 40%
    C. 60%
    D. 80%
    E. 100%

107. All of these tumor types are associated with von Hippel-Lindau disease except?
    A. Hemangioblastoma
    B. Pheochromocytoma
    C. Paraganglioma
    D. Renal cell carcinoma
108. You are seeing a patient with biopsy proven, non-AIDS-related primary CNS lymphoma. What is the best treatment?
A. Surgical resection followed by XRT and methotrexate chemotherapy
B. XRT + methotrexate chemotherapy
C. XRT + temozolomide chemotherapy
D. Surgical resection followed by XRT and temozolomide chemotherapy

109. What is the approximate 5-year survival of patients with biopsy proven primary CNS lymphoma?
A. 3 to 4%
B. 15 to 16%
C. 30 to 31%
D. 48 to 49%
E. 55 to 56%

110. A pituitary tumor is considered a macroadenoma after it has crossed what size threshold?
A. > 5 mm
B. > 1 cm
C. > 2 cm
D. > 3 cm
E. > 3.5 cm

111. Approximately what percentage of pituitary adenomas are functioning?
A. 15%
B. 35%
C. 50%
D. 65%
E. 80%

112. What type of visual field deficit would a large pituitary macroadenoma cause?
A. Right homonymous hemianopia
B. Left superior quadrant hemianopia
C. Central scotoma
D. Bitemporal hemianopia

113. What serum marker might help lead you to a diagnosis of suprasellar germinoma?
A. B-HCG
B. AFP
C. Sodium
D. Hematocrit

114. You are taking care of a patient that you suspect has pituitary apoplexy. What finding would lead you to perform emergent decompression of the sella?
A. Hypotension
B. Visual field cut
C. Hypernatremia
D. Elevated urine output

115. You see a patient with evidence of hypercortisolism. There appears to be a functioning pituitary adenoma. What is the diagnosis?
A. Cushing’s disease
B. Cushing’s syndrome
C. Nelson’s syndrome
D. Pituitary apoplexy

116. You are evaluating a patient who has had both adrenal glands removed as a treatment for her primary disease. She has noticed some worsening of her peripheral vision and states that her skin appears darker than usual. What is the diagnosis?
A. Cushing’s disease
B. Cushing’s syndrome
C. Nelson’s syndrome
D. Pituitary apoplexy

117. Patients with growth hormone-secreting pituitary adenomas have an elevated risk of what other type of cancer?
A. Lung cancer
B. Colon cancer
C. Pancreatic cancer
D. Hepatocellular carcinoma

118. You see a patient with a large pituitary tumor and bitemporal hemianopia. Prolactin level is 356. You decide to attempt medical management. The main medication used in this case works on what receptor?
A. D1 dopamine receptor
B. D2 dopamine receptor
C. GABA receptor
D. Glutamate receptor
119. You see a patient with a large pituitary tumor and bitemporal hemianopia. Prolactin level is 356. You decide to attempt medical management. You decide to use cabergoline. What is a worrisome side effect from the use of cabergoline?
A. Seizures
B. Diarrhea
C. Mitral regurgitation
D. Diabetes insipidus

120. You are treating a patient with acromegaly and a growth hormone-secreting pituitary tumor. You elect to start the patient on medication using octreotide. How does this medication work?
A. GH receptor antagonist
B. Dopamine agonist
C. Somatostatin analogue
D. Adrenal steroid synthesis inhibitor

121. You are treating a patient with acromegaly and a growth hormone-secreting pituitary tumor. You elect to start the patient on medication using pegvisomant. How does this medication work?
A. GH receptor antagonist
B. Dopamine agonist
C. Somatostatin analogue
D. Adrenal steroid synthesis inhibitor

122. A patient presents to you with known colonic polyposis and evidence of multiple cranial osteomas in X-ray of the skull. What is the diagnosis?
A. Turcot’s syndrome
B. Gardner’s syndrome
C. McCune-Albright syndrome
D. Paget’s disease

123. You are seeing a patient with a single abnormal protrusion of the skull in the right parietal region. X-rays demonstrate trabeculated bone. They decide they would like it removed and during surgery you observe a blue colored mass underneath the pericranium. What is the most likely diagnosis?
A. Osteoid osteoma
B. Hemangioma
C. Metastasis
D. Multiple myeloma

124. The Hand-Schüller-Christian triad is comprised of exophthalmos (from intraorbital tumor), lytic bone lesions (of the cranium), and what?
A. Diabetes insipidus
B. Seizures
C. Papilledema
D. Facial weakness

125. Fibrous dysplasia is associated with what syndrome?
A. Turcot’s syndrome
B. Gardner’s syndrome
C. McCune-Albright syndrome
D. Paget’s disease

126. You are operating on a cerebellar hemangioblastoma with a large associated cystic component. You open the dura and the cerebellum begins to herniate through the dural defect. What will be the most effective means to decrease posterior fossa pressure?
A. Hyperventilation
B. Mannitol
C. Dexamethasone
D. Needle aspiration of cystic contents

127. You resect a pathology proven cerebellar hemangioblastoma with a large cystic component. You have removed the mural nodule. Should you attempt to excise the entire cyst wall?
A. Yes
B. No

128. You resect a pathology proven cerebellar pilocytic astrocytoma with a large cystic component. You have removed the mural nodule. Should you attempt to excise the entire cyst wall?
A. Yes
B. No
129. During endoscopic third ventriculostomy, aggressive manipulation of the endoscope within the third ventricle should be avoided to prevent injury to what structure?
A. Mamillary bodies
B. Caudate head
C. Fornix
D. Thalamus

130. Approximately what length of temporal lobe can be resected safely during a temporal lobectomy on the dominant side?
A. 1 to 2.5 cm
B. 3 to 4.5 cm
C. 5 to 5.5 cm
D. 6 to 6.5 cm

131. You are seeing a patient in the emergency department who had the worst headache of her life. She opens her eyes to voice, does not know the date or where she is, but is able to follow commands reliably with good strength x4. Subarachnoid hemorrhage is confirmed on imaging. What is her WFNS grade?
A. 1
B. 2
C. 3
D. 4
E. 5

132. You are seeing a patient in the emergency department who had the worst headache of her life. On imaging she has evidence of SAH in the basal cisterns that is >3 mm in diameter but no evidence of intra-ventricular hemorrhage. Based on the modified Fisher scale for SAH, what is her risk of vasospasm?
A. 0%
B. 24%
C. 33%
D. 40%
E. 50%

133. After a ruptured intracranial aneurysm, what is the approximate risk of rebleed per day while the aneurysm remains unsecured?
A. 1.5%
B. 5%
C. 25%
D. 33%

134. You are taking care of a patient who suffered a rupture of a carotid bifurcation aneurysm. It is postbleed day 5 and she is experiencing new left arm weakness. What is the most likely underlying mechanism?
A. Subclinical seizures
B. Hyponatremia
C. Vasospasm
D. Intracerebral hemorrhage

135. What is the single most common location for an intracranial aneurysm?
A. Anterior communicating artery
B. Posterior communicating artery
C. Carotid bifurcation
D. Posterior inferior cerebellar artery

136. You are evaluating a 55-year-old woman with a history of hypertension and smoking who has evidence of a third nerve palsy. Where is the aneurysm?
A. Anterior communicating artery
B. Posterior communicating artery
C. Carotid bifurcation
D. Posterior inferior cerebellar artery

137. What is the most important step in aneurysm surgery prior to clip placement?
A. Dissecting the dome free
B. Releasing CSF
C. Proximal control
D. ICG administration
138. You are seeing a patient with a right sided ophthalmic segment aneurysm that is growing and causing compression of the optic nerve from the aneurysm itself. What symptoms would you expect him to report?
A. Right inferior nasal quadrantanopsia  
B. Right superior nasal quadrantanopsia  
C. Right superior temporal quadrantanopsia  
D. Right inferior temporal quadrantanopsia

139. You are seeing a patient with a right sided ophthalmic segment aneurysm that is growing and causing compression of the optic nerve. This initially led to an ipsilateral superior nasal quadrantanopsia. Now he reports that he is developing an inferior nasal quadrantanopsia. What structure is causing further compression of the optic nerve?
A. Falciform ligament  
B. Tuburculum sellae  
C. Anterior clinoid process  
D. Middle clinoid process

140. You are seeing a patient with a right sided ophthalmic segment aneurysm that is growing and causing compression of the optic nerve. In order to gain access to the aneurysm neck you decide to perform an anterior clinoidectomy. What imaging modality might help you ensure that this procedure is safe in this patient’s case?
A. Conventional cerebral angiogram  
B. MRI brain  
C. CT head  
D. Carotid ultrasound

141. You are evaluating an angiogram in a patient with an AVM. The characteristics are: size = 3.6 cm; drainage = internal cerebral vein; location = right frontal. What is the Spetzler-Martin grade of this AVM?
A. 2  
B. 3  
C. 4  
D. 5  
E. 6

142. You are evaluating an angiogram in a patient with an AVM. The characteristics are: size = 3.6 cm; drainage = internal cerebral vein; location = right frontal. Based on Spetzler-Martin grade, what is the rate of good surgical outcome (no deficit postop)?
A. 95%  
B. 84%  
C. 73%  
D. 69%  
E. 53%

143. What is the approximate annual risk of hemorrhage in S-M grade 1 to 3 AVMs?
A. 0%  
B. 3.5%  
C. 10%  
D. 17.5%  
E. 25%

144. You are operating on a 35-year-old man with a brainstem cavernous malformation that has hemorrhaged twice. You successfully resect the cavernoma, but there appears to be a venous malformation deep in the resection cavity. True or false, you should coagulate and cut this venous malformation?
A. True  
B. False

145. You are operating on a 35-year-old man with a left temporal cavernous malformation that is thought to be causing his medically intractable epilepsy. As you approach to the cavernous malformation, you notice yellow discoloration of the surrounding brain parenchyma. True or false, you should resect this surrounding tissue?
A. True  
B. False

146. What is the most common presentation of a dural arteriovenous fistula?
A. Hemorrhagic stroke  
B. Seizure  
C. Ischemic stroke  
D. Pulsatile tinnitus
147. A Cognard grade II a + b dural arteriovenous fistula has what characteristic venous drainage?
A. Direct cortical venous drainage without ectasia
B. Direct cortical venous drainage with ectasia
C. Retrograde sinus and retrograde cortical venous drainage
D. Anterograde sinus and retrograde cortical venous drainage

148. What Cognard grade carries the highest risk of hemorrhage when grading a dural fistula?
A. Type II a + b
B. Type III
C. Type II b
D. Type II a

149. What is the most common presenting symptom of a vein of Galen malformation?
A. Hemorrhage
B. Seizure
C. Heart failure
D. Ischemic stroke

150. You are evaluating a 44-year-old woman in the emergency department who was just involved in a motor vehicle accident where she was unrestrained and hit her face on the dashboard. Since the accident she has noticed blurry vision out of the right eye only. You notice that she appears to have a VI nerve palsy on the right, chemosis, and some proptosis. What is the diagnosis?
A. Intraparenchymal contusion
B. Orbital blowout fracture
C. Ophthalmic artery dissection
D. Carotid-cavernous fistula

151. A hypoxic cell is more sensitive to radiation than an oxygenated cell, true or false?
A. True
B. False

152. Generally speaking, how old should a child be before they are able to receive cranial radiation therapy?
A. > 1 year
B. > 3 years
C. > 5 years
D. > 7 years
E. > 10 years

153. Gamma knife radiosurgery is used for tumors of what diameter?
A. 1 cm or less
B. 3 cm or less
C. 5 cm or less
D. 7 cm or less
E. 10 cm or less

154. What is the maximum safe dose of radiation to the optic apparatus?
A. 6 Gy
B. 10 Gy
C. 14 Gy
D. 18 Gy
E. 20 Gy

155. What is a standard stereotactic radiosurgery dose that gives good tumor control for vestibular schwannomas but preserves facial nerve function?
A. 10 Gy or less
B. 13 Gy or less
C. 16 Gy or less
D. 19 Gy or less
E. 22 Gy or less

156. What is the maximum safe dose of radiation to the lens of the eye?
A. 6 Gy or less
B. 8 Gy or less
C. 10 Gy or less
D. 12 Gy or less
E. 15 Gy or less
157. At the 10-year post-treatment mark, what percentage of patients who received standard sellar radiation for a residual pituitary tumor will experience side effects including hypopituitarism?
A. 10 to 20%
B. 20 to 30%
C. 30 to 40%
D. 40 to 50%
E. 50 to 60%

158. What is considered the mean safe dose of radiation to the cochlea?
A. < 2 Gy
B. 4 to 6 Gy
C. 7 to 9 Gy
D. 10 to 12 Gy
E. 13 to 15 Gy

159. You are seeing a 56-year-old man with a single brain metastasis which is proven to be a radiosensitive tumor based on histology. You elect to perform stereotactic radiosurgery for this mass that measures approximately 1.8 cm in maximum diameter. What dose of radiation should you plan to deliver to the tumor?
A. 10 Gy
B. 18 Gy
C. 24 Gy
D. 30 Gy
E. 40 Gy

160. You are seeing a 56-year-old man with a single brain metastasis which is proven to be a radiosensitive tumor based on histology. You elect to perform stereotactic radiosurgery for this mass that measures approximately 2.8 cm in maximum diameter. What dose of radiation should you plan to deliver to the tumor?
A. 10 Gy
B. 18 Gy
C. 24 Gy
D. 30 Gy
E. 40 Gy

161. You just resected a known, solitary lung cancer metastasis from the right frontal lobe in a 62-year-old man. Pathology confirms lung cancer metastasis. What is the next step for treatment?
A. Proton-beam radiation
B. Stereotactic radiosurgery
C. Whole brain radiation
D. Observation

162. Current literature supports use of stereotactic radiosurgery to treat how many concurrent cerebral metastases?
A. 5 or less
B. 10 or less
C. 15 or less
D. 20 or less

163. You are seeing a 34-year-old woman with a Spetzler-Martin grade II AVM (2.8 cm nidus, borders eloquent cortex), and she prefers stereotactic radiosurgery as an initial attempt at treating her currently asymptomatic AVM. She asks you how long it takes for the radiation to close the AVM. You tell her...
A. < 1 week
B. < 1 month
C. < 1 year
D. < 3 years
E. > 5 years

164. You are seeing a 34-year-old woman with a Spetzler-Martin grade II AVM (2.8 cm nidus, borders eloquent cortex), and she prefers stereotactic radiosurgery as an initial attempt at treating her currently asymptomatic AVM. What radiation dose should you administer to the AVM?
A. 14 to 16 Gy
B. 18 to 20 Gy
C. 23 to 25 Gy
D. 29 to 31 Gy
165. What is the overall AVM obliteration rate when treated by stereotactic radiosurgery?
A. 10 to 20%
B. 30 to 40%
C. 50 to 60%
D. 70 to 80%
E. 90 to 100%

166. What is the approximate “pain-free” control rate of trigeminal neuralgia when treated by stereotactic radiosurgery?
A. 25%
B. 45%
C. 65%
D. 85%

167. What is the primary deleterious side effect of whole brain radiation?
A. Intracerebral hemorrhage
B. Seizures
C. Headaches
D. Dementia

168. You are evaluating a patient in the emergency department with known multiple myeloma who is presenting with signs and symptoms of spinal cord compression. Imaging confirms an epidural mass emanating from the vertebral body. You call a colleague in radiation oncology and she says she can administer emergency radiation to shrink the tumor. Approximately what dose will she deliver in this situation?
A. 8 Gy
B. 15 Gy
C. 22 Gy
D. 30 Gy

169. What is the standard radiation dose administered to the spine for metastatic disease?
A. 10 Gy in 10 fractions
B. 20 Gy in 10 fractions
C. 30 Gy in 10 fractions
D. 40 Gy in 10 fractions

170. You are seeing a 55-year-old woman with severe right sided trigeminal neuralgia currently on carbamazepine that is currently controlled. What percentage of patients managed with medication will ultimately require a procedure?
A. 5%
B. 50%
C. 75%
D. 100%

171. During a microvascular decompression, you do not see a compressive vessel and you elect to squeeze the nerve. What is a significant risk of performing this procedure?
A. Anesthesia dolorosa
B. Worsened facial pain
C. Brainstem ischemic stroke
D. Seizure

172. You are seeing a 55-year-old woman who reports pain in her lower right jaw and teeth. It seems lancinating in nature and brought on by brushing her teeth. She has lost weight because she finds it difficult to eat. What should be your next step?
A. Start carbamazepine
B. Start oxycodone
C. Right sided microvascular decompression
D. Observation

173. You are seeing a 55-year-old woman who reports pain in her lower right jaw and teeth. It seems lancinating in nature and brought on by brushing her teeth. She has lost weight because she finds it difficult to eat. What should be your next step?
A. Start carbamazepine
B. Start oxycodone
C. Right sided microvascular decompression
D. Right sided percutaneous trigeminal rhizotomy
174. What is the success rate of microvascular decompression at 10 years?
A. 30%
B. 50%
C. 70%
D. 90%

175. How do you determine the difference between SIADH and cerebral salt wasting?
A. Urine osmolality
B. Serum sodium
C. Fluid status
D. Urine output

176. What is an initial step for treating SIADH and hyponatremia in a patient who is conscious and able to follow commands?
A. Hypertonic saline
B. Fluid restriction
C. DDAVP
D. Demeclocycline

177. You are treating a patient with SIADH refractory to fluid restriction. You decide to utilize medical management. What medication should you start?
A. Furosemide
B. Hydrocortisone
C. DDAVP
D. Demeclocycline

178. You are treating a patient with cerebral salt wasting refractory to fluid resuscitation. You decide to utilize medical management. What medication should you start?
A. Furosemide
B. Fludrocortisone
C. DDAVP
D. Demeclocycline

179. What is an initial step for treating cerebral salt wasting and hyponatremia in a patient with subarachnoid hemorrhage?
A. Normal saline infusion
B. Fluid restriction
C. DDAVP
D. Demeclocycline

180. Untreated diabetes insipidus leads to what medical condition?
A. Hyponatremia
B. Severe dehydration
C. Coma
D. Status epilepticus

181. How much secretory capacity for ADH must be lost before central diabetes insipidus occurs?
A. 25%
B. 55%
C. 85%
D. 100%

182. You are taking care of a conscious, ambulatory patient with mild diabetes insipidus. How should you manage the patient’s sodium?
A. Drink to thirst
B. DDAVP administration
C. Salt tablets
D. Hypertonic saline infusion

183. At what dose does the use of a dopamine infusion become a vasoconstrictor rather than a positive inotrope?
A. > 2 µg/kg/min
B. > 5 µg/kg/min
C. > 10 µg/kg/min
D. > 15 µg/kg/min
184. You elect to use dobutamine to increase the cardiac output of one of your postop patients. How long will this medication be effective?
A. 12 hours  
B. 24 hours  
C. 48 hours  
D. 72 hours

185. How long can an outpatient be on steroids before you should consider starting GI (ulcer) prophylaxis?
A. < 2 days  
B. < 1 week  
C. < 3 weeks  
D. < 6 months  
E. 1 year

186. One unit of platelets (out of a “six pack”) is expected to raise the platelet count by approximately how much?
A. 1 to 5K  
B. 5 to 10K  
C. 10 to 15K  
D. 15 to 20K

187. What platelet count should cause you to transfuse platelets even in the setting of no evidence of bleeding?
A. 10K  
B. 30K  
C. 50K  
D. 75K

188. What is the dose for reversing unfractionated heparin utilizing protamine sulfate?
A. 1 mg protamine/10 u heparin  
B. 1 mg protamine/100 u heparin  
C. 1 mg protamine/1,000 u heparin  
D. 1 mg protamine/10,000 u heparin

189. You see a stable patient with a subdural hematoma who is on Dabigatran (Pradaxa). In order to reverse the anticoagulation you elect to give Idarucizumab (Praxbind). How long should you wait before proceeding to the operating room?
A. Immediately  
B. 4 hours  
C. 12 hours  
D. 24 hours

190. You are evaluating a post-operative craniotomy patient in the PACU. The anesthesia team utilized succinylcholine during intubation. The patient appears to be tachypneic, tachycardia, severe rigidity and high fever. What is the likely diagnosis?
A. Hyperkalemia  
B. Seizure  
C. Malignant hyperthermia  
D. Respiratory failure

191. You are evaluating a postoperative craniotomy patient in the PACU. The anesthesia team utilized succinylcholine during intubation. The patient appears to be tachypneic, tachycardic, with severe rigidity and high fever. What medication should be administered?
A. Benzodiazepines  
B. Propofol  
C. Dantrolene  
D. Desmopressin

192. You are evaluating a postoperative craniotomy patient in the PACU. The anesthesia team utilized succinylcholine during intubation. The patient appears to be tachypneic, tachycardic, with severe rigidity and high fever. This condition is thought to arise from genetic defects in what receptor?
A. Nicotinic  
B. Ryanodine  
C. NMDA  
D. GABA
193. Based on the NASCET study, what is the reduction in stroke risk after carotid endarterectomy in symptomatic patients with high grade stenosis at 18 months post-procedure compared to best medical management?
A. 6%
B. 11%
C. 17%
D. 23%
E. 28%

194. Based on the current literature, what should the overall risk of postoperative complications be to justify a carotid endarterectomy for a patient with symptomatic high-grade stenosis?
A. 1% or less
B. 3% or less
C. 5% or less
D. 7% or less
E. 10% or less

195. You are evaluating a patient in the PACU in whom you just performed a left sided carotid endarterectomy. She reports that she has had two episodes since surgery of her usual amaurosis fugax TIA. Her neck is not enlarged. What is the next best step?
A. EEG
B. CT angiogram
C. MRI
D. Bedside decompression

196. You are evaluating a patient in the ICU in whom you just performed a left-sided carotid endarterectomy approximately 12 hours ago. She reports that she has a fairly severe left-sided headache and her left eye hurts. What next step will most likely improve her symptoms?
A. Pain medication administration
B. CT angiogram
C. Blood pressure control
D. Operative exploration

197. What is the most common cranial neuropathy to occur after carotid endarterectomy?
A. Hypoglossal palsy
B. Spinal accessory palsy
C. Vagus palsy
D. Glossopharyngeal palsy

198. You are called emergently to the PACU to evaluate a post-operative carotid endarterectomy patient who is having trouble breathing. She has obvious stridor and her saturations are dropping. She appears to have a bulging mass in the operative site. What should you do?
A. CT Angiogram
B. Bedside decompression
C. Intubation
D. Oxygen administration

199. You are evaluating a patient who just experienced a stroke with a small fixed deficit and evidence of high grade stenosis of the left carotid artery. You elect to offer a carotid endarterectomy. This procedure should be performed within what timeframe from the stroke onset to improve outcome?
A. 1 week
B. 2 weeks
C. 3 weeks
D. 1 month

200. The carotid revascularization endarterectomy versus stenting trial demonstrated what when comparing the outcomes of carotid angioplasty and stenting to carotid endarterectomy?
A. Superiority
B. Nonsuperiority
C. Inferiority
D. Noninferiority
E. Worsened outcomes
201. To be considered a burst fracture, what aspects of the spine must be fractured?
A. Anterior cortex only  
B. Anterior and posterior cortex  
C. Anterior/posterior cortices and pedicles  
D. Anterior/posterior cortices, pedicles and posterior ligamentous complex

202. What type of fracture is demonstrated in the CT scan below?

A. Compression fracture  
B. Burst fracture  
C. Chance fracture  
D. Fracture dislocation

203. You are evaluating a 65-year-old woman who fell and has evidence of a lumbar burst fracture. Overall alignment appears to be intact and she has no neurologic compromise. What is the best step in management?
A. Observation and pain control only  
B. TLSO bracing  
C. Decompressive laminectomy  
D. Fusion

204. To be considered a compression fracture, what aspects of the spine must be fractured?
A. Anterior cortex only  
B. Anterior and posterior cortex  
C. Anterior/posterior cortices and pedicles  
D. Anterior/posterior cortices, pedicles and posterior ligamentous complex

205. What type of fracture is demonstrated in the imaging below?

Use the following figure to answer questions 205 and 206:

A. Compression fracture  
B. Burst fracture  
C. Chance fracture  
D. Fracture dislocation
I Questions

206. What force mechanism leads to the fracture in the image shown in Question 205?
A. Flexion compression
B. Pure axial load
C. Flexion distraction
D. Shear

207. What force mechanism leads to the fracture in the image shown in Question 202?
A. Flexion compression
B. Pure axial load
C. Flexion distraction
D. Shear

208. What force mechanism leads to the fracture in the image below?
A. Flexion compression
B. Pure axial load
C. Flexion distraction
D. Shear

209. What force mechanism leads to the fracture in the image below?
A. Flexion compression
B. Pure axial load
C. Flexion distraction
D. Shear
E. Extension distraction
210. What force mechanism leads to the fracture in the image below?
A. Flexion compression  
B. Pure axial load  
C. Extension distraction  
D. Shear

211. What is the most common location for burst fractures of the spine?
A. T6-7  
B. T9-10  
C. T12-L1  
D. L3-4

212. Based on the thoracolumbar injury classification and severity score, how would you classify a burst fracture with indeterminate ligamentous injury and nerve root injury?
A. Operative  
B. Nonoperative  
C. "Gray zone"

213. Based on the thoracolumbar injury classification and severity score, how would you classify a burst fracture with intact posterior ligamentous complex and evidence of new urinary retention and flaccid plegia of the lower extremities?
A. Operative  
B. Nonoperative  
C. "Gray zone"

214. Based on the thoracolumbar injury classification and severity score, how would you classify a burst fracture with intact posterior ligamentous complex and full strength on examination?
A. Operative  
B. Nonoperative  
C. "Grey zone"

215. Based on the thoracolumbar injury classification and severity score, ligamentous injury gives how many points for complete spinal cord injury?
A. 1  
B. 2  
C. 3  
D. 4  
E. 5

216. Based on the thoracolumbar injury classification and severity score, ligamentous injury gives how many points for translational/rotational injury morphology?
A. 1  
B. 2  
C. 3  
D. 4  
E. 5

217. Based on the thoracolumbar injury classification and severity score, ligamentous injury gives how many points for definite injury to the posterior ligamentous complex?
A. 1  
B. 2  
C. 3  
D. 4  
E. 5

218. According to the 3-column model of Denis, the posterior vertebral body is located in what column of the spine?
A. Anterior column  
B. Middle column  
C. Posterior column  
D. Ligamentous complex

219. According to the 3-column model of Denis, the facet joints are located within what column?
A. Anterior column  
B. Middle column  
C. Posterior column  
D. Ligamentous complex
220. You are evaluating a 35-year-old woman who was just involved in a motor vehicle accident. On imaging you notice that she has evidence of transverse process fractures on the left from L3-5. Is this fracture pattern stable or unstable?
A. Stable
B. Unstable

221. Which type of odontoid fracture is considered stable?
A. Type I
B. Type II
C. Type III
D. Type IV

222. Which type of odontoid fracture is pictured below?

A. Type I
B. Type II
C. Type III
D. Type IV

223. What is generally thought to be the non-union rate for type II odontoid fractures at long-term follow-up?
A. 5%
B. 20%
C. 30%
D. 50%
E. 70%

224. A measurement of atlanto-dental interval greater than what is suggestive of transverse ligament injury?
A. 3 mm
B. 6 mm
C. 9 mm
D. 12 mm

225. You are evaluating a 33-year-old woman who was in a motor vehicle accident and was thrown from the car as it flipped. Imaging is demonstrated below. What is the diagnosis?

A. Type II dens fracture
B. Traumatic spondylolisthesis of the axis
C. Jefferson fracture
D. Atlanto-occipital disassociation

226. A powers ratio of what is suggestive of atlanto-occipital disassociation?
A. 1
B. < 1
C. > 1
D. 0

227. Which type of traumatic spondylolisthesis of the axis should not be put in traction?
A. Type I
B. Type II
C. Type IIa
D. Type III
E. Type IV
228. Which type of axis fracture is depicted below?

A. Type I  
B. Type II  
C. Type IIa  
D. Atypical

229. How much angulation is required to consider a traumatic spondylolisthesis of the axis to be a Type IIa injury?

A. 5 degrees  
B. 11 degrees  
C. 16 degrees  
D. 21 degrees

230. Is this fracture stable or unstable?

A. Stable  
B. Unstable

231. What is the approximate AP diameter of the normal cervical spinal canal?

A. 10 mm  
B. 13 mm  
C. 17 mm  
D. 21 mm  
E. 25 mm

232. What is the approximate AP diameter of the normal cervical spinal cord?

A. 10 mm  
B. 13 mm  
C. 17 mm  
D. 21 mm

233. You are evaluating a 14-year-old boy who fell backwards and hit his head on a rock. He lost consciousness but is fully awake in the trauma bay. He has a burning sensation in both his hands and forearms, and has some bilateral proximal lower extremity weakness. CT scan of the cervical spine is negative for acute fracture or displacement. What is the next best step?

A. Collar immobilization and observation  
B. Posterior C3-7 laminectomy  
C. Halo placement  
D. MRI

234. You are evaluating a 17-year-old adolescent girl who was in an unrestrained motor vehicle accident. Imaging is demonstrated, and she has significant posterior midline neck pain. What is the diagnosis?

A. Jumped facets  
B. Traumatic spondylolisthesis of the axis  
C. Jefferson fracture  
D. Tear drop fracture  
E. Atlanto-occipital dislocation
235. You are evaluating a construction worker who fell off a ladder and hit the back of his head. He has a reassuring head CT, but is having midline neck pain and his imaging is demonstrated below. What is the next best step?

A. Traction
B. Collar immobilization/observation
C. MRI scan
D. Posterior decompression/fusion

236. You are evaluating a patient who was just involved in a motor vehicle accident and is currently in a cervical collar with evidence of a fracture dislocation of C5-6 with anterior displacement. She has 2/5 strength in bilateral deltoids and 3-5 strength in bilateral biceps. She is awake and interactive. What is the next best step?

A. Traction
B. Collar immobilization/observation
C. MRI scan
D. Posterior decompression/fusion

237. You are evaluating a patient who was just involved in a motor vehicle accident and is currently in a cervical collar with evidence of a fracture dislocation of C5-6 with anterior displacement. She was intubated and paralyzed at the scene. She remains on propofol and is not following commands. What is the next best step?

A. Traction
B. Collar immobilization/observation
C. MRI scan
D. Posterior decompression/fusion

238. When applying traction, approximately how much weight should be applied per level?

A. 1 lb
B. 5 lbs
C. 10 lbs
D. 20 lbs
E. 25 lbs

239. You are evaluating the images of a patient who, the ED told you, has a cervical fracture. You are looking at an open mouth odontoid view and you remember to calculate the “rule of Spence.” This measurement is utilized to determine the integrity of which ligament?

A. Apical ligament
B. Alar ligaments
C. Transverse ligament
D. Atlanto-occipital membrane

240. You are using the rule of Spence to determine the integrity of a cervical ligament. To calculate this the total overhang of the C1 lateral masses on the C2 joints should be greater than what to suggest ligament injury?

A. 4 mm
B. 7 mm
C. 11 mm
D. 15 mm
E. 20 mm

241. You are evaluating a 45-year-old woman in whom you performed an L5-S1 right diskectomy 3 months ago. This improved her pain, but now it is back in the same distribution. You decide to obtain further imaging, what should you order?

A. Non-contrast lumbar CT
B. Contrast enhanced lumbar CT
C. Lumbar spine MRI without gadolinium
D. Lumbar spine MRI with gadolinium

242. What percentage of patients with a lumbar disc herniation and leg pain will improve with 6 weeks of nonoperative management?

A. 50%
B. 70%
C. 85%
D. 100%
243. Which of these findings on exam would make you consider surgery for a herniated lumbar disc in the acute setting?
A. Sensory loss
B. Progressive weakness
C. Acute severe pain
D. Positive straight leg raise

244. What is the most consistent finding in acute cauda equina syndrome?
A. Saddle anesthesia
B. Motor weakness
C. Urinary retention
D. Bowel incontinence

245. In patients with confirmed acute cauda equina syndrome and urinary retention, how many are able to return to normal bladder function?
A. 25%
B. 50%
C. 75%
D. 100%

246. You have booked a patient for surgery on a herniated lumbar disk with associated radicular leg pain. She asks what percentage of patients will be pain free 1 year postop, what do you quote her?
A. ~25%
B. ~50%
C. ~75%
D. ~100%

247. You have booked a patient for surgery on a herniated lumbar disk with associated radicular leg pain. She asks what percentage of patients will experience a recurrent herniation, what do you quote her?
A. 1% at 10 years
B. 4% at 10 years
C. 7% at 10 years
D. 10% at 10 years

248. You are seeing a patient back in follow-up in whom you performed an uncomplicated ACDF at C5-6. You are looking at flexion/extension films to evaluate whether or not the patient has developed a pseudoarthrosis. How much movement of the spinous processes between flex/ex films is tolerated to be considered a stable fusion?
A. 0 mm
B. 2 mm or less
C. 5 mm or less
D. 10 mm or less

249. What makes up the roof of the lateral recess of the lumbar spine?
A. Spinous process
B. Pedicle
C. Superior articulating process
D. Inferior articulating process

250. What is the normal height of the lateral recess as measured on lumbar spine CT?
A. 3 mm or greater
B. 5 mm or greater
C. 7 mm or greater
D. 9 mm or greater

251. In a patient with L4-5 spondylolisthesis, which nerve root is likely to be compressed?
A. L3
B. L4
C. L5
D. S1
E. S2

252. A fusion should be strongly considered with what levels of spondylolisthesis listed below (Meyerding classification)?
A. I, II, III, IV
B. II, III, IV
C. I, IV
D. IV only
253. What is the most common manifestation of rheumatoid arthritis in the spine?
   A. L4-5 spondylolisthesis  
   B. Atlantoaxial subluxation  
   C. Thoracic disc herniation  
   D. Ankylosing spondylitis

254. 70% of spinal cord syrinxes are associated with what condition?
   A. Chiari I malformation  
   B. Chiari II malformation  
   C. Chiari III malformation  
   D. Chiari IV malformation

255. You are seeing a 40-year-old woman who has been found to have an incidentally discovered spinal cord syrinx within the cervical spinal cord. She is currently asymptomatic. What do you recommend?
   A. Observation/serial imaging  
   B. Percutaneous drainage  
   C. Syringosubarachnoid shunt  
   D. Posterior fossa decompression

256. You are performing a syringosubarachnoid shunt for a patient with a spinal cord syrinx. Where should you enter the spinal cord to place the shunt catheter?
   A. Dorsal root entry zone  
   B. Midline  
   C. Anterior to the dentate ligament  
   D. Dorsal column

257. You are performing a syringosubarachnoid shunt for a patient with a spinal cord syrinx. What is the rate of clinical stabilization at 10-year follow-up with this procedure?
   A. 13%  
   B. 37%  
   C. 54%  
   D. 86%

258. Spinal epidural lipomatosis is associated with chronic use of what medication?
   A. Methotrexate  
   B. Hydrocortisone  
   C. Octreotide  
   D. Oxycodone

259. You are seeing a patient with a BMI of 43 who has symptoms of pseudoclaudicatory pain and evidence of spinal epidural lipomatosis on MR imaging. What would be a good initial treatment option?
   A. Weight loss  
   B. Epidural steroid injection  
   C. Lumbar laminectomy  
   D. Lumbar laminectomy and fusion

260. You are seeing a patient with a BMI of 43 who has symptoms of pseudoclaudicatory pain and evidence of spinal epidural lipomatosis on MR imaging. What diameter of epidural fat is a useful guideline to diagnose spinal epidural lipomatosis?
   A. > 3 mm  
   B. > 5 mm  
   C. > 7 mm  
   D. > 9 mm

261. Symptomatic adjacent segment disease occurs at what percentage per year after ACDF?
   A. 2.9%  
   B. 6.7%  
   C. 12.3%  
   D. 16.5%

262. Which of these fusion mechanisms describes a solid matrix for new bone to form within?
   A. Osteogenesis  
   B. Osteoconduction  
   C. Osteoinduction  
   D. Osteointegration

263. The load-bearing rule of Harms states what percentage of axial loading of the spine is borne by the anterior and posterior columns, respectively?
   A. 50-50  
   B. 20-80  
   C. 80-20  
   D. 60-40
264. What is the 5-year fusion rate for patients undergoing a single level ACDF?
A. 80%
B. 85%
C. 90%
D. 95%

265. Which of the following is not part of the NEXUS criteria for management of questioned C-spine injuries in the emergency department?
A. No midline tenderness
B. No distracting injury
C. Presence of a cervical collar
D. Awake/interactive patient

266. Which of these factors is not part of the McCormack and Gaines load-sharing classification of thoracolumbar fractures?
A. Degree of comminution
B. Posterior ligamentous complex injury
C. Fracture apposition
D. Degree of kyphosis

267. True or false; high-dose methylprednisolone should be administered to patients who have a traumatic cervical spinal cord injury with neurologic deficit.
A. True
B. False

268. You are seeing a patient with a cervical spinal cord injury and you decide to provide blood pressure augmentation. What should your target mean arterial pressure be?
A. 70 mm Hg
B. 85 mm Hg
C. 100 mm Hg
D. 115 mm Hg

269. A classic “chance” fracture is considered to be what type of fracture in the AO classification system?
A. A
B. B
C. C
D. D

270. According to the SPORT trial, what were the findings on intention-to-treat analysis for patients undergoing treatment for lumbar disc herniation?
A. No difference between groups
B. Significant benefit of surgery out to 4 years
C. Significant benefit of conservative management out to 4 years
D. No improvement with either management strategy

271. According to the SPORT trial, what were the findings on as-treated analysis for patients undergoing treatment for lumbar disc herniation?
A. No difference between groups
B. Significant benefit of surgery out to 4 years
C. Significant benefit of conservative management out to 4 years
D. No improvement with either management strategy

272. What percentage of the facet should be preserved in order to maintain stability during a lumbar laminectomy for stenosis?
A. 25%
B. 50%
C. 75%
D. 100%

273. What percentage of patients with achondroplasia will have evidence of spinal stenosis?
A. 10%
B. 35%
C. 67%
D. 90%

274. You are seeing a patient with evidence of a radio-resistant metastatic lesion causing epidural spinal cord compression. Which of the following would lead you to avoid surgical decompression?
A. Multiple non-contiguous stenotic regions
B. < 6 months life expectancy
C. Total paraplegia for 24 hours
D. Age > 65
Questions

275. You are seeing a 65-year-old patient with evidence of a radio-resistant metastatic lesion causing epidural spinal cord compression at T12-L1. She has had complete paraplegia for the last 18 hours. Her life expectancy from primary disease is thought to be 6 months. Would you offer her wide surgical decompression and appropriate reconstruction?
A. Yes
B. No

276. What is the normal sagittal vertical axis measurement in the adult population?
A. -5-0 cm
B. 0-5 cm
C. 6-10 cm
D. 11-15 cm

277. Which of these pelvic parameters cannot be changed?
A. Sagittal vertical axis
B. Pelvic tilt
C. Pelvic incidence
D. Sacral slope

278. According to recent literature, better outcomes are demonstrated when the difference between the pelvic incidence and lumbar lordosis is what?
A. 1 degree or less
B. 10 degrees or less
C. 20 degrees or less
D. 30 degrees or less
E. 40 degrees or less

279. Which of these is not a compensatory mechanism in patients with a severely positive sagittal vertical axis?
A. Pelvic retroversion
B. Knee flexion
C. Pelvic incidence reduction
D. Cervical extension

280. What is the mean lumbar lordosis in normal adults?
A. ~20 degrees
B. ~40 degrees
C. ~60 degrees
D. ~80 degrees

281. In the cervical spine, approximately how much axial load is borne by the anterior and posterior columns, respectively?
A. 50%-50%
B. 35%-65%
C. 65%-35%
D. 80%-20%

282. In coronal plane deformity, dextroscoliosis means diversion of the spine to which side?
A. Right
B. Left

283. Which pelvic parameter is determined by an angle measured from a line drawn from the mid-sacral surface to the midpoint of the femoral head and then straight up?
A. Sacral slope
B. Pelvic tilt
C. Pelvic incidence
D. Sagittal vertical axis

284. Which of these pelvic parameter relationships is true?
A. PI = PT + SS
B. PI = PT - SS
C. PT = SS + PI
D. SS = PI + PT
E. Sagittal vertical axis

285. You are seeing a patient with a lumbar lordosis measured at 21 degrees and a pelvic incidence of 60 degrees. These two measurements lead you to a potential diagnosis of what?
A. Lumbar kyphosis
B. Coronal scoliosis
C. Flat-back syndrome
D. Ankylosing spondylitis
286. According to Schwab, when planning to correct a scoliotic patient, SVA should be < 5 cm, PI/LL should be within 10 degrees and pelvic tilt should be what?
A. < 50 degrees  
B. < 40 degrees  
C. < 30 degrees  
D. < 20 degrees

287. According to the Smith et al. scoliosis research study, the rate of major medical complications in patients undergoing scoliosis surgery in the 65 to 85 years of age range was what?
A. 6%  
B. 15%  
C. 29%  
D. 44%  
E. 56%

288. According to the Smith et al. scoliosis research study, the rate of improvement in disability and leg pain was most significant in what age group?
A. 18 to 24 years  
B. 25 to 44 years  
C. 45 to 64 years  
D. 65 to 85 years

289. According to current literature, the majority of patients who develop proximal junctional kyphosis after a spinal fusion procedure will exhibit symptoms within what time interval?
A. < 2 years  
B. < 1 year  
C. < 6 months  
D. < 3 months

290. This patient underwent a thoracolumbar fusion for scoliosis correction. The immediate postoperative x-ray is demonstrated, as well as an x-ray 1 week later. What is the diagnosis?
A. Instrumentation failure  
B. Proximal junctional kyphosis  
C. Inadequate correction  
D. Infection

291. A major curve with a Cobb angle of what has been shown to lead to progression of deformity?
A. > 10 degrees  
B. > 20 degrees  
C. > 30 degrees  
D. > 40 degrees

292. Is a structural scoliosis curve considered flexible or nonflexible?
A. Flexible  
B. Nonflexible

293. To determine coronal balance, a plumb line is drawn from the C7 spinous process on AP radiograph and compared to the central sacral vertical line. For coronal balance to be normal, the offset should be within what distance?
A. 10 cm or less  
B. 4 cm or less  
C. 2 cm or less  
D. 7 cm or less

294. How much correction of lordosis can be achieved at each level utilizing a Smith-Peterson osteotomy?
A. 5 to 10 degrees  
B. 11 to 15 degrees  
C. 16 to 20 degrees  
D. 21 to 25 degrees
1 Questions

295. How much correction of lordosis can be achieved at each level utilizing a pedicle subtraction osteotomy?
   A. 5 to 10 degrees
   B. 11 to 20 degrees
   C. 21 to 30 degrees
   D. 31 to 40 degrees

296. An ALIF (anterior lumbar interbody fusion) is best utilized at what level?
   A. L2-3
   B. L3-4
   C. L4-5
   D. L5-S1

297. What leg function is at the highest risk during the DLIF (direct lateral interbody fusion) procedure?
   A. Hip flexion
   B. Knee extension
   C. Knee flexion
   D. Ankle dorsiflexion

298. What is a major reported risk of performing a pedicle subtraction osteotomy?
   A. Durotomy
   B. Massive blood loss
   C. Infection
   D. Iatrogenic spine fracture

299. A pedicle subtraction osteotomy places the fulcrum of the correction at what point in the spine?
   A. Facets
   B. Posterior longitudinal ligament
   C. Mid-vertebral body
   D. Anterior longitudinal ligament

300. Releasing the anterior column (cutting the ALL) can lead to approximately how much improvement in sagittal vertical axis per level?
   A. 1 cm
   B. 2 cm
   C. 3 cm
   D. 4 cm

301. You just performed an uncomplicated L3-5 laminectomy on a 75-year-old man and you have been called from the neurosurgery floor with a report that he has had a sudden worsening of his back pain and he is now demonstrating significant weakness in both lower extremities that was not present preoperatively. What is the most likely diagnosis?
   A. Epidural hematoma
   B. Deep venous thrombosis
   C. Spinal cord injury
   D. Proximal junctional kyphosis

302. You just performed an uncomplicated L3-5 laminectomy on a 75-year-old man and you have been called from the neurosurgery floor with a report that he has had a sudden worsening of his back pain and he is now demonstrating significant weakness in both lower extremities that was not present preoperatively. You suspect an epidural hematoma. What is the next best step?
   A. Bedside reopening
   B. Spinal imaging
   C. Observation
   D. Administration of PCCs
   E. EMG

303. Patients with spinal cord injury have a high rate of subsequent development of deep venous thrombosis. What is the overall mortality after DVT in SCI patients?
   A. 3%
   B. 9%
   C. 15%
   D. 21%
   E. 25%

304. A deep venous thrombosis that is limited to the calf has what approximate risk of embolization?
   A. < 1%
   B. 5%
   C. 10%
   D. 15%
305.
You are taking care of a 33-year-old woman on whom you just performed a battery replacement procedure for a vagal nerve stimulator. She will stay overnight in the hospital. Based on her DVT risk, what is the recommended prophylaxis?
A. Pneumatic compression boots/none
B. SQ heparin 5,000 BID
C. 1,000 u heparin/hour infusion
D. Initiate warfarin

306.
You are taking care of a 68-year-old man on whom you just performed a L3-5 decompressive laminectomy and fusion. Based on his DVT risk, what is the recommended prophylaxis?
A. Pneumatic compression boots/none
B. SQ heparin 5,000 BID
C. 1,000 u heparin/hour infusion
D. Initiate warfarin

307.
You are taking care of a 68-year-old man on whom you just performed a L3-5 decompressive laminectomy and fusion. What is his approximate risk of developing a deep venous thrombosis?
A. < 10%
B. 10 to 40%
C. 41 to 80%
D. 81 to 100%

308.
You are taking care of a 68-year-old man on whom you just performed a resection of a right temporal GBM. What is his approximate risk of developing a deep venous thrombosis?
A. < 10%
B. 10 to 40%
C. 41 to 80%
D. 81 to 100%

309.
What is the study of choice to order when you suspect a pulmonary embolism?
A. D-dimer
B. DVT ultrasound of the lower extremity
C. Contrast enhanced CT scan
D. Coagulation parameters

310.
You are taking care of a 68-year-old man in whom you just resected a large right temporal GBM. On postoperative day 3, he is found to be tachypneic and tachycardic with desaturations. Contrast enhanced CT demonstrates a pulmonary embolism. Postop MRI does not demonstrate any evidence of bleeding. You decide to treat, what medication should you order?
A. SQ heparin 5,000 u TID
B. IV heparin 5,000 u followed by 1,000 u/hr infusion
C. Fresh frozen plasma
D. Warfarin 5 mg daily

311.
Acute oliguria is defined as urine output of what?
A. < 100 mL/day
B. < 400 mL/day
C. < 800 mL/day
D. < 1,200 mL/day

312.
NSAIDs predominantly cause what type of acute oliguric renal failure?
A. Prerenal
B. Intrinsic renal
C. Postrenal
D. Ureteral

313.
Acute tubular necrosis is considered what type of oliguric renal failure?
A. Prerenal
B. Intrinsic renal
C. Postrenal
D. Ureteral

314.
You are evaluating an 80-year-old man with oliguria. Urinary sodium is 18 mEq/L. Is this renal failure likely prerenal or intrinsic renal?
A. Prerenal
B. Intrinsic renal
I Questions

315. You are evaluating an 80-year-old man with oliguria. Urinary sodium is 49 mEq/L. Is this renal failure likely prerenal or intrinsic renal?
A. Prerenal
B. Intrinsic renal

316. You are evaluating an 80-year-old man with oliguria. Fractional excretion of sodium is < 1%. Is this renal failure likely prerenal or intrinsic renal?
A. Prerenal
B. Intrinsic renal

317. What is the most serious arrhythmia associated with magnesium deficiency?
A. Polymorphous ventricular tachycardia (torsades)
B. Ventricular fibrillation
C. Bradycardia
D. Wolf-Parkinson-White syndrome

318. What calcium lab value is the physiologically important value?
A. Total calcium
B. Ionized calcium

319. Tetany is seen in what calcium state?
A. Hypercalcemia
B. Hypocalcemia

320. Refeeding syndrome is characterized by severe abnormalities in which electrolyte?
A. Sodium
B. Potassium
C. Calcium
D. Phosphorous

321. What is the current risk of being infected with HIV after a blood transfusion?
A. 1 in 20,000
B. 1 in 200,000
C. 1 in 2,000,000
D. 1 in 20,000,000

322. What is the current risk of being infected with Hepatitis B after a blood transfusion?
A. 1 in 30,000
B. 1 in 300,000
C. 1 in 3,000,000
D. 1 in 30,000,000

323. What is the major clinical risk of heparin-induced thrombocytopenia?
A. Hemorrhage
B. Thrombosis
C. Hypotension
D. Hypertension

324. What is the initial management step for treating heparin-induced thrombocytopenia?
A. Platelet transfusion
B. Warfarin administration
C. Stop all heparin
D. Fluid resuscitation

325. Which of these factors is likely to induce hypokalemia?
A. Beta agonists
B. Hyperglycemia
C. Respiratory acidosis
D. Hyperthermia

326. Which of these factors is likely to induce hyperkalemia?
A. Beta agonists
B. Insulin administration
C. Respiratory acidosis
D. Hypothermia

327. At what potassium level would you expect to see changes in the ECG?
A. 5.5 mEq/L
B. 6.0 mEq/L
C. 6.5 mEq/L
D. 7.0 mEq/L
E. 8.0 mEq/L
328. What is the first ECG change observed in patients with hyperkalemia?
A. Increased PR interval
B. Peaked T waves
C. Widening of the QRS complex
D. Asystole

329. You are evaluating a postop patient who was feeling funny and the electrolyte panel returned with a potassium of 7.3 mEq/L. The ECG demonstrates loss of P waves. What should be your first step in management?
A. Call a code
B. Administer calcium gluconate
C. Obtain echocardiogram
D. Recheck the electrolyte panel

330. You are evaluating a postop patient who was feeling normal and the electrolyte panel returned with a potassium of 7.8 mEq/L. The ECG looks unchanged from preop. What should be your first step in management?
A. Call a code
B. Administer calcium gluconate
C. Obtain echocardiogram
D. Recheck the electrolyte panel

331. According to the SRS-Schwab classification, a lumbar curve with a Cobb angle of > 30 degrees but a thoracic curve < 30 degrees would be classified as what?
A. T
B. L
C. D
D. N

332. According to the SRS-Schwab classification, a lumbar curve with a Cobb angle of > 30 degrees and an opposite thoracic curve > 30 degrees would be considered what?
A. T
B. L
C. D
D. N

333. According to the Oswestry disability index, what score would indicate that activities of daily living are affected by the patient’s pain?
A. 0 to 20%
B. 21 to 40%
C. 41 to 60%
D. 61 to 80%

334. According to the Oswestry disability index, what score would indicate that the patient has pain, but it can be improved and dealt with utilizing repositioning and activity modification?
A. 0 to 20%
B. 21 to 40%
C. 41 to 60%
D. 61 to 80%

335. What Meyerding grade would this spondylolisthesis be?

336. You are seeing a patient in the emergency department who was involved in a motor vehicle accident and has a C5-6 fracture dislocation with no preserved motor or sensory function below this level. What is the ASIA score?
A. A
B. B
C. C
D. D
I Questions

337. You are seeing a patient in the emergency department who was involved in a motor vehicle accident and has a C5-6 fracture dislocation with sensation in the lower extremities, but no appreciable movement below C5. What is the ASIA score?
A. A
B. B
C. C
D. D

338. You are seeing a patient in the emergency department who was involved in a motor vehicle accident and has a cervical fracture with perched facets and interspinous widening on CT scan. On exam he is ASIA B. What is the SLIC score for fracture morphology?
A. 1
B. 2
C. 3
D. 4

339. You are seeing a patient in the emergency department who was involved in a motor vehicle accident and has a cervical fracture with perched facets and interspinous widening on CT scan. On exam he is ASIA B. What is the SLIC score for interspinous widening?
A. 1
B. 2
C. 3
D. 4

340. You are seeing a patient in the emergency department who was involved in a motor vehicle accident and has a cervical fracture with perched facets and interspinous widening on CT scan. On exam he is ASIA B. What is the SLIC score for the neurologic exam?
A. 1
B. 2
C. 3
D. 4

341. When examining muscle strength based on the MRC (modified research council) system, full range of motion against gravity gives what score?
A. 2
B. 3
C. 4
D. 5

342. Which of these findings can only be observed on EMG?
A. Myoclonus
B. Fibrillations
C. Fasciculations
D. Tetany

343. What time frame is generally used to denote a time frame of denervation after which there is little hope of recovery of motor function?
A. 6 months
B. 12 months
C. 24 months
D. 36 months

344. What is the timeframe for recovery of a neurapraxic peripheral nerve injury?
A. 6 to 8 days
B. 6 to 8 weeks
C. 6 to 8 months
D. 6 to 8 years

345. What finding separates a neurapraxia from axonotmesis based on the Seddon classification?
A. Fasciculations
B. Preserved SNAP
C. Wallerian degeneration
D. Presence of voluntary potentials

346. According to the Sunderland classification, what nerve injury involves disruption of the endoneurium with preserved perineurium and epineurium?
A. Grade I
B. Grade II
C. Grade III
D. Grade IV
347. According to the Sunderland classification, what nerve injury involves disruption of the endoneurium and perineurium with preservation of the epineurium?
A. Grade I
B. Grade II
C. Grade III
D. Grade IV

348. According to the Sunderland classification, what nerve injury involves disruption of the axon and all supporting structures?
A. Grade II
B. Grade III
C. Grade IV
D. Grade V

349. What exam finding might help you differentiate between a Sunderland grade IV lesion and a Sunderland grade III lesion?
A. Fibrillation potentials
B. Muscle atrophy
C. Immobile Tinel's sign
D. MRC grade IV strength

350. In a Sunderland grade II injury, movement of the Tinel's sign on exam should progress distally at what rate?
A. 1 mm/day
B. 1 cm/day
C. 1 mm/week
D. 1 cm/month

351. You are evaluating a 34-year-old man who punched through a plate glass window at 1 AM and has a large laceration on the lateral aspect of his elbow. He had a complete wrist drop immediately after the injury. You suspect a radial nerve injury. The wound appears clean. Repair of the nerve should occur within what interval?
A. < 6 hours
B. < 24 hours
C. < 72 hours
D. < 1 week

352. You are evaluating a 34-year-old man who was using a chainsaw to cut down a tree and lost control of the saw resulting in a severe injury to his elbow. Has a large laceration on the lateral aspect of his elbow. He had a complete wrist drop immediately after the injury. You suspect a radial nerve injury. The wound has evidence of wood fragments and dirt present as well as a compound fracture of the bone. Regarding the nerve injury, what is the next best step?
A. Immediate debridement and direct repair
B. Debridement and tagging of the nerve endings
C. Debridement and closure of the wound
D. Debridement and nerve graft

353. You are evaluating a 34-year-old man who punched through a plate glass window at 1 AM and has a large laceration on the lateral aspect of his elbow. He had a complete wrist drop immediately after the injury. You suspect a radial nerve injury. The wound appears clean. You elect to operate. What technique will most likely provide the best functional outcome?
A. Direct nerve repair
B. Nerve graft repair
C. Nerve transfer
D. Tendon transfer

354. After a nerve injury that is suspected to be a Sunderland grade II or higher, initial EMG should be performed after what time interval?
A. 24 hours
B. 1 week
C. 3 weeks
D. 3 months

355. What is the most important factor when considering when to operate on a nerve injury that will likely require nerve grafting or direct repair?
A. Preoperative MRC grade
B. Distance from injury to end muscle
C. Age
D. Sunderland grade
356. A patient presents to your office with a brachial plexus injury asking if you will perform an operation to restore muscle function. Which muscle will you be very unlikely to provide any meaningful recovery to with a nerve repair operation?
   A. Deltoid  
   B. Biceps  
   C. Triceps  
   D. Abductor pollicis brevis

357. Which of these findings suggests a postganglionic injury to the brachial plexus?
   A. Horner’s syndrome  
   B. Winged scapula  
   C. Pseudomeningocele on MRI  
   D. Disrupted SNAP

358. You are evaluating a 3-month-old child with an obstetrical brachial plexus palsy that appears to be upper trunk in nature (deltoid/bicep weakness with preserved hand function). What should be your recommendation?
   A. Continue to observe  
   B. Perform plexus exploration

359. Involvement of which nerve may help distinguish a preganglionic from a postganglionic brachial plexus injury?
   A. Thoracodorsal nerve  
   B. Long thoracic nerve  
   C. Medial antebrachial cutaneous nerve  
   D. Suprascapular nerve

360. You are operating on an upper trunk brachial plexus injury and you have determined that it is a Sunderland grade IV injury that requires nerve grafting. Resecting the neuroma leads to a 3 cm gap. How much sural nerve should you harvest in order to bridge this gap?
   A. 3 cm  
   B. 5 cm  
   C. 7 cm  
   D. 9 cm

361. You have been called to the postanesthesia unit to evaluate your patient in whom you just performed a lumbar laminectomy that was uncomplicated. In the PACU she developed severe onset left shoulder pain and while her exam was initially normal per report, when you examine her she has 3/5 strength in the left deltoid while all other myotomes are full strength. What is the likely diagnosis?
   A. Positioning palsy  
   B. Idiopathic brachial plexitis  
   C. Nerve root stretch  
   D. Epidural hematoma

362. You have been called to the postanesthesia unit to evaluate your patient in whom you just performed a lumbar laminectomy that was uncomplicated. In the PACU she developed severe onset left shoulder pain and while her exam was initially normal per report, when you examine her she has 3/5 strength in the left deltoid while all other myotomes are full strength. You suspect Parsonage-Turner syndrome. Should you give steroids?
   A. Yes  
   B. No

363. Struther’s ligament leads to compression of what nerve?
   A. Median  
   B. Ulnar  
   C. Radial  
   D. Musculocutaneous

364. What physical exam finding suggests an anterior interosseus nerve compression?
   A. Benedictine hand  
   B. Froment’s sign  
   C. Abnormal pinch sign  
   D. Positive Phalen test

365. You are seeing a 55-year-old drummer who has noticed the onset of weakness in grip strength of his right hand, dysesthesias of the radial 3 digits that wake him from sleep. You notice thenar atrophy. What should be your next step?
   A. Give oral cortisone  
   B. Right carpal tunnel decompression  
   C. EMG  
   D. Steroid injection
366. You are seeing a 55-year-old drummer who has noticed the onset of weakness in grip strength of his right hand, dysesthesias of the radial 3 digits that wake him from sleep. You notice thenar atrophy. EMG confirms carpal tunnel syndrome. You decide to offer surgery. What chance of satisfactory success should you quote the patient?

A. 35%
B. 55%
C. 75%
D. 95%

367. What finding would you not expect to see in a patient with ulnar neuropathy caused by compression at Guyon’s canal?

A. Hypothenar atrophy
B. Sensory loss on the palmar aspect of the hand
C. Sensory loss on the dorsal aspect of the hand
D. Intenoseuli weakness

368. You are evaluating a police officer with a BMI of 35 who has noticed the onset of burning pain in his right thigh that has been fairly persistent for the last 2 months. It does not go below the knee and is mostly anteromedial on the thigh. It seems to go away when he rubs the leg during the day, and he doesn’t notice the pain when he is home from work. What is the most likely diagnosis?

A. Herniated lumbar disk
B. Discogenic back pain
C. Meralgia paresthetica
D. Muscle spasm

369. You are evaluating a police officer with a BMI of 35 who has noticed the onset of burning pain in his right thigh that has been fairly persistent for the last 2 months. It does not go below the knee and is mostly anteromedial on the thigh. It seems to go away when he rubs the leg during the day, and he doesn’t notice the pain when he is home from work. What should you recommend?

A. Surgical decompression
B. Steroid injection
C. Weight loss
D. Observation

370. What percentage of patients with meralgia paresthetica will improve with nonsurgical management?

A. 30%
B. 50%
C. 70%
D. 90%

371. What exam finding differentiates radial nerve injury from posterior interosseus nerve palsy?

A. Finger extensor weakness
B. Wrist drop
C. Flexor pollicis longus weakness
D. Coracobrachialis weakness

372. How do you differentiate common peroneal nerve palsy from an L5 radiculopathy?

A. Foot eversion
B. Foot inversion
C. Ankle dorsiflexion
D. Ankle plantarflexion

373. What branch of the common peroneal nerve innervates the anterior tibialis?

A. Deep
B. Superficial
C. Articular
D. None of the above

374. True or false, in tarsal tunnel syndrome there is sparing of sensation of the heel?

A. True
B. False

375. You are evaluating a patient who has weakness of shoulder abduction (initiation) and external rotation. Which nerve should you evaluate?

A. Suprascapular nerve
B. Dorsal scapular nerve
C. Axillary nerve
D. Long thoracic nerve
Questions

376. True or false, Type II compression of the ulnar nerve in Guyon's canal leads to sensory abnormalities in the ulnar nerve distribution?
A. True
B. False

377. What is the most common cause of compression of the ulnar nerve in Guyon's canal?
A. Wrist ganglion
B. Aneurysm
C. Transverse carpal ligament
D. Bone spur

378. A cervical rib causing neurologic compression most likely leads to what physical exam finding?
A. Martin-Gruber hand
B. Riches-Cannieu hand
C. Gilliatt-Sumner hand
D. Froment's sign

379. You are performing a brachial plexus exploration. As you expose the anterior scalene muscle you should be watching for which nerve?
A. Dorsal scapular nerve
B. Long thoracic nerve
C. Phrenic nerve
D. Suprascapular nerve

380. Sensory latency of what is diagnostic of carpal tunnel syndrome on EMG?
A. > 1.4 msec
B. > 2.3 msec
C. > 3.0 msec
D. > 3.7 msec

381. Which of the following is not a phase of the EMG examination?
A. Stimulated activity
B. Insertional activity
C. Spontaneous activity
D. Volitional activity

382. True or false, in an EMG examination of a lumbar radiculopathy caused by a herniated lumbar disk the sensory nerve action potential will be normal?
A. True
B. False

383. True or false, in an EMG examination of a suspected brachial plexopathy the sensory nerve action potential will be normal?
A. True
B. False

384. True or false, in an EMG examination of a suspected nerve root avulsion the sensory nerve action potential will be normal?
A. True
B. False

385. What is the approximate accuracy of diagnosing the correct level of a lumbar radiculopathy from a herniated disk based on EMG alone?
A. 35%
B. 55%
C. 85%
D. 100%

386. Motor unit action potentials are recorded during what phase of an EMG examination?
A. Insertional activity
B. Spontaneous activity
C. Volitional activity
D. Stimulated activity

387. Fibrillation potentials are recorded during what phase of an EMG examination?
A. Insertional activity
B. Spontaneous activity
C. Volitional activity
D. Stimulated activity

388. The F wave is most helpful in determining what underlying disorder?
A. Herniated lumbar disk
B. Multilevel radiculopathy
C. Nerve root avulsion
D. Neuroma formation
389. What is the earliest onset of fibrillations after denervation injury on EMG examination?
A. 24 hours  
B. 7 to 10 days  
C. 3 months  
D. 12 months

390. Sharp waves on spontaneous EMG are seen in what condition?
A. Denervation  
B. Ischemic muscle  
C. Guillain-Barre syndrome  
D. Malignant peripheral nerve sheath tumor

391. The H-reflex is used on EMG to evaluate which nerve root?
A. L4  
B. L5  
C. S1  
D. S2

392. What finding is present on EMG approximately 6 weeks after reinnervation begins following nerve injury?
A. H-reflex  
B. F-wave  
C. Polyphasic MUAPs  
D. Sharp waves

393. How long after onset of radiculopathy will it take for reliable acute EMG findings to be present?
A. 12 hours  
B. 1 week  
C. 3 weeks  
D. 3 months

394. How long after onset of radiculopathy will it take for reliable chronic EMG findings to be present?
A. 1 month  
B. 3 months  
C. 6 months  
D. 12 months

395. True or false, EMG can be helpful to determine the presence or absence of radiculopathy of the C4 nerve root?
A. True  
B. False

396. Which of these patients would you expect to have no paraspinal muscle activity on EMG?
A. Patient with lumbosacral plexopathy  
B. Post-laminectomy patient  
C. Patient with meralgia paresthetica  
D. Patient with common peroneal nerve injury

397. Interference pattern is evaluated during what phase of the EMG examination?
A. Insertional activity  
B. Spontaneous activity  
C. Volitional activity  
D. Stimulated activity

398. Reduced interference pattern is indicative of what on EMG examination?
A. Motor unit loss  
B. Nerve root avulsion  
C. Multiple affected nerve roots  
D. Abnormal S1 nerve root

399. The classic “dive bomber” sound on EMG is indicative of what?
A. Myotonic discharges  
B. Motor unit loss  
C. Multiple affected nerve roots  
D. Abnormal S1 nerve root

400. True or false, an EMG examination will pick up a motor neuropathy even in cases where there is a normal neurologic examination?
A. True  
B. False

401. When it comes to lumbar radiculopathy, is EMG more sensitive or specific for localization?
A. Sensitive  
B. Specific
2 Neurology

1. You are evaluating a 56-year-old woman who had the onset of midthoracic back pain which has progressed to quadriparesis over the last several days. She has also noted the onset of bilateral severe eye pain and is losing vision in the left eye based on your visual acuity exam. Her imaging is demonstrated below. The underlying pathophysiology of this condition is thought to arise due to auto-antibodies against what?

   A. BK virus infection  
   B. Amoeba infection  
   C. HIV virus infection  
   D. JC virus infection  
   E. Toxoplasmosis

2. You are evaluating a 33-year-old woman with AIDS who has the following imaging. She has headaches, mild vision loss, and ataxia. What is the underlying cause of this patient’s condition?

3. Ciliary paralysis is seen in what condition listed below?
   A. Myasthenia gravis  
   B. Botulism  
   C. AIDP  
   D. CIDP  
   E. PML

4. You are evaluating a patient in the emergency department that has an interesting neurologic finding on examination. When you ask the patient to look up, his eyes converge and retract in a bilateral jerk-movement fashion. The lesion is most likely located where?
   A. Ventral midbrain  
   B. Dorsal pons  
   C. Dorsal midbrain  
   D. Ventral pons  
   E. Hypothalamus

A. T lymphocytes  
B. Aquaporin channel  
C. Myelin  
D. Presynaptic calcium channel  
E. Postsynaptic acetylcholine channel
5. In a patient with a hypertensive hemorrhage of the pons, what exam finding would you expect?
   A. Mydriasis
   B. Bilateral third nerve palsy
   C. Productive aphasia
   D. Miosis
   E. Expressive aphasia

6. What neuron must be intact for amphetamine (Paredrine) to affect pupillary size?
   A. First order neuron
   B. Second order neuron
   C. Third order neuron
   D. Fourth order neuron
   E. Fifth order neuron

7. Friedrich’s ataxia is inherited in what fashion?
   A. Autosomal recessive
   B. Autosomal dominant
   C. X-linked recessive
   D. Sporadic
   E. Autosomal dominant with incomplete penetrance

8. The following MRI finding is often demonstrated in what inherited condition?
   ![MRI Image]
   A. Neurofibromatosis type I
   B. Neurofibromatosis type II
   C. Sturge-Weber disease
   D. Tuberous sclerosis
   E. VHL

9. In many patients with HIV that go on to develop intracranial primary lymphoma, what is thought to be the underlying causative mechanism and type of lymphoma?
   A. Epstein-Barr virus/T cell type
   B. Epstein-Barr virus/B cell type
   C. JC virus/T cell type
   D. JC virus/B cell type
   E. BK virus/B cell type

10. What protein is found in Alzheimer’s-associated neurofibrillary tangles?
    A. Amyloid
    B. Ubiquitin
    C. Tau protein
    D. Alpha-synuclein
    E. APOE e4

11. In patients with advanced Alzheimer’s dementia, neurofibrillary tangles and plaques seen in what region are associated with the highest grade of dementia?
    A. Substantia nigra
    B. CA1 hippocampus
    C. Ventral medulla
    D. Occipital cortex
    E. Corpus callosum
12. You are evaluating a 5-year-old boy who has had difficulty with walking since age 3. He has a waddling gait and has difficulty standing due to proximal muscle weakness. A muscle biopsy is demonstrated below. What gene is affected?

![Image of muscle biopsy]

A. Emerin/completely absent
B. Emerin/partial dysfunction
C. Dystrophin/completely absent
D. Dystrophin/partial dysfunction
E. Myotonin/completely absent

13. Which autoantibody is found in patients with limbic encephalitis?

A. Anti-Hu
B. Anti-Yo
C. Anti-Ri
D. Anti-glutamic acid decarboxylase
E. Anti-Ma

14. You are asked to evaluate a high school football player on the sideline of his football game where he was hit hard on the helmet and appears confused. The brain dysfunction seen during the acute post-concussive syndrome is thought to arise due to what process?

A. Axon disruption
B. Subclinical seizures
C. ATP pump failure
D. Neurotransmitter depletion
E. Excitatory toxicity

15. What is the best initial management of post-concussive syndrome?

A. Immediate return to play
B. Cognitive rest
C. Prophylactic antiepileptic medications
D. Opioid pain medications
E. Intensive blood pressure management

16. You are evaluating a pediatric patient who is thought to have Rasmussen’s encephalitis, resulting from chronic encephalitis with spreading cortical inflammation. This results in epilepsy partialis continua. What is a common treatment technique in these patients?

A. VA nucleus DBS
B. Functional hemispherectomy
C. Medical management
D. Vagal nerve stimulator
E. Motor cortex stimulator

17. You are rotating in the EEG department and see a patient with the following EEG. What is the best medication for this patient?

![Image of EEG]

A. Valproic acid
B. Carbamazepine
C. Ethosuxamide
D. Levetiracetam
E. Zonisamide

18. What percentage of patients with an uncomplicated, simple febrile seizure will go on to develop adult epilepsy?

A. < 5%
B. 15%
C. 25%
D. 35%
E. 50%
19. The following MRI demonstrates findings associated with what syndrome?
   A. Hemimegalencephaly
   B. Focal cortical dysplasia
   C. Joubert syndrome
   D. Lhermitte-Duclos syndrome
   E. Rhombencephalosynapsis

20. How do patients with postoperative brachial neuritis (Parsonage-Turner syndrome) present?
   A. Pain before weakness
   B. Weakness before pain
   C. Weakness alone
   D. Pain alone
   E. Hyperreflexia alone

21. In patients with the following finding, what syndrome should you suspect?
   A. Sturge-Weber syndrome
   B. Neurofibromatosis type I
   C. Blue rubber bleb nevus syndrome
   D. Ataxia telangiectasia
   E. Friedrich's ataxia

22. You see a patient on rounds that appears to have transverse white lines on her fingernails, also known as Mees' lines. What toxic exposure are these signs associated with?
   A. Lead
   B. Arsenic
   C. Mercury
   D. Strychnine
   E. Botulinum toxin

23. A patient with a PTEN mutation may be found to have what underlying process?
   A. Dysembryoplastic gangliocytoma of the cerebellum
   B. Optic glioma
   C. Brainstem cavernous malformation
   D. Butterfly glioma
   E. Multiple meningiomas

24. Patients with narcolepsy exhibit onset of what sleep stage immediately upon falling asleep?
   A. Stage II sleep
   B. Stage IV sleep
   C. REM sleep
   D. Stage I sleep
   E. Stage III sleep

25. When reading an EEG, what electrode corresponds to the right frontal region?
   A. F1
   B. F2
   C. C3
   D. C4
   E. O2
26. Cheyne-Stokes respirations are thought to arise from destruction of what brain region?
A. Medullary destruction  
B. Pontine destruction  
C. Bifrontal destruction  
D. Bithalamic destruction  
E. Pontomedullary destruction

27. Nelson's syndrome describes what process after bilateral adrenalectomy?
A. Pituitary adenoma enlargement  
B. Panhypopituitarism  
C. Pituitary apoplexy  
D. Spontaneous CSF leak  
E. Optic chiasm compression in nonfunctioning pituitary adenomas

28. The patient with the findings depicted in this image would have what findings on laboratory evaluation?

A. Low serum ceruloplasmin, high urine copper  
B. High serum ceruloplasmin, high urine copper  
C. Low serum ceruloplasmin, low urine copper  
D. High serum ceruloplasmin, low urine copper

29. You are preparing to perform a C6-7 ACDF on a patient with a single-level traumatic jumped facet. You elect to utilize MEP and SSEP monitoring for the case. Before making incision, the monitoring technician informs you that there is prolonged latency of the ulnar SSEPs at Erb's point on the right. What is the most likely cause of this change?
A. Spinal cord compression  
B. Positioning-related brachial plexus compression  
C. Intracranial hemorrhage, parietal cortex  
D. Spinal cord vascular compromise  
E. Intracranial hemorrhage, thalamus

30. A diabetic third nerve palsy is often?
A. Painful and permanent  
B. Painful and temporary  
C. Painless and permanent  
D. Painless and temporary

31. You are evaluating a 32-year-old woman who reports ongoing difficulties with severe, burning pain of the right upper extremity. She has no history of trauma to the extremity. It appears red and warm, and she will not let you touch the extremity due to significant allodynia. She has not had good benefit from medical management. What is another potential treatment for her pain?
A. Limb amputation  
B. Sensory neurectomy  
C. Percutaneous cordotomy  
D. Sympathetic blockade  
E. Cervical laminectomy
32. You are evaluating a 44-year-old man who developed a sudden headache and speech difficulty. His imaging is demonstrated below. What condition might this patient have?

A. Neurofibromatosis  
B. AIDS  
C. Homocystinuria  
D. Phenylketonuria  
E. Blue rubber bleb nevus syndrome

33. You have a patient in burst suppression on pentobarbital for elevated ICP. You decide to turn off the pentobarbital now in order to get a neuro exam. Approximately how long will you have to wait for return of neurological function?

A. 5 hours  
B. 24 hours  
C. 48 hours  
D. 72 hours  
E. 100+ hours

34. You are evaluating the EMG of a patient in whom there is an intact F wave, but the H-reflex is absent. Where is the injury most likely located?

A. Motor endplate  
B. Distal motor nerve  
C. Dorsal root ganglion  
D. Upper cervical spine  
E. Anterior horn cells

35. Which of the following findings would help you to determine whether a patient has zoster oticus or Bell's palsy?

A. Upper facial weakness  
B. Lower facial weakness  
C. Ear vesicles  
D. Facial pain  
E. Corneal abrasion

36. You are asked to see an 86-year-old woman who reports dizziness. She says she hasn't really had this before the last 2 days and it seemed to start all of a sudden. She has had difficulty standing and walking due to the dizziness. On exam she has spontaneous, direction changing nystagmus and skew deviation. She reports minimal nausea and no vomiting since onset. What is the next best step in management?

A. Scopolamine patch  
B. Otolith repositioning  
C. Antibiotics  
D. Brain MRI  
E. Dexamethasone

37. What structure of the auditory system is most sensitive to high volume?

A. Tympanic membrane  
B. Inner hair cells  
C. Outer hair cells  
D. Semicircular canals  
E. Spiral ganglion
1 Questions

38. Internuclear ophthalmoplegia affects what brain-stem tract?
A. Medial longitudinal fasciculus
B. Paramedian pontine reticular formation
C. Corticospinal tract
D. Rubrospinal tract
E. Optic tract

39. Bilateral carpal tunnel syndrome would be classified as what?
A. Polyradiculopathy
B. Mononeuropathy
C. Mononeuropathy multiplex
D. Polyneuropathy
E. Peripheral neuropathy

40. What would you expect to see on EMG of a patient with Lambert-Eaton syndrome?
A. Decremental response
B. Incremental response
C. Steady response
D. No response

41. This MRI demonstrates lesions discovered in a 29-year-old man with known AIDS. What is the diagnosis?
A. HIV encephalopathy
B. Staph aureus abscess
C. Listeria abscess
D. Toxoplasmosis
E. PML

42. What is the most common neurologic complication in patients with AIDS?
A. Toxoplasmosis
B. Primary lymphoma
C. Leukoencephalopathy
D. Bacterial abscess
E. Glioma

43. Charcot joints are thought to be due to what process?
A. Obesity
B. Peripheral neuropathy
C. Complex regional pain syndrome
D. Infection
E. Tumor

44. A patient who demonstrates the opsoclonus-myoclonus reaction (rapid, involuntary conjugate eye movements in multiple directions associated with myoclonic jerks) may have which of the following tumors?
A. Glioblastoma
B. Hemangioblastoma
C. Neuroblastoma
D. Pineoblastoma
E. Choroid plexus carcinoma

45. You see a pediatric patient who suffers from intractable epilepsy that manifests as drop attacks. He has had several injuries related to his seizures. What surgical procedure might provide him some relief from his condition?
A. Functional hemispherectomy
B. Corpus callosotomy
C. Temporal lobectomy
D. Selective amygdalohippocampectomy
46. You are evaluating a child on the pediatric neurology service that is currently hospitalized for a subdural hematoma. He appears to have kinked hair, and laboratory studies have demonstrated low levels of ceruloplasmin. What is the inheritance pattern of this disorder?
   A. X-linked  
   B. Autosomal dominant  
   C. Sporadic  
   D. Autosomal recessive

47. The term “palinopsia” refers to what symptom?
   A. Color blindness  
   B. Inability to recognize faces  
   C. Burned in images when eyes are closed  
   D. Cortical blindness  
   E. Visual field cut

48. The following findings are often seen in patients with what genetic condition?
   A. NF1  
   B. NF2  
   C. Sturge-Weber syndrome  
   D. Blue rubber bleb nevus syndrome  
   E. Tuberous sclerosis

49. You evaluate a patient with macrocephaly, developmental delay, and seizures. He is an infant. MRI imaging demonstrates bifrontal symmetric T2 hyperintensities. There is concern for Alexander disease. If a brain biopsy were to be performed, what would you expect to see on pathology?
   A. Hirano bodies  
   B. Rosenthal fibers  
   C. Lewy bodies  
   D. Neurofibrillary tangles  
   E. Eosinophilic cytoplasmic inclusion bodies

50. Which of the following is not a part of Wernicke’s triad?
   A. Ataxia  
   B. Ophthalmoplegia  
   C. Confusion  
   D. Aphasia
51. Elevated alpha fetoprotein is a primary marker utilized for diagnosis of a condition that results from what embryologic defect?
A. Gastrulation defect
B. Failure of closure of anterior neuropore
C. Primary neurulation defect
D. Secondary neurulation defect

52. Diastematomyelia results from what embryologic deficit?
A. Gastrulation defect
B. Failure of closure of anterior neuropore
C. Primary neurulation defect
D. Secondary neurulation defect

53. Myelomeningocele is associated with what condition?
A. Arnold-Chiari type I malformation
B. Arnold-Chiari type II malformation
C. Klippel-Feil anomaly
D. Caudal regression syndrome

54. Agenesis of the corpus callosum is associated with trisomy of all chromosomes listed below except?
A. 13
B. 15
C. 18
D. 21

55. Premature closure of the metopic suture leads to what named craniosynostosis?
A. Scaphocephaly
B. Oxycephaly
C. Trigonocephaly
D. Posterior plagiocephaly

56. A 17-year-old adolescent boy is referred to you due to gait imbalance. He has a positive Romberg sign on testing. You also note several cherry red spots on his skin and face. What other manifestation is associated with this autosomal recessive condition?
A. Fused cervical vertebrae
B. Hypotelorism
C. Pes cavus
D. Thymic atrophy

57. You are evaluating a 3-week-old infant with marked hypotonia and respiratory problems. If the underlying disease is a lower motor neuron disorder, what is the most likely diagnosis?
A. Spinal muscle atrophy type I
B. Spinal muscle atrophy type II
C. Amyotrophic lateral sclerosis
D. Charcot-Marie-Tooth disorder

58. You are evaluating a 38-year-old man who has multiple cutaneous telangiectasias of the skin and mucosa, as well as recurrent epistaxis. He has evidence of a brain arteriovenous malformation. This condition runs in his family in an autosomal dominant fashion. What receptor is mutated in this condition?
A. EGFR
B. VEGF
C. TGF-B
D. MuSK

59. You have been consulted on a 40-year-old woman who is found to have multiple cutaneous facial nevi and is currently hospitalized for subarachnoid hemorrhage that appears to be coming from an orbital arteriovenous malformation that extends posteriorly along the optic tract. What is the most likely diagnosis?
A. Hereditary hemorrhagic telangiectasia
B. Wyburg-Mason syndrome
C. Sturge-Weber syndrome
D. Klippel-Feil anomaly

60. You are in Rome on vacation and you overhear a neighboring conversation from a man who is describing a medical illness that his friend is suffering from. Despite his inability to properly pronounce the anatomic structures, it seems his friend is suffering from necrosis and demyelination of the corpus callosum. If his friend consumes large quantities of wine, what is the diagnosis?
A. Hereditary hemorrhagic telangiectasia
B. Wyburg-Mason syndrome
C. Sturge-Weber syndrome
D. Marchiafava-Bignami disease
61. You are evaluating an infant with evidence of dwarfism, coarse facial features, corneal clouding, cardiac disease, and deafness. This condition results from defects in what process?
A. Mucopolysaccharide degradation  
B. Oxidation of very long chain fatty acids  
C. Deficiency in glycogen storage  
D. Mitochondrial DNA abnormalities

62. You have been asked to see a 6-year-old boy with mental retardation, spasticity, and evidence that he has been chewing on his fingers. What enzyme deficiency would you expect?
A. Alpha-L-iduronidase  
B. Hypoxanthine-guanine-phosphoribosyltransferase  
C. Sphingomyelinase  
D. Glucocerebrosidase

63. You are consulted on a patient admitted to the medicine service with the acute onset of seizures, abdominal pain, diarrhea, myalgias, and peripheral neuropathy. The patient has also demonstrated evidence of psychosis. What is the most likely diagnosis?
A. Halloherden-Spatz disease  
B. Acute intermittent porphyria  
C. Hurler's syndrome  
D. Wilson's disease

64. You are evaluating an 8-year-old girl who exhibits hyperreflexia, stiffness, and frozen facial expressions that make it very difficult for her to eat. MRI is shown below. What is the most likely diagnosis?

A. Halloverden-Spatz disease  
B. Acute intermittent porphyria  
C. Hurler's syndrome  
D. Wilson's disease

65. You performed an L3-5 laminectomy on a patient 2 years ago that was complicated by a CSF leak. A pseudomeningocele is evident on MR imaging. The patient presents with sensorineural hearing loss and cerebellar ataxia. There is some evidence of myelopathy. MR imaging of the brain demonstrates some GRE signal along the surface of the cerebellum. What is the most likely diagnosis?
A. CSF hypotension  
B. Superficial siderosis  
C. Arachnoiditis  
D. Spinal cord herniation
66. This syndrome is characterized by uncontrolled seizures, mental retardation, and spike and wave complexes at 1 to 2 Hz on EEG. What is the most likely diagnosis?
A. West syndrome  
B. Apert syndrome  
C. Pfeiffer syndrome  
D. Lennox-Gastaut syndrome

67. You are asked to evaluate a 5-month-old infant with a history of congenital CMV infection who has developed flexor/extensor spasms of the head, trunk, and limbs. EEG demonstrates hypsarrhythmia. What is the most likely diagnosis?
A. West syndrome  
B. Apert syndrome  
C. Pfeiffer syndrome  
D. Lennox-Gastaut syndrome

68. This syndrome involves craniosynostosis, deafness, hypertelorism, and dental problems. An image is shown below. What is the most likely diagnosis?
A. West syndrome  
B. Apert syndrome  
C. Pfeiffer syndrome  
D. Lennox-Gastaut syndrome

69. This syndrome involves craniosynostosis, hypertelorism, dental problems, as well as syndactyly of both hands and feet. An image is shown below. What is the most likely diagnosis?
A. West syndrome  
B. Apert syndrome  
C. Pfeiffer syndrome  
D. Lennox-Gastaut syndrome

70. This syndrome involves craniosynostosis, hypertelorism, dental problems, and cleft palate. An image is shown below. What is the most likely diagnosis?
A. West syndrome  
B. Apert syndrome  
C. Pfeiffer syndrome  
D. Crouzon syndrome
71. Loss of dopaminergic neurons in the substantia nigra pars compacta leads to what manifestations within the basal ganglia?
A. Atrophy of the putamen
B. Decreased activity of the indirect pathway
C. Increased activity of the indirect pathway
D. Increased activity of the direct pathway

72. What process is thought to result in the increase in α-synuclein and ubiquitin in the neurons of Parkinson patients?
A. Mitochondrial dysfunction
B. Loss of dopamine
C. Persistence of the Gs phase in the cell cycle
D. Silent infarcts

73. You are evaluating a 62-year-old man who is presenting with unexplained falls, axial and neck rigidity, downward gaze paralysis, masked facies, and dysarthria. L-DOPA has had little effect. What is the most likely diagnosis?
A. Parkinsonism
B. Progressive supranuclear palsy
C. Huntington’s disease
D. Multiple system atrophy

74. You are evaluating a 62-year-old man who is presenting with unexplained falls, axial and appendicular instability, nystagmus, resting tremor, and rigidity. What is the most likely diagnosis?
A. Huntington’s disease
B. Striatonigral degeneration
C. Shy-Drager syndrome
D. Olivopontocerebellar atrophy

75. You are evaluating a 75-year-old man presenting with asymmetric and marked dyspraxia of his left arm. He occasionally experiences movements of the arm that he feels he is not in control of. There is also bradykinesia, tremor, and rigidity within the arm. Deep tendon reflexes within the arm are elevated as well. What is the most likely diagnosis?
A. Corticobasal degeneration
B. Striatonigral degeneration
C. Shy-Drager syndrome
D. Olivopontocerebellar atrophy

76. Huntington’s disease affects what aspect of the basal ganglia primarily?
A. Dopaminergic projections from the substantia nigra
B. GABA projections from the striatum to the GPe
C. Glutamatergic projections from the striatum to the GPe
D. GABA projections from the GPi to the thalamus

77. Hemiballismus is caused by damage or degeneration of what structure?
A. Ipsilateral caudate
B. Contralateral subthalamic nucleus
C. Ipsilateral subthalamic nucleus
D. Contralateral substantia nigra

78. Essential tremor often occurs at what frequency?
A. 2 to 3 Hz
B. 3 to 5 Hz
C. 6 to 8 Hz
D. 8 to 13 Hz

79. Alzheimer’s dementia is associated with what chromosomal disorder?
A. Trisomy 13
B. Trisomy 18
C. Trisomy 21
D. Trisomy X

80. This genetic finding is associated with 25 to 40% of all cases of Alzheimer’s disease?
A. Presenilin 1
B. Presenilin 2
C. E4 of apolipoprotein E
D. Amyloid precursor protein

81. You have been following a patient who has had the onset of personality changes, hyperorality, hypersexuality, and has now developed sucking and rooting reflexes. There are associated speech deficits and urinary incontinence. What is the most likely diagnosis?
A. Alzheimer’s disease
B. Multiple system atrophy
C. Progressive supranuclear palsy
D. Pick’s disease
82. You are evaluating a 78-year-old woman who has had the onset of progressive cognitive difficulties, memory problems, urinary incontinence, and recurrent hallucinations. On exam there is mild rigidity present. What is the most likely diagnosis?
   A. Normal pressure hydrocephalus
   B. Dementia with Lewy bodies
   C. Corticobasal degeneration
   D. Pick’s disease

83. You see a 64-year-old man in your office who has had the onset of progressive cognitive difficulties and memory problems as well as mood changes. He has a long standing history of poorly controlled hypertension. MRI is demonstrated below. What is the most likely diagnosis?

![MRI Image](image)

   A. Normal pressure hydrocephalus
   B. Binswanger’s disease
   C. Alzheimer’s disease
   D. Multi-infarct dementia

84. What dementia classically presents with a step-wise decline in cognitive function?
   A. Normal pressure hydrocephalus
   B. Alzheimer’s disease
   C. Binswanger’s disease
   D. Multi-infarct dementia

85. Carbidopa is administered with L-DOPA in order to decrease the peripheral metabolism of L-DOPA by what enzyme?
   A. Tyrosine hydroxylase
   B. Catechol-O-methyltransferase
   C. Aromatic amino acid decarboxylase
   D. Acetylcholinesterase

86. You are asked to evaluate a patient who has evidence of peripheral neuropathy, progressive night blindness and hearing loss that seems to improve when phytol is avoided in the diet. What is the most likely diagnosis?
   A. Refsum disease
   B. Dejerine-Sottas disease
   C. Charcot-Marie-Tooth disease
   D. Parsonage-Turner syndrome

87. Guillain-Barre syndrome has been shown to be associated with what pathogen?
   A. E. Coli
   B. Staphylococcus aureus
   C. Campylobacter jejuni
   D. Klebsiella pneumoniae

88. You are evaluating a patient with a progressive peripheral neuropathy causing weakness that started in the legs and has progressed up the trunk to involve the arms. Sensation remains intact. What would you expect to see on analysis of the CSF?
   A. High protein, low cellularity
   B. High protein, high cellularity
   C. Low protein, high cellularity
   D. Low protein, low cellularity

89. What is the most common major motor nerve affected by diabetic amyotrophy?
   A. Sciatic nerve
   B. Femoral nerve
   C. Tibial nerve
   D. Common peroneal nerve

90. What is the most common cause of infectious peripheral neuropathy worldwide?
   A. Mycobacterium tuberculosis
   B. Mycobacterium leprae
   C. Corynebacterium diphtheriae
   D. Human immunodeficiency virus
91. You are evaluating a 40-year-old woman who has noticed the onset of proximal leg weakness. On further examination, you note a rash on extensor surfaces, but most notably involving the nose, cheeks, and eyelids. She also has scaly macules on the extensor surfaces of the hand. What is the most likely diagnosis?
A. Polymyositis  
B. Dermatomyositis  
C. Blue rubber bleb nevus syndrome  
D. Hand-foot-mouth disease

92. You see a patient with mental retardation, microcephaly, delayed speech, and inappropriate laughter. This named disorder results from what genetic error?
A. Paternal imprinting of chromosome 15  
B. Maternal imprinting of chromosome 15  
C. Trinucleotide repeat on chromosome 15  
D. Trisomy 15

93. Sleep spindles and K-complexes are seen during what stage of sleep on EEG?
A. Stage 1  
B. Stage 2  
C. Stage 3  
D. Stage 4

94. Patients with narcolepsy exhibit what diagnostic phenomenon on EEG?
A. Lack of K-complexes  
B. Lack of REM sleep  
C. Sleep-onset REM  
D. Increased theta rhythm

95. Narcolepsy is thought to arise from abnormalities in what neurotransmitter system?
A. Hypocretin/orexin  
B. Serotonin  
C. Norepinephrine  
D. Histamine

96. You are performing a microvascular decompression on a patient with V3 distribution facial pain. While you are retracting, the monitoring tech alerts you that Wave V of the brainstem auditory-evoked potentials is increasing. Wave V represents what aspect of the auditory pathway?
A. Cochlear nuclei  
B. Superior olive  
C. Lateral lemniscus  
D. Inferior colliculus

97. You are evaluating a patient admitted to the neuro intensive care unit for respiratory compromise. She has fatigable weakness of the face and ocular muscles and profound neck weakness. This condition is caused by what?
A. Antibodies against presynaptic voltage gated calcium channels  
B. Antibodies against postsynaptic acetylcholine receptors  
C. Antibodies against neuronal sodium channels  
D. Exotoxin production inhibiting presynaptic release of acetylcholine

98. You are asked to evaluate a patient currently being worked up for presence of a lung mass. You are consulted because she appears to have proximal muscle weakness early in the morning that seems to improve as the day goes on. This disorder is caused by what?
A. Antibodies against presynaptic voltage gated calcium channels  
B. Antibodies against postsynaptic acetylcholine receptors  
C. Antibodies against neuronal sodium channels  
D. Exotoxin production inhibiting presynaptic release of acetylcholine
99. You are asked to evaluate a patient currently admitted to the neuro intensive care unit for respiratory weakness. She initially presented with nausea, vomiting, constipation, severe ptosis, diplopia, and unreactive pupils. This was followed by progressive weakness of the limbs and face. This condition is caused by what mechanism?

A. Antibodies against presynaptic voltage gated calcium channels
B. Antibodies against postsynaptic acetylcholine receptors
C. Antibodies against neuronal sodium channels
D. Exotoxin production inhibiting presynaptic release of acetylcholine

100. Myasthenia gravis is associated with tumors of what organ?

A. Lung
B. Liver
C. Thymus
D. GI tract
3 Neuroanatomy

1. The medial posterior choroidal artery originates from which segment of the posterior cerebral artery?
   A. P1
   B. P2
   C. P3
   D. P4

2. While performing an anterior temporal lobectomy, your medial resection ends at the ambient cistern. What cranial nerve passes through this space?
   A. Trigeminal
   B. Oculomotor
   C. Trochlear
   D. Optic

3. The vidian artery originates from which segment of the internal carotid artery?
   A. Cavernous
   B. Lacerum
   C. Ophthalmic
   D. Petrous

4. While operating on an anterior convexity meningioma, you attempt to obtain negative margins around the tumor. What structure do you need to disconnect the falx from to ensure a clean inferior margin?
   A. Crista galli
   B. Anterior clinoid
   C. Orbital roof
   D. Sphenoid ridge

5. Brodmann area 17 is supplied by which artery?
   A. Superior cerebellar artery
   B. Callosal marginal artery
   C. Calcarine artery
   D. Splenial artery

6. Brodmann area 44 corresponds to which cortical region?
   A. Precentral gyrus
   B. Inferior frontal gyrus
   C. Gyrus rectus
   D. Middle frontal gyrus

7. The lentiform nucleus is comprised of which structures?
   A. Caudate and putamen
   B. Putamen and globus pallidus
   C. Caudate and globus pallidus
   D. Primary motor cortex and putamen

8. The claustrum separates which two structures?
   A. Putamen and external capsule
   B. Extreme capsule and insular cortex
   C. Globus pallidus and internal capsule
   D. External capsule and extreme capsule

9. While assessing a patient after a stroke, your exam identifies a pure conductive aphasia. Which structure has been damaged?
   A. Arcuate fasciculus
   B. Broca's area
   C. Wernicke's area
   D. Primary motor cortex

10. While clipping a posterior communicating artery aneurysm, the clip is inadvertently placed across an artery in the region. What postoperative deficit would not be expected after ligation of this artery?
    A. Contralateral hemiparesis
    B. Contralateral hemisensory loss
    C. Contralateral hemianopia
    D. Ipsilateral monocular blindness

11. During exposure of an anterior communicating artery aneurysm, you decide to drain CSF directly from the third ventricle. In order to do this, you perforate a structure just posterior to the optic chiasm. This structure is formed on which day of embryologic development?
    A. Day 22
    B. Day 24
    C. Day 26
    D. Day 28
12. Which of the following is the correct association of a thalamic nucleus and its corresponding cortical projections?
   A. Pulvinar–Cingulate gyrus
   B. Anterior nuclei–Orbital frontal cortex and frontal eye fields
   C. Mediodorsal nuclei–Primary and secondary visual cortices
   D. Ventral posterolateral nuclei–Somatosensory cortex

13. Which hippocampal region is most resistant to hypoxia?
   A. CA1
   B. CA2
   C. CA3
   D. CA4

14. The main artery feeding the pachymeninges enters the skull through which foramen?
   A. Foramen spinosum
   B. Foramen lacerum
   C. Foramen ovale
   D. Foramen rotundum

15. In the roof of the third ventricle, where are the fornices in relation to the internal cerebral veins?
   A. Medial
   B. Superior
   C. Lateral
   D. Inferior

16. Through what structure does the hypothalamus receive projections from the hippocampus?
   A. Medial forebrain bundle
   B. Fornix
   C. Stria terminalis
   D. Inferior longitudinal fasciculus

17. What is the largest input to the amygdala?
   A. Locus ceruleus
   B. Ventral tegmentum
   C. Nucleus basalis of Meynert
   D. Insular cortex

18. Primary input to Brodmann areas 41 and 42 come from which region?
   A. Medial geniculate body
   B. Lateral geniculate body
   C. Inferior colliculus
   D. Superior colliculus

19. You have been following a patient with epilepsy. Her seizure semiology consists of olfactory hallucinations followed by behavioral arrest, lip smacking and left upper extremity shaking. You offer surgical resection for attempted cure. What deficit is possible in this case if resection is carried too far posterior?
   A. Right hemiplegia
   B. Left hemiplegia
   C. Left superior quadrantanopsia
   D. Left inferior quadrantanopsia

20. A 60-year-old man has bradykinesia, rigidity and impaired balance. You are performing a DBS electrode placement to the most commonly targeted nuclei that improve rigidity in this disorder. During test stimulation of the electrode, the patient develops ipsilateral eye deviation. Which direction should you move the electrode?
   A. Lateral
   B. Medial
   C. Superior
   D. Inferior

21. You are performing bilateral STN DBS for a patient with advanced Parkinsonism. During test stimulation, the patient develops contralateral facial pulling and contralateral arm twitching. Which direction should you move the electrode?
   A. Anteromedial
   B. Posteromedial
   C. Anterolateral
   D. Posterolateral

22. You are performing DBS electrode placement for dystonia. While targeting the most common nuclei for this disorder, the patient develops contralateral muscle contractions, which direction do you need to move the electrode?
   A. Lateral
   B. Medial
   C. Anterior
   D. Posterior
23. During a DBS lead placement for dystonia, your patient develops phosphenes in her visual field during test stimulation, which direction should you move the electrode?
A. Inferior  
B. Superior  
C. Medial  
D. Lateral

24. You are placing DBS electrodes in a 45-year-old man who has been diagnosed with essential tremor. While targeting the most common nuclei for this disorder, your patient develops muscle contractions during test stimulation. Which direction should you move the electrode?
A. Inferior  
B. Superior  
C. Medial  
D. Lateral

25. While placing DBS electrodes for essential tremor into VIM thalamus, the patient develops persistent paresthesias during test stimulation. Which direction should you move the electrode?
A. Anterior  
B. Posterior  
C. Medial  
D. Lateral

26. You are exposing a right sided ICA terminus aneurysm for surgical clipping. You decide to dissect along the MCA (M1 segment) to reach the ICA terminus and the aneurysm. Which area of the M1 segment of the MCA is considered safe?
A. Posterosuperior  
B. Posteroinferior  
C. Anterosuperior  
D. Anteroinferior

27. This structure connects the temporal and orbital cortical regions. Medially it is bordered by the anterior perforated substance. Laterally it is bordered by the insular cortex.
A. Medial forebrain bundle  
B. Limen insulae  
C. Inferior longitudinal fasciculus  
D. Diagonal band of Broca

28. You are performing an anterior interhemispheric approach to the third ventricle for a presumed teratoma. In order to expose the corpus callosum for division, you must retract the cortex. What is the gyrus located immediately superior to the corpus callosum.
A. Cingulate gyrus  
B. Paracentral lobule  
C. Supramarginal gyrus  
D. Precentral gyrus

29. Which vein does not drain directly into the great cerebral vein of Galen?
A. Precentral cerebellar vein  
B. Basal vein of Rosenthal  
C. Internal cerebral vein  
D. Thalamostriate vein

30. You are performing an ETV on a pediatric patient for congenital aqueductal stenosis. You are looking at the floor of the third ventricle and you have identified the mammillary bodies. Which direction in relation to the mammillary bodies is the safe zone for puncture?
A. Anterior  
B. Lateral  
C. Posterior  
D. Medial

31. In the anterior floor of the third ventricle, what structure is located just above the suprachiasma recess?
A. Anterior commissure  
B. Lamina terminalis  
C. Optic chiasm  
D. Mammillary bodies

32. Descending laterally across the posterior skull, which suture marks the border between the occipital and parietal bones?
A. Squamosal  
B. Coronal  
C. Lambdoid  
D. Sphenosquamosal
I Questions

33. Which sutures connect to form the bregma?
A. Sagittal-lambdoid
B. Parietomastoid-occipitomastoid
C. Squamosal-parietomastoid
D. Coronal-sagittal

34. Which structure is not part of the deep cerebellar nuclei?
A. Globose
B. Fastigial
C. Emboliform
D. Vestibular

35. Which structure forms the superolateral border of the 4th ventricle?
A. Brachium conjunctivum
B. Restiform body
C. Brachium pontis
D. Vermis

36. Which structure forms the inferolateral border of the 4th ventricle?
A. Brachium conjunctivum
B. Restiform body
C. Brachium pontis
D. Vermis

37. Which cerebellar lobe forms what is considered to be the functional cerebellar division known as the vestibulocerebellum?
A. Anterior lobe
B. Posterior lobe
C. Vermis
D. Flocculonodular lobe

38. Which cerebellar region forms what is considered to be the functional cerebellar division known as the cerebrocerebellum?
A. Anterior lobe
B. Lateral hemisphere
C. Vermis
D. Flocculonodular lobe

39. Which cerebellar region forms what is considered to be the functional cerebellar division known as the spinocerebellum?
A. Anterior lobe
B. Lateral hemisphere
C. Vermis
D. Flocculonodular lobe

40. What is the primary output of the paramedian pontine reticular formation (PPRF)?
A. Trochlear nucleus
B. Abducens nucleus
C. Oculomotor nucleus
D. Facial nucleus

41. You are evaluating a patient with double vision. When you are testing external ocular movements, the right eye fails to adduct when you attempt to make the patient track your finger to the patient’s left. What structure is likely damaged?
A. Right abducens nerve
B. Medial longitudinal fasciculus
C. Left abducens nerve
D. Medial lemniscus

42. After resecting a 4th ventricular subependymoma, you are viewing the floor of the 4th ventricle. You notice bilateral raised circular structures. What is the most likely structure that you notice?
A. Trochlear nuclei
B. Facial colliculus
C. Stria medullaris
D. Middle cerebellar peduncle

43. On the floor of the 4th ventricle, the vagal trigone is located where in relation to the hypoglossal trigone?
A. Medial
B. Lateral
C. Superior
D. Inferior
44. Myelinated neurons from the nucleus gracilis and nucleus cuneatus decussate in the medulla to form the medial lemniscus. What are the decussating connections called?
   A. Medial longitudinal fasciculus
   B. Internal arcuate fibers
   C. Pyramids
   D. Mossy fibers

45. What structure is located lateral to the red nucleus within the midbrain?
   A. IIIrd nerve fibers
   B. Periaqueductal grey
   C. Medial longitudinal fasciculus
   D. Medial lemniscus

51. Which artery provides the majority of blood supply to the deep cerebellar nuclei?
   A. Anterior inferior cerebellar artery
   B. Posterior inferior cerebellar artery
   C. Superior cerebellar artery
   D. Posterior cerebral artery

52. Within the midbrain, the descending corticospinal tracts are arranged somatotopically. The tracts controlling function of the upper extremity are in which direction compared to tracts controlling the lower extremity?
   A. Lateral
   B. Posterior
   C. Medial
   D. Anterior

53. At the level of the midbrain, fibers conveying sensory information from the upper extremity are in what position relative to the fibers conveying information from the lower extremity?
   A. Medial
   B. Lateral
   C. Anterior
   D. Posterior
55. While exposing the posterior fossa via an extended retrosigmoid craniotomy for a brainstem tumor, you decide to divide the tentorium to increase your superior access. If you inadvertently injure a nerve while dividing the tentorium, what deficit is the patient likely to experience?
A. Lateral rectus palsy
B. Medial rectus palsy
C. Superior oblique palsy
D. Monocular visual loss

56. You are evaluating a patient for brain death and choose to perform a cold calorics test in the right ear. If the vestibular nuclei are intact, what eye movements do you expect to observe?
A. Nystagmus to the right
B. Nystagmus to the left
C. Superior nystagmus
D. Ocular bobbing

57. The cochlea is arranged tonotopically. Where are high frequency sounds processed?
A. Base
B. Apex
C. Scala vestibuli
D. Scala tympani

58. What is the name of the structure that deflects the ciliary processes of the inner and outer hair cells within the cochlea?
A. Tectorial membrane
B. Basilar membrane
C. Scala vestibuli
D. Scala tympani

59. As a part of the slow acting auditory system, the trapezoid body connects which two structures?
A. Ventral cochlear nucleus–inferior colliculus
B. Ventral cochlear nucleus–medial geniculate body
C. Ventral cochlear nucleus–superior olive
D. Ventral cochlear nucleus–inferior olive

60. You are watching a 100-m dash at a local track event. You are frightened by the sound of the starting gun and you jump. This response is mediated by the fast-acting auditory pathway. As a part of the fast-acting auditory pathway, the dorsal cochlear nucleus sends fibers to the inferior colliculus via what structure?
A. Medial lemniscus
B. Trapezoid body
C. Lateral lemniscus
D. Restiform body

61. While evaluating a patient for brain death, you use a small amount of irrigation to the cornea to look for a blink. What brainstem structure mediates this reflex?
A. Spinal trigeminal nucleus
B. Oculomotor nucleus
C. Superior olive
D. Abducens nucleus

62. Which fibers travel around the abducens nucleus?
A. Spinal trigeminal tract
B. Facial nerve
C. Medial longitudinal fasciculus
D. Internal arcuate fibers

63. Which hypothalamic nucleus controls satiety?
A. Lateral
B. Ventromedial
C. Paraventricular
D. Preoptic

64. Which hypothalamic nucleus is involved in fluid balance?
A. Lateral
B. Ventromedial
C. Arcuate
D. Supraoptic

65. Fibers carrying gustatory information from cranial nerves VII, IX, and X travel between the nucleus of the solitary tract and VPM thalamus via which structure?
A. Central tegmental tract
B. Lateral lemniscus
C. Medial lemniscus
D. Trapezoid body
66. In order to protect the auditory organs against sudden loud noises, the stapedius and tensor tympani contract to dampen sounds. Which nucleus controls this reflex?
A. Inferior colliculus
B. Superior colliculus
C. Superior olivary nucleus
D. Inferior olivary nucleus

67. The cribiform plate is part of which cranial bone?
A. Frontal bone
B. Ethmoid bone
C. Zygomatic bone
D. Nasal bone

68. Which nerve does not pass through the superior orbital fissure?
A. Frontal nerve
B. Maxillary nerve
C. Trochlear nerve
D. Abducens nerve

69. The vagus nerve exits the base of the skull through what structure?
A. Pars nervosa of the jugular foramen
B. Pars vascularis of the jugular foramen
C. Foramen lacerum
D. Foramen ovale

70. You are watching a local slow-pitch softball game and someone is hit in the side of the head with a throw at high velocity. As a neurosurgeon, you are worried about the formation of an epidural hematoma. Through what foramen does the main offending artery enter the skull?
A. Foramen ovale
B. Foramen rotundum
C. Foramen spinosum
D. Foramen lacerum

71. The anterior and posterior ethmoidal arteries are branches from which artery?
A. Carotid artery
B. Internal maxillary artery
C. Sphenopalatine artery
D. Ophthalmic artery

72. During an endoscopic approach to a pituitary tumor, the middle turbinate is removed by the access surgeon. What is the source of blood supply to the middle turbinate?
A. Anterior ethmoid artery
B. Posterior ethmoid artery
C. Kesselbach's plexus
D. Sphenopalatine artery

73. What structure separates the optic canal from the superior orbital fissure?
A. Optic strut
B. Anterior clinoid process
C. Carotid process
D. Lateral opticocarotid recess

74. What is the name of the structure located anterosuperior to the sella turcica, but posterior to the ethmoid air cells?
A. Optic strut
B. Planum sphenoidale
C. Anterior clinoid process
D. Pterygoid plate

75. The vidian nerve is continuous with which other nerve of the skull base?
A. Lesser superficial petrosal nerve
B. Greater superficial petrosal nerve
C. Nervus intermedius
D. Chorda tympani

76. Which foramen is just lateral to the vidian canal?
A. Optic canal
B. Foramen rotundum
C. Foramen ovale
D. Foramen spinosum

77. Which nerve does not run in the double layer of dura making up the lateral wall of the cavernous sinus?
A. Oculomotor nerve
B. Trochlear nerve
C. Ophthalmic nerve
D. Abducens nerve
I Questions

78. Which triangle of the skull base is bordered by the inferior aspect of the mandibular nerve, the greater superficial petrosal nerve, and a line drawn between the foramen spinosum and the arcuate eminence?
   A. Glasscock's triangle
   B. Kawase's triangle
   C. Infratrochlear triangle
   D. Trigeminal triangle

79. Which triangle of the skull base is located superior to the greater superficial petrosal nerve, posterior to the mandibular nerve and anterior to the superior petrosal sinus?
   A. Glasscock's triangle
   B. Kawase's triangle
   C. Infratrochlear triangle
   D. Trigeminal triangle

80. Which triangle of the skull base is bordered by CN IV, CN V1, and the tentorial edge?
   A. Glasscock's triangle
   B. Kawase's triangle
   C. Infratrochlear triangle
   D. Trigeminal triangle

81. Bill's bar is a structure within the IAC. Which nerves does it separate?
   A. Facial nerve–cochlear nerve
   B. Superior vestibular nerve–inferior vestibular nerve
   C. Facial nerve–superior vestibular nerve
   D. Cochlear nerve–inferior vestibular nerve

82. The abducens, facial, and vestibular nerves are associated with which blood vessel in the posterior fossa?
   A. Posterior cerebral artery
   B. Superior cerebellar artery
   C. Anterior inferior cerebellar artery
   D. Posterior inferior cerebellar artery

83. Which skull landmark is a rough marker of the location of the transverse-sigmoid sinus junction?
   A. Bregma
   B. Inion
   C. Pterion
   D. Asterion

84. Which is the only cranial nerve to exit on the dorsal aspect of the brainstem?
   A. Oculomotor
   B. Trochlear
   C. Vagus
   D. Hypoglossal

85. The meninges of the skull base arise from which embryological layer?
   A. Ectoderm
   B. Mesoderm
   C. Endoderm
   D. Somites

86. Which artery travels with cranial nerves VII and VIII in the IAC?
   A. Posterior inferior cerebellar artery
   B. Calcarine artery
   C. Splenial artery
   D. Labyrinthine artery

87. What is the first intradural branch of the internal carotid artery?
   A. Meningohypophyseal trunk
   B. Ophthalmic artery
   C. Superior hypophyseal artery
   D. Posterior communicating artery

88. Special visceral afferent fibers from which cranial nerve do not synapse within the thalamus?
   A. Facial nerve
   B. Hypoglossal nerve
   C. Olfactory nerve
   D. Trigeminal nerve

89. Axons of which retinal cells make up the optic nerve?
   A. Ganglion cells
   B. Bipolar cells
   C. Horizontal cells
   D. Amacrine cells
90. Which muscle is not innervated by the inferior division of the oculomotor nerve?
A. Levator palpebrae
B. Inferior oblique
C. Medial rectus
D. Inferior rectus

91. You are evaluating a patient with a superior oblique palsy, and she leans her head to the left side to compensate for her injury. If the superior oblique palsy is due to damage within the brainstem, which nucleus is involved?
A. Left oculomotor nucleus
B. Right oculomotor nucleus
C. Left trochlear nucleus
D. Right trochlear nucleus

92. Which cranial nerve mediates the efferent component of the auditory reflex via the tensor tympani?
A. Trigeminal nerve
B. Facial nerve
C. Vestibulocochlear nerve
D. Vagus nerve

93. You are evaluating a patient who has a lateral gaze palsy of the right eye. During your exam you also notice that the patient cannot cross midline with the left eye on attempted right lateral gaze. Where is the lesion?
A. Left oculomotor nerve
B. Left oculomotor nucleus
C. Right abducens nerve
D. Right abducens nucleus

94. The nervus intermedius carries fibers for all of the following except?
A. Efferent arm of the corneal reflex
B. Parasympathetic efferents to the lacrimal gland
C. Parasympathetic efferents to the submandibular gland
D. Taste from the anterior two-thirds of the tongue

95. The cochlear nerve connects which ganglion to which nucleus?
A. Spiral–vestibular nuclei
B. Spiral–cochlear
C. Scarpa’s–cochlear
D. Scarpa’s–vestibular nuclei

96. The glossopharyngeal nerve mediates salivation from the parotid gland via which nerve?
A. Lesser superficial petrosal nerve
B. Greater superficial petrosal nerve
C. Vidian nerve
D. Chorda tympani

97. Which muscle is not innervated by the recurrent branch of the laryngeal nerve?
A. Palatoglossus
B. Styloglossus
C. Genioglossus
D. Hyoglossus

98. The spinal portion of the spinal accessory nerve passes in what location relative to the dentate ligament?
A. Anterior
B. Medial
C. Posterior
D. Lateral

99. Which extrinsic muscle of the tongue is not innervated by the hypoglossal nerve?
A. Palatoglossus
B. Styloglossus
C. Genioglossus
D. Hyoglossus

100. The motor root of the trigeminal nerve arises where in relation to the main sensory root of the trigeminal nerve?
A. Caudal
B. Posterior
C. Lateral
D. Rostral
101. This structure connects the upper border of C1 to the foramen magnum?
A. Apical ligament
B. Posterior atlanto-occipital membrane
C. Tectorial membrane
D. Anterior atlanto-occipital membrane

102. The single structure connecting the dens to the foramen magnum is a remnant of what embryological structure?
A. Alar plate
B. Notochord
C. Basal plate
D. Neural tube

103. These paired ligaments in the cervical spine are strong ligaments that restrict rotation of the head?
A. Alar
B. Apical
C. Transverse
D. Cruciate

104. You are evaluating a 79-year-old man who slipped, fell, and hit his head on the sidewalk. He had the onset of neck pain and presented to the ED in a cervical collar. On CT scan of the cervical spine, you see that the dens is indenting the upper cervical spinal cord and the atlanto-dental interval is significantly increased > 3 mm. Which structure is clearly damaged?
A. Alar ligament
B. Apical ligaments
C. Transverse ligament
D. Cruciate ligament

105. The tectorial membrane of the cervical spine is the superior continuation of which spinal structure?
A. Anterior longitudinal ligament
B. Posterior longitudinal ligament
C. Intertransverse ligament
D. Supraspinous ligament

106. You decided to offer a C1-2 fusion for a 70-year-old man with an unstable Type II odontoid fracture. Prior to the start of your procedure, which structure should you evaluate at C2 that may change your fusion technique?
A. Carotid artery
B. Vertebral artery
C. C2 nerve root
D. Recurrent laryngeal nerve

107. Which anatomical variant is associated with atlantoaxial instability?
A. Split anterior arch of atlas
B. Split posterior arch of atlas
C. Os odontoideum
D. Klippel-Feil syndrome

108. The first ossification centers of the spine develop in utero at the cervicothoracic junction. What week of development does the first ossification center develop?
A. 6 weeks
B. 9 weeks
C. 12 weeks
D. 15 weeks

109. You are evaluating a 2-year-old for suspected non-accidental trauma in the emergency department. The radiology resident read the CT scan of the cervical spine and reported the presence of three fractures through the atlas consistent with a Jefferson-type fracture. You believe these are ossification centers. At what age are most posterior ossification centers of the atlas closed?
A. 6 months
B. 1 year
C. 3 years
D. 6 years
110. You are seeing an 8-year-old boy in the emergency department. He was brought in after playing tackle football. He was hit and developed neck pain. The CT scan of the cervical spine was read as possible type II odontoid fracture. You believe the findings are consistent with normal development. At what age should the ossification centers of the axis no longer be visible?
A. 7 years  
B. 9 years  
C. 11 years  
D. 13 years

111. In the developing embryo, which structure divides the alar plate from the basal plate?
A. Median eminence  
B. Sulcus limitans  
C. Neural groove  
D. Henson's node

112. During embryologic development, failure of separation of neural ectoderm from superficial ectoderm leads to what pathology?
A. Dermal sinus tract  
B. Myelomeningocele  
C. Split-cord malformation  
D. Spinal cord lipoma

113. During embryologic development, somites develop from the paraxial mesoderm at what days of development?
A. 15 to 17  
B. 19 to 21  
C. 23 to 25  
D. 27 to 29

114. During embryologic development, somites differentiate into what structures?
A. Motor neurons  
B. Sympathetic ganglia  
C. Vertebral column and spinal musculature  
D. Intervertebral discs

115. The sacral spinal cord is developed during which embryologic process?
A. Primary neurulation  
B. Secondary neurulation  
C. Disjunction  
D. Cell migration

116. Sensory information from above T6 travels in what structure within the spinal cord?
A. Fasciculus cuneatus  
B. Fasuculus gracilis  
C. Ventral corticospinal tract  
D. Dorsal spinocerebellar tract

117. Which rexed lamina lies between the dorsal and ventral horns of the spinal cord?
A. Lamina II  
B. Lamina V  
C. Lamina VII  
D. Lamina IX

118. The substantia gelatinosa is located in which rexed lamina?
A. Lamina II  
B. Lamina V  
C. Lamina VII  
D. Lamina IX

119. The interomediolateral cell column and dorsal nucleus of Clarke are located in which lamina of the spinal cord?
A. Lamina II  
B. Lamina V  
C. Lamina VII  
D. Lamina IX

120. Renshaw cells of the spine are located in which rexed lamina?
A. Lamina II  
B. Lamina V  
C. Lamina VII  
D. Lamina IX
121. Primary motor neurons are located in which rexed lamina?
A. Lamina II  
B. Lamina V  
C. Lamina VII  
D. Lamina IX

122. Pain and temperature sensation from the peripheral nervous system is conveyed through which spinal cord tract?
A. Anterior spinothalamic tract  
B. Lateral spinothalamic tract  
C. Dorsal spinocerebellar tract  
D. Lateral corticospinal tract

123. Second order ascending neurons originating in Clarke's nucleus travel in which spinal cord tract?
A. Anterior spinothalamic tract  
B. Lateral spinothalamic tract  
C. Dorsal spinocerebellar tract  
D. Ventral spinocerebellar tract

124. You are falling asleep during neurosurgery teaching rounds and your co-resident pinches the back of your left arm. You immediately wake up and turn your head to the left to see what caused the pain. Which spinal cord tract is involved, causing you to turn and look at the source of the pain?
A. Lateral reticulospinal tract  
B. Spinotectal tract  
C. Lateral corticospinal tract  
D. Ventral corticospinal tract

125. What percentage of corticospinal tract fibers originate from the large Betz pyramidal cells of the motor cortex?
A. 3%  
B. 10%  
C. 30%  
D. 100%

126. In which rexed lamina do the majority of lateral corticospinal fibers synapse?
A. Lamina II  
B. Lamina V  
C. Lamina VII  
D. Lamina IX

127. You are evaluating a patient in the neuro ICU who has bithalamic compression from a very large subdural hematoma. She is comatose and is exhibiting decorticate posturing. What nonpyramidal spinal tract mediates this response?
A. Vestibulospinal tract  
B. Rubrospinal tract  
C. Reticulospinal tract  
D. Medial longitudinal fasciculus

128. You are evaluating a patient in the emergency department who is comatose from a large subdural hematoma. He demonstrates decerebrate posturing and fixed, nonreactive pupils. What spinal cord tract mediates his peripheral response?
A. Vestibulospinal tract  
B. Rubrospinal tract  
C. Reticulospinal tract  
D. Medial longitudinal fasciculus

129. Which spinal cord tract mediates postural reflexes responsive to visual and auditory stimuli?
A. Vestibulospinal tract  
B. Rubrospinal tract  
C. Reticulospinal tract  
D. Tectospinal tract

130. What uncrossed pyramidal tract fibers descend adjacent to the anterior median fissure of the spinal cord and decussate via the anterior commissure in upper cervical levels?
A. Lateral corticospinal tract  
B. Anterolateral corticospinal tract  
C. Anterior corticospinal tract  
D. Vestibulospinal tract

131. The blood supply to the dorsal columns of the spinal cord descends longitudinally in which orientation compared to the dorsal roots?
A. Lateral  
B. Medial  
C. Superior  
D. Inferior
132. The cervical spinal cord receives the majority of its blood supply from which originating vessels?
   A. Anterior radicular arteries
   B. Posterior radicular arteries
   C. Vertebral arteries
   D. Carotid arteries

133. Which segment of the spinal cord is the most susceptible to ischemic injury?
   A. C3-C7
   B. T1-T4
   C. L1-L4
   D. Conus medullaris

134. Which spinal cord segment is most likely to contain the artery of Adamkiewicz?
   A. Left T2
   B. Right T2
   C. Left T10
   D. Right T10

135. You have evaluated a 30-year-old woman with progressive lower extremity weakness and urinary incontinence. Imaging demonstrates T2 signal change in the spinal cord over multiple levels and is suggestive of tortuous vessels. On vascular imaging a spinal cord dAVF on the left at T12 is discovered. You decide to treat with endovascular coiling. If you inadvertently occlude the artery of Adamkiewicz, what deficit would you expect the patient to have?
   A. Ipsilateral paraplegia, contralateral loss of pinprick sensation, ipsilateral loss of pain/temperature sensation
   B. Preserved strength, bilateral loss of pinprick sensation, preserved pain/temperature sensation
   C. Paraplegia, ipsilateral loss of pinprick sensation, contralateral loss of pain/temperature sensation
   D. Paraplegia, preserved pinprick sensation, bilateral loss of pain/temperature sensation

136. You are evaluating a 65-year-old man who had the onset of severe, radiating right leg pain down to his knee. On physical exam, he has weakness of knee extension. If his pathology is a paramedian herniated lumbar disc, what level is it most likely to be at?
   A. L2-3
   B. L3-4
   C. L4-5
   D. L5-S1

137. You are evaluating a 45-year-old woman who had the onset of severe, radiating right leg pain down to her ankle. On physical exam, she has weakness of ankle dorsiflexion. If her pathology is a herniated lumbar disc, what level is it most likely to be at?
   A. L2-3
   B. L3-4
   C. L4-5
   D. L5-S1

138. You are evaluating a 45-year-old woman who had the onset of severe, radiating right leg pain down the back of her thigh. On physical exam, she has weakness of ankle plantarflexion. If her pathology is a herniated lumbar disc, what level is it most likely to be at?
   A. L1-2
   B. L3-4
   C. L4-5
   D. L5-S1

139. You are evaluating a 40-year-old woman who had the onset of severe, radiating right leg pain to the top of her ankle. On physical exam, she has weakness of ankle dorsiflexion. If her pathology is a herniated lumbar disc, where would you expect the herniation to be?
   A. Paracentral L3-4
   B. Paracentral L4-5
   C. Far lateral L2-3
   D. Far lateral L3-4
140. You are evaluating a 40-year-old woman who had the onset of severe, radiating right leg pain to her ankle. On physical exam, she has some weakness of ankle dorsiflexion, but obvious weakness of EHL function. If her pathology is a herniated lumbar disc, where would you expect the herniation to be?
A. Paracentral L3-4
B. Far lateral L4-5
C. Paracentral L5-S1
D. Far lateral L5-S1

141. You are evaluating a 50-year-old man who had the onset of severe, radiating left neck pain to his shoulder. On physical exam, he has weakness of his shoulder with patchy sensory loss of the shoulder as well. If his pathology is a herniated cervical disc, what level do you expect it to be?
A. C2-3
B. C3-4
C. C4-5
D. C5-6

142. You are evaluating a 50-year-old man who has a herniated cervical disc on the right at C5-6, where would you expect him to have sensory loss on exam?
A. Right shoulder
B. Right thumb
C. Right third finger
D. Right 5th finger

143. You are evaluating a 50-year-old man who has a herniated cervical disc on the right at C6-7, where would you expect him to have weakness on exam?
A. Right shoulder
B. Right wrist flexion
C. Right wrist extension
D. Right finger extension

144. You are evaluating a 50-year-old man who has a herniated cervical disc on the right at C7-T1, where would you expect him to have weakness on exam?
A. Right interossei
B. Right wrist flexion
C. Right wrist extension
D. Right distal finger flexion

145. You are evaluating a 50-year-old man who has had difficulty walking as he gets pain in his back and legs when standing up. MR imaging demonstrates spinal stenosis at L4-5. On exam he has four-fifth strength in bilateral hip flexors with clonus and a positive Hoffman’s sign. What is your next step?
A. L4-5 decompressive laminectomy
B. Lower extremity EMG
C. Cervical MRI
D. Physical therapy and pain control

146. You are evaluating a 50-year-old man who has been found to have osteomyelitis as a complication from ongoing pyelonephritis. Which structure is theorized to allow spread of pelvic infections to the spine?
A. Lumbar nerve roots
B. Batson’s plexus
C. Thoracic duct
D. Artery of Adamkiewicz

147. The nucleus pulposus of the intervertebral disc is derived from what embryological origin?
A. Somites
B. Neural crest cells
C. Notochord
D. Neural tube

148. Which ligament of the spine is noncontiguous?
A. Supraspinous ligament
B. Ligamentum flavum
C. Posterior longitudinal ligament
D. Anterior longitudinal ligament

149. What is the smallest pedicle in the spine in most patients?
A. T1
B. T4
C. T7
D. L1

150. The annulus fibrosus is composed primarily of which type of collagen fibers?
A. Type I
B. Type II
C. Type III
D. Type IV
151. You are performing a minimally invasive lumbar discectomy for a herniated disk in a 55-year-old man with radiculopathy. An intraoperative picture is shown. What structure is being elevated by the blunt nerve hook?

A. Lamina  
B. Ligamentum flavum  
C. Dura  
D. Interspinous ligament  
E. Disc fragment

152. The vertebral artery enters the foramen transversarium at what cervical level?

A. C4  
B. C5  
C. C6  
D. C7  
E. T1

153. The carotid tubercle is located on which cervical vertebral body?

A. C4  
B. C5  
C. C6  
D. C7  
E. T1

154. Which structure of the spine is demonstrated (arrow) in this intraoperative image leading into the abnormal mass?
Questions

155. Which structure of the spine is depicted by number 2 in this axial MRI?

A. Dentate ligament  
B. Nerve root  
C. Artery of Adamkiewicz  
D. Filum terminale

156. Which structure of the spine is depicted by the arrow in this axial image?

A. Cruciate ligament  
B. Apical ligament  
C. Alar ligament  
D. Transverse ligament

157. How far lateral from midline on the superior C1 posterior arch is the vertebral artery?

A. 0.5 cm  
B. 1.0 cm  
C. 1.5 cm  
D. 2.0 cm

158. Which structure is fractured on these images?

A. Pars interarticularis  
B. Pedicle  
C. Spinous process  
D. Superior articulating process

159. Which structure is demonstrated by number 11 on the corresponding images?

A. Zygapophyseal joint  
B. Uncinate process  
C. Facet joint  
D. Costovertebral joint
160. Which vertebral body is depicted in this image?

A. Atlas  
B. Axis  
C. C3  
D. C4

161. Each segment of the brachial plexus gives rise to a branch that innervates the upper extremity except?

A. Roots  
B. Trunks  
C. Divisions  
D. Cords

162. The lateral root of the median nerve (from the lateral cord) innervates what upper extremity functions?

A. Hand intrinsics  
B. Wrist extensors  
C. Wrist flexors  
D. Hand sensation

163. What is the first branch off of the brachial plexus?

A. Long thoracic nerve  
B. Dorsal scapular nerve  
C. Nerve to the subclavius  
D. Suprascapular nerve

164. You are evaluating a patient who had an upper respiratory tract illness 1 week ago. Two days after his symptoms resolved, he had the onset of severe right shoulder pain followed 24 hours later by weakness of shoulder abduction for the first 15 degrees and some weakness of external rotation. Which nerve is affected?

A. Axillary nerve  
B. Musculocutaneous nerve  
C. Dorsal scapular nerve  
D. Suprascapular nerve

165. The musculocutaneous nerve innervates all of these muscles except?

A. Coracobrachialis  
B. Biceps brachii  
C. Brachioradialis  
D. Brachialis

166. Which is the most distal branch of the medial cord listed here?

A. Anterior division  
B. Medial pectoral nerve  
C. Medial brachial cutaneous nerve  
D. Medial antebrachial cutaneous nerve

167. You are evaluating a patient who clearly has dysfunction of her latissimus dorsi. Which segment of the brachial plexus does its innervating nerve branch from?

A. Lateral cord  
B. Posterior cord  
C. Medial cord  
D. Ventral roots

168. Which muscle listed below does the axillary nerve innervate?

A. Teres minor  
B. Teres major  
C. Infraspinatus  
D. Supraspinatus

169. What is the pure motor branch of the radial nerve in the forearm?

A. Anterior interosseous nerve  
B. Posterior interosseous nerve  
C. Superficial branch  
D. Dorsal digital branch

170. What is the pure motor branch of the median nerve in the forearm?

A. Anterior interosseous nerve  
B. Posterior interosseous nerve  
C. Superficial branch  
D. Dorsal digital branch
171. You are evaluating a patient with cramping of the hand that is better when he shakes the hand, thenar atrophy, and sensory disturbances in the first three digits and the lateral aspect of the 4th. Which structure is causing the nerve compression?
A. Volar carpal ligament
B. Transverse carpal ligament
C. Ligament of Struthers
D. Arcade of Frohse

172. You are evaluating a patient with cramping of the hand that is better when he shakes the hand, thenar atrophy, and sensory disturbances in the medial aspect of the distal 4th digit and all of the distal 5th digit. What structure is causing the nerve compression?
A. Volar carpal ligament
B. Transverse carpal ligament
C. Ligament of Struthers
D. Arcade of Frohse

173. This image demonstrates examination for scapular winging. Which nerve is the examiner testing for injury?
A. Dorsal scapular nerve
B. Long thoracic nerve
C. Thoracodorsal nerve
D. Lateral pectoral nerve

174. The following image demonstrates sensory innervation from what nerve?

175. In this image the examiner is having the patient adduct the arm with the elbow fixed at 90 degrees. The muscle being tested here is innervated by what nerve from the brachial plexus?
A. Lateral pectoral nerve
B. Thoracodorsal nerve
C. Long thoracic nerve
D. Medial brachial cutaneous nerve
176. The following image demonstrates an examiner testing a muscle that is innervated by which nerve?

A. Dorsal scapular nerve  
B. Medial antebrachial cutaneous nerve  
C. Upper subscapular nerve  
D. Lower subscapular nerve

177. In this image, the examiner is providing resistance while the patient is attempting to abduct the arm from the side. Which nerve is being tested here?

A. Dorsal scapular nerve  
B. Nerve to subclavius  
C. Suprascapular nerve  
D. Lateral pectoral nerve

178. In this image the examiner is resisting external rotation of the arm at 90 degrees flexion. What nerve innervates the muscle that performs this action?

A. Dorsal scapular nerve  
B. Nerve to subclavius  
C. Suprascapular nerve  
D. Lateral pectoral nerve

179. Which nerve is depicted in this image?

A. Musculocutaneous nerve  
B. Radial nerve  
C. Median nerve  
D. Ulnar nerve
183. You are evaluating an overweight police officer who has started to note the onset of patchy sensory loss and pain over the anterolateral right thigh. What nerve is affected in this classic condition?
A. Ilioinguinal nerve
B. Lateral femoral cutaneous nerve
C. Iliohypogastric nerve
D. Genitofemoral nerve

184. The common peroneal component is located where in relation to the tibial component of the sciatic nerve?
A. Anterior
B. Posterior
C. Medial
D. Lateral

185. Which nerve has contributions from both the tibial and common peroneal nerve?
A. Sural nerve
B. Saphenous nerve
C. Superficial peroneal nerve
D. Deep peroneal nerve

186. The tibialis anterior is innervated by which nerve?
A. Superficial peroneal nerve
B. Deep peroneal nerve
C. Tibial nerve
D. Sural nerve

187. You are evaluating a patient in the emergency department who is having urinary incontinence after a massive central disc herniation. The motor neurons that are damaged causing urinary incontinence are located where?
A. Interomediolateral nucleus
B. Marginal nucleus
C. Substantia gelatinosa
D. Onuf’s nucleus

188. Injury to the superficial branch of the common peroneal nerve would lead to what deficit on exam?
A. Impaired foot eversion
B. Impaired foot inversion
C. Impaired foot dorsiflexion
D. Impaired foot plantarflexion
189. Which structure is not located in the tarsal tunnel?
A. Tibial nerve  
B. Flexor hallucis longus tendon  
C. Tibialis posterior tendon  
D. Flexor digitorum brevis tendon  

190. You are seeing a patient with concerns for an L5 disc herniation. On exam, you note that she has weakness of her right extensor hallucis longus. What peripheral nerve innervates the EHL?
A. Superficial peroneal nerve  
B. Deep peroneal nerve  
C. Tibial nerve  
D. Sural nerve  

191. Which muscle extends the hip with some assistance of the hamstrings?
A. Gluteus minimus/medius and tensor fascia lata  
B. Gluteus maximus  
C. Gracilis  
D. Adductor magnus  

192. Fibers from Onuf’s nucleus are carried through which nerve?
A. Pudendal nerve  
B. Superior gluteal nerve  
C. Inferior gluteal nerve  
D. Obturator nerve  

193. Fibers ultimately destined for the peroneus longus travel through which nerve?
A. Femoral nerve  
B. Obturator nerve  
C. Sciatic nerve  
D. Tibial nerve  

194. Fibers ultimately destined for the flexor hallucis longus travel through which nerve?
A. Femoral nerve  
B. Obturator nerve  
C. Sciatic nerve  
D. Peroneal nerve  

195. Which nerve provides the sensory innervation depicted in the following image?

A. Sural nerve  
B. Sciatic nerve  
C. Tibial nerve  
D. Saphenous nerve  

196. You are evaluating a patient with sensory loss on the anterolateral aspect of the thigh. Which nerve innervates the anterolateral thigh?
A. Ilioinguinal nerve  
B. Genitofemoral nerve  
C. Lateral femoral cutaneous nerve  
D. Obturator nerve
197. Which nerve is being evaluated by the examiner in this image?

A. Obturator nerve  
B. Sciatic nerve  
C. Femoral nerve  
D. Ilioinguinal nerve

198. Which nerve controls adduction of the thigh?

A. Obturator nerve  
B. Sciatic nerve  
C. Femoral nerve  
D. Ilioinguinal nerve

199. You are evaluating a 53-year-old woman who presents with sensory loss in the upper anterior thigh region as well as part of her labia. Where does this nerve pass in relation to the inguinal ligament?

A. Above  
B. Below  
C. Both  
D. Neither

200. Depicted here is the lumbar plexus. The lumbosacral trunk connects to which structure?

A. Sciatic nerve  
B. Sacral plexus  
C. Psoas muscle  
D. Rectus fascia
4 Neurobiology

1. You are caring for an outpatient who has a history of spinal cord injury. You have prescribed oxybutynin for frequent urination. What class of medication is oxybutynin?
   A. Muscarinic
   B. Anticholinergic
   C. Cholinergic
   D. Nicotinic
   E. Glutamatergic

2. Astrocytes of the brain sequester what ion?
   A. Sodium
   B. Potassium
   C. Calcium
   D. Chloride
   E. Magnesium

3. What receptor utilizes an excitatory neurotransmitter of the brain as a ligand?
   A. GABA
   B. Ryanodine
   C. NMDA
   D. Muscarinic
   E. Nicotinic

4. Which of the following hypothalamic nuclei are associated with ADH secretion?
   A. Periventricular
   B. Lateral
   C. Ventromedial
   D. Median eminence
   E. Supraoptic

5. Which of the following hypothalamic nuclei is associated with ADH secretion and has diffuse connections in the spinal cord and brainstem?
   A. Periventricular
   B. Paraventricular
   C. Supraoptic
   D. Posterior
   E. Suprachiasmatic

6. The use of variable angle screws on a plate during anterior cervical discectomy and fusion surgery helps to diminish what according to Wolf’s law?
   A. Graft subsidence
   B. Screw pullout
   C. Development of kyphosis
   D. Stress shielding
   E. Dysphagia

7. Activated rhodopsin is involved in phototransduction. What downstream effect does activated rhodopsin have?
   A. cGMP deactivation, hyperpolarization
   B. cGMP activation, depolarization
   C. Potassium channel activation, depolarization
   D. Potassium channel activation, hyperpolarization
   E. Sodium channel activation, depolarization

8. Which cortical layer primarily projects back to the thalamus?
   A. Layer II
   B. Layer III
   C. Layer IV
   D. Layer V
   E. Layer VI

9. The Betz cells of the cerebral cortex are located in what layer?
   A. External pyramidal
   B. External granular
   C. Multiform
   D. Internal pyramidal
   E. Internal granular
10. You decide that on your weekend off you would like to build a supercapacitor in your garage, and you need a phase transfer catalyst to make this system work. You choose TEA, tetraethylammonium, as your agent. During the process, you spill it on the floor and inhale large amounts of the fumes. You start to have difficulty breathing and are slowly becoming paralyzed due to the competitive inhibition of acetylcholine receptors. This compound also affects voltage gated receptors in nerve tissue that are associated with what ion?
   A. Sodium
   B. Potassium
   C. Magnesium
   D. Chloride

11. Myelination of peripheral nerves leads to what?
   A. Increased transmembrane resistance, decreased capacitance
   B. Increased transmembrane resistance, increased capacitance
   C. Decreased transmembrane resistance, increased capacitance
   D. Decreased transmembrane resistance, decreased capacitance

12. A mutation of the gene PTEN is most likely to be seen in the genotyping of what tumor type listed below?
   A. Pilocytic astrocytoma
   B. WHO grade II glioma
   C. Primary GBM
   D. Secondary GBM
   E. Central neurocytoma

13. Cerebellar mossy fibers synapse in what region?
   A. Granular layer
   B. Molecular layer
   C. Purkinje layer
   D. Multiform layer
   E. Pyramidal layer

14. The Schaffer collateral pathway connects what two regions of the hippocampus?
   A. Dentate gyrus–CA1
   B. CA1–CA3
   C. CA3–subiculum
   D. CA1–subiculum
   E. Dentate gyrus–subiculum

15. The perforant pathway of the hippocampus connects what two intrinsic hippocampal structures?
   A. Dentate gyrus–CA1
   B. CA1–CA3
   C. Entorhinal cortex–dentate gyrus
   D. CA3–fornix
   E. Dentate gyrus–CA1

16. What receptor type is stimulated by neurons that originate in the substantia nigra pars compacta?
   A. Glutamate
   B. GABA
   C. Dopamine
   D. Acetylcholine
   E. NMDA

17. Cortical projections to the striatum use what neurotransmitter?
   A. Glutamate
   B. GABA
   C. Dopamine
   D. Acetylcholine
   E. Glycine

18. How many cortical layers are present in the hippocampus?
   A. 2
   B. 3
   C. 4
   D. 5
   E. 6
19. You are asked to evaluate a patient with an interesting endocrinologic phenomenon. Her body temperature varies with the temperature of her surrounding environment. She most likely has bilateral destruction of what hypothalamic nucleus?
   A. Anterior nucleus
   B. Posterior nucleus
   C. Ventromedial nucleus
   D. Supraoptic nucleus
   E. Suprachiasmatic nucleus

20. Destruction of the ventromedial nucleus of the thalamus results in what clinical condition?
   A. Hyperthermia
   B. Anorexia
   C. Hyperphagia
   D. Diabetes insipidus
   E. Addison's disease

21. Which of the following hypothalamic nuclei is involved with parasympathetic functions?
   A. Anterior nucleus
   B. Posterior nucleus
   C. Lateral nuclei
   D. Ventromedial nucleus
   E. Supraoptic nucleus

22. You are asked by nursing to evaluate a severely agitated and delirious postoperative patient. He is swinging at nursing and very confused. You decide to give a dose of a medication in the butyrophene class to treat his agitation. This medication works on what subtype of receptors located in the frontal lobe, the hippocampus, and limbic system.
   A. GABA
   B. Glutamate
   C. Serotonin
   D. D1
   E. D2

23. You are seeing a patient with severe, unilateral mydriasis. You suspect that the first-order efferent nerve in this pathway is disrupted. What two structures are connected by the first order neuron in this pathway?
   A. Pretectal nucleus – ciliary ganglion
   B. Sympathetic chain – ciliary ganglion
   C. Hypothalamus – sympathetic chain
   D. Hypothalamus – intermediolateral cell column
   E. Ciliary ganglion – radial fibers

24. You are evaluating a patient in the emergency department with altered mental status, lactic acidosis, and seizures. You suspect cyanide toxicity. What effect does cyanide have on the body?
   A. Blocks voltage-gated potassium channel
   B. Blocks alpha subunit of acetylcholine receptor
   C. Uncouples oxidative phosphorylation
   D. Cleaves synaptobrevin
   E. Inhibits glycine release in the spinal cord

25. The dorsal motor nucleus of the vagus nerve innervates what target organ(s)?
   A. Muscles of the larynx and pharynx
   B. Thoracic and abdominal viscera
   C. Pharyngeal mucosa
   D. Aortic arch
   E. External ear

26. Cyclic adenosine monophosphate is a second messenger system for what class of receptors?
   A. Tyrosine kinase
   B. Gprotein
   C. NMDA
   D. Ionotropic

27. You are working at a neurosurgical clinic in an underdeveloped country. You overhear another physician discussing her patient who drank contaminated water and now has severe diarrhea. The organism has been identified as a vibrio species. You try to remember your basic science days. What receptor protein does the toxin produced by this microbe activate?
   A. $G_i$
   B. $G_s$
   C. cAMP
   D. IP$_3$
28. Lithium selectively inhibits the phosphatases that degrade what second messenger?
   A. DAG
   B. Phospholipase C
   C. Protein kinase C
   D. IP₃

29. Nitric oxide (NO) is liberated after stimulation of what receptor system?
   A. Tyrosine kinase
   B. G protein
   C. NMDA
   D. Ionotropic

30. What ligand would bind to a tyrosine kinase receptor mechanism?
   A. Epidermal growth factor
   B. Glutamate
   C. Benzodiazepine
   D. Substance P

31. Within an acetylcholine-activated receptor system, what specific subunit binds acetylcholine?
   A. Alpha
   B. Beta
   C. Gamma
   D. Delta
   E. Lambda

32. You are hiking through Bryce Canyon National Park on your day off and while you are enjoying the beautiful views, you feel a sharp pain in your ankle. You have been bitten by an odd-looking snake that contains alpha-bungarotoxin in its venom. You remember studying this toxin in medical school while you are losing consciousness. What downstream cellular effect is inhibited by alpha-bungarotoxin?
   A. Phosphorylation of serine and threonine residues
   B. Sodium influx into the cytosol
   C. Synthesis of NO
   D. Liberation of arachidonic acid from the plasma membrane

33. Which of these agents is a depolarizing neuromuscular blocker?
   A. Vecuronium
   B. D-tubocurarine
   C. Succinylcholine
   D. Gallamine

34. G-protein coupled muscarinic receptors are located in what CNS location?
   A. Dorsal nucleus of Clarke
   B. Onuf’s nucleus
   C. Renshaw cells of the spinal cord
   D. Lateral geniculate nucleus

35. You are called by the emergency department to evaluate a 34-year-old man with new-onset confusion, high fever, and severe spasticity. You discover after looking at X-rays that he has an intrathecal pump in place. You believe the pump is malfunctioning and he is withdrawing from his medication. What receptor does this medication bind to?
   A. Muscarinic
   B. NMDA
   C. GABA_A
   D. GABA_B

36. What protein stimulates ACh receptor gene transcription in the muscle fiber ultimately leading to increased concentration of ACh receptors in the NMJ?
   A. Rapsyn
   B. Agrin
   C. Neuregulin
   D. Muscle-specific tyrosine kinase

37. Increased calcium concentration within the muscle cell is mediated by what cellular structure?
   A. Sarcoplasmic reticulum
   B. Endoplasmic reticulum
   C. Mitochondria
   D. Golgi complex
38. Sarcomeres are connected to one another by what structure?
   A. A band
   B. H zone
   C. Z disk
   D. M line

39. Which area of the sarcomere shortens during muscle contraction?
   A. A band
   B. H zone
   C. Z disk
   D. M line

40. Ca\(^{2+}\) binds with what structure to disinhibit actin binding sites, ultimately allowing actin-myosin crossbridges to be made and muscle contraction to occur?
   A. Tropomyosin
   B. Troponin I
   C. Troponin C
   D. Troponin T

41. You are evaluating a 40-year-old man who is noticing decreased peripheral vision bilaterally. Visual fields demonstrate bitemporal hemianopia. You appropriately order an MRI (demonstrated below). You obtain blood work and discover the following hormone levels:
   8 AM cortisol = 12 µg/100 mL
   Prolactin = 117 ng/mL
   IGF-1 = 187 ng/mL
   What is the most likely diagnosis?
   A. Prolactinoma
   B. Nonfunctioning pituitary adenoma
   C. ACTH-producing adenoma
   D. GH-producing adenoma

42. You resected a difficult suprasellar craniopharyngioma. That evening, the nurse pages you because the patient has had very high urine output for several hours in a row. You order a urine specific gravity, and it returns at 1.003. The depleted hormone you are worried about is released from what structure?
   A. Pineal gland
   B. Organ vasculosum of the lamina terminalis
   C. Adenohypophysis
   D. Neurohypophysis

43. You evaluated a patient in the office with a pituitary mass. She is set to undergo transsphenoidal resection. If her pituitary function tests are listed below, what medication should you give in the postoperative period to avoid complications?
   8 AM cortisol = 19 µg/100 mL
   Prolactin = 16 ng/mL
   IGF-1 = 134 ng/mL
   A. Bromocriptine
   B. Octreotide
   C. DDAVP
   D. Hydrocortisone

44. You have resected a pituitary tumor from a patient with these pituitary function tests preoperatively. What lab test should you order on postoperative day 1 to determine the success of the procedure?
   8 AM cortisol = 9 µg/100 mL
   Prolactin = 22 ng/mL
   IGF-1 = 500 ng/mL
   A. 8 AM cortisol
   B. Sodium
   C. Growth hormone
   D. IGF-1
1 Questions

45. Which result below distinguishes a patient as having Cushing’s disease versus ectopic ACTH secretion?
   A. Random ACTH = 3.4 ng/L
   B. 50% reduction in cortisol levels after high dose DMZ suppression test
   C. Negative inferior petrosal sinus sampling
   D. Negative metyrapone test

46. What protein is utilized during retrograde axonal transport?
   A. Dynamin
   B. Dynein
   C. Actin/myosin
   D. Kinesin

47. What protein is utilized during fast anterograde axonal transport?
   A. Dynamin
   B. Dynein
   C. Actin/myosin
   D. Kinesin

48. What drug listed below inhibits fast anterograde axonal transport?
   A. Temozolomide
   B. Carmustine
   C. Vinblastine
   D. Cyclophosphamide

49. What is the only neurotransmitter synthesized within the synaptic vesicle?
   A. Acetylcholine
   B. Norepinephrine
   C. Dopamine
   D. Glutamate

50. What is the rate-limiting step for norepinephrine synthesis?
   A. Dopamine hydroxylase
   B. Aromatic amino acid decarboxylase
   C. Tyrosine hydroxylase
   D. Choline acetyltransferase
51. Serotonergic neurons are located primarily in what brainstem nucleus?
A. Locus ceruleus
B. Raphe nucleus
C. Nucleus basalis of Meynert
D. Periaqueductal gray

52. Which neurotransmitter is not considered an amino acid neurotransmitter?
A. Glutamate
B. GABA
C. Glycine
D. Histamine

53. Which neurotransmitter is utilized by Renshaw cells of the spinal cord?
A. Glutamate
B. GABA
C. Glycine
D. Acetylcholine

54. The neurotransmitter used by all preganglionic autonomic neurons is synthesized by what enzyme?
A. Dopamine hydroxylase
B. Tyrosine hydroxylase
C. Choline acetyltransferase
D. 5-hydroxytryptophan decarboxylase

55. Acetylcholine is the primary neurotransmitter of what nucleus?
A. Locus coeruleus
B. Raphe nucleus
C. Substantia nigra
D. Nucleus basalis of Meynert

56. What cell structures make up the blood–brain barrier?
A. Astrocytic foot processes
B. Endothelial tight junctions
C. Neuronal cell plasma membrane
D. Myelin

57. This cell of the CNS from mesodermal origin is activated during infection/inflammation and is primarily phagocytic in function?
A. Fibrous astrocyte
B. Bergmann cell
C. Protoplasmic astrocyte
D. Microglia

58. Which segment of the neuron does not contain Nissl substance?
A. Dendrite
B. Cytoplasm
C. Axon hillock
D. Presynaptic terminal

59. Substance P is synthesized solely in what location?
A. Endoplasmic reticulum
B. Golgi complex
C. Synaptic vesicle
D. Cytoplasm

60. You are finishing your basement and you see a rusty nail in the corner. You are concerned someone will step on the nail and get a bacterial infection that can have CNS effects. The toxin released by this microbe has what effect on neuron function?
A. Cleavage of v-SNAREs causing inhibition of synaptic transmission
B. Cleavage of synaptobrevin causing inhibition of synaptic transmission
C. Microtubule dysfunction inhibiting fast anterograde transport
D. Neuronal apoptosis

61. Which region of the hippocampus is a site of neurogenesis?
A. CA1
B. CA3
C. Subgranular layer
D. Entorhinal cortex

62. Which axon type will have the fastest conductance?
A. Large, unmyelinated
B. Large, myelinated
C. Small, unmyelinated
D. Small, myelinated
63. Which sensory axon type has the fastest conduction?
A. Primary muscle spindle afferents
B. Cutaneous touch afferents
C. Temperature afferents
D. Pain afferents

64. What nerve type violates the Bell-Magendie law?
A. Type Ia
B. Type III
C. B fibers
D. C fibers

65. Which of these sensory receptors exhibits rapid adaptation?
A. Merkel disk
B. Meissner's corpuscles
C. Ruffini endings
D. Golgi tendon organs

66. Which blood-brain barrier transport mechanism is energy independent?
A. L system
B. MDR system
C. Glut-1 system
D. Active transport system

67. What is considered to be normal blood flow to the brain?
A. 30 cc/100 g/min
B. 50 cc/100 g/min
C. 70 cc/100 g/min
D. 90 cc/100 g/min

68. At what rate of diminished blood flow is electrical failure observed?
A. 12 cc/100 g/min
B. 18 cc/100 g/min
C. 24 cc/100 g/min
D. 30 cc/100 g/min

69. During cerebral ischemia, glutamate is released and a subsequent increase in cytosolic Ca\(^{2+}\) is observed. If the Ca\(^{2+}\) concentration reaches high enough levels, what enzyme is activated leading to cell damage?
A. Fas ligand
B. Dopamine decarboxylase
C. Phospholipase C
D. Caspase 9

70. The resting membrane potential of the neuron is approximately -60 to -70 mV. This is closest to the equilibrium potential of what ion?
A. Na\(^+\)
B. K\(^+\)
C. Ca\(^{2+}\)
D. Cl\(^-\)

71. A miniature end plate potential requires release of roughly how many molecules of ACh?
A. 10,000 molecules
B. 100,000 molecules
C. 1,000,000 molecules
D. 10,000,000 molecules

72. The only monosynaptic reflex in the body is mediated by what type of sensory fibers?
A. Ia
B. Ib
C. II
D. IV

73. What sensory fiber has the slowest conductance?
A. I
B. II
C. III
D. IV
74. The structure involved in spinal reflexes that is in series with muscle cells utilizes what sensory fibers?
   A. Ia
   B. Ib
   C. III
   D. IV

75. Catechol-O-methyl transferase (COMT) metabolizes what neurotransmitter?
   A. Acetylcholine
   B. Serotonin
   C. Norepinephrine
   D. Dopamine
5 Neuropathology

1. You are evaluating a 65-year-old woman with the onset of low-grade headache and occasional word finding difficulties. Imaging demonstrates a left-sided ring-enhancing mass. You complete a gross total resection and the final pathology is demonstrated below. What gene amplification is often seen in this tumor type?

A. VEGF upregulation
B. EGFR amplification
C. 10p/19Q co-deletion
D. SHH deletion

2. A 30-year-old man experiences a first time seizure after a night of drinking with friends. In the emergency department, a head CT is obtained which is suggestive of a right anterior temporal hypodensity. Subsequent MRI confirms a non-enhancing, T2 hyperintense mass. Surgical resection is performed and final pathology is below. What is the most common chromosomal abnormality in this tumor type?

Use the following figure to answer questions 2 and 3:

A. Loss of 1P/19Q
B. EGFR amplification
C. Loss of sex chromosome
D. Loss of chromosome 22

3. You resect a tumor from a 53-year-old man. Final pathology slide is shown in Question 2. What is likely to be demonstrated on further staining of the pathologic tissue?

A. IDH wild-type
B. IDH mutant
C. Loss of chromosome 22
D. Loss of chromosome 10
4. You see a patient with this MRI. What histologic findings would you expect if this was found to be a glial neoplasm?

A. Prominent Rosenthal fibers
B. Focal calcification
C. Prominent reticulin staining
D. “Fried-egg appearance”

5. A 21-year-old woman patient with the tumor demonstrated on this slide is most likely to present with what symptoms?

A. Focal neurologic deficit
B. Headache
C. Seizures
D. Nausea

6. A 30-year-old man patient with the tumor demonstrated on this slide likely has what other abnormalities?

A. Cortical malformations
B. Optic glioma
C. Retinoblastoma
D. Hypotelorism

7. The tumor seen in this pathology slide often exhibits what genetic abnormality?

A. Chromosome 17 loss
B. Chromosome 21 loss
C. Isochromosome 17q
D. 1p/19q co-deletion
8. You resect a tumor in a 40-year-old man that was causing triventricular hydrocephalus. Final pathology is demonstrated below. What characteristic is classic for these tumors?

A. S-100 positivity  
B. EMA positivity  
C. Synaptophysin positivity  
D. 1p/19q co-deletion

9. You resect a tumor in a 60-year-old man that was causing triventricular hydrocephalus. Final pathology is demonstrated below. What characteristic is classic for these tumors?

A. Homogenous gadolinium enhancement on MRI  
B. Cystic cavity with enhancing mural nodule on MRI  
C. Multicentric calcification on CT scan  
D. Lack of gadolinium enhancement on MRI

10. You resect a tumor in a 5-year-old girl with persistent seizures and an abnormality of the temporal lobe on MRI. Final pathology is below. What tumor type did you resect?

A. Pleomorphic xanthoastrocytoma  
B. Low-grade glioma  
C. Juvenile pilocytic astrocytoma  
D. Ganglioglioma

11. You resect a tumor in a 30-year-old girl. Final pathology is below. This tumor type is often seen in what location?

A. Attached to septum pellucidum  
B. 4th ventricle  
C. Lateral ventricle  
D. Temporal lobe
12. You biopsy a multifocal lesion in the brain of a 60-year-old woman. The final pathology slide is shown below. What is the primary method of initial treatment for this neoplasm?

A. Temozolamide/External beam radiotherapy
B. Steroids
C. PCV chemotherapy
D. Stereotactic radiosurgery

13. The tumor depicted in the slide below originates from which cells?

A. Astrocytes
B. Ependymal cells
C. Schwann cells
D. Arachnoid cap cells

14. What type of meningioma is depicted below? Use the following figure to answer Questions 14 and 15:

A. Fibrous
B. Psammomatous
C. Transitional
D. Angiomatous

15. What is the most common genetic malformation in the tumor type depicted in the figure in Question 14?

A. 1p/19q co-deletion
B. Loss of chromosome 22
C. EGFR amplification
D. P53 mutation

16. Which type of meningioma is considered a WHO grade III lesion?

A. Angiomatous
B. Psammomatous
C. Rhabdoid
D. Chordoid

17. Meningiomas tend to demonstrate what characteristic positivity?

A. Vimentin
B. GFAP
C. Synaptophysin
D. Neurofilament
18. A tumor with the histology demonstrated below is most likely to arise from what region?

A. Sellar/suprasellar  
B. Cerebellum  
C. Convexity  
D. Pineal

19. You are evaluating a 52-year-old patient with large hands, coarse fascies, excessive sweating and muscle pain. Ultimately a tumor is resected and the pathology is below. 40% of these tumors exhibit mutations in what gene?

A. n-Myc  
B. gsp  
C. P53  
D. SHH

20. You are evaluating a patient who is found on imaging to have a large pituitary mass. Pituitary function testing returns normal. You are concerned given the size that pituitary failure will develop. What is the first peptide deficiency you should expect to see?

A. GH  
B. FSH/LH  
C. TSH  
D. ACTH

21. You resect a mass that appears to be originating in the suprasellar region. Final pathology is demonstrated below. What is the diagnosis?

A. Rathke’s cleft cyst  
B. Germinoma  
C. Papillary craniopharyngioma  
D. Pilocytic astrocytoma
22. This mass is resected over the convexity, and the final pathology is demonstrated below. What markers distinguish it from a meningioma?

A. EMA positive  
B. EMA negative  
C. Vimentin positive  
D. Vimentin negative

23. A 42-year-old woman has chronic headaches and undergoes surgery to resect a mass lesion. Final pathology is below. What is the diagnosis?

A. Colloid cyst  
B. Mature teratoma  
C. Pilocytic astrocytoma  
D. Dermoid cyst

24. The mass demonstrated in the pathology slide below originates from what structure?

A. Adenohypophysis  
B. Pars intermedia  
C. Tuberculum sellae  
D. Pituitary stalk

25. A 22-year-old man has this tumor removed after presenting with headaches and nausea. Where is this tumor most likely to arise from?

Use the following figure to answer Questions 25 and 26:

A. Superior medullary velum  
B. Floor of the 4th ventricle  
C. Choroid plexus  
D. C1 nerve root
Questions

26. You would expect the lesion pictured in Question 25 to stain positive for all markers except?
   A. GFAP
   B. Vimentin
   C. EMA
   D. PTAH

27. You are evaluating a patient who has headaches and received an MRI. The MRI demonstrated a small lesion in the 4th ventricle that does not enhance. The patient is adamant about removing the mass. At surgery, you resect it and send it for pathology, which is demonstrated below. What is the diagnosis?
   A. Subependymoma
   B. Ependymoma
   C. Colloid cyst
   D. Schwannoma

28. If the tumor type below was found to secrete bioactive amines, what is the diagnosis?
   A. Ganglioglioma
   B. Pleomorphic xanthoastrocytoma
   C. Paraganglioma
   D. Hemangiopericytoma

29. This MRI demonstrates evidence of what process?
   Use the following figure to answer Questions 29 and 30:

   A. Metastases
   B. Alcoholic cerebellar degeneration
   C. Turcot’s syndrome
   D. Lhermitte-Duclos disease

30. What gene mutation is often linked with patients exhibiting the findings as shown under Question 29?
   A. P53
   B. SHH
   C. PTEN
   D. H-ras
31. This lesion is resected from the 4th ventricle of a 45-year-old woman. What is the most likely diagnosis?

Use the following figure to answer Questions 31 and 32:

A. Ependymoma  
B. Choroid plexus papilloma  
C. Subependymoma  
D. Vestibular schwannoma

32. The tumor demonstrated under Question 31 is associated with a syndrome caused by mutation in which gene?

A. P53  
B. PTEN  
C. SHH  
D. H-ras

33. This tumor is resected from the CP angle of a 55-year-old man. What histologic finding is demonstrated by the black arrow?

A. Antoni A  
B. Antoni B  
C. Verocay body  
D. Flexner-Wintersteiner rosette

34. This tumor is resected from the CP angle of a 55-year-old man. What histologic finding is demonstrated in this slide?

A. Antoni A  
B. Antoni B  
C. Verocay body  
D. Flexner-Wintersteiner rosette

35. A neurofibroma is thought to arise from what structure?

A. Epineurium  
B. Perineurium  
C. Endoneurium  
D. Schwann cell
36. A patient with multiple cutaneous nodules has several painful masses resected. They are sent for pathology and are demonstrated below. What is the diagnosis?

*Use the following figure to answer Questions 36 and 37:*

A. Schwannoma  
B. Paraganglioma  
C. Meningioma  
D. Neurofibroma

37. The lesion depicted in Question 36 most likely stains positive for what marker?

A. S-100  
B. CD20  
C. Vimentin  
D. EMA

38. A 9-year-old girl presents with wrist drop and a tumor is discovered. The lesion is resected with negative margins and final pathology is demonstrated below. What is the most likely diagnosis?

A. Schwannoma  
B. MPNST  
C. Neuroblastoma  
D. Synovial sarcoma
39. A 42-year-old man has two lesions removed from his cerebellum. Final pathology is below. Mutations on what chromosome are associated with this neoplasm?

A. 3  
B. 7  
C. 17  
D. 22  

40. This mass is removed from the CP angle in a 28-year-old woman. What is the most likely diagnosis?

A. Vestibular schwannoma  
B. Ependymoma  
C. Epidermoid cyst  
D. Choroid plexus papilloma

41. A patient presents to you with tongue deviation to the left and reports that he has been feeling like food is getting stuck in his throat. You resect a mass and the pathology is shown below. What is the most likely diagnosis?

A. Meningioma  
B. Ependymoma  
C. Epidermoid cyst  
D. Chordoma
42. You resect a mass lesion in a 12-year-old boy with intractable epilepsy. Pre-operative imaging demonstrated an abnormality in the right anterior temporal pole. Final pathology is below, what is the most likely diagnosis?

A. PXA  
B. Ganglioglioma  
C. Dysembryoplastic neuroepithelial tumor  
D. Juvenile pilocytic astrocytoma

43. All of these are subtypes of the tumor depicted below except?

Use the following figure to answer Questions 43, 44 and 49:

A. Wnt  
B. SHH  
C. Group 4  
D. Group 5

44. The tumor depicted in Question 43 is thought to arise from what brain region?

A. Floor of the 4th ventricle  
B. External granular layer of the cerebellum  
C. Choroid plexus  
D. Vestibulocochlear nerve

45. A mass is resected from the suprasellar region in a 14-year-old boy. Final pathology is below. What CSF marker would you expect to be elevated in this patient?

A. Placental alkaline phosphatase  
B. B-HCG  
C. Glucose  
D. Cell count

46. A mass is resected from the suprasellar region in a 14-year-old boy. Final pathology is below. What CSF marker would you expect to be elevated in this patient?

A. Placental alkaline phosphatase  
B. B-HCG  
C. AFP  
D. Cell count
47. A mass is resected from the suprasellar region in a 14-year-old boy. Final pathology is yolk sac tumor. What CSF marker would you expect to be elevated in this patient?

A. Placental alkaline phosphatase  
B. B-HCG  
C. AFP  
D. Cell count

48. A mass is resected from the suprasellar region in a 14-year-old boy. Final pathology is below. If CSF markers are negative, what is the presumed diagnosis?

A. Mature teratoma  
B. Choriocarcinoma  
C. Yolk-sac tumor  
D. Medulloblastoma

49. Of the subtypes of tumor depicted under Question 43, which one has the best prognosis of long-term survival?

A. Wnt  
B. SHH  
C. Group 3  
D. Group 4

50. This tumor is resected from the midline in a 13-year-old girl, what is the most likely diagnosis?

A. Epidermoid cyst  
B. Dermoid cyst  
C. Germinoma  
D. Choriocarcinoma
51. The abnormality demonstrated below is most likely due to what?

A. Demyelinating disease  
B. Infarction  
C. Electrolyte abnormalities  
D. Neoplastic disease

52. A patient experiences loss of short term memory, confusion and asterixis. At autopsy, brain slices are demonstrated below. What is the most likely diagnosis?

A. Alzheimer's dementia  
B. Corticobasal degeneration  
C. Lewy body dementia  
D. Hepatic encephalopathy

54. This MRI demonstrates abnormalities within the white matter in a classic pattern. This disorder results from what defect?

A. Abnormal very long-chain fatty acid metabolism  
B. Glucocerebrosidase deficiency  
C. Galactocerebrosidase deficiency  
D. Sphingomyelinase deficiency

55. This slide is most consistent with what disease?

A. Lymphoma  
B. Multiple sclerosis  
C. Progressive multifocal leukoencephalopathy  
D. Gliomatosis cerebri
56. This MRI is taken from a patient with right sided facial weakness. Sural nerve biopsy demonstrates non-caseating granuloma. What is the most likely diagnosis?

A. Malignant peripheral nerve sheath tumor  
B. Lymphoma  
C. Neurosarcoïdoïsis  
D. Gliomatosis cerebri

58. This MRI was taken from a patient who exhibited transient neurologic deficits during the final years of his life. What is the most likely diagnosis?

A. Carotid stenosis  
B. Multiple sclerosis  
C. Alzheimer's dementia  
D. Lymphoma

57. The disease demonstrated by the slide below is associated with all alleles except?

A. HLA B27  
B. HLA B7  
C. HLA A3  
D. DR 15

59. You are called to review the autopsy slides of a 3-month-old infant, which demonstrate balloon neurons. MRI is demonstrated. What is the most likely diagnosis?

A. Gaucher's disease  
B. Alexander's disease  
C. Canavan's disease  
D. Tay-Sach's disease
60. The findings on this pathology slide are caused by which virus?

A. Epstein-Barr virus  
B. JC virus  
C. Human immunodeficiency virus  
D. Hepatitis-B virus

61. Tay-Sach's disease is caused by a deficiency in what enzyme?

A. Glucocerebrosidase  
B. Galactocerebrosidase  
C. Aryl sulfatase A  
D. Hexosaminidase A

62. The abnormal cells in this image are representative of what underlying disorder?

A. Mucopolysaccharidoses  
B. Gaucher's disease  
C. Tay-Sach's disease  
D. Krabbe's disease

63. A patient with multiple peripheral neuropathies has a sural nerve biopsy, the results of which are demonstrated below. There are also lower extremity deformities. What is the most likely diagnosis?

A. MPNST  
B. Charcot-Marie-Tooth disease  
C. Idiopathic brachial plexitis  
D. NF-1

64. This patient presented acutely to the emergency department with symptoms of nystagmus, ataxia and severe confusion. The MRI result is shown below. What enzyme deficiency is associated with these findings?

A. Aryl sulfatase A  
B. Pyruvate dehydrogenase  
C. Citrate synthase  
D. Succinate dehydrogenase

65. You evaluate a slide that demonstrates chromatolysis of Betz cells in a patient with the onset of dementia and watery diarrhea as well as skin lesions. What is the most likely cause?

A. Nicotinic acid deficiency  
B. Pyruvate dehydrogenase deficiency  
C. Thiamine deficiency  
D. Cobalamin deficiency
66. A patient has an abnormality on MRI and undergoes an open biopsy with resection of the dura. The intra-operative picture is shown below. What other finding would you expect the patient to have on exam?

A. Multiple subcutaneous nodules
B. Gelastic seizures
C. Hypotelorism
D. Cutaneous vascular nevi

67. What is the diagnosis?

A. Holoprosencephaly
B. Agenesis of the corpus callosum
C. Polymicrogyria
D. Agyria

68. This patient had profound mental retardation, what is the diagnosis?

A. Pachgyria
B. Agenesis of the corpus callosum
C. Polymicrogyria
D. Agyria
69. If this patient had this abnormality as well as hepatic fibrosis and polycystic kidney disease, what is the diagnosis?

A. Meckel-Gruber syndrome  
B. Foster-Kennedy syndrome  
C. Weber syndrome  
D. Benedikt’s syndrome

70. A patient undergoes an autopsy for an unknown cause of death and the gross pathology findings below are discovered. What was the likely cause of death?

A. Gliomatosis cerebri  
B. Wernicke’s syndrome  
C. Carbon monoxide poisoning  
D. Osmotic demyelination syndrome

71. A 35-year-old woman was involved in a motor vehicle accident at highway speeds and she sustained multiple fractures, including a left femur fracture, a T12 3-column spine fracture and 5 broken ribs. She remained comatose despite no evidence of mass lesions and no elevated ICP. You are concerned about fat embolism, what stain should you use on the slide?

A. PAS  
B. Oil red O stain  
C. H&E  
D. Reticulin

72. A disheveled patient presents to the ED and promptly has a seizure that was unable to be controlled with lorazepam. He quickly becomes comatose and ultimately dies despite best efforts. A slide from his brain specimen is shown below. What was the most likely underlying diagnosis?

A. Diffuse axonal injury  
B. Coup/Contrecoup injury  
C. Herpes encephalitis  
D. Gunshot wound
73. A neonate develops hydrocephalus and has evidence of periventricular calcifications on imaging as well as chorioretinitis. A pathology slide is demonstrated below. What is the cause?

A. Cytomegalovirus  
B. Toxoplasmosis  
C. Epstein-Barr virus  
D. Rabies virus

74. If an HIV positive patient were to develop meningitis, what is the most likely cause?

A. Coccidioides immitis  
B. E. Coli  
C. Proteus mirabilis  
D. Cryptococcus neoformans

75. What is the most common isolate from brain abscesses?

A. S. pneumoniae  
B. H. influenzae  
C. S. milleri  
D. E. coli

76. At what stage of abscess formation is necrosis first noted?

A. 1 to 2 days  
B. 3 to 7 days  
C. 8 to 14 days  
D. 15+ days

77. This slide demonstrates a section through a cerebral abscess. What timeframe of abscess formation does this most likely represent?

A. 1 to 2 days  
B. 3 to 7 days  
C. 8 to 14 days  
D. 15+ days

78. You evaluate a slide from a brain abscess that demonstrates multinucleated giant cells, what is the most likely pathogen?

A. S. milleri  
B. M. tuberculosis  
C. E. coli  
D. H. influenzae

79. An 85-year-old man with poorly controlled diabetes undergoes a biopsy of a frontal lobe mass that appears to be arising from the floor of the anterior fossa. Intraoperative picture is below. What is the most likely diagnosis?

A. Glioblastoma  
B. Aspergillus infection  
C. Mucormycosis infection  
D. Hemangioblastoma
80. A 65-year-old woman with an ongoing undiagnosed lung condition undergoes a biopsy of a suspicious nodule within the brain. When the biopsy was taken, bleeding was encountered. Final pathology is below, what is the most likely diagnosis?

A. Glioblastoma  
B. Aspergillus infection  
C. Mucormycosis infection  
D. Hemangioblastoma

81. This lesion was resected from the temporal lobe of a patient with seizures. What is the most likely diagnosis?

Use the following figure to answer Questions 81 and 83:

A. Glioblastoma  
B. Cavernous malformation  
C. Dural arteriovenous fistula  
D. Hemangioblastoma

82. The lesion pictured below can present in familial form. What chromosome listed below is mutated leading to the familial form of this disease?

A. 3  
B. 5  
C. 17  
D. 21

83. The lesion shown in Question 81 most likely presents with what symptom?

A. Headache  
B. Visual loss  
C. Seizures  
D. Nausea

84. What is the most likely diagnosis based on this pathology slide?

A. Cavernous malformation  
B. Arteriovenous malformation  
C. Dural arteriovenous fistula  
D. Glioblastoma

85. Intracranial aneurysms lack what vessel wall structure?

A. Tunica intima  
B. Internal elastic laminae  
C. Tunica adventitia  
D. External elastic laminae
86. What is the most common mycotic infection of the CNS?
A. Aspergillus  
B. Cryptococcus  
C. Mucormycosis  
D. Candidiasis  

87. This MRI was obtained in a patient who ultimately underwent biopsy. The pathologic specimen demonstrated budding yeasts and hyphae. What is the most likely diagnosis?

88. What is the most likely diagnosis based on this CSF sample?

89. This ultrasound of the temporal artery is obtained from a 72-year-old man with chronic pain, systemic myalgias, malaise and fever. What is the most likely diagnosis?
90. A temporal artery biopsy is obtained from a 72-year-old man with chronic pain, systemic myalgias, malaise and fever. It demonstrates granulomas in the vessel wall. If this condition goes untreated, what may result?
   A. Aphasia
   B. Intracranial hemorrhage
   C. Blindness
   D. Seizures

91. ALS is caused by a mutation in what gene in 25% of cases?
   A. H-ras
   B. SOD-1
   C. SOD-2
   D. N-myc

92. ALS causes motor neuron loss in which cranial nerve listed below?
   A. III
   B. IV
   C. VI
   D. XII

93. What condition is demonstrated in the pathology slide below, in which ubiquitin staining has been performed?

   A. Huntington's disease
   B. Amyotrophic lateral sclerosis
   C. Parkinson's disease
   D. Corticobasal degeneration

94. This pathology slide is taken from a patient with a neurodegenerative condition. What is the most likely diagnosis?

95. This slide was taken from a patient who also had cardiomyopathy. What is the most likely diagnosis?
96. This image was taken from a patient who exhibited choreiform movements. What is the underlying reason for the development of this disorder?

A. Nucleotide deletion  
B. Nucleotide substitution  
C. Nucleotide duplication  
D. Chromosome deletion

97. This silver stain slide was taken from an 85-year-old woman with progressive cognitive decline. Depletion of what neurotransmitter has been associated with this condition?

A. Glycine  
B. Dopamine  
C. Acetylcholine  
D. Glutamate

98. A pathology slide from the CA1 region of the hippocampus in a 78-year-old patient with cognitive decline demonstrates Hirano bodies. The medications used in this condition target what nucleus?

A. Locus ceruleus  
B. Raphe nucleus  
C. Substantia Nigra  
D. Basal nucleus of Meynert

99. This slide was taken from an 85-year-old man with progressive cognitive decline. What is this inclusion body made of?

A. Actin-associated proteins  
B. Phosphorylated tau protein  
C. Viral proteins  
D. Ubiquitin

100. This slide was taken from a 35-year-old man who works in a meat processing plant who has exhibited rapid neurologic decline. What is the most likely diagnosis?

A. Creutzfeldt-Jakob disease  
B. Corticobasal degeneration  
C. Lewy body dementia  
D. Huntington's disease
6 Neuroimaging

1. A 45-year-old man has an abnormality discovered on MRI. From the MR spectroscopy study shown in the following image, what is the most likely diagnosis?

   ![Image of MRI study]

   A. Abscess  
   B. Infarction  
   C. Glioma  
   D. Hemorrhage

2. A 73-year-old man has an abnormality discovered on MRI. The MR spectroscopy study indicates an elevated lactate. What is the most likely diagnosis?

   A. Abscess  
   B. Infarction  
   C. Glioma  
   D. Hemorrhage

3. A 55-year-old man undergoes resection of a right frontal glioblastoma. He undergoes a standard temozolomide and radiation regimen postoperatively. Nine months later, enhancement is seen within the resection cavity. MR spectroscopy demonstrates the NAA peak to be double the choline peak. What is the most likely diagnosis?

   A. Abscess  
   B. Infarction  
   C. Recurrent glioma  
   D. Radiation necrosis

4. This MRI is from a 50-year-old woman who was having headaches. What mutation listed below would suggest that this lesion is primary and not due to malignant transformation?

   ![Image of MRI study]

   A. PTEN mutant  
   B. PTEN wild type  
   C. IDH-1 mutant  
   D. IDH-1 wild type

5. What is the most likely diagnosis?

   ![Image of MRI study]

   A. Glioblastoma  
   B. Infarction  
   C. Hemorrhage  
   D. Huntington's disease
6. What is the most likely diagnosis?

A. Glioblastoma
B. Meningioma
C. Metastasis
D. Low-grade glioma

7. If final pathology of the image below comes back as chordoid type, what WHO grade is the lesion?

A. WHO grade I
B. WHO grade II
C. WHO grade III
D. WHO grade IV

9. Where are the lesions pictured below most often located within the brain?

A. Cortical surface
B. Gray–white matter junction
C. White matter
D. Ependymal lining

10. This MRI demonstrates a metastatic lesion with edema. What is the most likely primary source?

A. Skin
B. Lung
C. Breast
D. Colon
11. What chromosomal abnormality does the patient with the MRI findings below most likely have?

A. 3  
B. 7  
C. 17  
D. 22

12. What is the most likely diagnosis?

A. Vestibular schwannoma  
B. Epidermoid cyst  
C. Subependymoma  
D. Ependymoma

13. A 45-year-old man presents with headaches and persistent nausea prompting an MRI pictured below. What is the most likely diagnosis?

A. Vestibular schwannoma  
B. Epidermoid cyst  
C. Subependymoma  
D. Ependymoma

14. A 45-year-old man presents with headaches and persistent nausea prompting an MRI pictured below. What foramen is this tumor extending through?

A. Magendie  
B. Luschka  
C. Magnum  
D. Lacerum
15. A 52-year-old woman presents with persistent headaches prompting an MRI pictured below. What is the most likely diagnosis?

A. Ependymoma  
B. Subependymoma  
C. Vestibular schwannoma  
D. Medulloblastoma

16. A 52-year-old woman presents with a severe headache that resolves. An MRI is obtained and is shown below. What is the most likely diagnosis?

A. Dural arteriovenous fistula  
B. Arteriovenous malformation  
C. Cavernous malformation  
D. Aneurysm

17. A 28-year-old man has sudden onset of dysarthria and a left sixth nerve palsy. MRI is shown below. What is the most likely diagnosis?

A. Ependymoma  
B. Subependymoma  
C. Vestibular schwannoma  
D. Medulloblastoma

18. A patient is set to undergo a Wada test to determine language dominance. Before the procedure commences, a standard angiogram is performed. In this lateral DSA of the internal carotid artery, what is demonstrated?

A. PICA aneurysm  
B. Dural arteriovenous malformation  
C. Fetal posterior cerebral artery  
D. Persistent trigeminal artery
19. A 54-year-old woman has an abnormality discovered on routine MRI and undergoes a formal cerebral angiogram, which is pictured below. What type of aneurysm is this?

A. Posterior communicating artery aneurysm
B. Carotid-ophthalmic aneurysm
C. Superior hypophyseal aneurysm
D. Cavernous sinus aneurysm

20. Where is this aneurysm located?

A. Intracranial/intradural
B. Intracranial/extradural
C. Extracranial/intradural
D. Extracranial/extradural

21. What structure is demonstrated (arrows, not arrowheads) in this angiogram in a patient with a sagittal sinus thrombosis?

A. Anastomotic vein of Trolard
B. Anastomotic vein of Labbé
C. Vein of Galen
D. Petrosal sinus

22. What characteristic makes this a pituitary macroadenoma?

A. Encirclement of the carotid
B. Optic nerve compression
C. Size greater than 10 cm
D. Size greater than 2.0 cm

23. What is the most likely diagnosis?

A. Pituitary macroadenoma
B. Craniopharyngioma
C. Tuberculum meningioma
D. Chordoma
24. An 8-year-old boy is developing slowly progressive visual loss prompting an MRI shown below. What condition is this mass associated with?

A. NF1  
B. NF2  
C. Tuberous sclerosis  
D. Cowden's syndrome

25. An 8-year-old boy has headaches and an MRI is performed. The lesion pictured below is associated with a syndrome caused by which chromosomal abnormality?

A. 17  
B. 22  
C. 9  
D. 3
26. What structure does number 8 in this MRI demonstrate?

A. Septum pellucidum  
B. Basal vein of Rosenthal  
C. Choroid plexus  
D. Internal cerebral veins

27. What structure does number 18 in this coronal, T2-weighted MRI demonstrate?

A. Limen insulae  
B. Amygdala  
C. Diagonal band of Broca  
D. Hippocampus
28. A 65-year-old man has sudden onset of headache and starts having difficulty controlling generalized tonic–clonic seizures in the emergency department. Ultimately, he requires intubation for seizure control. MRI is shown below; what is the most likely diagnosis?

A. Aneurysmal subarachnoid hemorrhage
B. Metastatic tumor
C. Posterior reversible encephalopathy syndrome
D. Multiple system atrophy

29. A 62-year-old man has sudden onset of headache and starts having difficulty controlling generalized tonic–clonic seizures in the emergency department. Ultimately, he requires intubation for seizure control. MRI is shown below; what is the next best step?

A. Start acyclovir
B. Start barbiturates
C. Check blood sugar
D. Arrange for needle biopsy

30. You are seeing a 35-year-old man with difficulty controlling seizures. The MRI scan is demonstrated below. What is the most likely diagnosis?

A. Metastases
B. Neurocysticercosis
C. Familial cavernomatosis
D. Gliomatosis cerebri
31. You are asked to evaluate a 2-month-old infant who has been found to have hydrocephalus and altered mental status. Head CT is demonstrated below. What is the most likely diagnosis?

A. Aqueductal stenosis
B. Cytomegalovirus (CMV) encephalitis
C. Germinal matrix hemorrhage
D. Vein of Galen malformation

32. You are evaluating a 46-year-old woman with a history of headaches and intermittent clumsiness of the left hand that resolves completely several weeks after onset. MRI is demonstrated below. What is the most likely diagnosis?

A. Balo’s concentric sclerosis
B. CNS lymphoma
C. Tumefactive multiple sclerosis
D. Glioblastoma

33. You are evaluating a 37-year-old woman with a history of headaches and intermittent neurologic deficits that seem to resolve completely over time. Now she is in the emergency department with a GCS of 12 (E3, V4, M5). MRI is demonstrated below. What is the most likely diagnosis?

A. Balo’s concentric sclerosis
B. CNS lymphoma
C. Tumefactive multiple sclerosis
D. Glioblastoma

34. The syndrome that causes the findings on this MRI is due to abnormality in what cellular process?

A. Very long chain fatty acid synthesis
B. Glucocerebrosidase deficiency
C. Isocitrate dehydrogenase deficiency
D. Glycogen storage
35. You are evaluating a 35-year-old homeless man who reports intravenous (IV) drug use who has developed persistent headaches. An abnormality is seen on CT; findings are shown below. What is the most likely diagnosis?

A. Metastasis  
B. Cerebral abscess  
C. Glioblastoma  
D. Meningioma

36. You are evaluating a 35-year-old homeless man who has developed persistent headaches. An abnormality is seen on CT scan prompting an MRI; findings are shown below. If the diagnosis of a cerebral abscess is confirmed, what would be the most likely isolate?

A. *Streptococcus milleri*  
B. *Listeria monocytogenes*  
C. *Staphylococcus aureus*  
D. *Klebsiella pneumoniae*
37. A 26-year-old woman is 6 months postpartum and is found to be in diabetes insipidus by her primary care provider. An MRI is obtained and is demonstrated below. What is the most likely diagnosis?

A. Pituitary macroadenoma  
B. Craniopharyngioma  
C. Pituitary apoplexy  
D. Lymphocytic hypophysitis

38. A 26-year-old woman is 3 days post vaginal delivery that was complicated by uterine hemorrhage resulting in approximately 2 L of blood loss. On postpartum day 3, her blood pressure suddenly increases due to pain while walking and she experiences onset of headaches and visual disturbances. An MRI is demonstrated below. What should be your next step?

A. Emergent pituitary decompression  
B. Obtain MRI  
C. Check sodium  
D. Give hydrocortisone

39. A 67-year-old man has onset of right facial droop, tongue deviation to the left, and some dysmetria on finger–nose–finger testing. Postcontrast MRI is demonstrated below. What is the most likely diagnosis?

A. CNS lymphoma  
B. Leptomeningeal carcinomatosis  
C. Neurosarcoïdosis  
D. Acute disseminated encephalomyelitis

40. Which neurotransmitter does the structure identified by number 2 in this coronal MRI use?

A. Acetylcholine  
B. Dopamine  
C. Norepinephrine  
D. Serotonin
41. An 80-year-old man has started to develop changes in personality and socially disruptive behavior. More recently, his language has been affected. MRI is demonstrated below. What is the most likely diagnosis?

A. Corticobasal degeneration  
B. Parkinson's disease  
C. Frontotemporal dementia  
D. Alzheimer's disease

42. What signal intensity on T1-weighted imaging does hyperacute (<24) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

43. What signal intensity on T2-weighted imaging does hyperacute (<24) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

44. What signal intensity on T2-weighted imaging does acute (1–3 days) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

45. What signal intensity on T1-weighted imaging does acute (1–3 days) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

46. What signal intensity on T1-weighted imaging does early subacute (3–7 days) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

47. What signal intensity on T2-weighted imaging does early subacute (3–7 days) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

48. What signal intensity on T2-weighted imaging does late subacute (7–14 days) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

49. What signal intensity on T1-weighted imaging does late subacute (7–14 days) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense

50. What signal intensity on T1-weighted imaging does chronic (>14 days) hemorrhage demonstrate?

A. Isointense  
B. Hyperintense  
C. Hypointense  
D. Hyperdense
51. What signal intensity on T2-weighted imaging does chronic (> 14 days) hemorrhage demonstrate?
A. Isointense
B. Hyperintense
C. Hypointense
D. Hyperdense

52. A 42-year-old woman has the MRI shown below. What is the most likely presentation?
A. Ipsilateral hemiparesis and 2-point discrimination loss, contralateral pain/temperature loss
B. Circumferential weakness
C. Bowel/bladder incontinence
D. Bilateral lower extremity paresthesias

53. A 56-year-old man has noticed the onset of bilateral lower extremity weakness that has been slowly progressive. MRI is shown below. What is the most likely diagnosis?
A. Ependymoma
B. Spinal cord astrocytoma
C. Meningioma
D. Hemangioblastoma

54. What is the most common intramedullary spinal cord tumor?
A. Ependymoma
B. Spinal cord astrocytoma
C. Meningioma
D. Hemangioblastoma

55. A 23-year-old man has been developing proximal lower extremity weakness and sensory loss in bilateral upper extremities in a capelike distribution. MRI findings are below. What condition is this mass associated with?
A. NF1
B. NF2
C. Tuberous sclerosis
D. Li–Fraumeni syndrome

56. What is the most likely diagnosis based on the MRI shown?
A. Spinal cord astrocytoma
B. Meningioma
C. Myxopapillary ependymoma
D. Hemangioblastoma
57. A 23-year-old man has been developing proximal lower extremity weakness and sensory loss in bilateral upper extremities in a capelike distribution. MRI findings are below. What condition is this mass associated with?

A. NF1  
B. NF2  
C. Tuberous sclerosis  
D. Li–Fraumeni syndrome

58. What is the most likely diagnosis based on the MRI demonstrated below?

A. Ependymoma  
B. Astrocytoma  
C. Metastasis  
D. Meningioma

59. A 14-year-old adolescent girl has severe low back pain that is most severe at night. CT scan of L5 is below. What is the most likely diagnosis?

A. Hemangioma  
B. Aneurysmal bone cyst  
C. Metastatic lesion  
D. Osteoid osteoma

60. A 33-year-old woman has a trauma spine CT after she was involved in a motor vehicle accident. The axial slice through T10 is shown below. What is the most likely diagnosis?

A. Hemangioma  
B. Burst fracture  
C. Metastatic lesion  
D. Osteoid osteoma
I Questions

61. A 16-year-old adolescent girl has the onset of persistent back pain. MRI is demonstrated below. What is the most likely diagnosis?

A. Hemangioma  
B. Aneurysmal bone cyst  
C. Metastatic lesion  
D. Osteoid osteoma

62. A 33-year-old woman has had the onset of urinary and fecal incontinence. Imaging is demonstrated below. What is the most likely finding on hisc specimen?

A. Rosenthal fibers  
B. Physaliphorous cells  
C. Eosinophilic intranuclear inclusion bodies  
D. Homer Wright rosettes

63. A 33-year-old woman has had the onset of urinary and fecal incontinence. Imaging is demonstrated below. What is the most likely diagnosis?

A. Chordoma  
B. Aneurysmal bone cyst  
C. Lipomyelomeningocele  
D. Metastasis

64. An 82-year-old man notices the onset of severe, aching back and leg pain when he is upright and walking, relieved by leaning forward on a counter. MRI is shown below. The stenosis at the level with the yellow arrow is caused by a bulging disc and what structure?

Use the following figure to answer questions 64 and 65:

A. Posterior longitudinal ligament  
B. Anterior longitudinal ligament  
C. Ligamentum flavum  
D. Spinous process
65. An 82-year-old man notices the onset of severe, aching back and leg pain when he is upright and walking, relieved by leaning forward on a counter. MRI is shown in Question 64. What extracellular structure is the posterior element causing compression mainly comprised of?
A. Type I collagen
B. Type II collagen
C. Elastin
D. Laminin

66. A 54-year-old woman has the onset of right leg pain that has been persistent despite physical therapy. MRI is shown below. What nerve root is most likely involved?

Use the following figure to answer questions 66 and 67:

A. Right L4
B. Left L4
C. Right L5
D. Left L5

67. A 54-year-old woman has the onset of right leg pain that has been persistent despite physical therapy. MRI is shown in Question 66. If she were to develop weakness, what would you expect to see on examination?
A. Right quadriceps weakness
B. Right hip adduction weakness
C. Right extensor hallucis longus weakness
D. Right gastrocnemius weakness

68. A 54-year-old man has the onset of right leg pain that has been persistent despite physical therapy. Imaging of the L3-4 region is demonstrated. If he were to have weakness on presentation, what would you expect to see?

Use the following figure to answer questions 68 and 69:

A. Right iliopsoas weakness
B. Right quadriceps weakness
C. Right extensor hallucis longus weakness
D. Right gastrocnemius weakness

69. A 54-year-old man has the onset of right leg pain that has been persistent despite physical therapy. Imaging of the L3-4 space is shown in Question 68. What nerve root is compressed?
A. Right L3
B. Left L4
C. Right L5
D. Left L5
I Questions

70. A 68-year-old man has the onset of severe, bilateral lower extremity pain that is persistent despite physical therapy. MRI is shown below. What is the most likely diagnosis?

Use the following figure to answer questions 70 and 71:

A. Lumbar spondyloptosis
B. Lumbar spondylolisthesis
C. Lumbar burst fracture
D. Chance fracture

71. An 88-year-old man has the onset of severe, bilateral lower extremity pain that is persistent despite physical therapy. X-ray is shown below. What other imaging modality should be considered prior to offering a procedure?

A. 36-inch-long cassette X-rays
B. Lumbar spine MRI
C. Lumbar CT scan
D. CT myelogram

72. You are seeing back a 52-year-old woman that had a routine MIS diskectomy at L4-5 on the right side 5 months ago. She has noticed the return of her leg pain that she had prior to the initial procedure. What imaging study should you order?

A. Noncontrast lumbar spine MRI
B. Contrast-enhanced lumbar spine MRI
C. Standing AP/lateral lumbar spine X-rays
D. Lumbar spine CT

73. A 59-year-old woman has severe back and leg pain and she appears to be flexing her legs and retroverting her pelvis to maintain the horizontal gaze. CT scan is demonstrated below. What is the most accurate diagnosis?

A. Burst fracture
B. Grade I spondylolisthesis
C. Spondyloptosis
D. Spondylolysis

74. What is the diagnosis?
75. A 44-year-old woman had been experiencing the onset of transient tetraparesis, and imaging demonstrated a mass. Ultimately she underwent decompression and fusion with resolution of the mass pictured below. Laxity of what may be contributing to her transient weakness?

A. Anterior longitudinal ligament
B. Transverse ligament
C. Apical ligament
D. Ligamentum nuchae

76. You are evaluating a 65-year-old man from Japan who has symptoms of cervical myelopathy. MRI is demonstrated below. What would be the next best step?

Use the following figure to answer questions 76 and 77:

A. Anterior cervical diskectomy and fusion
B. CT scan of the cervical spine
C. EMG
D. Physical therapy

77. What is the diagnosis?
A. Ossification of the posterior longitudinal ligament
B. Diffuse idiopathic skeletal hyperostosis
C. Ankylosing spondylitis
D. Klippel–Feil syndrome

78. You are evaluating a 45-year-old woman with the onset of neck and right arm pain. Axial MRI scan is demonstrated below. What nerve root is compressed?

Use the following figure to answer questions 78 and 79:

A. Right C6
B. Left C6
C. Right C7
D. Left C7

79. You are evaluating a 45-year-old woman with the onset of neck and right arm pain. MRI scan is demonstrated in Question 78. Where would you expect the patient to have sensory symptoms?

A. Right shoulder
B. Right thumb
C. Right middle finger
D. Right fifth digit
80. You are evaluating a 55-year-old woman with the onset of back pain worsened by being upright and walking. MRI is shown below. What is the most likely diagnosis?

A. Myxopapillary ependymoma  
B. Synovial cyst  
C. Epidural lipomatosis  
D. Spinal stenosis

81. You are evaluating a 55-year-old woman with the onset of left leg pain worsened by being upright and walking. MRI is shown below. What is the most likely diagnosis?

A. Ependymoma  
B. Spinal dural arteriovenous fistula  
C. Spinal arteriovenous malformation  
D. Spinal astrocytoma

82. A 42-year-old woman has the onset of progressive proximal leg weakness, hand incoordination, and urinary incontinence. MRI is shown below. What is the most likely diagnosis?

Use the following figure to answer questions 82 and 83:

A. Herniated disk  
B. Synovial cyst  
C. Epidural lipomatosis  
D. Spinal stenosis

83. A 42-year-old woman has the onset of progressive proximal leg weakness, hand incoordination, and urinary incontinence. MRI is shown below. What is the next best step?

A. Flexion/extension X-rays  
B. Cervical spine CT  
C. Conventional angiogram  
D. Gadolinium-enhanced MRI
84. A 42-year-old woman has the onset of progressive lower extremity weakness and urinary incontinence. MRI is shown below. What is the next best step?

A. Flexion/extension X-rays
B. Lumbar spine CT
C. Conventional angiogram
D. Gadolinium-enhanced MRI

85. A 42-year-old woman has the onset of progressive lower extremity weakness and urinary incontinence. MRI is shown below. What is the most likely diagnosis?

A. Spinal cavernous malformation
B. Spinal dural arteriovenous fistula
C. Spinal cord infarction
D. Spinal hemangioblastoma

86. A 66-year-old woman has persistent low back and leg pain, worsened while she is upright and walking. She is pacemaker dependent and cannot undergo an MRI. What is the next best step?

A. Flexion/extension X-rays
B. Lumbar CT scan
C. CT myelogram
D. Lumbar MRI

87. A 75-year-old man underwent a complex spinal fusion procedure 3 months ago. He initially had improvement in his back pain, but over the last 24 hours his pain has returned. X-rays are demonstrated below. What is the most likely diagnosis?

A. CSF leak
B. Hardware failure
C. Junctional kyphosis
D. Adjacent segment disease
88. What is likely to be present in this patient?

A. Improved NDI score  
B. Pseudoarthrosis  
C. Complete bony fusion  
D. Deltoid weakness  
E. Triceps weakness

89. A 75-year-old man sustains a fall and a head injury. You are covering spine call and are asked to comment on his cervical spine imaging. What is the most likely diagnosis?

Use the following figure to answer questions 89 and 90:

A. HLA-DR2  
B. HLA-DR3  
C. HLA-B27  
D. HLA-B47

90. An 88-year-old man sustains a fall and a head injury. You are covering spine call and are asked to comment on his cervical spine CT. With what human leukocyte antigen is this condition associated?

A. HLA-DR2  
B. HLA-DR3  
C. HLA-B27  
D. HLA-B47

91. An 88-year-old man is involved in a motor vehicle accident and undergoes a trauma evaluation of his spine. The CT scan is below. With what human leukocyte antigen is this condition associated?

Use the following figure to answer questions 91 and 92:

A. HLA-DR2  
B. HLA-DR3  
C. HLA-B27  
D. HLA-B47

92. An 88-year-old man is involved in a motor vehicle accident and undergoes a trauma evaluation of his spine. The CT scan is shown in Question 91. What is the most likely diagnosis?

A. Ankylosing spondylitis  
B. Diffuse idiopathic skeletal hyperostosis  
C. Osteochondroma  
D. In situ surgical fusion
93. What is the most likely diagnosis based on this lateral spine X-ray?

A. Ankylosing spondylitis  
B. Diffuse idiopathic skeletal hyperostosis  
C. Osteochondroma  
D. In situ surgical fusion

94. A 54-year-old woman with no history of neurologic disease has the sudden onset of paraplegia and urinary incontinence over the last 24 hours. MRI is demonstrated below. What is the most likely diagnosis?

A. Spinal cord astrocytoma  
B. Cauda equine syndrome  
C. Congenital cervical stenosis  
D. Transverse myelitis

95. A 28-year-old man with a history of intravenous drug use develops the onset of back pain that is unremitting. MRI scan is demonstrated below. What is the most likely diagnosis?

Use the following figure to answer questions 95 and 96:

A. Osteochondroma  
B. Spinal hemangioma  
C. Diskitis/osteomyelitis  
D. Vertebral metastasis

96. A 28-year-old man with a history of intravenous drug use develops the onset of back pain that is unremitting. MRI scan is demonstrated in Question 95. What is the most likely pathogen?

A. *Streptococcus milleri*  
B. *Staphylococcus aureus*  
C. *Staphylococcus epidermidis*  
D. *Enterococcus*
97. A 44-year-old man presents with back pain. X-ray and CT are demonstrated below. What is the most likely diagnosis? 

*Use the following figure to answer questions 97 and 98:*

A. Scheuermann's nodes
B. Schmorl's nodes
C. Spinal stenosis
D. Synovial cyst

98. A 44-year-old man presents with back pain. X-ray is demonstrated in Question 97. What blood test should you order?

A. Serum alkaline phosphatase
B. Serum calcium
C. Serum phosphorous
D. Vitamin B12
This X-ray is performed on a 15-year-old adolescent girl with a deformity discovered during school screening. What is the most likely diagnosis?

A. Scheuermann's disease  
B. Schmorl's nodes  
C. Junctional kyphosis  
D. Dystonia
1. Approximately what percentage of total body fluid is intravascular?
   A. 3%
   B. 8%
   C. 25%
   D. 50%
   E. 75%

2. You evaluate a patient in the emergency department who has a history of a syringopleural shunt and now is having difficulty breathing. Chest X-ray is shown. What treatment should you consider in this patient?

   A. Diuretics
   B. Needle decompression
   C. Shunt externalization/removal
   D. Antibiotics
   E. Observation

3. What finding on invasive monitoring would a patient with cardiogenic pulmonary edema likely have?
   A. Hypoxemia with a normal A–a gradient
   B. PCWP > 18 mm Hg
   C. PCWP < 18 mm Hg
   D. \( \text{PAO}_2/\text{FiO}_2 \) 255 mm Hg
   E. Hypoventilation with normal A–a gradient

4. What medication can be used in patients with severe ARDS to improve oxygenation?
   A. Diuretics
   B. Dobutamine
   C. Dexamethasone
   D. Beta blocker
   E. Nimodipine

5. In treating what type of arrhythmia is adenosine useful?
   A. Narrow complex tachycardia
   B. Wide complex tachycardia
   C. Ventricular fibrillation
   D. Atrial fibrillation
   E. Wolff–Parkinson–White syndrome

6. You are caring for a patient in the ICU who has suddenly developed a wide complex tachycardia. She is awake, conversive, and currently stable. What would be an appropriate treatment for her condition?
   A. Defibrillation
   B. Lidocaine infusion
   C. Coronary angiogram
   D. tPA administration
   E. Adenosine

7. You are evaluating a new admission to the neuro-ICU. The patient was involved in a motor vehicle collision and currently demonstrates flexor posturing of the upper extremities, briefly opens his eyes to pain, and is nonverbal. What is his GCS score?
   A. 15
   B. 0
   C. 3
   D. 6
   E. 9
8. In the neuro-ICU, you are called by a nurse to evaluate a patient with pupillary abnormalities. When you see the patient, you observe rhythmic dilation and contraction of the pupillary sphincter muscles. What is causing this?
   A. Normal physiologic response
   B. Uncal herniation
   C. Diabetic oculomotor palsy
   D. Transient ischemic attacks
   E. Shearing injury of the oculomotor nerve

9. You are caring for a patient in the neuro-ICU after an intracerebral hemorrhage. She has baseline progressive dementia. In the ICU, her delirium worsens significantly in the evening and at night. This condition is thought to be due to degeneration of what hypothalamic nucleus?
   A. Anterior nucleus
   B. Ventromedial nucleus
   C. Suprachiasmatic nucleus
   D. Supraoptic nucleus
   E. Lateral nucleus

10. Which of the following is not a type of opioid receptor?
    A. Mu
    B. Delta
    C. Kappa
    D. N/OFQ
    E. Gamma

11. Which of the following coagulation cascade factors is inhibited by warfarin?
    A. 3
    B. 5
    C. 8
    D. 9
    E. 12

12. Approximately how long will it take for IV vitamin K to normalize the INR in a patient who is anticoagulated with warfarin?
    A. 4 hours
    B. 8 hours
    C. 12 hours
    D. 18 hours
    E. 24+ hours

13. On what coagulation factor does the combination of heparin/antithrombin exert anticoagulant effects?
    A. III
    B. VII
    C. IX
    D. Xa
    E. XII

14. You are treating a patient in the ICU who is in acute renal failure and needs to have DVT prophylaxis initiated. Unfortunately, she has developed heparin-induced thrombocytopenia and you need another option. Which of the following anticoagulants would be contraindicated in her current condition?
    A. Aspirin
    B. Dabigatran
    C. Argatroban
    D. Warfarin
    E. Clopidogrel

15. What is the approximate half-life of aspirin?
    A. 30 minutes
    B. 6 hours
    C. 24 hours
    D. 7 days
    E. 1 month

16. Via what mechanism does clopidogrel exhibit an antiplatelet effect?
    A. Inhibition of thromboxane synthesis via COX 1 inhibition
    B. P2Y12 receptor binding inhibiting ADP mediated platelet aggregation (GPIIb/IIIa)
    C. Thienopyridine-mediated ADP receptor blockade
    D. Factor IIa inhibition
    E. Binds antithrombin III

17. What level of urine output suggests adequate volume replacement?
    A. 0.1 to 0.5 mL/kg/h
    B. 0.5 to 1.0 mL/kg/h
    C. 1.0 to 1.5 mL/kg/h
    D. 1.5 to 2.0 mL/kg/h
    E. 2.0 to 2.5 mL/kg/h
18. What is the best immediate reversal agent of a patient with an elevated INR and ICH who also has coexistent heart failure?
A. Prothrombin complex concentrates
B. Fresh frozen plasma
C. IV vitamin K
D. Transexamic acid
E. Protamine

19. You are about to discharge a hospitalized patient who is now at POD 3 from a lumbar laminectomy. Her hospital course was complicated by development of an unprovoked left lower extremity DVT. It has been recommended that she discharge on oral anticoagulation for treatment of her DVT. How long should she be on anticoagulation for this event?
A. 1 week
B. 1 month
C. 3 months
D. 6 months
E. 1 year

20. You are caring for a 33-year-old woman who is on oral contraceptive pills and intermittently smokes. She developed a severe headache and has the findings demonstrated in the images below. What is the best initial management of her condition?
A. Intravenous heparin
B. Observation
C. Aspirin
D. Transarterial tPA
E. Dabigatran administration

21. What brain tissue partial pressure of oxygen level is thought to be the threshold below which anaerobic respiration takes over and secondary injury via lactic acidosis occurs?
A. 50 mm Hg
B. 40 mm Hg
C. 30 mm Hg
D. 20 mm Hg
E. 10 mm Hg

22. According to the guidelines for the management of severe traumatic brain injury, a GCS of what is considered severe head injury?
A. 12 or less
B. 10 or less
C. 8 or less
D. 6 or less
E. 3

23. You are asked to evaluate a patient with a severe head injury in the ED after a motor vehicle collision. As you are arriving to the ED, you see the ED resident starting to intubate. You are told that the patient was given rocuronium for paralytic just prior to intubation. How long will you likely have to wait before you can get an adequate neurologic exam?
A. 15 minutes
B. 30 minutes
C. 90 minutes
D. 6 hours
E. 24 hours

24. Via what mechanism can hyperventilation of the intubated patient with elevated ICP decrease ICP?
A. Decreased pH
B. Increased pH
C. Increased CSF production
D. Decreased CSF production
E. Decreased cardiac output
25. You are evaluating a patient who has suffered a severe brain injury and unfortunately no measures have led to improvement of the patient’s condition. He is currently on comfort cares and as you observe, his breathing pattern consists of a prolonged pause at full inspiration. Where does this breathing pattern localize the injury?
A. Diffuse forebrain  
B. Thalamus  
C. Pons  
D. Medulla  
E. Upper cervical spine

26. What is the average cerebral blood flow to the brain in the normal, healthy adult?
A. 20 mL/100 g/min  
B. 35 mL/100 g/min  
C. 50 mL/100 g/min  
D. 75 mL/100 g/min  
E. 100 mL/100 g/min

27. What is the normal cerebral blood flow in a normal, healthy 4-year-old?
A. 20 mL/100 g/min  
B. 35 mL/100 g/min  
C. 50 mL/100 g/min  
D. 75 mL/100 g/min  
E. 100 mL/100 g/min

28. Which of the following tumors is associated with hyponatremia?
A. Bronchogenic carcinoma  
B. Small cell lung cancer  
C. Medullary thyroid cancer  
D. Neuroblastoma  
E. Medulloblastoma

29. You are evaluating a 38-year-old woman who has severe migraines, several seizure episodes, and a recent subclinical stroke that was demonstrated on MRI. She also has an associated mood disorder. Dilutional testing is suggestive of an inhibitor present. You suspect lupus. How do you confirm the diagnosis of neuropsychiatric SLE?
A. Skin biopsy  
B. CSF antineuronal antibodies  
C. CSF anti-Jo antibodies  
D. CSF anti-RI antibodies  
E. CSF glucose

30. You are evaluating a 64-year-old woman with left arm and leg weakness. MRI has the following findings. Genetic testing demonstrates an abnormality on chromosome 19. What is the diagnosis?

31. You are evaluating a 76-year-old man who presents with persistent temporal headaches, jaw claudication, and tenderness of the temporal artery. If this patient were to go on to develop blindness, what mechanism underlies the ischemic optic neuropathy?
A. Inflammation  
B. Thrombosis  
C. Embolic infarct  
D. Arterial rupture

32. You are caring for a patient with giant cell arteritis, newly diagnosed. You are concerned about the development of blindness in this patient. What should be your initial management?
A. Clopidogrel  
B. Heparin  
C. Prednisone  
D. Hydroxychloroquine  
E. Infliximab
33. What serum osmolality represents a threshold after which mannitol administration is contra-indicated due to an elevated risk of acute tubular necrosis?
   A. 300
   B. 310
   C. 320
   D. 330
   E. 340

34. You are asked to review the CT scan of a 7-week-old newborn with a head mass. What is the diagnosis?
   A. Epidermoid cyst
   B. Eosinophilic granuloma
   C. Growing skull fracture
   D. Calcified cephalohematoma
   E. Nonaccidental trauma

35. You are asked to evaluate a 5-day-old newborn who has a cephalohematoma that has not resolved at this point. It does not appear to have increased in size; the child remains afebrile and stable both neurologically and systemically. What treatment should you recommend?
   A. Further observation
   B. Surgical decompression
   C. Needle aspiration
   D. Serial CT scans
   E. Tight head wrap

36. Retinal hemorrhages are a classic symptom of severe, abusive pediatric head trauma, occurring in up to 80% of patients. How often are retinal hemorrhages present in cases of confirmed accidental trauma?
   A. 5%
   B. 15%
   C. 35%
   D. 55%
   E. 75%

37. You are seeing a patient in the ED. You were called emergently as this patient has evidence of an epidural hematoma and has now developed pupillary anisocoria. You decide to go emergently to the OR for evacuation. Based on current evidence, after the onset of pupillary changes, within what time interval should you achieve decompression of the hematoma to promote a good outcome?
   A. < 10 minutes
   B. < 70 minutes
   C. < 120 minutes
   D. < 6 hours
   E. < 24 hours

38. Which of the following measurements of an acute subdural hematoma meets criteria for evacuation regardless of GCS?
   A. 7-mm thick/4-mm midline shift
   B. 12-mm thick/6-mm midline shift
   C. 3-mm thick/3-mm midline shift
   D. 9-mm thick/2-mm midline shift
   E. 13-mm thick/1-mm midline shift

39. You are caring for a patient who has developed postsurgical brachial neuritis (Parsonage–Turner syndrome). She is experiencing significant shoulder girdle pain. What medication should you use to help her symptoms?
   A. Prednisone
   B. NSAIDs
   C. Ketamine
   D. Methotrexate
   E. Temozolomide
40. In patients with nonhereditary brachial neuritis (Parsonage–Turner syndrome), what is the expected rate of full recovery at 3 years?
A. 50%
B. 60%
C. 70%
D. 90%
E. 100%

41. Which of the following is a known side effect of dexmedetomidine use for sedation in the neuro-ICU?
A. Seizures
B. Agitation
C. Bradycardia
D. Hypertension
E. Tachycardia

42. What brainstem nucleus is thought to be mediated by administration of dexmedetomidine?
A. Raphe nucleus
B. Nucleus accumbens
C. Periaqueductal gray
D. Locus coeruleus
E. Solitary tract

43. Only for what time frame is continuous infusion of dexmedetomidine approved by the FDA?
A. 1 hour
B. 6 hours
C. 12 hours
D. 24 hours
E. 48 hours

44. What might you see as an initial symptom of propofol infusion syndrome in a patient who has received high doses of propofol for the last 72 hours?
A. Hypertension
B. New right bundle branch block
C. Seizures
D. Metabolic alkalosis
E. Hypokalemia

45. Which of the following anesthetic agents inhibits the formation of ACTH?
A. Propofol
B. Etomidate
C. Ketamine
D. Pentobarbital
E. Isoflurane

46. Which of the following conditions would be a contraindication to performing a supracerebellar, infratentorial approach to a pineal region tumor in the sitting position?
A. Patent foramen ovale
B. Pre-existing DVT
C. Restrictive lung disease
D. History of cervical fusion
E. Ongoing cervical radiculopathy

47. Which of the following anesthetic medications can lower the seizure threshold?
A. Propofol
B. Pentobarbital
C. Etomidate
D. Midazolam
E. Methohexital

48. You are evaluating a 38-year-old man with right-sided temporal lobe epilepsy from presumed hippocampal sclerosis. According to the landmark controlled trial focusing on temporal lobe epilepsy, what percentage of surgical patients will be completely seizure free at 1 year?
A. ~ 25%
B. ~ 33%
C. ~ 40%
D. ~ 60%
E. ~ 90%
49. You are evaluating a 52-year-old man with medically refractory epilepsy that appears to be located in eloquent cortex (motor cortex) on the right side. There are no other options and you and the patient are considering a procedure to perform multiple pial transections in attempt to control the epilepsy. What should you counsel this patient about during the postoperative course?
A. Permanent motor deficit
B. Temporary motor deficit
C. Initial seizure worsening
D. High risk of infection
E. High risk of postoperative hemorrhage

50. You are seeing a patient in clinic with drug-resistant epilepsy who is being considered for surgical treatment. She describes her seizure onset including a rising epigastric sensation just prior to initiation of her seizure episode. Where is the most likely location of her epilepsy?
A. Medial frontal lobe
B. Occipital lobe
C. Temporal lobe
D. Lateral frontal lobe
E. Parietal lobe

51. Which of the following factors is more consistent with type II or atypical trigeminal neuralgia?
A. Lancinating pain
B. Pain-free intervals
C. Unilateral
D. Throbbing pain

52. What percentage of patients with classic type I trigeminal neuralgia pain will have “excellent to good” pain relief long term with microvascular decompression?
A. 25%
B. 65%
C. 75%
D. 85%
E. 95%

53. What percentage of patients with atypical type II trigeminal neuralgia pain will have “excellent to good” pain relief long term with microvascular decompression?
A. 25%
B. 65%
C. 75%
D. 85%
E. 95%

54. You are asked to see a patient who is having severe, episodic pain in the right lower jaw. She describes lancinating pain that is worsened by brushing her teeth. You suspect trigeminal neuralgia. What is the best initial management of her condition?
A. Balloon compression
B. Radiofrequency rhizotomy
C. Microvascular decompression
D. Medical management
E. Glycerol rhizotomy

55. What is the mechanism of action for trigeminal neuralgia pain relief via administration of the medication oxcarbazepine?
A. Voltage-gated sodium channel blockade
B. Voltage-gated calcium channel blockade
C. Mu opioid receptor agonist
D. NMDA receptor agonist
E. GABA agonist
56. You are performing a balloon compression of the trigeminal nerve in a patient with TN. If the patient has primarily V3 distribution pain, where in the foramen ovale should you attempt to place the catheter?

A. Superior  
B. Inferior  
C. Lateral  
D. Medial  
E. Intermediate

57. Which of the following patients is most likely to have the findings on MRI demonstrated below?

A. A 67-year-old woman with breast cancer  
B. A 55-year-old male alcoholic  
C. A 42-year-old male IV drug user  
D. An 18-year-old woman with lymphoma  
E. An 80-year-old woman with carotid stenosis

58. Which of the following conditions causes peaked T waves on ECG?

A. Hypokalemia  
B. Hyperkalemia  
C. Hypomagnesemia  
D. Hypercalcemia  
E. Hypernatremia

59. You are reading an ECG that demonstrates prolongation of the PR interval. What electrolyte abnormality can cause this finding on ECG?

A. Hyponatremia  
B. Hypocalcemia  
C. Hyperkalemia  
D. Hypernatremia  
E. Hypomagnesemia

60. Hypomagnesemia can lead to what changes on ECG?

A. Prolonged PR interval  
B. ST elevation  
C. Multifocality  
D. QRS prolongation  
E. Bundle branch block

61. Which of the following is a contraindication to the use of IV rtPA in the treatment of acute ischemic stroke?

A. Cortical-based tumor  
B. Symptoms for 4 hours  
C. History of seizures  
D. Age of 18 years  
E. Platelet count of 115,000

62. Occlusion of the PICA proximal to what point will likely result in a lateral medullary syndrome?

A. Caudal loop  
B. Choroidal point  
C. Cranial loop  
D. Spinal point  
E. Extradural segment
63. What is the first branch of the external carotid artery?
   A. Superior thyroid
   B. Ascending pharyngeal
   C. Lingual
   D. Facial
   E. Occipital

64. What artery is the primary vascular supply to the nasal cavity?
   A. Ophthalmic
   B. Anterior ethmoidal
   C. Posterior ethmoidal
   D. Sphenopalatine
   E. Vidian

65. You are caring for a 42-year-old smoker who has suffered an aneurysmal subarachnoid hemorrhage. The CT findings are demonstrated below. What is the approximate risk of aneurysm rebleeding in the first 24 hours?

   Use the following figure to answer questions 65 and 69:

   ![CT scans of subarachnoid hemorrhage]

   A. 4%
   B. 8%
   C. 12%
   D. 20%
   E. 33%

66. What is the approximate risk of aneurysmal rebleed in the first 2 weeks after aneurysmal subarachnoid hemorrhage?
   A. 10 to 15%
   B. 15 to 20%
   C. 20 to 25%
   D. 25 to 30%
   E. 30 to 35%

67. Neurogenic pulmonary edema after aneurysmal subarachnoid hemorrhage is thought to occur due to what mechanism?
   A. Iatrogenic fluid overload
   B. Catecholamine surge
   C. Heart failure
   D. Pulmonary embolism
   E. Prolonged mechanical ventilation

68. What is the most common electrolyte derangement after aneurysmal subarachnoid hemorrhage?
   A. Hyponatremia
   B. Hypernatremia
   C. Hypocalcemia
   D. Hyperkalemia
   E. Hypokalemia

69. You are caring for a patient with the subarachnoid hemorrhage demonstrated in the CT scans in the Question 65. If the patient had hypernatremia, where would you suspect the underlying aneurysm to be arising from?

   A. Posterior communicating artery
   B. MCA bifurcation
   C. Anterior communicating artery
   D. Basilar tip
   E. Posterior inferior cerebellar artery

70. Which of the following helps decrease stress ulcer formation in ventilated patients with subarachnoid hemorrhage?
   A. Aggressive glucose control
   B. Decreasing IV infusions
   C. TPN administration
   D. Early enteral nutrition
   E. Regular sedation holidays
71. You are evaluating a 24-year-old woman who was an unrestrained passenger in a motor vehicle collision and she struck her head on the windshield. She was transferred to the neuro-ICU and has been intubated since admission for a depressed GCS. A pressure monitor was placed and she has evidence of refractory ICP elevations. According to the Decompressive Craniectomy in Diffuse Traumatic Brain Injury (DECRA) trial, what is the most likely outcome of decompressive hemicraniectomy in this patient?

A. Mortality
B. Continued refractory ICP elevation
C. Good outcome and decreased ICP
D. Poor outcome and decreased ICP
E. Good outcome but increased ICP

73. You are caring for a patient who has significant hypertension at baseline. Her averaged systolic blood pressure is 178 in the office. You are concerned that her blood pressure remains greater than 160, and that she has a higher risk of spontaneous ICH. What is the increased risk of ICH in patients with SBP > 160?

A. 2 times
B. 5 times
C. 10 times
D. 50 times
E. 100 times

72. You are admitting an 80-year-old man to the neuro-ICU after he suffered a right-sided basal ganglia ICH with no intraventricular extension. His admission SBP is 206. According to the intensive blood pressure reduction in acute cerebral hemorrhage trial (INTERACT), intensive blood pressure control (SBP goal of 140 or less) will have what effect on this patient?

A. No change
B. Decreased hematoma volume; no clinical effect
C. Decreased hematoma volume; improved clinical course
D. Increased hematoma volume; no clinical effect
E. Increased hematoma volume; improved clinical course

74. What is the rate of functional independence at 3 months in patients who suffer a spontaneous ICH?

A. 0%
B. 20%
C. 50%
D. 75%
E. 100%

75. You are asked to consult on an 82-year-old woman with a large cerebellar hematoma from a presumed spontaneous cerebellar hemorrhage. Her admission GCS was 6 and there is evidence of intraventricular hemorrhage. The hematoma volume is measured to be 31 mL and there is brainstem compression. What is her 30-day mortality according to the ICH score?

A. 13%
B. 26%
C. 72%
D. 97%
E. 100%

76. You are evaluating a 76-year-old woman who has suffered a right-sided spontaneous cerebral hemorrhage. The neurointensivist is asking if you would consider surgically resecting the hematoma. According to the original surgical treatment for intracerebral hemorrhage (STICH) trial subgroup analysis, what hematoma characteristic might demonstrate a benefit from surgical resection?

A. Right hemisphere location
B. Age younger than 80 years
C. Superficial cortical (< 1 cm from the surface) location
D. No midline shift
E. Intraventricular extension
77. You are asked to evaluate the CT image of an 83-year-old woman with the following findings. What is the most common underlying cause of the findings on the CT scan?

*Use the following figure to answer questions 77–79:*

A. Hypertension
B. Age older than 80 years
C. Metastatic disease
D. Smoking
E. Drug use

78. You are asked to discuss possible surgical outcomes with the family of a patient with the CT scan demonstrated in Question 77. When you discuss the possibility of surgical resection and decompression of the posterior fossa, they ask what chance there is that their family member can live without daily assistance. According to current literature, what is the rate of good outcome (Glasgow Outcome Score 4 or 5) in patients treated surgically for this condition?

A. 0%
B. 25%
C. 50%
D. 75%
E. 100%

79. According to guidelines, which of the following factors present on admission should make you surgically decompress and resect the hematoma demonstrated in the CT scan in Question 77?

A. Hypertension (SBP > 160)
B. Hematoma enlargement on serial CT scan
C. GCS 15
D. Hydrocephalus
E. Elevated INR

80. What size threshold has been identified for spontaneous cerebellar hemorrhage under which most patients are less likely to deteriorate and require surgical decompression?

A. 1 cm
B. 2 cm
C. 3 cm
D. 4 cm
E. 5 cm

81. You performed a stereotactic needle biopsy on a 56-year-old woman who initially presented with headache and MRI demonstrated multifocal enhancement throughout the cortex. Her condition had started to worsen, and she developed cognitive impairment. The results of the biopsy are demonstrated below. What is the most likely diagnosis?

A. Glioblastoma
B. Hypertension
C. Vasculitis
D. Metastatic disease
E. Ischemic stroke

82. What is thought to be the underlying mechanism of normal pressure hydrocephalus?

A. CSF overproduction
B. Arachnoid granulation dysfunction
C. Aqueductal stenosis
D. Multiple subclinical hemorrhages
E. Decreased ventricular compliance

83. What diagnostic test can increase the rate of favorable response to ventriculoperitoneal (VP) shunting in patients with normal pressure hydrocephalus from approximately 50 to 80% or more?

A. Venticulomegaly on MRI
B. Adequate CSF flow on cine MRI
C. Leukocytosis
D. Improved gait after high-volume LP
E. Perceived cognitive improvement after high-volume LP
84. What is the diagnosis in this 18-year-old girl who presents with intermittent, right-sided holohemispheric headaches and the following MRI?

A. Pilocytic astrocytoma  
B. Optic glioma  
C. Epidermoid cyst  
D. Arachnoid cyst  
E. Metastatic disease

85. You are caring for a 3-year-old boy who has been admitted to the pediatric ICU after nonaccidental trauma by the father that has caused severe TBI. He has elevated ICP and a poor clinical exam. The pediatric team asks you about the administration of steroids in an attempt to improve his cerebral edema. What effect do steroids have on severe pediatric TBI?

A. Improvement in ICP and clinical outcome, no systemic complications  
B. Improvement in ICP and clinical outcome, increased systemic complications  
C. No improvement in ICP, improved clinical outcome, increased systemic complications  
D. Improvement in ICP, no clinical improvement, increased systemic complications  
E. No improvement in ICP, no clinical improvement, increased systemic complications

86. Intrauterine fetal surgery for the repair of myelomeningocele is undertaken at what time?

A. 18 to 20 weeks of gestation  
B. 24 to 26 weeks of gestation  
C. 30 to 32 weeks of gestation  
D. 36 to 38 weeks of gestation  
E. 40+ weeks of gestation
87. You are asked to evaluate a 22-year-old woman in the ED who developed a sudden headache with some mild word-finding difficulties and admission CT is demonstrated below. She does not have any history of drug use or other systemic disease process that the ED team is currently aware of. Her INR is 1.0. What is the next best step in management?

A. ICU admission and observation  
B. Intensive blood pressure management  
C. Intensive glucose management  
D. Further imaging  
E. PMR assessment

88. You are caring for a 33-year-old man with the following lesion on cerebral angiogram. What genetic condition might predispose him to development of this lesion?

A. Neurofibromatosis type I  
B. Kennedy’s disease  
C. Hereditary hemorrhagic telangiectasia  
D. Ataxia-telangiectasia  
E. Von Hippel–Lindau disease

89. You are caring for a 38-year-old man who has been diagnosed with bilateral moyamoya disease. He has been counseled that his rate of stroke over 5 years is between 67 and 90% without treatment. He was referred to you for potential indirect or direct bypass. If your surgery is successful, what will his new rate of stroke over the next 5 years be?

A. < 10%  
B. 11 to 20%  
C. 21 to 30%  
D. 31 to 40%  
E. 41 to 50%

90. You are evaluating a 5-year-old boy with known neurofibromatosis type I who has developed visual loss in the right eye. Imaging demonstrates a suspected right optic pathway glioma. What characteristic will determine if you are able to surgically cure this patient?

A. Baseline visual field tests  
B. Optic chiasm involvement  
C. Enhancement pattern on MRI  
D. Location (right vs. left)  
E. Patency of retinal artery on angiogram
91. What is created when a force vector is applied tangentially and from a distance to the instantaneous axis of rotation in the spinal column?
   A. Moment arm
   B. Bony fracture
   C. Ligamentous damage
   D. Load
   E. Stress shield

92. How is the material property stress defined in spine biomechanics?
   A. Change in unit length/original length
   B. Force applied per unit area
   C. Length of moment arm
   D. Overall weight (in kg) applied to the instantaneous axis of rotation
   E. Resistance of the object to deformation

93. Stiffness of a spinal implant is defined as what?
   A. The area under the force deformation curve
   B. The slope of the most linear region of the force deformation curve
   C. The point of maximum force on the force deformation curve
   D. The point of maximum deformation on the force deformation curve

94. On a force deformation curve, what is the term for the point where the line deflects and enters the elastic zone?
   A. Fracture
   B. Ultimate strength
   C. Yield point
   D. Preloading
   E. Breaking point

95. What percentage of patients aged 65 years will have evidence of spondylosis of the spine on imaging?
   A. 10%
   B. 25%
   C. 50%
   D. 75%
   E. 95%

96. What is thought to be the mechanism of discogenic axial back pain?
   A. Facet hypertrophy and nerve root impingement
   B. Disc herniation
   C. Excitation of recurrent sinuvertebral nerve endings
   D. Loss of disk height
   E. Increased disk vascularity

97. Small nerve fibers that innervate the facet joint have been implicated in facetogenic back pain. Where are these fibers thought to arise from?
   A. Recurrent sinuvertebral nerve
   B. Anterior spinal nerve ramus
   C. Posterior spinal nerve ramus
   D. Gray ramus communicans
   E. White ramus communicans

98. According to the National Osteoporosis Foundation guidelines, how much calcium and vitamin D should a 60-year-old woman be taking daily?
   A. 400-mg calcium, 400-IU vitamin D
   B. 800-mg calcium, 800-IU vitamin D
   C. 1,200-mg calcium, 1,000-IU vitamin D
   D. 2,000-mg calcium, 2,000-IU vitamin D
   E. 3,000-mg calcium, 4,000-IU vitamin D

99. What effect does calcitonin have?
   Answer choices:
   A. Inhibits osteoblasts
   B. Inhibits osteoclasts
   C. Promotes osteoclasts
   D. Promotes osteoblasts
   E. Provides structural framework for bone formation

100. The medication raloxifene is used to prevent osteoporosis in postmenopausal women who cannot tolerate bisphosphonate therapy. It acts by inhibit osteoclasts. What side effect should patients on raloxifene be aware of?
    A. Increased risk of heart attack
    B. Increased risk of breast cancer
    C. Increased risk of DVT
    D. Increased risk of esophagitis
    E. Increased bleeding tendencies
101. You are caring for a patient with ankylosing spondylitis who is having significant back pain. There is no associated fracture or soft-tissue compressive pathology. You feel that his pain is due to his primary disease. What medication can be used to both treat his pain and modify the disease process?
A. Acetaminophen
B. NSAIDs
C. Oxycodone
D. Ketamine
E. Dexamethasone

102. Which of the following spinal tumors is associated with development of a spinal cord syrinx?
A. Hemangioblastoma
B. Meningioma
C. Schwannoma
D. Neurofibroma
E. Astrocytoma

103. What is the most common urodynamic finding in tethered cord syndrome?
A. Bladder dyssynergy
B. Decreased bladder compliance
C. Altered sensation
D. Detrusor hyperreflexia

104. What percentage of the dry weight of bone is comprised of inorganic material?
A. 30%
B. 50%
C. 65%
D. 80%
E. 95%

105. What is the primary compound that makes up inorganic bone?
A. Calcium phosphate
B. Calcium carbonate
C. Fluoride derivatives
D. Trace elements

106. What cell involved in bone metabolism and formation does parathyroid hormone act on?
A. Osteoclasts
B. Osteogenic progenitor cell
C. Osteoblasts
D. Osteocytes
E. Pericytes

107. Which of the main properties of bone fusion gives the bone graft the ability to form new bones?
A. Osteoconduction
B. Osteogenesis
C. Osteoinduction
D. Arthrodesis

108. Which process of bony fusion refers to presence of a solid matrix for new bone formation?
A. Osteoconduction
B. Osteogenesis
C. Osteoinduction
D. Arthrodesis

109. What process of bony fusion refers to the process where osteoblastic precursors differentiate into bone-forming cells?
A. Osteoconduction
B. Osteogenesis
C. Osteoinduction
D. Arthrodesis
110. You are asked to evaluate a patient in the ED who has suffered a severe leg injury after being involved in a motorcycle accident. The laceration is just above the knee in the posterior aspect of the leg. What nerve are you worried could be severed in this location?

Use the following figure to answer questions 110 and 111:

A.Sciatic
B. Superficial peroneal
C. Common peroneal
D. Femoral
E. Obturator

111. You have evaluated a patient in the ED with a severe leg laceration and foot drop. This occurred earlier today in a motorcycle accident. The image of the laceration is demonstrated. You are considering proceeding to the OR for washout of the wound and identification of the nerve injury. What should you obtain before going to the OR?

A. Infectious disease consult
B. Neurology consult
C. Vascular surgery consult
D. PMR consult
E. Social work consult

112. What is the most important factor when evaluating a neurologic deficit from a suspected traumatic nerve injury?

A. Smoking history
B. BMI
C. Presence of nerve continuity
D. Grade of motor deficit
E. Presence of fasciculations

113. You are evaluating a 33-year-old man who has suffered a gunshot wound to the right posterior aspect of his leg above the knee. He has a complete foot drop and no associated vascular injury. If ultrasound imaging demonstrates a nerve laceration, when should you plan to repair the severed nerve via a direct anastomosis or nerve graft?

A. Immediately
B. 3 days
C. 3 weeks
D. 3 months
E. 1 year

114. What is required to diagnose brain death?

A. Brain MRI
B. Head CT
C. Silent EEG
D. Perfusion studies
E. Detailed neurological examination

115. You are performing a brain death evaluation on a patient who suffered a severe intracranial injury. You are about to perform the apnea test. You have drawn a blood gas before starting, and now you have removed the ventilator support and observed for 10 minutes. There has been no sign of inspiration and you draw another blood gas. What level does the PaCO₂ need to be at to diagnose brain death?

A. PaCO₂ > 60 mm Hg (or 20 mm Hg greater than baseline)
B. PaCO₂ > 50 (or 25 mm Hg greater than baseline)
C. PaCO₂ > 50 (or 10 mm Hg greater than baseline)
D. PaCO₂ > 40 (or 10 mm Hg greater than baseline)
E. PaCO₂ > 40 (or 10 mm Hg greater than baseline)

116. Based on the Cochrane review performed on this subject, what effect do corticosteroids have on patients with meningitis?

A. Decreased mortality, worsened hearing
B. Decreased mortality, improved hearing
C. No change in mortality, improved hearing
D. No change in mortality, worsened hearing
E. Increased mortality, worsened hearing
117. What laboratory test can help to determine whether a patient has syndrome of inappropriate antidiuretic hormone secretion (SIADH) or cerebral salt wasting in the setting of hyponatremia?
A. Electrolyte panel
B. Albumin concentration
C. Erythrocyte sedimentation rate
D. Complete blood count
E. BNP level

118. You are working in the neuro-ICU and have admitted a patient with the following MRI scan who also has severe encephalopathy. What other conditions would this patient likely present with?

A. SIADH
B. Motor deficit
C. Seizures
D. Intraparenchymal hemorrhage
E. Aphasia

119. Neurogenic shock after spinal cord injury is thought to arise from what mechanism?
A. Nitric oxide release
B. Impaired corticospinal tract function
C. Blood loss
D. Unopposed vagal tone
E. Pain

120. How do you determine the difference between neurogenic and hemorrhagic shock?
A. SBP
B. Heart rate
C. Urine output
D. Blood cultures
E. Diastolic blood pressure

121. The STICH II trial aimed to determine the outcome of surgical resection for ICH (10–100 mL, < 1 cm from cortical surface, no IVH in patients with GCS motor score 5–6 and eye opening sore of > 2). There was a small survival benefit in patients that underwent surgery, but no improvement in morbidity. This trial was performed with early surgery in mind. Within what time frame (in this trial) did surgery have to take place?
A. < 24 hours
B. < 48 hours
C. < 72 hours
D. < 1 week
E. < 1 month

122. The Clot Lysis Evaluation of Accelerated Resolution of IVH (CLEAR IVH) trial in 2011 determined that introduction of rtPA through the EVD into the ventricular system in cases of IVH was safe and had a dose dependent response. Since that time, the CLEAR III trial has been published. What effect does intraventricular administration of rtPA have on patients with IVH?
A. More cases of good functional outcome
B. No change in good functional outcome
C. Fewer cases of good functional outcome
D. Decreased mortality, more cases of poor functional outcome
E. Decreased mortality, fewer cases of poor functional outcome
123. This EEG may be recorded in a patient on what medication?

A. Levetiracetam  
B. Pentobarbital  
C. Carbamazepine  
D. Lorazepam  
E. Ketamine

124. Which antihypertensive should not be used in a patient with severe hypertension and coexisting elevated ICP from TBI?

A. Labetalol  
B. Nicardipine  
C. Hydralazine  
D. Esmolol  
E. Diltiazem

125. After severe neurologic injury the basal metabolic rate increases in response to increased energy demand during the healing phase. What is the average increase resting energy expenditure thought to be?

A. ~ 5%  
B. ~ 10%  
C. ~ 20%  
D. ~ 30%  
E. ~ 50%

126. Nicardipine decreases blood pressure by what mechanism?

A. NitricBeta blockade  
B. Oxide release  
C. Calcium channel blockade  
D. Alpha blockade

127. True or false, nitroglycerin raises ICP?

A. True  
B. False

128. True or false, labetalol raises ICP?

A. True  
B. False

129. Of the following, what medication is the least efficacious in a patient with spinal cord injury?

A. Phenylephrine  
B. Norepinephrine  
C. Dobutamine  
D. Epinephrine

130. What receptor leads to increased cardiac output from inotropic effects when activated?

A. A1  
B. A2  
C. B1

131. Omeprazole can affect the blood levels of what medication?

A. Morphine  
B. Warfarin  
C. Levetiracetam  
D. Acetazolamide

132. True or false, Remifentanil increases ICP?

A. True  
B. False

133. What is the main brainstem nucleus that is affected by dexmedetomidine?

A. Raphe nucleus  
B. Locus coeruleus  
C. Nucleus accumbens  
D. Periaqueductal gray
134. What affected factor in the initial use of warfarin can lead to warfarin necrosis?
A. Factor III  
B. Factor VII  
C. Proteins C + S  
D. Factor IX

135. Giving 1 mg of protamine for every 1 mg of enoxaparin (Lovenox) will reverse approximately what percentage of the drug?
A. 0%  
B. 30%  
C. 60%  
D. 100%

136. What does hyperventilation do to cerebral blood flow?
A. Increases  
B. Decreases

137. By how much does the cerebral metabolic rate of oxygen drop for each corresponding drop in temperature?
A. 7%/1 degree  
B. 25%/1 degree  
C. 33%/1 degree  
D. 50%/1 degree

138. Which inhalational neuroanesthetic increases cerebral metabolism?
A. Isoflurane  
B. Desflurane  
C. Nitric oxide  
D. Sevoflurane

139. True or false, the inhalational anesthetic medications increase ICP?
A. True  
B. False

140. Inhalational anesthetic use for how long can lead to an increase in CSF production?
A. > 30 minutes  
B. > 1 hour  
C. > 2 hours  
D. > 5 hours

141. What inhalational anesthetic should be avoided in the sitting position?
A. Isoflurane  
B. Desflurane  
C. Nitric oxide  
D. Sevoflurane

142. Which of these anesthetic agents is considered a halogenated anesthetic?
A. Isoflurane  
B. Remifentanil  
C. Nitric oxide  
D. Propofol

143. How long should nitric oxide anesthetic be discontinued before dural closure?
A. 10 minutes  
B. 30 minutes  
C. 1 hour  
D. 2 hours

144. Which of these agents can cause an isoelectric EEG without inducing metabolic toxicity?
A. Isoflurane  
B. Desflurane  
C. Nitric oxide  
D. Sevoflurane

145. Which of these agents can lead to decreased cardiac output?
A. Isoflurane  
B. Desflurane  
C. Nitric oxide  
D. Sevoflurane
146. What change in hemodynamics will propofol cause?
   A. Hypertension
   B. Hypotension
   C. Tachycardia
   D. Bradycardia

147. What anesthetic agent can decrease the seizure threshold?
   A. Sodium thiopental
   B. Methohexital
   C. Etomidate
   D. Isoflurane

148. True or false, etomidate has anesthetic, amnestic, and analgesic effects?
   A. True
   B. False

149. In patients with what type of underlying disorder should etomidate be avoided?
   A. Congestive heart failure
   B. Intrinsic renal disease
   C. Seizure disorder
   D. Obstructive lung disease

150. By having an effect on what receptor does ketamine provide anesthesia?
   A. Sodium channel
   B. GABA receptor
   C. NMDA receptor
   D. Glutamate receptor

151. What is the difference between synthetic and non-synthetic narcotic medications?
   A. Seizure risk
   B. Tachyphylaxis
   C. Histamine release
   D. Nausea induction

152. What anesthetic medication given IV can suppress laryngeal reflexes during intubation?
   A. Propofol
   B. Etomidate
   C. Methohexital
   D. Lidocaine

153. True or false, succinylcholine is a depolarizing paralytic?
   A. True
   B. False

154. What is the classic symptom of malignant hyperthermia?
   A. Bradycardia
   B. Decreased end-tidal CO₂
   C. Muscle rigidity
   D. Seizure

155. What medication is used to treat malignant hyperthermia?
   A. Dantrolene
   B. Desmopressin
   C. Epinephrine
   D. Beta blocker

156. The tendency of the cardiac ventricular wall to distend or stretch at any given ventricular volume is considered what?
   A. Elastance
   B. Compliance
   C. Rigidity
   D. Stability

157. After cardiac ventricular hypertrophy, there is a decrease in change of diastolic volume relative to diastolic pressure. This process is depicted by what statement?
   A. Increased compliance
   B. Decreased compliance
   C. Increase elastance

158. What is the sum of forces that oppose cardiac ventricular emptying?
   A. Preload
   B. Contractility
   C. Afterload
   D. Compliance
Questions

159. According to Poiseuille's law, vascular flow varies according to the radius of the vessel to what power?
   A. Second
   B. Fourth
   C. Sixth
   D. Eighth

160. When considering blood flow through the proximal internal carotid artery (average radius of 4 mm) and distal MCA (average radius of 2 mm), how much more blood flow would you expect in the ICA compared to the MCA?
   A. 2 times
   B. 4 times
   C. 8 times
   D. 16 times

161. True or false, a 50% reduction in hemoglobin will have a bigger impact on arterial oxygen content than a 50% reduction in PaO₂?
   A. True
   B. False

162. True or false, the primary cause of stress ulcers of the gastric mucosa is gastric acidity?
   A. True
   B. False

163. Clinically silent gastric erosions are present in what proportion of patients by the third day of ICU admission?
   A. 0%
   B. 30%
   C. 60%
   D. 90%

164. What pressure measurement is the true driving pressure for peripheral blood flow?
   A. Systolic pressure
   B. Mean arterial pressure
   C. Diastolic pressure
   D. Venous pressure

165. By what formula is mean arterial pressure calculated?
   A. Systolic pressure + one-third of pulse pressure
   B. Systolic pressure + two-thirds of diastolic pressure
   C. Diastolic pressure + one-third of pulse pressure
   D. Diastolic pressure + two-thirds of systolic pressure

166. Approximately what percentage of total body fluid is located in the intravascular compartment?
   A. 10%
   B. 25%
   C. 33%
   D. 50%

167. What is the approximate blood volume in an average 80-kg male?
   A. 4 L
   B. 5 L
   C. 6 L
   D. 7 L

168. After approximately how much blood loss would you expect resting tachycardia in an average 80-kg man?
   A. 150 mL
   B. 750 mL
   C. 15 L
   D. 3 L

169. What is often the first clinical symptom of hypovolemia?
   A. Hypotension
   B. Resting tachycardia
   C. Pre-syncope
   D. Delayed capillary refill

170. Approximately what percentage of crystalloid given through a peripheral IV will remain in the intravascular space?
   A. 0%
   B. 20%
   C. 40%
   D. 60%
171. Approximately what percentage of colloid given through a peripheral IV will remain in the intravascular space?
A. 20%
B. 40%
C. 60%
D. 80%

172. What is the sodium mEq in 0.9% NaCl?
A. 130
B. 140
C. 154
D. 161

173. What is the sodium concentration in lactated Ringer's solution?
A. 130
B. 140
C. 154
D. 161

174. True or false, 25% albumin should be used for fluid resuscitation in hypovolemia?
A. True
B. False

175. True or false, there is a measurable risk of viral transmission when using albumin?
A. True
B. False

176. True or false, there is a higher survival rate in patients who receive fluid resuscitation with colloid compared to crystalloid solutions?
A. True
B. False

177. What medication carries the risk of acute cyanide toxicity?
A. Nitroglycerin
B. Nitroprusside
C. Labetalol
D. Esmolol

178. What is the most common cause of postoperative atrial fibrillation?
A. Hypovolemia
B. Electrolyte abnormalities
C. Coronary ischemia
D. Hypervolemia

179. What heart rate in atrial fibrillation is an indication for electrical cardioversion?
A. > 90 BPM
B. > 110 BPM
C. > 130 BPM
D. > 150 BPM

180. True or false, severe atelectasis will lead to accumulation of dead space within the lung?
A. True
B. False

181. What PaCO₂ level is diagnostic of hypercapnia?
A. > 20 mm Hg
B. > 32 mm Hg
C. > 46 mm Hg
D. > 65 mm Hg

182. Which of the following is not a source of hypercapnia?
A. Increased pulmonary shunting
B. Increased dead space ventilation
C. Hypoventilation
D. Increased CO₂ production

183. True or false, acute respiratory distress syndrome is an accumulation of watery edema fluid in the lungs?
A. True
B. False

184. What tidal volume range is currently used in mechanical ventilation to decrease lung barotrauma?
A. 1 to 3 mL/kg
B. 4 to 6 mL/kg
C. 7 to 10 mL/kg
D. 11 to 15 mL/kg
185. During mechanical ventilation, FiO₂ should be maintained below 50% to decrease oxygen toxicity. If the FiO₂ cannot be reduced below 60%, what ventilator function can be increased to compensate?
   A. Tidal volume
   B. Positive end-expiratory pressure
   C. Peak inspiratory pressure
   D. Respiratory rate

186. True or false, positive pressure ventilation can reduce preload?
   A. True
   B. False

187. True or false, in mechanical ventilation, large inflation volumes should be used to keep the alveoli open?
   A. True
   B. False

188. The end-inspiratory peak pressure is calculated by all of the following, except what?
   A. Inflation volume
   B. Flow resistance
   C. Elastic recoil of the lung
   D. Respiratory rate

189. True or false, on assist/control mode of mechanical ventilation, the patient receives set inflation volumes?
   A. True
   B. False

190. True or false, on assist/control mode of mechanical ventilation, the patient can trigger breaths?
   A. True
   B. False

191. What patient could be harmed by assist/control mechanical ventilation?
   A. A patient taking low tidal volumes
   B. A patient breathing rapidly
   C. A patient taking high tidal volumes
   D. A patient breathing slowly

192. What mode of mechanical ventilation is often used to wean patients from the ventilator?
   A. Assist/control
   B. Intermittent mandatory ventilation
   C. Pressure support
   D. Volume-controlled ventilation

193. Positive end-expiratory pressure is used to prevent what from happening?
   A. Distal airway collapse
   B. Restriction
   C. Obstruction
   D. Proximal airway collapse

194. Which noninvasive ventilation strategy is useful for patients with hypoxia?
   A. Continuous positive airway pressure
   B. Bilevel positive airway pressure

195. Which noninvasive ventilation strategy is useful for patients with hypercapnia?
   A. Continuous positive airway pressure
   B. Bilevel positive airway pressure

196. Stridorous breathing immediately after extubation noted during what phase of the respiratory cycle should prompt consideration for immediate reintubation?
   A. Inspiration
   B. Expiration

197. What should be the first step during severe upper airway obstruction following extubation?
   A. Reintubation
   B. 6-mg IV dexamethasone
   C. Racemic epinephrine
   D. Tracheostomy

198. True or false, the severity of febrile response is a predictor for severity of infection?
   A. True
   B. False
199. True or false, there is an association between postoperative atelectasis and postoperative fever?
   A. True
   B. False

200. True or false, steroids should be given in severe septic shock?
   A. True
   B. False

201. What is the most common isolate in nosocomial, ventilator-associated pneumonia?
   A. Streptococcus pneumoniae
   B. Pseudomonas sp.
   C. Escherichia coli.
   D. Klebsiella sp.

202. What risk of transmission does a needle stick injury containing blood from a patient infected with human immunodeficiency virus (HIV) carry?
   A. 0.025%
   B. 0.25%
   C. 2.5%
   D. 25%

203. What risk of transmission does a mucous membrane exposure to blood from a patient infected with HIV carry?
   A. 0.09%
   B. 0.9%
   C. 9%
   D. 90%

204. What is the major complication of antifungal therapy with amphotericin?
   A. Seizures
   B. Gastric ulceration
   C. Nephrotoxicity
   D. Cardiomyopathy

205. What is the major complication of antibiotic therapy with imipenem?
   A. Seizures
   B. Gastric ulceration
   C. Nephrotoxicity
   D. Cardiomyopathy

206. What is the overall survival rate in patients that require cardiopulmonary resuscitation?
   A. 10%
   B. 30%
   C. 50%
   D. 70%
   E. 90%

207. If a subject satisfies the null hypothesis and the test accepts the null hypothesis, what have you demonstrated?
   A. True positive
   B. True negative
   C. False positive
   D. False negative

208. If a subject does not satisfy the null hypothesis but the test accepts the null hypothesis, what have you demonstrated?
   A. True positive
   B. True negative
   C. False positive
   D. False negative

209. Regarding sensitivity, which of the following is true?
   A. Sensitivity = TP / (TP + FN)
   B. Sensitivity = 1 − type I error
   C. Sensitivity = TN / (TN + FP)
   D. Sensitivity = FP / (FP + TN)

210. Regarding specificity, which of the following is true?
   A. Specificity = TP / (TP + FN)
   B. Specificity = 1 − type I error
   C. Specificity = TN / (TN + FP)
   D. Specificity = FP / (FP + TN)

211. Regarding positive predictive value, which of the following is true?
   A. PPV = TP / (TP + FN)
   B. PPV = 1 − type I error
   C. PPV = TP / (TP + FP)
   D. PPV = FP / (FP + TN)
Questions

212. Regarding negative predictive value, which of the following is true?
A. \( NPV = \frac{TP}{TP + FN} \)
B. \( NPV = 1 - \text{type I error} \)
C. \( NPV = \frac{TP}{TP + FP} \)
D. \( NPV = \frac{TN}{TN + FN} \)

213. Regarding type I error, which of the following is true?
A. \( \text{Type I error} = \frac{TP}{TP + FN} \)
B. \( \text{Type I error} = 1 - \text{sensitivity} \)
C. \( \text{Type I error} = \frac{FP}{FP + TN} \)
D. \( \text{Type I error} = \frac{TN}{TN + FN} \)

214. Regarding type II error, which of the following is true?
A. \( \text{Type II error} = \frac{TP}{TP + FN} \)
B. \( \text{Type II error} = 1 - \text{sensitivity} \)
C. \( \text{Type II error} = \frac{FP}{FP + TN} \)
D. \( \text{Type II error} = \frac{TN}{TN + FN} \)

215. How do you calculate number needed to treat?
A. \( NNT = \frac{1}{\text{absolute risk reduction}} \)
B. \( NNT = \frac{1}{\text{relative risk reduction}} \)
C. \( NNT = \frac{TP}{TP + FN} \)
D. \( NNT = \frac{TN}{TN + FP} \)

216. How is statistical power calculated?
A. \( \text{Power} = 1 - \text{type I error} \)
B. \( \text{Power} = 1 - \text{type II error} \)
C. \( \text{Power} = \frac{TP}{TP + FN} \)
D. \( \text{Power} = \frac{TN}{TN + FP} \)

217. According to Emergency Medical Treatment and Active Labor Act (EMTALA), what must a hospital do before transferring an uninsured patient to a public hospital?
A. Provide a social work consultation
B. Perform a medical examination
C. Obtain appropriate imaging
D. Perform a face-to-face handoff to the receiving physician

218. You are the on-call neurosurgeon at a local hospital and you receive a phone call from a local ED about a patient with a subdural hematoma with altered mental status. They do not have neurosurgical coverage. True or false, you are required by law to accept this transfer?
A. True
B. False

219. You are the on-call neurosurgeon at a hospital in Minnesota and you receive a phone call from an ED in Florida about a patient with a subdural hematoma with altered mental status. They do not have neurosurgical coverage and would like to transfer the patient to your tertiary care facility. True or false, you are required by law (EMTALA) to accept this transfer?
A. True
B. False

220. True or false, according to EMTALA, in the setting of an unstable patient, a physician must certify that the expected medical benefits of transfer must outweigh the risks of transfer itself?
A. True
B. False

221. True or false, the Good Samaritan law ensures that you have no liability when providing emergency care?
A. True
B. False

222. True or false, you are covered by the Good Samaritan law while on hospital property?
A. True
B. False
223. You exhibit a car accident in front of you and a patient is thrown from the vehicle. You get out of your car and evaluate the patient. There are obvious signs of respiratory distress and you are concerned about an upper obstruction requiring emergency tracheostomy. The patient is unconscious. True or false, you need to find someone to consent prior to performing this procedure?
A. True  
B. False

224. True or false, you are able to refer a patient of yours to a facility in which you have financial interest, be it ownership, investment or structured compensation arrangement?
A. True  
B. False

225. True or false, as a local neurosurgeon you are allowed to take a local primary care physician on an annual fishing trip to promote referrals into your spine center?
A. True  
B. False

226. True or false, you are able to communicate with members of your care team via text message regarding patient information?
A. True  
B. False
II Answers
1. **Subdural hematoma**
   This CT scan demonstrates an acute subdural hematoma, as evident by the hyperdense blood collection crossing the suture lines. A significant midline shift is associated. Blood remains hyperdense on CT scan for 1 to 3 days.

2. **1 to 3 days**
   This CT scan demonstrates an acute subdural hematoma, as evident by the hyperdense blood collection crossing the suture lines. A significant midline shift is associated. Blood remains hyperdense on CT scan for 1 to 3 days.

3. **Check INR**
   This CT scan demonstrates an acute subdural hematoma, as evident by the hyperdense blood collection crossing the suture lines. This patient has a history of a mechanical aortic valve and is likely on chronic anticoagulation. Before you choose to intervene you should know the coagulation status of the patient and reverse if necessary.

4. **Decompressive hemicraniotomy/ectomy**
   This CT scan demonstrates an acute subdural hematoma, as evident by the hyperdense blood collection crossing the suture lines. This patient will require surgery and due to the acute nature of this clot, the patient will likely not be adequately drained with burr holes. A decompressive hemicraniotomy/ectomy is recommended.

5. **Decompressive hemicraniotomy/ectomy**
   This CT scan demonstrates an acute subdural hematoma, as evident by the hyperdense blood collection crossing the suture lines. According to practice guidelines in the management of acute subdural hematoma, any time the acute hematoma is > 10 mm in maximum diameter or there is > 5 mm of associated midline shift, evacuation should be performed regardless of presenting GCS.

6. **Epidural hematoma**
   This CT scan demonstrates evidence of an acute epidural hematoma, as evident by the hyperdense fluid collection that does not cross the suture lines.

7. **Foramen spinosum**
   This CT scan demonstrates evidence of an acute epidural hematoma, as evident by the hyperdense fluid collection that does not cross the suture lines. It is often caused by damage to the middle meningeal artery, which enters the skull through the foramen spinosum.

8. **Operative evacuation**
   This CT scan demonstrates evidence of an acute epidural hematoma, as evident by the hyperdense fluid collection that does not cross the suture lines. This is a large EDH and should be evacuated emergently if possible via open surgery.

9. **Observation/rescan**
   This CT scan demonstrates evidence of an acute epidural hematoma, as evident by the hyperdense fluid collection that does not cross the suture lines. This is a small epidural hematoma (< 15 mm) with less than 30 cm³ of total volume in an awake patient with an exam to follow. This patient can be observed with an early rescan to demonstrate stability in the size of the epidural hematoma. If there is significant expansion or worsening of the exam, the patient should undergo operative evacuation.
10. **D Intubate**

   This CT scan demonstrates evidence of an acute epidural hematoma, as evident by the hyperdense fluid collection that does not cross the suture lines. This patient had a lucid interval and has now deteriorated. Ultimately he will need operative evacuation emergently, but securing his airway should be the first priority.


11. **B Rescan in 6 hours**

   This patient has bifrontal contusions likely from deceleration injury to the brain parenchyma. At this point she has an exam that can be followed, but a rescan should happen after at least several hours to look for expansion of the intraparenchymal hemorrhages. They can expand in a delayed fashion and become symptomatic. A rescan should occur earlier if she deteriorates clinically.


12. **D > 3 weeks**

   This MRI scan demonstrates a chronic subdural hematoma. It is uniform and has a fluid appearance. This likely has been present for > 3 weeks.


13. **B Burr hole evacuation**

   This CT scan demonstrates a chronic subdural hematoma. It is uniform and dark in appearance. This likely has been present for > 3 weeks, and very likely can be completely drained via burr hole evacuation. It will likely not require a full craniotomy.


14. **B 15%**

   Approximately 15% of patients who undergo subdural fluid evacuation have a residual fluid collection at 40 days. Often times these residual collections do not require repeat surgery and can be managed with observation and serial CT examinations.


15. **C Biventricular trajectory**

   Dating back to initial research done by Harvey Cushing and further studied recently, it has been demonstrated that biventricular trajectory through the third ventricle is uniformly fatal in the civilian literature. Bifrontal, holohemispheric, and isolated cerebellar trajectories have not been found to be uniformly fatal.


16. **C Tension pneumocephalus**

   This CT scan demonstrates tension pneumocephalus, the classic “Mount Fuji” sign. This is not a fluid collection given how dark the findings are on CT scan and can only be air.


17. **A Decompression**

   This CT scan demonstrates tension pneumocephalus, the classic “Mount Fuji” sign. This patient is symptomatic from this air collection and while the CSF leak certainly needs to be repaired, the patient should have some form of decompression of the pressurized gas within the skull, followed shortly thereafter by repair of the CSF leak.


18. **B No**

   This player has evidence of a concussion, including disorientation and amnesia to the event. Based on current concussion guidelines, this player should be removed from the game and not allowed to return until evaluated further by a licensed healthcare provider trained in evaluating concussions.


19. **C 10 to 15**

   Normal ICP range for adults and older children is 10 to 15 mm Hg. Young children generally range
from 3 to 7 mm Hg, and infants range from 1.5 to 6 mm Hg.


20.  
C CPP = MAP – ICP
Cerebral perfusion pressure is calculated by subtracting the intracranial pressure from the mean arterial pressure. Based on autoregulation, the brain can maintain normal cerebral blood flow at a wide range of CPP, generally between 50 and 150 mm Hg.


21.  
C Operative elevation/debridement
This patient has evidence of a depressed skull fracture with an underlying hematoma. Given the concerning underlying hematoma and depth of the depressed skull fracture segment, this fracture should be elevated and the hematoma should be addressed surgically.


22.  
A Longitudinal
There are two types of temporal bone fractures, longitudinal and transverse. Longitudinal fractures are parallel to the EAC and are the most common type of temporal bone fractures. The longitudinal fracture does not tend to put stretch forces on the geniculate ganglion and therefore is less likely to lead to VII nerve injury.


23.  
B Transverse
There are two types of temporal bone fractures, longitudinal and transverse. Transverse fractures are perpendicular to the EAC and are the less common type of temporal bone fractures (20–30%). The transverse fracture tends to pass through the cochlea and can put stretch forces on the geniculate ganglion leading to VII nerve injury.


24.  
C Start steroids
With a transverse temporal bone fracture, VII nerve injury can occur. While efficacy is currently unproven, many surgeons will start glucocorticoids in the presence of facial nerve dysfunction in the setting of a transverse temporal bone fracture. ENT consultation should be considered as decompression may be required if facial nerve function does not improve.


25.  
B NG tube insertion
Clival fractures are severe injuries that are often fatal. They can be associated with cranial nerve deficits, diabetes insipidus, and anterior/posterior circulation vascular injury. NG tube insertion should be avoided as there have been reports of intracranial NG tube insertion through a diastased fracture of the clivus.


26.  
C Type III
There are three types of Lefort facial fractures, and of these, type III involves the zygomatic arches, the nasofrontal suture, and orbital floors. Given the type of fracture and the forces required, there is a high incidence of brain injury with type III Lefort fractures.


27.  
B Observation
In a neurologically normal infant, this fracture should be managed nonoperatively. This is the classic “ping-pong” fracture, and over time the CSF pulsations will remodel the bone and heal this fracture. Operative intervention is generally not required.


33. A Continued medical management
   According to the initial results of the DECRA trial, decompressive hemicraniectomy in the setting of elevated ICP in patients < 60 years of age within 72 hours of injury refractory to first line medical management was associated with a higher rate of unfavorable outcome than the control group who did not undergo surgery. In a subgroup analysis, there was no difference when patients who had bilaterally unreactive pupils were controlled for (initial analysis had significantly higher rate of bilaterally unreactive pupils in the surgical arm). While some providers would perform a decompression, strictly according to the results of the DECRA trial, this will lead to unfavorable outcomes. Further surgical trials are underway, and results depend on the definition of favorable outcome.

34. C Drilling to the floor of the middle fossa
   It is important to ensure that a decompressive craniectomy is large enough to not only decompress the cerebral hemisphere, but to also avoid complications that have been shown to occur when the AP diameter of the craniectomy is < 12 cm. Subsequent herniation of the brain can, through the craniectomy defect, lead to vascular injury and further infarction of the brain. When uncal herniation is suspected, making sure the craniectomy reaches the floor of the middle fossa is important to fully decompress the temporal lobe.

35. A Hypotension
   Cushing’s triad is seen often during terminal elevation of ICP immediately before herniation. It consists of bradycardia, hypertension, and breathing irregularities. If these findings are seen together in a patient with elevated ICP, action should be taken immediately to decrease ICP as the patient is likely about to herniate.
36. 
B 30 minutes

CO₂ is a potent vasodilator and hyperventilation can be used to decrease intracranial pressure by decreasing CO₂. The brain is able to buffer efficiently, and therefore this technique may only transiently decrease ICP as the brain will adjust to new levels of CO₂ within 20 to 30 minutes.


37. 
D 31 to 35 mm Hg

CO₂ is a potent vasodilator and hyperventilation can be used to decrease intracranial pressure by decreasing CO₂. The brain is able to buffer efficiently, and therefore this technique may only transiently decrease ICP as the brain will adjust to new levels of CO₂ within 20 to 30 minutes. You are aiming for a PaCO₂ of 31 to 35 mm Hg.


38. 
D 324

Mannitol is a very effective osmotic diuretic that is often used to decrease intracranial pressure. When utilized in a scheduled fashion, monitoring of serum osmolality should take place. When serum osmolality is greater than 320, other options should be considered for medical treatment of raised ICP.


39. 
B 11 cm back from the nasion, mid-pupillary line

Kocher’s point is thought to be located generally between 10.5 and 11.5 cm back from the nasion and roughly 3 to 3.5 cm lateral, or in the mid-pupillary line. Generally speaking this is a good location to place a burr hole for an EVD placement for acute hydrocephalus. In many situations, simply placing the EVD perpendicular to the skull will lead to ventricular puncture, depending on ventricular size.


40. 
B 3%

Hypertonic saline can be used for ICP management either as a first line agent or in patient’s refractory to mannitol administration. The patient can be given 3% saline as a continuous infusion through a peripheral IV, but 7% and 23.4% given as a bolus should be administered through a central line to avoid deleterious effects to the extremities.


41. 
B 150 mL

The approximate volume of CSF in the system is 150 mL at any given time. Roughly 450 to 500 mL of CSF is produced each day, and the CSF turns over 3 times daily.


42. 
B 10

This patient has a GCS of 10. E = 2, V = 3, M = 5.


43. 
A 4t

This patient has a GCS of 4t. E = 1, V = 1t, M = 2. This patient is decerebrate posturing (M = 2), is not opening his eyes (E = 1), and is intubated (V = 1t).


44. 
C 13.6 cm H₂O

There is a lack of convention among neurosurgeons as to what system should be utilized, mm Hg or cm H₂O. 1 mm Hg = 1.36 cm H₂O, meaning that 10 mm Hg = 13.6 cm H₂O.

45. **A** 
Lundberg A waves

There are three types of Lundberg waves seen during ICP monitoring: A, B, and C. Lundberg A (plateau waves) are associated with extremely high elevation of ICP that plateaus for 5 to 20 minutes and then decreases to ~20 mm Hg for 30 to 45 minutes followed by another elevation. MAP increases can be seen as well. These waves are not often seen in the ICU setting as active ICP management is taking place.


46. **B**
P2

The second ICP wave, P2, represents the pressure when the aortic pulse bounces off the ventricular wall (P1 is the aortic pulse itself). When the ventricular walls are stiffened due to hydrocephalus and lack compliance, the P2 wave will be greatly increased and will lead to the classic ICP waveform that is indicative of elevated ICP.


47. **B**

Cerebral perfusion pressure is calculated by subtracting ICP from the mean arterial pressure. The brain can autoregulate CPP to maintain stable cerebral blood flow at 55 to 60 mL/100 mg/min. This autoregulation curve in a normal brain keeps flow stable between CPPs of 50 and 150.


48. **B**

Cerebral perfusion pressure is calculated by subtracting ICP from the mean arterial pressure. The brain can autoregulate CPP to maintain stable cerebral blood flow at 55 to 60 mL/100 mg/min. This autoregulation curve in a normal brain keeps flow stable between CPPs of 50 and 150. It is thought during severe TBI that autoregulation fails and that CBF matches CPP much more closely. In this setting, an MAP of 85 with an ICP of 25 will give you a CPP of 60, exactly matching the standard CBF of the brain in normal conditions.


49. **B**

This patient has a GCS of 3. E = 1, V = 1, M = 1. GCS of 0 is not possible. You get 3 points just for showing up.


50. **D** Pentobarbital

Pentobarbital is a last resort medical management strategy for reducing raised ICP. It provides maximal reduction in CMRO₂ and CBF when compared to other agents, but should be used as a last resort. It should be titrated to burst suppression on EEG. It can cause severe hypotension and paralytic ileus. It also stores within fat deposits so dosing should be adjusted. It can confound any attempts at brain death examination until it has been completely metabolized from the system, which can take days.


51. **C** Awake language mapping

This imaging demonstrates a left frontal likely low grade astrocytoma of the frontal region. This should concern you for potential involvement of Broca’s area, and may make you consider performing the procedure awake with language mapping.


52. **C** Functional MRI

This MRI demonstrates a left frontal likely low grade astrocytoma frontal region. This should concern you for potential involvement of Broca’s area, and you could consider performing an fMRI to localize language structures prior to surgical decision making.


53. **A** Motor mapping

This MRI demonstrates a likely anaplastic astrocytoma of the posterior frontal lobe on the right. There is concern that this tumor involves the
motor strip and thus intraoperative motor mapping could be useful during this resection.

54.
C  Phase reversal
    When motor mapping for tumor resection near the motor strip, you are looking for phase reversal of the signal on monitoring. This shows the change from the sensory cortex to the motor cortex.

55.
D  5
    These intraoperative recordings demonstrate phase reversal between electrodes 3 and 5. This means that in this scenario the motor strip is likely located under electrode 5. Electrode 4 is very likely located directly over the central sulcus, given the lack of response.

56.
B  Metastases
    Metastases are the most common tumor of the central nervous system, and account for just over 50% of intracranial tumors.

57.
B  Lung
    Overall, lung cancer has the highest incidence of brain metastases based on autopsy data currently available.

58.
D  Breast
    Breast cancer metastases are the most common metastatic tumor to the brain in females.

59.
B  CT chest, abdomen, and pelvis
    This MRI demonstrates evidence of metastatic disease. In a patient with no prior history of primary cancer, workup should proceed with a CT CAP to look for primary disease.

60.
B  Renal cell carcinoma
    Renal cell carcinoma has a higher propensity for hemorrhagic conversion of a cerebral metastatic lesion.

61.
A  Multiple myeloma
    Of the tumor types listed here, multiple myeloma is radiosensitive. The other lesions are highly resistant.

62.
D  Renal cell carcinoma
    Of the tumor types listed here, renal cell carcinoma is highly resistant to radiation. The other lesions are considered radiosensitive to varying degrees.

63.
A  70
    KPS is used to determine patient function in follow-up for many tumor resections. A KPS of 70 or greater means the patient is able to at least care for himself or herself without assistance.
64. A Surgical resection
   In patients with a single brain met (of any type) with a KPS > 70 and no evidence of extra cranial disease, surgery plus radiation increased median survival by 25 weeks. Surgical resection should be offered in this case in order to obtain tissue diagnosis if no primary can be found.

65. B Leptomeninges
   Melanocytes are found in the leptomeninges and are thought to be the probable origination point for primary CNS melanoma.

66. B 33%
   Nearly 33% of patients with incidentally discovered meningiomas will exhibit no growth over a 3-year follow-up period. Many of these patients can simply be observed depending on symptomatology.

67. B Arachnoid cap cells
   Meningiomas arise from arachnoid cap cells of the CNS. They can arise from wherever these arachnoid cap cells are found, including between the brain and skull, ventricles, and surrounding the spinal cord.

68. A ~ 1 to 3%
   Meningiomas are thought to have roughly 1 to 3% incidence in the general population > 60 years of age based on autopsy studies.

69. B Parasagittal
   Parasagittal meningiomas are thought to be the most common location, followed by convexity meningiomas, based on a series of 336 cases.

70. C Olfactory groove meningioma
   Foster-Kennedy syndrome (anosmia, ipsilateral optic atrophy, and contralateral papilledema) was classically described in the setting of an olfactory groove meningioma.

71. D Fibrillar
   Fibrillary astrocytoma is the most common subtype of WHO grade II astrocytoma.

72. D Surgical resection
   Surgical resection is considered the principal treatment for low-grade gliomas to both establish the diagnosis and for cytoreduction. More aggressive surgical excision has been shown to be associated with better outcome and further time to malignant transformation. XRT and chemotherapy may follow later in the disease course.

73. C 5-year increase in progression-free survival
   In subtotally resected low-grade gliomas, 54 Gy XRT has been associated with an increased PFS from 3.4 to 5.3 years and is recommended as an early adjuvant treatment.

74. A No difference in progression-free survival
   In gross totally resected low-grade gliomas, 54 Gy XRT has been associated with no increase in PFS and should be deferred until progression occurs.

75. E > 97% 
   Extent of resection matters when undergoing attempted gross total resection of a GBM. Extent of resection > 97% has been shown to be associated with prolonged overall survival.

76. D 60 Gy XRT + temozolomide chemotherapy
   The Stupp regimen of chemoradiation for GBM consists of 60 Gy XRT in fractions along with concurrent TMZ and adjuvant chemotherapy. PCV chemotherapy was attempted, but showed no benefit in an RCT prior to publication of the Stupp regimen.

77. B 14.6 months
   The Stupp regimen of chemoradiation for GBM consists of 60 Gy XRT in fractions along with concurrent TMZ and adjuvant chemotherapy. In the classic article, median survival increased from 12.1 months to 14.6 months.

78. B 10.8 months
   The Stupp regimen of chemoradiation for GBM consists of 60 Gy XRT in fractions along with concurrent TMZ and adjuvant chemotherapy. In the classic article, median survival increased from 12.1 months to 14.6 months. When a subgroup of patients with MGMT promoter methylation was studied, it was found that these patients had a median survival of 23.4 months compared to 12.6 in non-MGMT methylated patients, leading to a median overall survival benefit of 10.8 months.

79. B Myelosuppression
   The main side effect of TMZ chemotherapy is myelosuppression, and it is an otherwise well tolerated chemotherapeutic. Patients undergo routine neutrophil testing and should have a neutrophil count of > 1.5 × 10^9/L and a platelet count > 100.

80. C Pseudoprogression
   In MGMT promoter methylated GBM patients, contrast enhancement can be seen at roughly 3 months post gross total resection and Stupp regimen. It is consistent with pseudoprogression and often decreases on subsequent imaging and symptoms can resolve with steroids. It is associated with radiation kill of the tumor. At this time there are no definitive imaging studies that can prove pseudoprogression vs tumor recurrence, but this is an active area of research.

81. D Myelosuppression
   Bevacizumab is a monoclonal antibody against VEGF and is FDA approved for the treatment of recurrent GBM. Its side effect profile consists of hypertension, arterial thromboembolism, hemorrhage, GI perforations, wound healing complications, and fistula formation.

82. A 1 to 20 years
   Pilocytic astrocytoma is a WHO grade I tumor with a predilection for younger patients. Approximately 75% of these tumors present in patients less than 20 years of age.

83. A Observation
   Pilocytic astrocytomas in the pediatric population that are incompletely resected should be initially observed as the rate of growth over 5, 10, or even 20 years can be minimal. Radiation and chemotherapy should be saved for obvious recurrence with growth demonstrated on serial imaging studies.
84. D Patients age at diagnosis + 9 months
Collins’ law suggests that pediatric patients with pilocytic astrocytomas can be considered cured if there is no recurrence after enough time has passed adding the patient’s age at time of diagnosis + 9 months. It is controversial, but often quoted.

89. C Facial weakness
Ependymomas often present in the fourth ventricle, originating from the floor of the fourth ventricle. Given their invasiveness, they may involve the facial colliculus which is located in the floor of the fourth ventricle, making facial weakness a likely cranial nerve deficit. Lateral rectus palsy (CN VI involvement) can be seen as well.

90. C MRI spinal axis
Ependymomas often present in the fourth ventricle, originating from the floor of the fourth ventricle. They can cause drop metastases within the spinal canal, and thus MRI imaging of the entire neuraxis should be performed prior to intervention.

91. C XRT alone
Ependymomas often present in the fourth ventricle, originating from the floor of the fourth ventricle. They tend to be radiosensitive and have not been shown to benefit from added chemotherapy. Traditional XRT therapy included 45 to 48 Gy to the tumor bed with 15 to 20 Gy reserved for recurrence. With the development of 3D conformal XRT, doses of 59.4 Gy to the tumor bed have been given. Prophylactic spinal XRT is usually given only if there is evidence of drop metastases on imaging.

92. B Central neurocytoma
Central neurocytomas are WHO grade II neuronal tumors often found attached to the septum pellucidum in the frontal horn of the lateral ventricles.
hypothalamic hamartomas or hypothalamic gliomas with a mass in the third ventricle.

94.  
D Observation  
DNETs are often seen in the temporal lobe and appear to have nodular enhancement on MRI. They are WHO grade I tumors and are associated with medically intractable epilepsy. After gross total resection, observation is recommended as XRT and chemotherapy have not shown any benefit in these benign tumors.

95.  
A Cardiac arrhythmia  
Paraganglioma (glomus tumors) can secrete epinephrine and norepinephrine based on histologic subtype, and therefore aggressive manipulation can lead to release of these catecholamines and hypertension/cardiac arrhythmias may occur.

96.  
D Carotid body tumor  
Carotid body tumor is the most common paraganglioma of the ones listed here. Overall, pheochromocytoma is the most common paraganglioma.

97.  
A Sympathetic ganglion  
Neuroblastomas are aggressive tumors that arise from the sympathetic ganglion. They often present in the adrenal gland (40%), but can present anywhere along the sympathetic chain and in certain presentations can cause a Horner’s syndrome.

98.  
B Choriocarcinoma  
CSF markers are important for pineal region tumors. In this case there is an isolated elevation of B-HCG which leads to the diagnosis of choriocarcinoma.

99.  
A Germinoma  
CSF markers are important for pineal region tumors. In this case there is elevation of both B-HCG and placental alkaline phosphatase (PLAP), which is suggestive of germinoma. While PLAP is often positive in germinomas, B-HCG has been shown to be positive in 10 to 50% of cases based on the microarchitecture of the tumor and whether or not syncytiotrophoblasts are present.

100.  
D Mature teratoma  
CSF markers are important for pineal region tumors. In this case, the markers are all negative, and this can be the case with a mixed germ cell tumor or a mature teratoma.

101.  
C Embryonal carcinoma  
CSF markers are important for pineal region tumors. In this case, AFP is elevated while the other markers are negative. This is suggestive of embryonal carcinoma, yolk sac carcinoma, or immature teratoma.

102.  
B Facial numbness  
Patients with vestibular schwannomas are actually more likely to present with facial numbness than weakness. Often times the facial nerve is distorted by the tumor but no weakness is present. However, with fairly minor compression of the trigeminal nerve, facial numbness can occur. This is likely due to resiliency of motor nerves compared to sensory nerves.
103. D Hearing loss
   Unilateral hearing loss is overall the most common presentation of vestibular schwannomas.

104. C Observation
   In patients with a vestibular schwannoma < 15 mm in size with intact hearing, observation with serial scans every 6 months should be the initial next step. If/when tumor growth is documented > 2 mm, treatment is recommended.

105. A Anterior
   The facial nerve is displaced anteriorly in up to 75% of cases, but can also be seen superiorly displaced. It can be completely thinned out over the surface of the tumor, so monitoring is recommended.

106. A 20%
   Hemangioblastomas can be associated with VHL, but can also occur sporadically. They seem to be associated with VHL approximately 20% of the time.

107. C Paraganglioma
   VHL is a disease associated with abnormalities on chromosome 3. It is associated with multiple tumor types including hemangioblastomas, retinal hemangioblastomas, pheochromocytomas, renal cell carcinoma, cystadenomas, pancreatic neuroendocrine tumors, and endolymphatic sac tumors.

108. B XRT + methotrexate chemotherapy
   Primary CNS lymphoma that is non-AIDS related and biopsy proven is best treated with XRT and methotrexate chemotherapy. There is no role for surgical debulking as this has demonstrated no improvement in survival in this patient population.

109. A 3 to 4%
   Primary CNS lymphoma that is non-AIDS related and biopsy proven is best treated with XRT and methotrexate chemotherapy. There is no role for surgical debulking as this has demonstrated no improvement in survival in this patient population. Approximate 5-year survival is 3 to 4%.

110. B > 1 cm
   Pituitary adenomas are considered macroadenomas after they have grown to >1 cm in size.

111. D 65%
   Approximately 65% of pituitary tumors secrete an active hormone, with prolactin being the most commonly secreted hormone (48%), followed by growth hormone (10%), ACTH (6%), and TSH (1%).

112. D Bitemporal hemianopia
   Pituitary macroadenomas cause compression of the optic chiasm and given their midline location lead to bitemporal hemianopia.

113. C Sodium
   Suprasellar germinomas can lead to compression of the pituitary stalk and lead to diabetes insipidus. With elevated serum sodium in a suprasellar mass, germinoma should be considered.
114. B Visual field cut
Pituitary apoplexy occurs when a pituitary tumor hemorrhages into the sella. These patients often need emergent corticosteroid administration, but progressive visual field deficit is a reason to emergently decompress the sella. This should ideally be performed within 7 days of onset to promote full recovery.

115. A Cushing’s disease
Cushing’s syndrome describes the general features of hypercortisolism, whereas Cushing’s disease is Cushing’s syndrome caused by an ACTH secreting pituitary adenoma.

116. C Nelson’s syndrome
Nelson’s syndrome occurs when ACTH producing pituitary adenoma cells remain after bilateral adrenalectomy for Cushing’s disease. Given the cross-reactivity between ACTH and melanocyte stimulating hormone, patients notice hyperpigmentation and signs/symptoms of an enlarging pituitary mass. She should undergo surgical resection of the mass.

117. B Colon cancer
Patients with growth hormone–secreting tumors and acromegaly have a two times increased risk of colon cancer compared to the normal population.

118. B D2 dopamine receptor
The main medication used for prolactinomas currently is cabergoline, a D2 receptor agonist, compared to bromocriptine which is a nonselective (D1 and D2) dopamine agonist.

119. C Mitral regurgitation
The main medication used for prolactinomas currently is cabergoline, a D2 receptor agonist, and it can lead to cardiac valve regurgitation.

120. C Somatostatin analogue
While many growth hormone–secreting pituitary adenomas can be treated with surgery, occasionally medical management is attempted using octreotide, which is a somatostatin analogue. Tumor volume decreases in approximately 30% of patients.

121. A GH receptor antagonist
While many growth hormone–secreting pituitary adenomas can be treated with surgery, occasionally medical management is attempted using pegvisomant, which is a growth hormone receptor antagonist. In patients treated for 12 months, normal IGF levels are seen in 97% of patients, but tumor size remains the same.

122. B Gardner’s syndrome
Gardner’s syndrome is comprised of colonic polyposis, multiple cranial osteomas, and soft tissue tumors. Osteomas of the skull consist of osteoid tissue within osteoblastic tissue with reactive bone formation around that region.

123. B Hemangioma
Hemangiomas of the skull can cause areas of skull protrusion with evidence of trabeculated bone on X-ray. During surgery they appear bluish in color underneath the pericranium. They should be excised completely to avoid recurrence.
124.
A  Diabetes insipidus
   The Hand-Schüller-Christian triad is a series of clinical symptoms caused by an underlying diagnosis of Langerhans cell histiocytosis. When this occurs in the suprasellar region, a mass emanating from the pituitary stalk can cause diabetes insipidus.

125.
C  McCune-Albright syndrome
   Fibrous dysplasia is a benign condition where bone is replaced by fibrous connective tissue, and it is seen commonly in McCune-Albright syndrome along with endocrine dysfunction, café au lait spots on one side of the midline, and precocious puberty.

126.
D  Needle aspiration of cystic contents
   While all of the above options are reasonable to decrease intracranial pressure, when a mass has a large cystic component, simple drainage of the cyst can lead to rapid decompression of the posterior fossa.

127.
B  No
   Generally, the wall of the associated cyst cavity within a hemangioblastoma does not need to be resected, unless there is a portion that enhances. Removal of the enhancing mural nodule should lead to sufficient resection.

128.
A  Yes
   Generally, the wall of the associated cyst cavity should be resected if it can be done safely. Certain pilocytic astrocytomas can have pseudocysts that are really more tumor tissue and attempts should be made to resect the wall if possible. Certainly any areas that are enhancing should be resected if it can be done safely.

129.
C  Fornix
   When the endoscope is advanced through the foramen of Monro, care should be taken to avoid significant manipulation if possible given that the fornix can be easily compressed on the superior aspect of the foramen by a rigid endoscope.

130.
B  3 to 4.5 cm
   Approximately 3 to 4.5 cm of dominant temporal lobe can be resected safely. Further posterior and risk to language function increases.

131.
B  2
   The WFNS grade is a way to evaluate clinical symptoms after SAH. A patient with a GCS of 13 to 14 without major motor deficit would be considered a WFNS grade 2.

132.
C  33%
   The modified Fisher scale rates the amount and location of SAH to predict risk of vasospasm. Grade 1 is thin (< 3 mm) clot only with no IVH–24% risk. Grade 2 is thin (< 3 mm) clot with IVH–33% risk. Grade 3 is thick (> 3 mm) clot with no IVH–33% risk, and grade 4 is thick clot with IVH–40% risk.

133.
A  1.5%
   After aneurysmal rupture there is an approximately 1.5% per day risk of rebleeding up to 13 days postbleed. At 6 months there is a risk of 50%.

134.
C  Vasospasm
   This patient is likely experiencing a vasospasm, which occurs usually between postbleed days 3 and 14. It is rare for vasospasm to occur < 3 days.
135.  
A  Anterior communicating artery  
Anterior communicating artery aneurysms are the most common location for intracranial aneurysms (30%).  

136.  
B  Posterior communicating artery  
Posterior communicating artery aneurysms classically present with a non-pupil sparing third nerve palsy (due to compression and not microvascular disease, which would be pupil sparing). While only 9% of posterior communicating artery aneurysms will present this way, given the location of the posterior communicating artery to the third nerve, it is a commonly tested subject.  

137.  
C  Proximal control  
Obtaining proximal control prior to dissecting the aneurysm or placing a clip. When proximal control is obtained, further dissection can take place. If the aneurysm ruptures, temporary clips can be applied to the areas of proximal control in order to decrease bleeding.  

138.  
B  Right superior nasal quadrantanopsia  
Ophthalmic segment aneurysms can grow and cause compression of the optic nerve. Given that they will compress the nerve from the inferior temporal side, you would expect him to have an ipsilateral superior nasal quadrantanopsia.  

139.  
A  Falciform ligament  
The falciform ligament is a dural fold overlying the superior aspect of the optic nerve. When an aneurysm pushes the optic nerve superiorly, compression can occur from above as the nerve is pressed against the falciform ligament. After an anterior clinoidectomy, opening of the falciform ligament can decompress the optic nerve.  

140.  
C  CT head  
Occasionally patients can have bridging bone between the anterior and posterior clinoid processes, so called the “middle clinoid process.” If the surgeon is unaware of the presence of this middle clinoid process bridging bone, aggressive removal of the anterior clinoid process can lead to transection of the carotid artery as the bridging bone often encases the carotid artery to some degree. A CT scan of the head can rule out the presence of the middle clinoid bridging bone.  

141.  
B  3  
The Spetzler-Martin grading system applies to AVMs and takes into account size of the nidus (< 3 cm, 3–6 cm, > 6 cm), venous drainage (deep/superficial), and location (eloquent/noneloquent cortex). The scale is 1 to 5.  

142.  
B 84%  
Based on the Spetzler-Martin grading system, grade 3 AVMs have an 84% chance of good outcome after surgical resection (grade 1 = 100%, grade 2 = 95%, grade 3 = 84%, grade 4 = 73%, grade 5 = 69%).  

143.  
B 3.5%  
The approximate annual risk of hemorrhage for grade 1 to 3 AVMs is 3.5%.  

144.  
B False  
Many cavernous malformations of the brain are associated with developmental venous anomalies. It is important to remember that these venous channels can drain normal brain tissue and should not be resected to avoid risk of postoperative venous stroke.  
145. A True
   When cavernous malformations hemorrhage they can cause hemosiderin staining of the surrounding brain parenchyma which gives it a yellowish color. Many surgeons believe that this hemosiderin stained brain can be a seizure focus and should be resected if it can be done safely.

146. D Pulsatile tinnitus
   The vast majority of dural arteriovenous fistulae present with pulsatile tinnitus.

147. C Retrograde sinus and retrograde cortical venous drainage
   There are two major classification systems for dural arteriovenous fistulae, the Borden classification and the Cognard classification. The Cognard classification consists of type I (anterograde drainage through a sinus), type IIa (retrograde sinus drainage only), type IIb (anterograde sinus drainage with retrograde cortical venous reflux), type II a + b (retrograde sinus and retrograde cortical venous reflux), type III (direct cortical venous drainage without ectasia), type IV (direct cortical venous drainage with ectasia), and type V (direct drainage into spinal perimedullary veins).

148. A Type II a + b
   Type II a + b (retrograde sinus and cortical venous reflux) carries the highest risk of hemorrhage, approximately 66%. Next is type IV with direct cortical venous drainage with ectasia, at 65%.

149. C Heart failure
   Vein of Galen malformations present in neonates with evidence of high output heart failure.

150. D Carotid-cavernous fistula
   Traumatic carotid-cavernous fistulae can occur after motor vehicle accidents or other intracranial trauma. They present with orbital pain, chemosis, proptosis, ophthalmoplegia, and visual loss. Patients should undergo vascular imaging and may require interventional or surgical treatment of the fistula.

151. B False
   Radiation therapy damages cells by firing particles into an atom and releasing free electrons causing damage downstream. In fully oxygenated cells, oxygen combines with unpaired free electrons to form peroxides, which are more stable and lethal than free radicals, and therefore an oxygenated cell is more sensitive to damage by radiation therapy.

152. B > 3 years
   Children less than 3 years of age are particularly sensitive to cranial radiation and can have severe developmental side effects. Children should be greater than 3 years of age to be eligible for cranial radiation. There may be demonstrable changes in IQ (decrease by 25 points) in children who receive radiation up to 7 years of age.

153. B 3 cm or less
   Gamma knife radiosurgery can be useful for cranial masses, but should be reserved for patients with brain tumors that are 3 cm or less in maximum diameter. This size cutoff decreases the risk of harmful radiation side effects to surrounding brain structures.
154.
B 10 Gy
Safe doses of radiation to the optic apparatus are generally thought to be 8 to 10 Gy. Doses beyond this can lead to visual loss.

155.
B 13 Gy or less
SRS doses for vestibular schwannomas have changed based on recent literature, and currently 12 to 13 Gy to the facial nerve seems to be a safe dose of radiation that causes good tumor control but greatly decreases the side effects to the seventh and eighth nerve.
Further Reading: Lunsford, Sheehan. Intracranial Stereotactic Radiosurgery, 2016, page 150.

156.
C 10 Gy or less
The lens of the eye can tolerate 10 Gy or less radiation with minimal side effects. Cataract formation will occur with doses up to 50 Gy.

157.
D 40 to 50%
At 10 years posttreatment, approximately 40 to 50% of patients who receive sellar radiation will experience hypopituitarism as a side effect from radiation.

158.
B 4 to 6 Gy
Based on current literature, the mean safe radiation dose to the cochlea is considered to be approximately 4.2 Gy, but has also been shown to range from 4 to 6 Gy. There is some controversy on this topic currently, but based on data available, doses from 4 to 6 Gy should be considered optimal.

159.
C 24 Gy
For tumors that are 10 to 20 mm, SRS doses up to 24 Gy can be used with acceptable risk of side effects.

160.
B 18 Gy
For tumors that are 21 to 30 mm, SRS doses up to 18 Gy can be used with acceptable risk of side effects.

161.
C Whole brain radiation
Current literature supports the use of whole brain radiation in patients who have undergone resection of a cerebral metastasis. Doses up to 50 Gy have been shown to control > 90% of micrometases, but at this dose there is a very high chance of early radiation side effects.

162.
B 10 or less
Based on current studies, up to 10 concurrent cerebral metastases can be treated with stereotactic radiosurgery with good outcome and low risk of side effects. There are surgeons who feel that even this number can be safely extended, research is pending.
Stereotactic radiosurgery can be a good option for low grade AVMs with a well formed nidus that border eloquent cortex. Radiation works by causing damage to the endothelium and ultimately causing fibrosis. This process can take 2 to 3 years to develop, so risk of hemorrhage needs to be discussed with the patient over that treatment timeframe.


Current literature suggests that 23 to 25 Gy radiation doses to AVMs lead to high rates of obliteration with low risk of complications. Higher radiation doses have been associated with an increased risk of complications and no significant improvement in obliteration rates.


Current literature suggests that 70 to 80% of all AVMs treated with stereotactic radiosurgery may achieve complete obliteration by 2 to 3 years after treatment.


While up to 86% of patients will experience a decrease in their pain after SRS for TGN, the long term pain free rate is approximately 65%.


Dementia is the main complication from whole brain radiation after use for intracranial metastases. Symptoms can develop as quickly as 1 year after WBRT is performed. Incidence has been shown to be higher when patients receiving doses of 25 to 39 Gy receive those doses in fractionations that are > 300c Gy.


Emergency radiation can be delivered to radiosensitive spine tumors when there is evidence of compression. In many circumstances, an initial dose of 8 Gy will be given to shrink the tumor, followed by further fractionated radiation after the acute situation has resolved.


Radiation to the spine for metastatic disease in the setting of radiosensitive tumors is often administered at a dose of 30 Gy delivered over 10 fractions.


While TGN can be treated medically, approximately 75% of patients will require a procedure directed at treating the TGN.


Anesthesia dolorosa is a feared complication of intentional damage to the trigeminal nerve. It occurs after damage to the V1 segment of the nerve, and can lead to anesthesia of the cornea, causing patients to get recurrent corneal abrasions. Significant care should be taken to avoid injuring the V1 segment.


This patient appears to have symptoms consistent with trigeminal neuralgia. Initially, imaging
of the brain should be performed to rule out mass lesions or evidence of multiple sclerosis.


173.
A  Start carbamazepine
   This patient appears to have symptoms consistent with trigeminal neuralgia. Initially, imaging of the brain should be performed to rule out mass lesions or evidence of multiple sclerosis. Following this, a trial of medical management utilizing carbamazepine 100 mg BID is a reasonable option.

174.
C  70%
   At 10 years, microvascular decompression has a pain free rate of 70%. It is an excellent option for patients who can tolerate a small craniotomy and have a life expectancy of longer than 5 years.

175.
C  Fluid status
   SIADH and CSW are both conditions that cause hyponatremia and can be seen after aneurysmal rupture. It is important to determine the difference between the two as treatment is different. CSW causes patients to be hypovolemic whereas in SIADH patients are euvoeemic.

176.
B  Fluid restriction
   In SIADH, patients are euvoeemic or hypervolemic. In a patient who can tolerate PO intake and is conscious, fluid restriction is a good initial step in management assuming the hyponatremia is not severe.

177.
D  Demeclocycline
   Demeclocycline is a tetracycline antibiotic that has side effects including antagonism of ADH. It can be used for medical management of SIADH if fluid restriction is not normalizing the sodium.

178.
B  Fludrocortisone
   Fludrocortisone acts directly on renal tubules to increase sodium absorption and can be a useful medication adjunct when treating cerebral salt wasting.

179.
A  Normal saline infusion
   In cerebral salt wasting, patients are hypovolemic and hyponatremic. Fluid resuscitation with normal saline at 100 to 125 mL/hr should be instituted in an attempt to normalize fluid status.

180.
B  Severe dehydration
   The main complication of untreated diabetes insipidus is severe dehydration

181.
C  85%
   Approximately 85% capacity to secrete ADH must be lost before symptoms of DI will be evident.

182.
A  Drink to thirst
   In an awake, conscious and ambulatory patient with mild diabetes insipidus, sodium levels should be monitored, but patients should be allowed to drink to thirst. They are often able to effectively manage their sodium via thirst mechanisms. Utilization of DDAVP occurs in unconscious patients or those who cannot adequately compensate using standard thirst mechanisms.
183.  
C > 10 µg/kg/min  
At doses from 2-10 µg/kg/min, dopamine is a positive inotrope, but remember that at least 25% of IV dopamine is converted to norepinephrine, so at doses > 10 µg/kg/min you are essentially giving norepinephrine and the alpha/beta/dopaminergic receptors are all activated.  

184.  
D 72 hours  
Dobutamine increases cardiac output by positive inotropy, but patients will exhibit tachyphylaxis after approximately 72 hours of administration.  

185.  
C < 3 weeks  
Generally speaking, patients who are on daily steroid medications should receive GI prophylaxis to prevent steroid induced ulcers after they have been on the medication for 3 weeks or longer. Acutely hospitalized patients or postoperative patients on steroids should be on GI prophylaxis as the stress of the hospitalization can lead to stress ulcer formation.  

186.  
B 5 to 10K  
One unit of platelets (out of the standard six pack) will raise the platelet count approximately 5 to 10K.  

187.  
A 10K  
In the absence of evidence of bleeding, platelets should be transfused prophylactically when the count drops to 10K.  

188.  
B 1 mg protamine/100 u heparin  
Protamine sulfate can be used to reverse the effects of unfractionated heparin, and should be administered in doses of 1 mg protamine/100 u heparin.  
A Hypoglossal palsy
The distal hypoglossal nerve is often seen during the dissection for a carotid endarterectomy and a postoperative palsy has been reported to be as high as 8% in some series. Care should be taken to avoid damaging the hypoglossal nerve during the dissection.

B Bedside decompression
This patient has an obvious arteriotomy closure disruption and it is causing tracheal deviation and respiratory compromise. While you may think intubation would be the initial management option, it can be difficult or impossible in patients with severe tracheal deviation, so bedside decompression of the clot should occur immediately, followed by intubation and return to the OR.

B 2 weeks
Pooled analysis of the symptomatic carotid stenosis trials have demonstrated that there is a benefit for patients who receive a CEA within 2 weeks of stroke compared to those patients who had a CEA at greater than 2 weeks.

C Blood pressure control
This patient is likely experiencing cerebral hyperperfusion syndrome given that blood flow to the ipsilateral hemisphere has now greatly increased. This is a controversial area, but close blood pressure control can help decrease the symptoms of cerebral hyperperfusion syndrome. Imaging should be obtained as well to ensure that no hemorrhage has occurred.

D Noninferiority
The CREST trial demonstrated non-inferiority of carotid angioplasty and stenting to open carotid endarterectomy. In many practices, surgeons utilize carotid angioplasty and stenting in patients with high-riding carotid bifurcations or very difficult appearing stenosis that might have a higher rate of operative complications.
II Answers

201.  
B  Anterior and posterior cortex  
A spinal fracture is considered a burst fracture when both the anterior and posterior cortices of the vertebral body are violated.  

202.  
B  Burst fracture  
A spinal fracture is considered a burst fracture when both the anterior and posterior cortices of the vertebral body are violated. This CT scan demonstrates a burst fracture of the lumbar spine.  

203.  
B  TLSO bracing  
In most patients with asymptomatic burst fractures and preserved alignment, bracing is a viable option. Patients should be fitted with a TLSO brace and baseline X-rays should be obtained. Follow-up X-rays in 6 weeks can be obtained to ensure no change in alignment. This treatment technique is based on the Kirkham Wood study evaluating asymptomatic burst fractures managed with bracing alone. Some surgeons are avoiding bracing completely in these patients, and this is a somewhat controversial issue that is still undergoing further research.  

204.  
A  Anterior cortex only  
A compression fracture of the spine occurs when imaging demonstrates violation of the anterior cortex only.  

205.  
A  Compression fracture  
A spinal fracture is considered a compression fracture when the anterior cortex is violated but other aspects of the spine remain intact. This X-ray demonstrates a compression fracture.


206.  
A  Flexion compression  
This image demonstrates a compression fracture, evidenced by violation of only the anterior cortex. This injury occurs via a flexion compression loading mechanism with the axis of rotation located within the anterior vertebral body.  

207.  
B  Pure axial load  
This image demonstrates a burst fracture (violation of both the anterior and posterior cortices). This injury is caused by a pure axial load mechanism.  

208.  
C  Flexion distraction  
This image demonstrates a three column pure bony injury, often referred to as a Chance fracture after the physician G.Q. Chance in 1948. It is caused by a flexion distraction force mechanism where the axis of rotation is anterior to the vertebral body.  

209.  
D  Shear  
This image demonstrates a severe spinal cord fracture caused by shear injury to the spinal column. It appears to be both a bony and soft tissue injury causing a fracture dislocation of the spine and certain ASIA A spinal cord injury. The forces applied to the spine in order to achieve this level of dislocation are significant.  

210.  
C  Extension distraction  
This image demonstrates a three column spine fracture in a patient with evidence of ankylosis of the spine. While these patients form bone easily,
the bone within the vertebral body is brittle and fractures easily. This fracture was caused by an extension distraction mechanism with the axis of rotation within the posterior spinal elements.


211.
C T12-L1
Burst fractures are caused by pure axial load mechanisms and most often occur in the T12-L1 region since the T12-L1 vertebral bodies are the most centered in the midline between the lordotic lumbar spine and kyphotic thoracic spine. It is in this region where the force vector in a pure axial load mechanism is applied directly through the center of the vertebral body causing a dispersion fracture mechanism leading to disruption of the anterior and posterior vertebral cortices causing a burst fracture to occur.


212.
A Operative
The TLICS score is becoming more common for evaluation and initial management of thoracolumbar traumatic injuries. Points are assigned based on fracture morphology, PLC integrity and presenting symptoms. In this setting, the patient gets 2 points for burst fracture, 2 points for indeterminate ligamentous status and 2 points for nerve root injury, leading to a score in the operative treatment range.


213.
A Operative
The TLICS score is becoming more common for evaluation and initial management of thoracolumbar traumatic injuries. Points are assigned based on fracture morphology, PLC integrity and presenting symptoms. In this setting, the patient gets 2 points for burst fracture, 0 points for PLC integrity and 3 points for cauda equina syndrome, leading to an operative management.


214.
B Nonoperative
The TLICS score is becoming more common for evaluation and initial management of thoracolumbar traumatic injuries. Points are assigned based on fracture morphology, PLC integrity and presenting symptoms. In this setting, the patient gets 2 points for burst fracture, 0 points for PLC integrity and 0 points for full strength exam leading to nonoperative management.


215.
B 2
The TLICS score is becoming more common for evaluation and initial management of thoracolumbar traumatic injuries. Points are assigned based on fracture morphology, PLC integrity and presenting symptoms. 2 points are assigned for complete spinal cord injury, in comparison to 3 points assigned for cauda equina syndrome and incomplete spinal cord injury.


216.
C 3
The TLICS score is becoming more common for evaluation and initial management of thoracolumbar traumatic injuries. Points are assigned based on fracture morphology, PLC integrity and presenting symptoms. 3 points are assigned for translational/rotational injury morphology.


217.
C 3
The TLICS score is becoming more common for evaluation and initial management of thoracolumbar traumatic injuries. Points are assigned based on fracture morphology, PLC integrity and presenting symptoms. 3 points are assigned for definite injury to the posterior ligamentous complex.

218.  
B  Middle column  
In the 3-column model of Denis, the posterior vertebral body is located within the middle column.  

219.  
C  Posterior column  
In the 3-column model of Denis, the facet joints are located within the posterior column.  

220.  
A  Stable  
Isolated transverse process fractures of the thoracolumbar spine are generally considered stable when not associated with other major injuries and can be managed expectantly.  

221.  
C  Type III  
There are three types of odontoid fractures, and type III odontoid fractures extend at the base of the odontoid process slightly into the body of C2. If there is not significant distraction across the fracture, these fractures are usually considered stable compared to type I and type II injuries.  

222.  
B  Type II  
This plain X-ray demonstrates a type II odontoid fracture.  

223.  
C  30%  
Approximately 30% of type II odontoid fractures will exhibit non-union at long-term follow-up. Specific rates depend on fracture characteristics including displacement and angulation, but 30% is a good rule to consider when deciding management.


224.  
A  3 mm  
The generally accepted normal value for ADI is 3 mm or less. More than 3 mm and the integrity of the transverse ligament should be evaluated to determine stability.  

225.  
D  Atlanto-occipital disassociation  
These images demonstrate AOD as evidenced by the increased interval between the occiput and atlas. It is clearly very unstable, and often times this is a fatal injury.  

226.  
C  > 1  
The powers ratio is used to diagnose AOD. It is measured by the length of a line drawn from the basion to the posterior arch of C1 divided by a line drawn from the opisthion to the anterior arch of C1. A ratio of > 1 is suggestive of AOD.  

227.  
C  Type IIa  
The type IIa Hangman’s fracture exhibits distraction and angulation and should not be put in traction as there is risk of causing spinal cord injury in traction.  

228.  
D  Atypical  
This axis fracture is one of the atypical variety given that the fracture occurs through the base of the C2 vertebral body and the posterior cortex of the body is left in place rather than fracturing through the pedicles of C2. This fracture type should be evaluated closely as the spike of remaining vertebral body can cause the spinal cord to be
draped over the shard anteriorly and cause spinal cord injury.  

229.

B 11 degrees  
Type IIa fractures of the axis are dangerous due to distraction and angulation. They should be recognized as they are a subset of fractures that should not be put in traction as this can worsen the injury type. Generally, 11 degrees of angulation should alert the neurosurgeon to the possible presence of a type IIa injury.  

230.

B Unstable  
This imaging demonstrates an elevated ADI both in the baseline X-ray and an increase in the ADI with flexion. This indicates likely transverse ligament injury. The TL is a stabilizing ligament and in the presence of injury, fusion should be considered as the atlantoaxial joint is likely unstable.  

231.

C 17 mm  
The normal cervical spinal canal is roughly 17 mm. When the AP diameter is 13 or less, congenital stenosis is likely present.  

232.

A 10 mm  
The normal cervical spinal cord is roughly 10 mm.  

233.

D MRI  
This patient may have suffered spinal cord injury without radiographic abnormality, but that cannot be fully determined until an MRI has been performed. The MRI will look for signal change within the spinal cord as well as the presence of any ligamentous injury. The patient should remain in a cervical collar until the results from the MRI are obtained.  

234.

A Jumped facets  
This axial CT scan demonstrates jumped facets. This patient has a fracture dislocation with jumped facets. There could be an underlying spinal cord injury and reduction with closed traction should be performed. If the patient is awake and responsive, an MRI may not be necessary before traction is implemented as the patient has a reliable exam to follow. However, if the patient is unconscious, an MRI may be beneficial to rule out a large disc herniation that could be worsened with closed reduction.  

235.

A Traction  
This axial CT scan demonstrates a unilateral jumped facet. The superior articulating process on the left is dorsal to the inferior articulating process and there is evidence of rotation. This patient should likely be placed in traction.  

236.

A Traction  
This patient is awake and has a neurologic exam that can be followed. Traction is safe to perform in this patient without an MRI scan first as you are able to follow her exam after addition of weight. If any change in the neuro exam occurs, the weight can be removed and the exam re-confirmed.  
237.  
C MRI scan  
This patient is intubated and sedated and therefore is not able to provide an exam during traction. An MRI should be performed first to rule out the presence of a large disc fragment anteriorly that could compress the cord. Traction is safe to perform in a patient without an MRI scan if you are able to reliably follow a neurologic exam in an awake patient. If any change in the neuro exam occurs, the weight can be removed and the exam re-confirmed. With obtunded/intubated patients, an MRI should be performed first.  

238.  
C 10 lbs  
Generally, when applying cervical traction, 10LBS of weight can be applied per level, but fluoroscopy should be utilized after the addition of any weight to determine if any change has occurred. If the patient is awake, an exam should be performed as well after the addition of any weight.  

239.  
C Transverse ligament  
The rule of Spence is calculated be measuring the displacement of the C1 lateral masses on the C2 joints. If the total overhang of the C1 lateral masses on the C2 joints is > 7 mm, disruption of the transverse ligament should be suspected.  

240.  
B 7 mm  
The rule of Spence is calculated be measuring the displacement of the C1 lateral masses on the C2 joints. If the total overhang of the C1 lateral masses on the C2 joints is > 7 mm, disruption of the transverse ligament should be suspected.  

241.  
D Lumbar spine MRI with gadolinium  
This patient likely has a recurrent herniated lumbar disk and should be evaluated with a gadolinium enhanced lumbar spine MRI. Scar tissue will enhance homogeneously while a recurrent disk may peripherally enhance but will not demonstrate homogeneous enhancement.  

242.  
C 85%  
Approximately 85% of patients with a herniated lumbar disc will improve with 6 weeks of nonoperative management, thus an initial period of non-surgical management should be attempted before surgical decompression is considered. This does not include patients with progressive weakness or cauda equina syndrome.  

243.  
B Progressive weakness  
While many patients with a HLD will improve with non-operative management, patients with progressive weakness of the lower extremity should be considered for more rapid intervention given the possibility of preserving or improving motor strength in the acute phase.  

244.  
C Urinary retention  
Urinary retention is the most consistent finding in CES, and has a sensitivity of approximately 90%. Patients can be evaluated with post void residual measurement.  

245.  
B 50%  
Urinary retention is the most consistent finding in CES, and has a sensitivity of approximately 90%. Patients can be evaluated with post void residual measurement. In patients with urinary retention and confirmed CES, only 50% will return to full bladder function. When full saddle anesthesia
develops, few patients will return to normal bladder function.


246.
C 75%  
Approximately 73% of patients will be free of leg pain 1 year after surgery for a herniated lumbar disc. At 5 to 10 years the number drops to 62%.


247.
B 4% at 10 years  
According to current literature, the rate of recurrent disc herniation at the same level on either side is approximately 4% at 10 years, with 1/3rd of those patients experiencing the recurrence within the 1st year postoperation.


248.
B 2 mm or less  
ACDFs should be evaluated in follow-up with flexion/extension films. To evaluate for a pseudoarthrosis, measurements should be taken between the spinous processes at that level. Movement greater than 2 mm between flex/ex films should make you consider that a pseudoarthrosis is present at that level.


249.
C Superior articulating process  
The superior articulating process of the lumbar spine makes up the roof of the gutter, or lateral recess and often causes nerve root impingement. When there is abnormal motion, the facets hypertrophy and this, in the setting of redundant ligamentum flavum and bulging discs, stenosis and nerve root impingement occurs.


250.
A 3 mm or greater  
When measured on CT scans of the lumbar spine, the normal lateral recess height is 3 mm or greater. A patient could be symptomatic at a height of 3 mm if other pathology is present, i.e., ligamentum flavum hypertrophy or disc bulging. In the absence of these findings, 3 to 4 mm should be adequate height that does not lead to symptoms when in extension.


251.
B L4  
In spondylolisthesis, the nerve root of the upper involved vertebral body is usually compressed. This is due to the superior articulating process of the vertebral body below as well as retropulsion of disc material.


252.
B II, III, IV  
A fusion should be strongly considered in any cases of spondylolisthesis beyond grade I based on the Meyerding classification. Flexion extension plain films should also be obtained to determine whether or not there is worsening of the spondylolisthesis in flexion. This finding would lead you to more strongly consider a fusion operation.


253.
B Atlantoaxial subluxation  
25% of patients with rheumatoid arthritis will exhibit exaggerated movement of the atlantoaxial joint, occasionally manifesting as frank instability and subluxation.


254.
A Chiari I malformation  
70% of spinal cord syrinxes are associated with chiari I malformations. They can also be seen after trauma to the spinal cord.

255. **A** Observation/serial imaging

Asymptomatic incidentally discovered spinal cord syrinxes should be initially observed with serial imaging over several years. If there is growth or symptoms arise, treatment can be considered.


256. **A** Dorsal root entry zone

The shunt catheter should be placed in the dorsal root entry zone. This is different from spinal cord tumors which should be approached through a midline myelotomy. In the case of a syrinx, the DREZ may be the thinnest portion of the spinal cord and sensory deficits from the syrinx may already be present, not placing any further neurologic function at risk.


257. **C** 54%

According to current literature, clinical stabilization is seen in 54% of patients who receive a syringosubarachnoid shunt for spinal cord syrinx at 10-year follow-up.


258. **B** Hydrocortisone

Spinal epidural lipomatosis is associated with prolonged use of exogenous steroids. It leads to overgrowth of epidural fat which can be compressive to the spinal cord.


259. **A** Weight loss

In obese patients not on steroid therapy, an initial trial of weight loss may reverse the symptoms and imaging findings of spinal epidural lipomatosis.


260. **C** > 7 mm

It has been suggested that a width of 7 mm or greater epidural fat should be present to make the diagnosis of spinal epidural lipomatosis.


261. **A** 2.9%

According to the literature, symptomatic adjacent segment disease occurs at roughly 2.9%/year after ACDF. The 10-year overall rate has been found to be 25.6%.

Further Reading: Hilibrand et al. Radiculopathy and myelopathy at segments adjacent to ACDF. JBJS 1999.

262. **B** Osteoconduction

There are three main principles of bone formation, osteogenesis, osteoinduction, and osteoconduction. Osteoconduction describes the placement of a solid matrix/scaffold for bone to form within.


263. **C** 80-20

The rule of Harms suggests that 80% of the axial load bearing capacity is borne by the anterior column, while 20% is borne by the posterior column. This becomes important when considering spinal fusion surgery and need for anterior or posterior fusion procedures.


264. **D** 95%

According to a series of 140 patients followed to 5 years, the rate of fusion for single level ACDF was 97%.

265. C Presence of a cervical collar
The nexus criteria were developed to decrease unnecessary C-spine imaging. It includes no midline tenderness, no focal neurologic deficit, normal alertness, no intoxication and no painful distracting injury. When all of these are present, imaging can be avoided with a negative predictive value of 99.8%

266. B Posterior ligamentous complex injury
The McCormack load sharing classification was developed to help surgeons decide whether or not a short segment fusion would be sufficient to fix certain types of thoracolumbar fractures. The classification takes into account degree of fracture comminution, fracture fragment apposition and degree of kyphosis in determining the length of the construct.

267. B False
While this remains an area of some controversy, multiple studies have failed to demonstrate benefit from the administration of high dose methylprednisolone in the setting of cervical SCI. Current guidelines do not recommend the use of steroids in this setting.

268. B 85 mm Hg
Most surgeons and intensivists support MAP augmentation after spinal cord injury. Often the MAP goals are 85-90 mm Hg.

269. B
The AO classification system is designed to describe fracture morphology. Type A injuries are often compression injuries, Type B are distraction injuries and Type C are rotational. An easy way to remember this is Type A = Axial (loading), Type B = Bending (forward or backward with distraction) and Type C = Circular (translational injuries). There is no type D.

270. A No difference between groups
The SPORT trial was used to look at outcomes after various spine management strategies. For lumbar disc herniations, there was no difference between conservative and surgical management out to 4 years of follow-up on intention-to-treat analysis, however there was a 22% cross-over between groups, a common criticism of this study.

271. B Significant benefit of surgery out to 4 years
The SPORT trial was used to look at outcomes after various spine management strategies. For lumbar disc herniations, there was no difference between conservative and surgical management out to 4 years of follow-up on intention-to-treat analysis, however there was a 22% cross-over between groups, a common criticism of this study.
When the subset as-treated analysis was performed, there was a significant improvement in all outcomes measured in the surgical group compared to conservative management with the exception of return to work.

272. B 50%
Many surgeons feel that 50% of the facet joint should remain intact during a simple decompression to preserve stability at that level. Further resection may cause iatrogenic instability.
II Answers

273.  
D 90%  
Patients with achondroplasia are at risk for several conditions affecting the spine including foramen magnum stenosis, spinal stenosis and thoracolumbar kyphosis. Spinal stenosis can be observed in up to 90% of patients with achondroplasia.  

274.  
A Multiple non-contiguous stenotic regions  
The Patchell study demonstrated that in patients with metastatic epidural spinal cord compression, wide decompression and reconstruction if appropriate can keep patients ambulating and extend life expectancy with several caveats. The patient’s paraplegia must be < 48 hours, there cannot be multiple non-contiguous stenotic regions and the life expectancy should be 3 months or greater.  

275.  
A Yes  
The Patchell study demonstrated that in patients with metastatic epidural spinal cord compression, wide decompression and reconstruction if appropriate can keep patients ambulating and extend life expectancy with several caveats. The patient’s paraplegia must be < 48 hours, there cannot be multiple non-contiguous stenotic regions and the life expectancy should be 3 months or greater.  

276.  
B 0-5 cm  
The sagittal vertical axis is a measurement taken from a plum line dropped midway through the C7 vertebral body. A measurement is taken from the posterior superior corner of the sacrum to the plum line to determine the distance. Normal is 0-5 cm.  

277.  
C Pelvic incidence  
The pelvic parameters are made up of the pelvic tilt, the pelvic incidence and the sacral slope. Of these, the pelvic incidence (measured as the angle from a line perpendicular to the sacral surface and a line drawn from the midpoint of the sacral surface to the midpoint of the femoral head) cannot be changed.  

278.  
B 10 degrees or less  
It is becoming clear that pelvic incidence and lumbar lordosis are related measurements, and patient outcomes are improved when the difference between these two measurements are 10 degrees or less. If there is a large mismatch between the PI and LL, further evaluation should occur because a larger deformity may be present.  

279.  
C Pelvic incidence reduction  
When patients have an abnormally positive sagittal vertical axis there are several mechanisms that they use to compensate in order to keep vision at the horizontal level. They utilize pelvic retroversion, knee flexion and cervical extension to maintain a view to the horizon. Pelvic incidence cannot be changed.  

280.  
C ~ 60 degrees  
Lumbar lordosis is measured by the Cobb angle between the superior endplate of L1 and the sacral surface. The mean value for adults is 62 degrees +/- 11 degrees. It is important to restore lumbar lordosis if possible, as well as match the PI–LL to within 10 degrees or less.  

281.  
B 35%-65%  
In the cervical spine, the anterior vertebral body does not bear the axial weight in the same distribution as the lumbar spine. In the cervical spine, approximately 35% of the axial load is borne by the anterior column and 65% is borne by the posterior column.
Patients aged 65 to 85 years who undergo scoliosis correction procedures have the highest rate of improvement in disability and leg pain postoperatively.


There are a wide range of studies that report incidence of proximal junctional kyphosis after spine fusion surgery. There seems to be a consensus that a large number of these cases (~ 60%) develop within the first 3 months after surgery.


This image demonstrates a proximal junctional kyphosis, which can occur after large scoliosis fusion procedures. Care should be taken when exposing the top level of the construct to avoid excessive muscle damage or damage to the posterior ligamentous complex/facet joints above the upper instrumented vertebrae to decrease the chances for development of PJK.


For coronal plane deformities, the term dextroscoliosis refers to right sided diversion, where levoscoliosis depicts a leftward deviation.


A Cobb angle of > 30 degrees has been demonstrated to be an independent predictor of deformity progression in patients with scoliosis.


There are two types of curves, structural and nonstructural. Structural cures are not flexible, and this is demonstrated by the fact that they do not correct during side bending.

293. **B** 4 cm or less
   Coronal balance is measured using a C7 plumb line compared to the central sacral vertical line on AP radiograph. Normal is an offset of 4 cm or less.

294. **A** 5 to 10 degrees
   A Smith Peterson osteotomy involves removing the facets, some lamina and the ligamentum flavum at a particular level and compressing this space to achieve lordosis. On average, 5 to 10 degrees of lordosis can be achieved with this technique per level.

295. **C** 21 to 30 degrees
   A pedicle subtraction osteotomy involves removing a triangle of bone including the facet joint, some lamina and a portion of the pedicle bilaterally with the hinge point at the ALL and then compressing this space posteriorly. Doing this procedure can lead to ~ 30 degrees of correction for each level.

296. **D** L5-S1
   An ALIF is a direct anterior approach to the lumbar spine for interbody fusion. It is best utilized for fusion of the L5-S1 space given that the great vessels have split and do not need to be mobilized. Further, significant correction of lordosis can be achieved and this correction is magnified by performing this procedure at the lowest level in the spine.

297. **B** Knee extension
   The DLIF procedure involves either splitting the psoas muscle or going just anterior to the psoas for exposure. This puts the femoral nerve at risk for traction or direct injury during surgery, thus knee extension weakness can be seen postoperatively.

298. **B** Massive blood loss
   Performing a PSO can be difficult and may lead to very significant blood loss, up to 3 L reported in one series.

299. **D** Anterior longitudinal ligament
   The fulcrum at the operative level after performing a PSO is the anterior longitudinal ligament.

300. **C** 3 cm
   After cutting the ALL, approximately 3 cm of SVA correction can be achieved at each level.

301. **A** Epidural hematoma
   This patient is likely experiencing a postoperative spinal epidural hematoma and should be evaluated immediately.

302. **B** Spinal imaging
   This patient is likely experiencing a postoperative spinal epidural hematoma and should be evaluated immediately. It would be wise to proceed with spinal imaging to determine the extent of the hematoma prior to returning to the OR to avoid the need to perform exploratory laminectomies to find the clot.

303. **B** 9%
   In SCI patients who develop DVTs, mortality has been shown to be 9% in one series.
Contrast enhanced CT scan

The contrast enhanced CT scan of the lungs under the PE protocol is the study of choice if your clinical suspicion is high enough for PE.


IV heparin 5,000 u followed by 1,000 u/hr infusion

If the patient can be anticoagulated, IV heparin 5,000 u should be administered followed by hourly infusions of 1,000 u of heparin with monitoring and further titration based on APTT. In postoperative neurosurgical patients administration of heparin should be monitored closely and with any neurologic change a STAT head CT should be obtained. Intracranial hemorrhage can occur during heparin administration.


< 400 mL/day

It is important to monitor postoperative I/Os especially for elderly patients or patients who have had a large procedure. Oliguria is characterized by < 400 mL of urine production/day


< 1%

A DVT that is limited to the calf only has a minute risk of embolism that is less than 1%. DVTs that extend into the more proximal venous system are higher risk.


Pneumatic compression boots/none

This patient falls under the low risk category (< 40, procedure < 30 minutes, mobile), and therefore no pharmacologic prophylaxis is required.


SQ heparin 5,000 BID

This patient falls under the medium risk category (> 40, procedure > 30 minutes, decreased mobility), and therefore pharmacologic prophylaxis either with SQ heparin BID/TID or LMWH is indicated when deemed safe from a postoperative perspective.


10 to 40%

This patient falls under the medium risk category (> 40, procedure > 30 minutes, decreased mobility), and therefore pharmacologic prophylaxis either with SQ heparin BID/TID or LMWH is indicated when deemed safe from a postoperative perspective. Overall risk in this group is approximately 10 to 40%.


41 to 80%

This patient falls under the high risk category (> 40, procedure > 30 minutes, metastatic disease or high grade glial neoplasm), and therefore pharmacologic prophylaxis either with SQ heparin BID/TID or LMWH is indicated when deemed safe from a postoperative perspective. Overall risk in this group is approximately 41 to 80%.


Prerenal

NSAIDS, along with ACE inhibitors and severe hypovolemia cause prerenal oliguric renal failure. NSAIDS cause this by promoting renal vasoconstriction.


Intrinsic renal

ATN is an intrinsic renal failure as the epithelial cells slough off and form an obstruction within the renal tubules. This is often caused by ischemia.

II Answers

314. A Prerenal
   This patient likely has pre-renal oliguric renal failure given the low urinary sodium. When perfusion is limited, urinary sodium excretion decreases, leading to a low urinary sodium. Urinary sodium < 20 mEq/L helps to establish the diagnosis.

315. B Intrinsic renal
   With intrinsic renal disease, urinary sodium excretion increases (compared to pre-renal where it decreases) and a urine sodium of > 40 mEq/L can help lead to the diagnosis. Urinary sodium cannot distinguish the patient that has intrinsic renal failure with a superimposed pre-renal syndrome however, so it is not absolute.

316. A Prerenal
   In patients with renal failure, FEna can be useful to determine etiology. A FEna of < 1% suggests pre-renal oliguria.

317. A Polymorphous ventricular tachycardia (torsades)
   Patients with severe magnesium deficiency can develop severe cardiac arrhythmias, including torsade de pointes (polymorphous ventricular tachycardia).

318. B Ionized calcium
   Calcium exists in the plasma in several forms, including protein bound (~ 50%) and ionized forms. The protein bound calcium is mostly bound to levels of albumin, which can fluctuate. The total calcium lab value fluctuates with this change, but the ionized calcium level remains the same, and it is the most important physiologic calcium level.

319. B Hypocalcemia
   Hypocalcemia can manifest neurologically with muscular and cardiac excitability as well as hyperreflexia. Tetany is seen in severe cases of hypocalcemia.

320. D Phosphorous
   Refeeding syndrome occurs in patients with chronic malnutrition and alcoholics. In these patients, the body already has severely low levels of phosphorous, and when a glucose load is given, phosphorous follows glucose into the cell and serum levels of phosphorous can drop to dangerous levels.

321. C 1 in 2,000,000
   The current reported risk of HIV seroconversion after receiving blood contaminated with HIV is roughly 1 in 2,000,000.
   Further Reading: http://www.redcrossblood.org/learn-about-blood/blood-transfusions/risks-complications

322. B 1 in 300,000
   The current reported risk of Hepatitis B infection after receiving blood contaminated with the virus is roughly 1 in 300,000.
   Further Reading: http://www.redcrossblood.org/learn-about-blood/blood-transfusions/risks-complications

323. B Thrombosis
   The major risk of heparin-induced thrombocytopenia is thrombosis, not hemorrhage. HIT occurs
when heparin combines with platelet factor 4 and forms an antigenic complex leading to production of IgG. The IgG then binds to platelets and promotes clumping of platelets which can ultimately lead to thrombosis of vessels.

Further Reading: Marino. The ICU Book, page 711.

324.
C Stop all heparin
The initial management of HIT is to of course stop all forms of heparin administration, including heparinized catheters and heparin flushes.

Further Reading: Marino. The ICU Book, page 711.

325.
A Beta agonists
Beta agonists (albuterol for example) can lead to transcellular shift of potassium and cause a serum hypokalemia. Other factors that can cause this include insulin administration, alkalosis and hypothermia.

Further Reading: Marino. The ICU Book, page 649.

326.
C Respiratory acidosis
Potassium acts as a buffering agent for hydrogen ions at the cellular level. When a patient is acidotic, hydrogen ions are shuttle into the cell in exchange for potassium which is shifted extracellularly. This can help decrease the acidosis, but a resultant hyperkalemia can occur.

Further Reading: Marino. The ICU Book, page 653.

327.
B 6.0 mEq/L
Hyperkalemia can lead to cardiac arrhythmias, and changes on a patient’s ECG can be seen with levels of 6.0 mEq/L.

Further Reading: Marino. The ICU Book, page 655.

328.
B Peaked T waves
Hyperkalemia can lead to cardiac arrhythmias, and changes on a patient’s ECG can be seen with levels of 6.0 mEq/L. Often the first sign is a tall, peaked T wave.

Further Reading: Marino. The ICU Book, page 655.

329.
B Administer calcium gluconate
Hyperkalemia can lead to cardiac arrhythmias, and changes on a patient’s ECG can be seen with levels of 6.0 mEq/L. Often the first sign is a tall, peaked T wave. Advanced ECG changes include loss of the P wave and widening of the QRS complex. In patients with advanced ECG changes and hyperkalemia, initial management should include administration of calcium gluconate, as calcium antagonizes the membrane effects of potassium.

Further Reading: Marino. The ICU Book, page 655.

330.
D Recheck the electrolyte panel
Hyperkalemia can lead to cardiac arrhythmias, and changes on a patient’s ECG can be seen with levels of 6.0 mEq/L. Often the first sign is a tall, peaked T wave. Advanced ECG changes include loss of the P wave and widening of the QRS complex. In patients with advanced ECG changes and hyperkalemia, initial management should include administration of calcium gluconate, as calcium antagonizes the membrane effects of potassium. In clinically normal patients with no ECG changes, the potassium level should be repeated due to the high rate of pseudohyperkalemia (20%) caused by traumatic hemolysis.

Further Reading: Marino. The ICU Book, page 652.

337. B B

Given that this patient has no motor function below the injury but has preserved sensation they would be classified as an ASIA B injury.


338. C 3

According to the SLIC system, this patient's fracture morphology would classify as distraction (perched facets) and receive a score of 3. This score is added to PLC integrity and neurology to determine the final score. A score of 5 suggests operative intervention is likely required.


339. A 1

According to the SLIC system, this patient's fracture morphology would classify as distraction (perched facets) and receive a score of 3. The interspinous widening suggests possible PLC injury and 1 point would be scored given the indeterminate PLC status. A score of 5 suggests operative intervention is likely required.


340. C 3

According to the SLIC system, this patient's fracture morphology would classify as distraction (perched facets) and receive a score of 3. The interspinous widening suggests possible PLC injury and 1 point would be scored given the indeterminate PLC status. A score of 5 suggests operative intervention is likely required.


336. A A

Given that this patient does not have motor or sensory function below the level of injury, they would classify as an ASIA A injury.

342. B Fibrillations
   Fibrillation potentials occur with muscle denervation and can only be observed on EMG. Fasciculations occur with the death of anterior horn cells and are observable at rest.

343. C 24 months
   Generally, after a muscle has atrophied after a period of denervation lasting 24 months there is little to no hope of recovery of function even with nerve grafting.

344. B 6 to 8 weeks
   While some neurapraxic peripheral nerve injuries will recover in hours, in many cases it can take 6 to 8 weeks for full recovery.

345. C Wallerian degeneration
   Based on the Seddon classification, there are three types of peripheral nerve injuries, neurapraxia (conduction block but preservation of the axon, spontaneous recovery occurs), axonotmesis (disruption of the axon but preservation of surrounding structures) and neurotmesis (complete disruption of the nerve structure). In axonotmesis and neurotmesis, Wallerian degeneration occurs distal to the injury, but it does not in neurapraxia.

346. C Grade III
   The Sunderland classification further subdivides the neurotmesis group of the Seddon classification. Sunderland grade I is the same as neurapraxia, Sunderland grade II is the same as axonotmesis (disruption of axon), grade III involves disruption of the endoneurium with preservation of the perineurium and epineurium, grade IV involves disruption of the perineurium and grade V involves disruption of all supporting fibers.

347. D Grade IV
   The Sunderland classification further subdivides the neurotmesis group of the Seddon classification. Sunderland grade I is the same as neurapraxia, Sunderland grade II is the same as axonotmesis (disruption of axon), grade III involves disruption of the endoneurium with preservation of the perineurium and epineurium, grade IV involves disruption of the perineurium and grade V involves disruption of all supporting fibers.

348. D Grade V
   The Sunderland classification further subdivides the neurotmesis group of the Seddon classification. Sunderland grade I is the same as neurapraxia, Sunderland grade II is the same as axonotmesis (disruption of axon), grade III involves disruption of the endoneurium with preservation of the perineurium and epineurium, grade IV involves disruption of the perineurium and grade V involves disruption of all supporting fibers.

349. C Immobile Tinel's sign
   In patients with grade III injuries, there will likely be a Tinel's sign over the area of injury that slowly progresses distally with nerve regeneration. This generally does not occur in grade IV injuries as a neuroma in continuity develops. At one month follow-up, a grade IV lesion will likely have a Tinel's sign at the same location, whereas a grade III lesion likely will have demonstrated some distal transition.

350. A 1 mm/day
   Nerves regenerate at roughly 1 mm/day. In grade II lesions, the Tinel's sign should progress distally at a rate of approximately 1 mm/day.
II Answers

351.
C < 72 hours
In clean transection injuries, direct nerve repair should be undertaken within 72 hours for the best outcome.

Further Reading: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1002&context=usuhs

352.
B Debridement and tagging of the nerve endings
In cases of contaminated nerve injury, wound debridement should occur and transected edges of nerve should be tagged and sutured to local structures to prevent nerve ending retraction. Antibiotics should be administered and nerve repair can occur when any infection has been fully treated. A contaminated nerve injury should not be immediately repaired as any subsequent infection may inhibit nerve regeneration.

Further Reading: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1002&context=usuhs

353.
A Direct nerve repair
In clean transection injuries, direct nerve repair should be undertaken within 72 hours for the best outcome. Direct neurorrhaphy will likely provide the best functional outcome rather than nerve grafting or other techniques. This is assuming a tension free repair is possible.

Further Reading: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1002&context=usuhs

354.
C 3 weeks
In suspected cases of Sunderland grade II+ lesions, initial EMG should be performed approximately 3 weeks after the injury to allow Wallerian degeneration to occur. Even in an axonotmesis or neurotmesis level injury, the distal stump can continue to conduct for 1 week after the injury. This topic is somewhat controversial however, as some believe that immediate EMG can be beneficial for injury localization.

Further Reading: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1002&context=usuhs

355.
B Distance from injury to end muscle
In most cases, surgical repair utilizing end to end direct repair or grafting occurs sometime between 3 and 6 months after injury. Timing is based on several factors, but most importantly, the distance of nerve regeneration between the area of injury and the target muscle should be considered. Longer distances for regeneration should be operated earlier in an attempt to beat the “24-month rule” where irrecoverable atrophy of the muscle has occurred. Some surgeons consider 18 months the point at which irrecoverable atrophy has occurred.

Further Reading: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1002&context=usuhs

356.
D Abductor pollicis brevis
At this time, recovery of hand function lost after brachial plexus injury is very unlikely to occur even with prompt surgical repair of the affected nerves. The distance required for nerve regeneration to the target muscle is too long and irreversible atrophy often occurs before regeneration can reach the hand.


357.
D Disrupted SNAP
It is important to determine whether a brachial plexus injury is pre-ganglionic or post-ganglionic. Preganglionic injuries are often caused by nerve root avulsion and no neurolysis or nerve repair of the brachial plexus will fix this type of injury. Patients with preganglionic injuries will often demonstrate a winged scapula (long thoracic loss), pseudomeningocele on MRI, a Horner’s syndrome (lower trunk injuries) and intact SNAP even in anesthetic regions.

"Parsonage-Turner syndrome." Often this presents with severe shoulder pain followed by development of weakness in one or more muscle groups. There are several potential etiologies including postoperative inflammatory reactions as well as viral disease, but nothing proven. Recovery is thought to be roughly 89% at 3 years. While many physicians give steroids, there are no studies demonstrating any benefit of steroids in this circumstance.


362.
B No

The onset of intense shoulder pain without weakness initially should concern you for the development of idiopathic brachial plexitis, or "Parsonage-Turner syndrome." Often this presents with severe shoulder pain followed by development of weakness in one or more muscle groups. There are several potential etiologies including postoperative inflammatory reactions as well as viral disease, but nothing proven. Recovery is thought to be roughly 89% at 3 years.

weight loss should first be attempted as this can reverse the condition. Approximately 90% of these cases will resolve with conservative management and do not require surgery.


371.
B  Wrist drop
The radial nerve branches into the posterior interosseous nerve and the superficial radial sensory nerve. The PIN can be compressed leading to finger extensor weakness, but since the branches to the wrist extensors have already branched prior to the PIN, wrist drop is not present in PIN palsy.


372.
B  Foot inversion
Differentiating an L5 radiculopathy from a CPN palsy can be difficult, and hints are given based on the presentation. EMG can be helpful. Foot inversion will be weak in cases of L5 radiculopathy but preserved in CPN palsy.


373.
A  Deep
The deep branch of the CPN innervates the anterior tibial while the superficial branch innervates the peroneus longus and brevis.


374.
A  True
In tarsal tunnel syndrome there is often pain on the bottom of the foot as well as weakness of toe flexion/intrinsic musculature. There is often sparing of sensation of the heel given that the sensory branches to the heel have already left the tibial nerve before it passes through the retinaculum.

375.  
A Suprascapular nerve  
The suprascapular nerve innervates the supraspinatus (shoulder abduction) and infraspinatus (external rotation).  

376.  
B False  
Type II compression of the ulnar nerve in Guyon’s canal is purely compression of the deep branch which is a pure motor branch with no sensory innervation. Types I and III both have involvement of varying degrees of ulnar sensation.  

377.  
A Wrist ganglion  
A wrist ganglion is the most common cause of compression within Guyon’s canal.  

378.  
C Gilliatt-Sumner hand  
A cervical rib causing neurologic compression can lead to thoracic outlet syndrome which has a characteristic physical exam finding, the Gilliatt-Sumner hand, with weakness and atrophy of both the thenar and hypothenar areas as well as interossei weakness. Atrophy of both of these regions should make you think of a plexus etiology or aberrant hand innervation.  

379.  
C Phrenic nerve  
The phrenic nerve runs on the anterior scalene muscle and can be damaged during brachial plexus exploration. Care should be taken to protect the phrenic nerve during dissection.  

380.  
D > 3.7 msec  
EMG is a very sensitive test for CTS, and a gold standard EMG evaluation includes sensory latency across the median nerve at the wrist. Sensory latency > 3.7 msec is diagnostic of CTS.  

381.  
A Stimulated activity  
There are three phases to the EMG examination, insertional activity, spontaneous activity and volitional activity. There is no stimulated activity as a part of the routine EMG examination.  

382.  
A True  
A lumbar radiculopathy caused by a HLD involves the nerve roots, and given that the DRG will not be affected (at least initially) the SNAP will be normal on EMG.  

383.  
B False  
In a suspected brachial plexopathy the injury is most likely distal to the DRG and therefore the SNAP will be abnormal on EMG.  

384.  
A True  
In a suspected nerve root avulsion the DRG will remain intact and therefore the SNAP will be normal on EMG.  
385.  
C 85%  
EMG examinations can be highly dependent on the EMG technician, but the approximate accuracy of diagnosing the level of a lumbar radiculopathy based on EMG alone is ~ 85%.  

386.  
C Volitional activity  
MUAPs are recorded during the volitional activity portion of the EMG examination to determine if the patient is able to recruit any function with volitional activity. Stimulated activity is not a phase of the routine EMG examination.  

387.  
B Spontaneous activity  
Muscle fibrillations occur spontaneously and therefore are best evaluated during the spontaneous activity phase of the EMG examination. Stimulated activity is not a phase of the routine EMG examination.  

388.  
B Multilevel radiculopathy  
The F wave on EMG is helpful in that it suggests multilevel involvement rather than an individual level.  

389.  
B 7 to 10 days  
Initial EMG after nerve injury should be delayed for at least 7 to 10 days to allow for Wallerian degeneration to occur if present and for fibrillations to occur. Many surgeons would recommend waiting 3 to 4 weeks for full degeneration to occur prior to initial EMG.  
395. 
B False
There are no reliable muscle groups that can be utilized to determine the presence of a C4 radiculopathy on EMG.

396. 
B Postlaminectomy patient
Postlaminectomy patients often do not have paraspinal muscle activity on EMG given that those muscles are often affected by the surgical exposure.

397. 
C Volitional activity
Interference pattern is evaluated during volitional activity. During volitional muscle contraction, the interference should block out all other activity on the EMG examination.

398. 
A Motor unit loss
Interference pattern is evaluated during volitional activity. During volitional muscle contraction, the interference should block out all other activity on the EMG examination. When reduced interference is seen, it is likely due to loss of motor units.

399. 
A Myotonic discharges
The dive bomber sound on EMG is consistent with myotonic discharges from muscle. This is seen in any condition causing myotonia.

400. 
B False
EMG can be useful to help differentiate location or even etiology of a neuropathy, but in cases where there is a normal motor examination the EMG findings are highly likely to be normal as well.

401. 
B Specific
For lumbar radiculopathy, EMG may have some difficulty with sensitivity in picking up the radiculopathy, however when an abnormality is present, EMG is highly specific.
1. B Aquaporin channel
   This patient has neuromyelitis optica (Devic’s disease) which is a variant of multiple sclerosis that involves the optic nerves and often presents with longitudinal spinal cord T2 signal change that spans three levels (compared with transverse myelitis which does not span that many segments).

2. D JC virus infection
   This patient has classic signs and symptoms of progressive multifocal leukoencephalopathy, caused by JC virus infection that destroys oligodendrocytes in patients with AIDS. It often presents as an asymmetric, parieto-occipital area of demyelination.

3. B Botulism
   Both myasthenia gravis and botulism can affect extraocular muscles but the pupils are spared in myasthenia and involved in botulism.

4. C Dorsal midbrain
   This patient has convergence-retraction nystagmus, which can be a form of Perinaud’s syndrome, caused by compression or destruction of dorsal midbrain nuclei.

5. D Miosis
   Pontine hemorrhage leads to bilateral pinpoint pupils. This occurs because the descending sympathetic tracts are disrupted while the parasympathetic tracts to the pupil remain intact.

6. C Third order neuron
   The third order neuron involved in pupillary dilation must be intact for Paredrine to cause dilation of the pupil.

7. A Autosomal recessive
   Friedreich’s ataxia is caused by a mutation in the frataxin gene, and dysfunction causes failure of iron transport into mitochondria. It often involves a trinucleotide repeat and causes degeneration of the dentate nucleus and spinocerebellar tract. It is inherited in an autosomal recessive fashion.

8. A Neurofibromatosis type I
   Sphenoid hypoplasia is often seen in patients with NF1.

9. B Epstein-Barr virus/B cell type
   Lymphoma is thought to develop in up to 5% of patients with HIV. It is associated with Epstein-Barr virus. It is a B cell lymphoma. Treatment involves chemotherapy and dexamethasone as well as whole brain radiation. Survival is short, with the median survival being 3 months.
10. **C** Tau protein

   Neurofibrillary tangles are found in patients with Alzheimer’s dementia. They are comprised of tau protein.


11. **D** Occipital cortex

   Alzheimer’s dementia is graded pathologically, and when neurofibrillary tangles and plaques are found in the occipital cortex, the highest grade (grade IV disease) is diagnosed.


12. **C** Dystrophin/completely absent

   This describes a patient with Duchenne’s muscular dystrophy, a rapidly progressive muscular dystrophy causing wasting of proximal muscles. It is caused in many cases by a frameshift mutation which leads to complete absence of the dystrophin gene. Becker’s muscle dystrophy causes partial dysfunction of the dystrophin gene but has similar symptoms to Duchenne’s, except that it progresses in a much slower fashion.


13. **E** Anti-Ma

   Patients with limbic encephalitis can be found to have autoantibodies (Anti-Ma). It is important to rule out herpes encephalitis in these patients.


14. **C** ATP pump failure

   The cognitive dysfunction that occurs in the postconcussive syndrome is thought to occur due to ATP pump failure at the cellular level. There are multiple cellular events that are also thought to be associated with this condition.


15. **B** Cognitive rest

   Patients who have experienced a concussion should go through a regimen of cognitive and physical rest until they can progress through stages of increased activity without symptoms.


16. **B** Functional hemispherectomy

   Rasmussen’s encephalitis is a debilitating disease process that causes epilepsy partialis continua in some patients. Prolonged seizures lead to intellectual disability and significant brain dysfunction. Functional hemispherectomy has been utilized to treat this condition.


17. **C** Ethosuxamide

   This EEG demonstrates a burst of generalized 3 Hz spike and wave activity associated with absence seizures. These seizures are best treated with ethosuxamide.


18. **A** < 5%

   In patients who experience a simple febrile seizure, very few (< 5%) will go on to develop any ongoing epilepsy after the initial febrile seizure.


19. **C** Joubert syndrome

   This MRI demonstrates the “molar tooth” malformation commonly seen in Joubert syndrome. There is cerebellar peduncle hypoplasia, a small midbrain and a batwing-shaped fourth ventricle.

20. Pain before weakness
Brachial neuritis can occur after viral infection, and sometimes in the postoperative setting. The full pathophysiology is not well understood, but is thought to be an inflammatory reaction in multiple nerve distributions. It presents with severe shoulder pain followed by resolution and then development of motor weakness of the affected extremity.

This patient has a persistent connection between the extracranial veins and the superior sagittal sinus, known as sinus pericranii. This is often seen in patients with blue rubber bleb nevus syndrome.

22. Arsenic
Mees' transverse white lines on the fingernails are associated with arsenic exposure.

23. Dysembryoplastic gangliocytoma of the cerebellum
Dysembryoplastic gangliocytoma of the cerebellum (Lhermitte-Duclos disease) is a finding associated with PTEN mutations and Cowden's syndrome. This syndrome is also associated with multiple trichilemmomas, breast, and endometrial carcinoma.

24. REM sleep
Patients with narcolepsy exhibit sleep-onset REM. This is classic for this condition.

25. EEG electrodes are placed in a standard fashion, with corresponding letters as follows: F = frontal, C = central, P = parietal, O = occipital. Even numbers correspond with the right side of the head, and odd numbers correspond to the left side of the head.

26. Bithalamic destruction
While respiratory patterns are difficult and unreliable for diagnosing lesion locations, Cheyne-Stokes respiratory patterns (waxing and waning respiratory patterns) can be seen in patients with bithalamic injury.

27. Pituitary adenoma enlargement
Nelson's syndrome occurs when a patient with a previously unknown ACTH secreting pituitary adenoma undergoes a bilateral adrenalectomy. Loss of feedback inhibition of ACTH production leads to rapid enlargement of the pituitary adenoma.

28. Low serum ceruloplasmin, high urine copper
This image demonstrates Kayser-Fleischer rings and confirms the diagnosis of Wilson's disease. This patient would be expected to have low serum ceruloplasmin and high urinary excretion of copper.

29. Positioning-related brachial plexus compression
Erb's point is near the shoulder and when sensory latency is prolonged at Erb's point, a positioning palsy of the brachial plexus should be considered. In this case, with a low ACDF, pulling on the shoulders to achieve a better X-ray line of sight can lead to brachial plexus traction.
30.  
**B** Painful and temporary  
Diabetic third nerve palsies are often pupil-sparing (center of the nerve is involved rather than the parasympathetic fibers that travel in the peripheral aspect of the nerve). It is painful and temporary.  

31.  
**D** Sympathetic blockade  
This patient has complex regional pain syndrome type I (no nerve injury). Often medications are used to treat this condition, but when these fail, sympathetic blockade can be considered. Neurectomy and cordotomy may worsen the condition.  

32.  
**C** Homocystinuria  
This patient has a transverse sinus thrombosis which has resulted in a temporal lobe infarction. Patients with homocystinuria can have prothrombotic states that lead to intracranial sinus thrombosis.  
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 213.

33.  
**C** 48 hours  
Pentobarbital is a long-acting sedative that can be used for refractory ICP elevation. When therapy is ceased, it can take 48 hours for neurologic function to return.  

34.  
**C** Dorsal root ganglion  
The H-reflex is used in the S1 nerve and approximates the reflex arc of the spinal cord. Signal is sent through the peripheral sensory nerves and motor response is recorded. The F-wave involves supramaximal stimulation of the peripheral motor nerves and the wave propagates proximally through the nerve root into the spinal canal, also firing several other nerve roots as well in the process. It is a way to determine the integrity of the motor roots. If the H-reflex is absent but the F-wave is normal, the problem is likely to be in the DRG.  

35.  
**C** Ear vesicles  
Ramsay Hunt syndrome (zoster oticus) can present similar to Bell’s palsy with facial weakness, but attention should be paid to the development of vesicular rashes on the ear, as this leads to the diagnosis of zoster oticus.  

36.  
**D** Brain MRI  
This patient has vertigo and there are several signs that would make you think this is central in origin rather than peripheral. She is having difficulty standing and walking, it was a fairly acute onset, there is little nausea, and she has both skew deviation and spontaneous direction changing nystagmus. MRI will likely demonstrate a cerebellar stroke.  

37.  
**B** Inner hair cells  
The inner hair cells of the ear are extremely sensitive to high volume and repeated exposure to high volume can lead to loss of inner hair cells.  

38.  
**A** Medial longitudinal fasciculus  
Internuclear ophthalmoplegia can be seen in patients with MS. It is caused by disruption of the medial longitudinal fasciculus, which connects the abducens nucleus to the contralateral oculomotor nucleus in order to preserve conjugate eye movements.  
41. B Incremental response
Lambert-Eaton syndrome involves autoantibodies directed against calcium channels on the presynaptic membrane. This decreases neurotransmitter release due to lack of calcium. EMG will initially be flat, but with repetitive actions there will be an incremental response as calcium levels increase.

42. C Leukoencephalopathy
The most common neurological complication of HIV infection is HIV leukoencephalopathy.
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 22.

43. B Peripheral neuropathy
Charcot joints (neuropathic osteoarthropathy) are commonly seen in patients with diabetes who have peripheral neuropathy. The neuropathy leads to destruction of the joint over time.

44. C Neuroblastoma
Opsoclonus-myoclonus syndrome is a rare disease seen in some patients with neuroblastoma. It is thought to be mediated by an autoimmune phenomenon.
51. C Primary neurulation defect

Spina bifida is one type of spinal dysraphism that is often discovered on imaging or utilizing serum alpha fetoprotein levels. It is caused by errors in primary neurulation.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 64.

52. A Gastrulation defect

Diastematomyelia (split cord malformation) results from an error in gastrulation. There are two subtypes: Type I, when there are two separate dural tubes divided by a fibrous band, and Type II, where there are two hemicords but one continuous dural covering.


53. B Arnold-Chiari type II malformation

Myelomeningocele (herniation of the dura and neural elements through a spinal defect posteriorly) is often associated with Chiari II malformations. Other associations include hydrocephalus, microgyria, basilar invagination, and bending or “beaking” of the brainstem can be seen.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, Page 66.

54. D 21

Agenesis of the corpus callosum is associated with trisomy 13, 15, and 18, but not trisomy 21.


55. C Trigonocephaly

The metopic suture is located in the midline of the forehead and regresses as normal aging occurs. When craniosynostosis involves the metopic suture, trigonocephaly (wedge-shaped or triangle-shaped head) occurs.


56. D Thymic atrophy

This patient has ataxia-telangiectasia, an autosomal recessive condition associated with cutaneous telangiectasias and ataxia, dysarthria, and chorea. These patients have difficulty with DNA repair and can be very sensitive to CT scans. They also exhibit atrophy of the thymus and can be susceptible to infections and malignancies (especially lymphoma).


57. A Spinal muscle atrophy type I

This child has spinal muscle atrophy type I (Werdnig-Hoffman disease), a progressive lower motor neuron disease that leads to advanced hypotonia and muscle atrophy in infants. Ultimately these children die after 4 to 6 weeks of respiratory failure. There are 4 spinal muscle atrophies based on age and symptoms. SMA type I is quickly progressive and presents in infants, while type IV presents in adults and is more slowly progressive.

58. C  TGF-B
   This patient has hereditary-hemorrhagic telan-
   giectasia, or Osler-Weber-Rendu disease. It is asso-
   ciated with AVMs of the brain and other organs.
   TGF-B receptors are mutated in this condition.
   Further Reading: Psarros. The Definitive Neurosur-
   gical Board Review, page 74.
   Albright, Pollack, Adelson. Principles and Practice

59. B  Wyburg-Mason syndrome
   This patient has Wyburg-Mason syndrome, a
   disorder that presents with facial nevi and orbit-
   al/optic pathway AVMs. The underlying cause of
   this disorder is currently unknown. Patients often
   present with SAH and seizures.
   Further Reading: Psarros. The Definitive Neurosur-
   gical Board Review, page 74.
   Citow, Macdonald, Refai. Comprehensive Neuro-
   surgery Board Review, 2nd edition, 2010, neuro-
   l ogy section.

60. D  Marchiafava-Bignami disease
   This is the classic “Italian-man” disorder origi-
   nally described in Italian men who consume large
   quantities of wine. These patients are found to
   have demyelination and necrosis of the corpus cal-
   losum. The onset often leads to initially nonspecif-
   ic symptoms including depression, memory loss,
   and confusion.
   Further Reading: Psarros. The Definitive Neurosur-
   gical Board Review, page 77.
   Citow, Macdonald, Refai. Comprehensive Neuro-
   surgery Board Review, 2nd edition, 2010, neuro-
   l ogy section.

61. A  Mucopolysaccharide degradation
   These symptoms describe Hurler’s syndrome (as
   compared to Hunter’s syndrome without corneal
   clouding), which is caused by a defect in α-L-iduro-
   nidase, one of the mucopolysaccharidoses.
   Further Reading: Psarros. The Definitive Neurosur-
   gical Board Review, page 78.
   Albright, Pollack, Adelson. Principles and Practice

62. B  Hypoxanthine-guanine-phosphoribosyltrans-
   ferase
   This child has the classic symptoms of Lesch-
   Nyhan syndrome, with mental retardation and
   self-mutilation often presenting with chewing of
   the fingertips. This is caused by a deficiency in the
   enzyme HPRT and leading to an increase in levels
   of uric acid.
   Further Reading: Psarros. The Definitive Neurosur-
   gical Board Review, page 80.
   Albright, Pollack, Adelson. Principles and Practice

63. B  Acute intermittent porphyria
   This patient has the classic symptoms of acute
   intermittent porphyria, an unfortunately often
   tested disorder on the neurosurgery boards. It
   results from abnormal metabolism of heme, and
   there is evidence of urinary excretion of ami-
   nolevulinic acid, porphobilinogen, and several
   porphyrins.
   Further Reading: Psarros. The Definitive Neurosur-
   gical Board Review, page 81.
   Citow, Macdonald, Refai. Comprehensive Neuro-
   surgery Board Review, 2nd edition, 2010, neuro-
   l ogy section.

64. A  Halloverden-Spatz disease
   This child has symptoms consistent with
   Halloverden-Spatz disorder, and the MRI confirms
   the diagnosis. These patients have movement
   disorders, and MRI demonstrates the classic “eye
   of the tiger” phenomenon in the globus pallidus
   bilaterally.
   Further Reading: Psarros. The Definitive Neurosur-
   gical Board Review, page 81.
   Citow, Macdonald, Refai. Comprehensive Neuro-
   surgery Board Review, 2nd edition, 2010, neuro-
   l ogy section.

65. B  Superficial siderosis
   This patient has evidence of superficial sider-
   osis, as evident by the clinical symptoms (hearing
   loss, ataxia) and the imaging findings (GRE) posi-
   tivity on the surface of the cerebellum). These signs
   and symptoms, taken with evidence of a chronic
   CSF leak lead to a diagnosis of superficial siderosis.

66.  
D Lennox-Gastaut syndrome  
Lennox-Gastaut syndrome is a chronic epilepsy condition that is characterized but multiple, uncontrolled daily seizures, mental retardation, and spike and wave complexes at 1 to 2 Hz on EEG.

67.  
A West syndrome  
West syndrome, also known as infantile spasms, presents with flexor/extensor spasms that are persistent and demonstrate hypsarrhythmia on EEG (chaotic appearance). West syndrome can present after CNS infections/hypoxic events or be sporadic.

68.  
C Pfeiffer syndrome  
This patient has Pfeiffer syndrome, characterized by craniosynostosis, deafness, hypertelorism, and dental problems. It is caused by mutations in the FGFR gene and is inherited in an autosomal dominant fashion.

69.  
B Apert syndrome  
This patient has Apert syndrome, characterized by craniosynostosis, hypertelorism, dental problems, and syndactyly of at least 3 fingers on each hand and at least 3 toes on each foot. This is a helpful way to distinguish from Pfeiffer syndrome, which can also have syndactyly, but does not require it on each hand/foot for the diagnosis.

70.  
D Crouzon syndrome  
This patient has evidence of Crouzon syndrome, characterized by craniosynostosis, deafness, hypertelorism, and cleft palate. The cleft lip/palate is characteristic for this syndrome and helps to distinguish it from Apert syndrome and Pfeiffer syndrome.

71.  
C Increased activity of the indirect pathway  
Loss of dopaminergic neurons in the SNR leads to Parkinsonism, characterized by 3 to 5 Hz resting tremor, bradykinesia, cog-wheel rigidity, postural imbalance, and masked facies. The loss of dopaminergic input into the striatum leads to overactivity of the indirect pathway and decreased activity of the direct pathway, leading to the classic symptoms.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 68.

72.  
A Mitochondrial dysfunction  
Mitochondrial dysfunction is thought to play a role in Parkinsonism. Specifically, loss of mitochondrial complex I activity is thought to result in the increased levels of α-synuclein and ubiquitin within neurons.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 68.

73.  
B Progressive supranuclear palsy  
This patient has progressive supranuclear palsy, which can present like Parkinson patients and is considered a Parkinson plus disorder. It has the characteristic findings of Parkinsonism, but patients lack the tremor and have downward gaze paralysis. The disease course is rapidly progressive. Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 68.

74.  
D  Olivopontocerebellar atrophy  
This patient has signs and symptoms of Parkinsonism; however, there are multiple findings concerning for cerebellar involvement. This makes one of the multiple system atrophies more likely, specifically olivopontocerebellar atrophy, which presents predominantly with cerebellar findings. Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 68.  

75.  
A  Corticobasal degeneration  
This patient has symptoms consistent with corticobasal degeneration, specifically the involvement of only one limb as well as the “alien-limb” phenomenon. These patients also exhibit Parkinson-like symptoms of the limb and have increased deep tendon reflexes. Dementia is not often a part of this disorder. Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 69.  

76.  
B  GABA projections from the striatum to the GPe  
Huntington’s disease is known to cause caudate atrophy, but also greatly affects the GABA projections from the striatum to the GPe (indirect pathway). Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 69.  

77.  
B  Contralateral subthalamic nucleus  
Hemiballismus (the sudden, brief movement of a limb from the resting position without continued contraction) results from damage or degeneration of the contralateral subthalamic nucleus. Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 69.  

78.  
C  6 to 8 Hz  
Essential tremor is often seen at a frequency of 6 to 8 Hz. Intention tremor occurs at 2 to 3 Hz, 3 to 5 Hz describes the resting tremor of Parkinsonism, and physiologic or postural tremor occurs at 8 to 13 Hz. Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 70.  

79.  
C  Trisomy 21  
Alzheimer’s dementia is associated with Down’s syndrome (Trisomy 21). Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 70.  

80.  
C  E4 of apolipoprotein E  
The E4 allele of apolipoprotein E has been found to be associated with 25 to 40% of cases of Alzheimer’s disease. Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 70.  

81.  
D  Pick’s disease  
Pick’s disease is one of the frontotemporal dementias, characterized by symptoms of frontal and temporal lobe degeneration as well as progressive dementia. This patient has Klüver-Bucy syndrome as well as frontal release signs (sucking and rooting reflexes). This constellation of symptoms leads to the diagnosis of a FTD, in this case Pick’s disease. Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 71.  

82.  
B  Dementia with Lewy bodies  
This patient has symptoms classic for dementia with Lewy bodies. Progressive cognitive difficulties as well as mild Parkinsonism and recurrent hallucinations lead to the diagnosis.

83.
C  Binswanger’s disease
This patient has cognitive decline at a fairly young age in the setting of chronic hypertension and evidence of small vessel white matter ischemic disease on MRI. This can lead to a diagnosis of Binswanger’s disease.
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 3.

84.
D  Multi-infarct dementia
Multi-infarct dementia classically presents with stepwise decline in function. It is considered degeneration of cortical structures while Binswanger’s disease is a subcortical infarct-based dementia.

85.
C  Aromatic amino acid decarboxylase
Carbidopa is an inhibitor of aromatic amino acid decarboxylase in the periphery in order to decrease degradation of L-DOPA before it reaches the brain in sufficient levels. Carbidopa does not cross the blood brain barrier.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 68.

86.
A  Refsum disease
This patient has Refsum disease, a progressive peripheral neuropathy that is due to increased levels of phytic acid in tissues. The findings are reversible if patients are able to cut phytol (phytanic acid precursor) from their diets.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 82.

87.
C  Campylobacter jejuni
Guillain-Barre syndrome can be associated with bacterial infections of the GI tract, specifically campylobacter infections.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 83.

88.
A  High protein, low cellularity
This patient has Guillain-Barre syndrome and the classic findings include albuminocytologic dissociation, leading to high protein and low cellularity within the CSF.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 83.

89.
B  Femoral nerve
Diabetic amyotrophy usually involves the femoral nerve, and presents with asymmetric muscle weakness, atrophy of iliopsoas, quadriceps, and thigh adductor muscles with burning pain.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 83.

90.
B  Mycobacterium leprae
Several pathogens can cause the development of peripheral neuropathy, but the most common worldwide is Mycobacterium leprae.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 84.

91.
B  Dermatomyositis
This patient presents with the classic heliotrope rash of the face, proximal leg weakness (myositis), as well as scaly macules of the hand (Gottron’s
sign). These findings lead to the diagnosis of dermatomyositis.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, Page 86.


92. Maternal imprinting of chromosome 15
This patient has Angelman syndrome, and inappropriate laughter is a helpful key to the diagnosis. This condition results from maternal imprinting on chromosome 15. Prader-Willi syndrome results from paternal imprinting.


93. Stage 2
Sleep spindles (12–14 Hz sinusoidal waves) and K-complexes (brief high voltage discharges) are EEG phenomena seen during stage 2 of sleep.


94. Sleep-onset REM
Patients with narcolepsy exhibit REM sleep very early during their sleep cycles, the so called “sleep-onset REM” which is diagnostic of the condition.


95. Hypocretin/orexin
Narcolepsy is thought to arise from abnormalities within the hypocretin/orexin signaling pathway. These neuropeptides are involved in sleep regulation.


96. Inferior colliculus
BAER monitoring is utilized during many MVD procedures. The waves and corresponding structures are listed as follows: Wave I (auditory nerve), Wave II (cochlear nuclei), Wave III (trapezoid body), Wave IV (lateral lemniscus), Wave V (inferior colliculus), Wave VI (medial geniculate body), and Wave VII (auditory radiations).

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 89.


97. Antibodies against postsynaptic acetylcholine receptors
This patient has symptoms of myasthenia gravis, a condition that arises due to development of antibodies against postsynaptic acetylcholine receptors.


98. Antibodies against presynaptic voltage gated calcium channels
This patient has Lambert-Eaton syndrome, caused by antibodies to presynaptic calcium channels. This condition is associated with paraneoplastic disorders, specifically small cell lung cancer. The weakness is overcome with exercise.


99. Exotoxin production inhibiting presynaptic release of acetylcholine
This patient has botulism, caused by exotoxin release that ultimately inhibits release of acetylcholine at the NMJ. Botulism can cause respiratory
weakness similar to myasthenia gravis, but presents with nausea/vomiting, GI symptoms, and bilateral pupillary paralysis.


100.

C Thymus

Around 15% of patients with MG have an encapsulated tumor of the thymus.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 90.
1. B P2
   Ascending deep to the rest of the PCA, the medial posterior choroidal artery supplies the tegmentum, midbrain, posterior thalamus and pineal gland as the cisternal segment. It then penetrates the velum interpositum, running in the roof of the third ventricle supplying the choroid plexus.

2. C Trochlear
   Structures passing through the ambient cistern include the posterior cerebral artery, the supracerebellar artery, the basal veins of Rosenthal and the trochlear nerve (CN IV). Further Reading: Binder, Sonne, Fischbein. Cranial Nerves: Anatomy, Pathology, Imaging, 2010, chapter 4, trochlear nerve.

3. D Petrous
   The vidian artery originates from the C2 segment of the ICA, the petrous segment. It passes through the vidian canal and can anastomose with a branch of the internal maxillary artery forming an ICA/ECA anastomosis site. The other branch from the C2 (petrous segment) is the caroticotympanic artery.

4. A Crista galli
   The crista galli is a structure arising from the surface of the ethmoid bone, serving as the point of attachment for the falx. It is a midline structure and projects into the anterior cranial fossa.

5. C Calcarine artery
   Brodmann area 17 is the primary visual cortex (V1), also known as the calcarine cortex, and it is the primary input of signals coming from the retina. This cortical region lies inferior to the calcarine sulcus in the medial border of the occipital lobe.

6. B Inferior frontal gyrus
   Brodmann area 44 corresponds to the inferior frontal gyrus, or Broca's area. It is made of three structures, from anterior to posterior, the pars orbitalis, the pars triangularis and the pars opercularis. Broca's area is thought to be formed mainly by the pars triangularis and the pars opercularis.

7. B Putamen and globus pallidus
   The lentiform nucleus is the combination of the putamen and globus pallidus. Lentiform nucleus comes from lenticular, meaning biconvex, similar to a lens. These structures appear lens-like, giving them this name.

8. D External capsule and extreme capsule
   The claustrum is a thin sheet of neurons separating the external capsule from the extreme capsule. It receives input from almost all regions of cortex and projects back to almost all regions of cortex. While exact function is not fully understood, it is currently thought to play a role in communication between cerebral hemispheres, and may play a role in attention.
9. Arcuate fasciculus

The arcuate fasciculus is a set of association fibers connecting the superior temporal gyrus/angular gyrus (Wernicke's region) to the inferior frontal gyrus (Broca's area). Lesions disrupting these fibers lead to a conductive aphasia, whereby patients have difficulty repeating phrases, but productive and receptive language remains intact.


10. Ipsilateral monocular blindness

The anterior choroidal artery arises from the internal carotid in the communicating segment (C7). It arises approximately 3 mm distal to the posterior communicating artery and 3 mm proximal from the ICA terminus. It has a characteristic superior bend as it crosses the tentorial edge. Anterior choroidal artery infarctions lead to a characteristic syndrome including contralateral hemiparesis, contralateral hemianesthesia and contralateral hemianopia. Since the lesion is posterior to the optic chiasm, monocular blindness is not a part of the anterior choroidal artery syndrome.


11. Day 24

The lamina terminalis lies just posterior to the optic chiasm and may be perforated during exposure to drain CSF from the third ventricle and relax the brain. The lamina terminalis is formed after closure of the anterior neuropore on day 24 of development. The posterior neuropore closes on day 26, and forms the neural elements of the lumbar spine.

Further Reading: Torres-Corzo, Rangel-Castilla, Nakaji. Neuroendoscopic Surgery, 2016, lamina terminalis fenestration.

12. Ventral posterolateral nuclei–Somatosensory cortex

The thalamus is comprised of multiple relay nuclei and their afferent/efferent projections are often tested on the written boards. The anterior nuclei receive input from the mammillothalamic tract and fornix and project largely to the cingulate cortex. The mediodorsal nuclei receive input from the amygdala, substantia nigra pars reticulata, hippocampus, hypothalamus and entire prefrontal cortex. They project to the orbital frontal cortex and frontal eye fields. The VPL nuclei are the primary sensory relay station, they receive input from the medial lemniscus and both spinothalamic tracts (anterior and lateral). The VPL nuclei project to the somatosensory cortex. The pulvinar receives input from the superior colliculus and occipital striate cortex, sending projections to the primary and secondary visual cortices.


13. CA3

The hippocampus is made of 4 regions. CA1, also known as Sommer’s sector, is extremely sensitive to hypoxia, while CA3 is located at the genu of the hippocampal formation and is relatively resistant to hypoxia.

Further Reading: Greenstein B, Greenstein A. Color Atlas of Neuroscience, 2000, the hippocampus.

14. Foramen spinosum

The primary artery feeding the pachymeninges is the middle meningeal artery, and it enters the skull through the foramen spinosum.


15. Superior

In the roof of the third ventricle, the body of the fornix resides superior to the paired internal cerebral veins.


16. Fornix

Part of the Papez circuit, the hypothalamus receives input from the hippocampus through the fornix, which projects to the hypothalamic septal, dorsal and lateral preoptic regions through the precommissural fibers, and to the mammillary
bodies through the postcommissural fibers. Information is then sent to the thalamus through the mammillothalamic tract.

Greenstein B, Greenstein A. Color Atlas of Neuroscience, 2000, the hippocampus.

17. D Insular cortex
The amygdala is part of the limbic system and receives input from all structures mentioned above. By far, the largest input to the amygdala is through the insular cortex.


18. A Medial geniculate body
Brodmann areas 41 and 42 correspond to Heschel’s gyrus, or the primary auditory cortex located in the superior temporal gyrus. The primary input is the medial geniculate body. The lateral geniculate body and superior colliculus are involved in visual pathways, while the inferior colliculus provides projections to the medial geniculate body via the brachium of the inferior colliculus.

Greenstein B, Greenstein A. Color Atlas of Neuroscience, 2000, the special senses: auditory cortical areas and descending auditory pathways.

19. C Left superior quadrant anopsia
The seizure semiology presented in this case is classic for temporal lobe epilepsy, often caused by mesial temporal sclerosis. The symptoms from this patient localize to the right temporal lobe. This condition can be treated by selective amygdalohippocampectomy, or even complete temporal lobectomy. On the left side, resection of cortex should not exceed 4 to 5 cm to avoid harming language function presumed to be on the left side near the angular gyrus. On the right side, resection can often be safely carried 6 to 7 cm posterior given that language function is not presumed to be located on the right side. Care must be taken at the posterior-superior aspect of the resection in this region, as aggressive resection can involve the optic radiations (Meyer's loop), causing the classic “pie in the sky” visual field cut, a contralateral superior quadrant anopsia.

Further Reading: Greenstein B, Greenstein A. Color Atlas of Neuroscience, 2000, the visual fields and pathways.

20. A Lateral
The patient has Parkinsonism, and you are performing bilateral STN deep brain stimulation. If ipsilateral eye deviation is noticed during test stimulation, your electrode is too medial and needs to be moved lateral. Efferent fibers ultimately forming the IIIrd nerve pass just medial to the STN and can be stimulated causing eye deviation if the electrode is too medial.

Further Reading: Greenstein B, Greenstein A. Color Atlas of Neuroscience, 2000, oculomotor nuclei and nerves.

21. B Posteromedial
Descending corticospinal motor neuron tracts from the internal capsule travel anterolateral to STN. If contralateral facial pulling or muscle twitching is noted during test stimulation, the electrode is too far in the anterior or lateral position and should be moved posteromedially.

Further Reading: Greenstein B, Greenstein A. Color Atlas of Neuroscience, 2000, descending motor tracts and cranial nerve nuclei.

22. A Lateral
The most commonly targeted nucleus for patients with dystonia is GPI. If the DBS electrode is too medial, stimulation current can spread to the internal capsule, which is medial to the GPI nucleus. The electrode should be moved laterally.


23. B Superior
If a patient develops phosphenes in their visual field (flashing lights), it indicates that the electrode is too deep. Optic pathways run inferior to the GPI nucleus, and the electrode should be moved superiorly.

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24.
C Medial
   For essential tremor, DBS electrode placement into bilateral VIM thalamus has shown excellent results. The internal capsule is lateral to the thalamus, and if your patient develops muscle contractions, you should move the electrode medially.

25.
A Anterior
   VIM thalamus is just anterior to the VPL nucleus of the thalamus, the main sensory relay nucleus of the thalamus. If the electrode is placed correctly into VIM, patients can develop transient paresthesias during test stimulation, but these symptoms often resolve quite quickly. If the patient develops persistent paresthesias, current is likely spreading into VPL thalamus, and the electrode should be moved anteriorly.

26.
D Anteroinferior
   Utilizing the MCA M1 segment to reach the ICA terminus is one technique to expose an ICA terminus aneurysm. The main concern dissecting along the M1 segment of the MCA is preservation of the lateral lenticulostriate perforating arteries, which are located on the posterosuperior aspect of the M1 segment. The safe zone of dissection is on the anteroinferior surface of the vessel.

27.
B Limen insulae
   The limen insula is a structure that connects the temporal and orbital cortical regions. It often marks the MCA bifurcation, and laterally is continuous with the insular cortex. Medially it is bordered by the anterior perforated substance.

28.
A Cingulate gyrus
   The cingulate gyrus is located immediately superior to the corpus callosum, and must be gently retracted to expose the corpus callosum for division. Care must be taken to avoid damaging the pericallosal arteries, which are also running immediately over the corpus callosum

29.
D Thalamostriate vein
   The vein of Galen may have numerous supplying veins, but most often it receives the paired internal cerebral veins, the paired basal veins of Rosenthal and the precentral cerebellar vein. The thalamostriate vein of the lateral ventricle drains into the internal cerebral vein at the venous angle near the foramen of Monro, but this vein does not directly drain into the vein of Galen.

30.
A Anterior
   During an endoscopic third ventriculostomy, one of the easiest structures to identify are the paired mammillary bodies. Just anterior to the mammillary bodies is the safe zone for puncture. Care must be taken to not injure the basilar artery or posterior cerebellar arteries, which are just deep and slightly posterior to the puncture location
   Further Reading: Torres-Corzo, Rangel-Castilla, Nakaji. Neuroendoscopic Surgery, 2016, lateral and third ventricle anatomy.

31.
B Lamina terminalis
   In the anterior floor of the third ventricle, the lamina terminalis is located superior to the supraoptic recess. It is formed during closure of the anterior neuropore on embryological day 24. Division of the lamina terminalis allows access to the third ventricle for drainage of CSF and brain relaxation if required during anterior fossa aneurysm surgery.
   Further Reading: Torres-Corzo, Rangel-Castilla, Nakaji. Neuroendoscopic, Surgery, 2016, lateral and third ventricle anatomy.
32. C Lambdoid
   The lambdoid suture connects the occipital and parietal bones while descending laterally across the posterior skull.

33. D Coronal-sagittal
   The bregma is a midline skull structure that is the location where the coronal and sagittal sutures conjoin. It is the location of the anterior fontanelle, which closes in most pediatric patients around 18 months of age.

34. D Vestibular
   The deep cerebellar nuclei are the dentate, emboliform, globose and fastigial, going from lateral to medial. A mnemonic to remember is “Don’t Eat Greasy Foods.” Since the deep cerebellar nuclei control all output from the cerebellum, damage to these structures can mimic a complete cerebellar resection and are considered by some to be “eloquent cortex.”
   Further Reading: Psarros. The Definitive Neurosurgical Board Review.

35. A Brachium conjunctivum
   The 4th ventricle has lateral walls formed superiority by the superior cerebellar peduncle (brachium conjunctivis), and lateral walls formed inferiorly by the inferior cerebellar peduncle (restiform body). The middle cerebellar peduncle (brachium pontis) does not form a lateral wall of the 4th ventricle. The roof of the 4th ventricle is formed by both the superior and inferior medullary velum, and the floor is formed by the brainstem.
   Further Reading: Psarros. The Definitive Neurosurgical Board Review.

36. B Restiform body
   The 4th ventricle has lateral walls formed superiority by the superior cerebellar peduncle (brachium conjunctivis), and lateral walls formed inferiorly by the inferior cerebellar peduncle (restiform body). The middle cerebellar peduncle (brachium pontis) does not form a lateral wall of the 4th ventricle. The roof of the 4th ventricle is formed by both the superior and inferior medullary velum, and the floor is formed by the brainstem.
   Further Reading: Psarros. The Definitive Neurosurgical Board Review.

37. D Flocculonodular lobe
   The cerebellum can be divided into three functional segments, the vestibulocerebellum, the spinocerebellum and the cerebrocerebellum. The vestibulocerebellum is formed by the flocculonodular lobe and it receives projections from the vestibular nuclei, the superior colliculi and visual cortex. This system controls head and eye movements as well as postural and balance adjustments.

38. B Lateral hemisphere
   The functional division of the cerebellum known as the cerebrolateral hemisphere is comprised of the lateral hemispheres. It projects to the dentate nucleus of the deep cerebellar nuclei. Further connections include the VL nuclei of the thalamus and red nucleus, followed by motor cortex, and helps to provide feedback to motor cortex regarding accuracy of movement.

39. C Vermis
   The functional division of the cerebellum known as the spinocerebellum is comprised mainly
of the vermis. It projects to the fastigial nucleus of the deep cerebellar nuclei. It receives afferent connections from the spinocerebellar tract. Efferent connections from the fastigial nucleus project to the reticular formation and lateral vestibular nuclei, as well as the contralateral motor cortex via the VL thalamus.


40.  
B Abducens nucleus  
The paramedian pontine reticular formation is also known as the lateral gaze center, and it is located near the abducens nucleus. It receives input from the superior colliculus to coordinate vertical eye movements, and from the frontal eye fields via the frontopontine fibers to coordinate lateral gaze. Contralateral eye movement in a conjugate fashion is mediated by crossing fibers from the medial longitudinal fasciculus.


41.  
B Medial longitudinal fasciculus  
In this scenario, the patient is not able to adduct the right eye when attempting to look left, while the left eye is able to abduct. This likely represents a lesion of the medial longitudinal fasciculus.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 32.

42.  
B Facial colliculus  
The paired facial colliculi form noticeable structures on the surface of the floor of the 4th ventricle. They are located above the bilateral stria medullari. Care should be taken to not violate the floor of the 4th ventricle.


43.  
B Lateral  
There are several observable structures on the surface of the floor of the 4th ventricle. The paired facial colliculi are prominences that can be seen above the laterally projecting fibers of the stria medullari. Below the stria, the hypoglossal trigone is closest to midline, with the vagal trigone located lateral to the hypoglossal trigone.


44.  
B Internal arcuate fibers  
The nuclei gracilis and cuneatus receive sensory input from the dorsal columns of the spinal cord. In the medulla they decussate and form the medial lemniscus. The decussating fibers cross the midline as internal arcuate fibers.


45.  
A Area prostrema  
The circumventricular organs are regions of the brain located at the boundaries of the ventricular system and they are regions with an incomplete blood brain barrier. This allows these regions to sense peptide levels within the brain without requiring active transport mechanisms. There circumventricular organs include the median eminence, posterior pituitary, subcommissural organ, subfornical organ, area prostrema, choroid plexus, vascular organ of the lamina terminalis and pineal gland. The only paired circumventricular organ is the area prostrema.


46.  
C Laterally  
The cerebral peduncles contain descending corticospinal tracts organized in a somatotopic organization with the sacral fibers occupying the most lateral aspect of the corticospinal tracts, and fibers controlling the head/arms are the most medial.
Further Reading: Psarros. The Definitive Neurologic Surgery Board Review, page 34.

47.
B Superior colliculi
The nucleus of the IIIrd nerve, the oculomotor nucleus, is located roughly at the same horizontal level as the superior colliculi.
Further Reading: Psarros. The Definitive Neurologic Surgery Board Review, page 34.

48.
C Pretectal
The pretectal nucleus controls the direct and consensual pupillary light reflex
Further Reading: Psarros. The Definitive Neurologic Surgery Board Review, page 34.

49.
A Subcommissural organ
The subcommissural organ is made of ependymal cells that secrete somatostatin. It is the only circumventricular organ with an intact blood brain barrier.
Further Reading: Psarros. The Definitive Neurologic Surgery Board Review, page 34.

50.
D Medial lemniscus
The medial lemniscus appears as a curved structure projecting laterally from the red nucleus on a horizontal section through the midbrain.

51.
C Superior cerebellar artery
The deep cerebellar nuclei are located very close to the superior cerebellar peduncle within the vicinity of the superior lateral wall of the 4th ventricle. The superior cerebellar artery provides blood supply to the superior surface of the cerebellum as well as to the superior cerebellar peduncle and the majority of the deep cerebellar nuclei.

52.
C Medial
At the level of the midbrain, the descending corticospinal tracts are located in the ventral region of the midbrain and are arranged in a somatotopic fashion. The tracts controlling the upper extremity are located medial to tracts controlling lower extremity function.

53.
A Medial
At the level of the medulla, after the internal arcuate fibers have crossed and formed the medial lemniscus, the fibers conveying information from the upper extremity are located dorsal and the fibers from the lower extremity are located ventrally. As these fibers ascend to the level of the midbrain, the medial lemniscus becomes a curve structure extending laterally from the red nucleus. In this region, the fibers from the upper extremity are the most medial, while the lower extremity fibers are located laterally.

54.
D Nasociliary nerve
The annulus of Zinn is a structure located in the superior orbital fissure, dividing it into sections. There are multiple structures that pass through the annulus of Zinn, including the oculomotor nerve, the nasociliary nerve, the abducens nerve and roots of the ciliary ganglion. The frontal nerve, trochlear nerve and lacrimal nerve all pass outside of the annulus of Zinn.
55. C Superior oblique palsy
The IVth nerve (trochlear nerve), runs at the edge of the tentorial incisura in the ambient cistern and is at risk during complete division of the tentorium.

56. B Nystagmus to the left
Cold calorics involve irrigating cold saline into the patient’s ear and observing the movements of the eyes. The mnemonic COWS (cold-opposite, warm-same) is useful to remember, but it must be noted that this mnemonic refers to the nystagmus portion of the eye movements. In this patient, you irrigate the right ear with cold saline, and you would expect a slow drift of the eyes to the right followed by a fast-jerk nystagmus back to the left. The cold saline decreases the temperature of the tympanic membrane and hyperpolarizes the vestibular cells, tricking the system into thinking the head is moving to the left.

57. A Base
The cochlea is a coiled organ that process auditory input. It is arranged tonotopically with high frequency sounds processed at the base, and low-frequency sounds processed at the apex.

58. A Tectorial membrane
As sound travels through the cochlea it causes movement of the basilar membrane, which in turn moves the organ of Corti at specific locations. This movement causes a shearing motion against the tectorial membrane, to which the ciliary processes of the hair cells are connected. This movement causes opening of these processes and depolarization of the hair cells.

59. C Ventral cochlear nucleus–superior olive
The trapezoid body conveys information from the cochlear nucleus to the superior olive. Fibers then travel to the inferior colliculus and subsequently the medial geniculate body.

60. C Lateral lemniscus
The lateral lemniscus connects the dorsal cochlear nucleus to the inferior colliculus via the lateral lemniscus. It is involved in the response to sudden loud noises.

61. A Spinal trigeminal nucleus
The corneal blink reflex pathway involves sensory information from the cornea passing through the trigeminal nerve to the spinal trigeminal nucleus and tract. Further connections include the bilateral facial nuclei which mediate eye closure.

62. B Facial nerve
Fibers traveling from the facial nucleus travel around the abducens nucleus in the brainstem.

63. B Ventromedial
The ventromedial nucleus of the hypothalamus controls satiety. A way to remember this is “if the ventromedial nucleus is destroyed, you grow ventrally and medially.”
II Answers

64.

D Supraoptic
   The supraoptic nuclei of the hypothalamus are involved in fluid balance regulation.

65.

A Central tegmental tract
   Gustatory information from the tongue and oropharynx travels through the chorda tympani and VIIth nerve, as well as the IX/X nerves. 1st order neurons synapse in the nucleus of the solitary tract. Then, 2nd order neurons travel via the central tegmental tract to VPM thalamus and 3rd order neurons travel from VPM thalamus to the postcentral gyrus.
Further Reading: Greenstein B, Greenstein A. Color Atlas of Neuroscience, 2000, transverse section of medulla oblongata II.

66.

C Superior olivary nucleus
   The auditory dampening reflex is mediated by the superior olivary nucleus and involves contraction of the stapedius (VIIth nerve) and tensor tympani (Vth nerve).
Further Reading: Psarros. Intensive neurosurgery board review.

67.

B Ethmoid bone
   The cribiform plate is a bony structure that is part of the ethmoid bone in the anterior cranial fossa. It supports the olfactory bulb and has numerous foramina through which the olfactory nerves pass to reach the nose.

68.

B Maxillary nerve
   The maxillary nerve, or V2, does not pass through the superior orbital fissure.

69.

B Pars vascularis of the jugular foramen
   The vagus nerve exits the skull through the jugular foramen, which is divided into two regions by the jugular spine, the pars nervosa (carrying the glossopharyngeal nerve and inferior petrosal sinus) and the pars vascularis (carrying the jugular bulb, vagus nerve and spinal accessory nerve).

70.

C Foramen spinosum
   The middle meningeal artery is the most common offending artery in cases of epidural hematoma. It enters the skull as a branch from the internal maxillary artery through the foramen spinosum.

71.

D Ophthalmic artery
   The anterior and posterior ethmoidal arteries give blood supply to the mucosal surfaces of the ethmoid bone, and they are both branches from the ophthalmic artery.

72.

D Sphenopalatine artery
   The sphenopalatine artery gives blood supply to the middle turbinate, which can be removed by an access surgeon to allow expanded access for endoscopic approaches to the sella and anterior skull base.

73.

A Optic strut
   The optic strut joins the lesser wing of the sphenoid to the body of the sphenoid bone. It forms the inferior and lateral wall of the optic canal. It separates the optic canal from the superior orbital fissure. From an endonasal approach, it is
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located inferior to the optic protuberence, superiormedial to the carotid protuberence, and medial to the lateral opticocarotid recess.


74.
B Planum sphenoidale

Just anterosuperior to the sella turcica is the planum sphenoidale. This can be a site of meningioma growth, and tumors in this region can be accessed via an expanded endonasal approach.


75.
B Greater superficial petrosal nerve

The vidian nerve is continuous with the greater superficial petrosal nerve and passes through the vidian canal lateral to the ethmoid air cells. The vidian nerve carries sensory fibers from the facial nerve supplying the soft palate. It is an important landmark in endoscopic endonasal surgery as it leads directly to the carotid artery.


76.
B Foramen rotundum

The foramen rotundum is just lateral to the vidian canal and contains the maxillary nerve. Both the vidian canal and foramen rotundum are openings in the greater wing of the sphenoid bone. In this location they connect the middle cranial fossa to the pterygopalatine fossa.


77.
D Abducens nerve

The cavernous sinus contains several nerves, including CN III, IV, V1, and VI. All nerves run in the lateral wall of the cavernous sinus except for the abducens nerve, which runs with the carotid artery through the cavernous sinus.


78.
A Glasscock’s triangle

The posterolateral triangle of the skull base is bordered by V3 (mandibular nerve), the greater superficial petrosal nerve, and a line drawn between the foramen spinosum and the arcuate eminence. This triangle can be important during skull base neurosurgery given that it allows for the exposure of the horizontal segment of the petrous internal carotid artery by drilling out bone inferior to the border of V3.


79.
B Kawase’s triangle

The posteromedial triangle of the skull base is bordered by V3 (mandibular nerve), the greater superficial petrosal nerve (inferiorly), and the superior petrosal sinus. This triangle can be important during skull base neurosurgery given that drilling in this region allows for an anterior petrosectomy, connecting the middle and posterior cranial fossae. It contains the petrous corner of the ICA and in its lateral aspect contains the cochlea.


80.
C Infratrochlear triangle

The infratrochlear triangle (Parkinson’s triangle) of the skull base is bordered by the trochlear nerve (superior), V1, and the tentorial edge. This triangle can be important during skull base neurosurgery as it contains the horizontal segment of the cavernous carotid, the abducens nerve and the meningohypophyseal trunk. It has been described as the original access location to the cavernous sinus.

81. **B** Superior vestibular nerve–inferior vestibular nerve
   Bill’s bar is a vertically oriented bone within the IAC that separates the Facial nerve (anterior-superior) from the superior vestibular nerve (posterosuperior). The cochlear nerve is located anteroinferior, and the inferior vestibular nerve is located posteroinferior.

82. **C** Anterior inferior cerebellar artery
   The posterior fossa can be thought of as three distinct neurovascular regions. The superior region contains CN III, IV, and V, and is associated with the superior cerebellar artery. The middle neurovascular region consists of CN VI, VII, and VIII as well as the anterior inferior cerebellar artery. The inferior neurovascular region contains CN IX, X, XI, and XII, and is associated with the posterior inferior cerebellar artery.

83. **D** Asterion
   The asterion is located where the squamous and parietomastoid sutures join. It is a rough landmark for the transverse sigmoid sinus, and can be an important marker for burr hole location in retrosigmoid craniectomies.

84. **B** Trochlear
   The trochlear nerve is the only cranial nerve to exit from the dorsal aspect of the brainstem.

85. **B** Mesoderm
   The meninges of the skull base arise from the mesoderm of the embryo. This differs from telencephalic meninges which arise from neural crest cells.

86. **D** Labyrinthine artery
   The labyrinthine artery is most commonly a branch from the anterior inferior cerebellar artery, and it follows the vestibulocochlear nerve into the IAC.

87. **B** Ophthalmic artery
   Special visceral afferent fibers conveying sense of smell travel through the olfactory nerve directly to the primary olfactory areas via the medial and lateral olfactory striae.
   Further Reading: Psarros. The Definitive Neurosurgical Board Review.

88. **C** Olfactory nerve
   Special visceral afferent fibers conveying sense of smell travel through the olfactory nerve directly to the primary olfactory areas via the medial and lateral olfactory striae.
   Further Reading: Psarros. The Definitive Neurosurgical Board Review.
90. **A** Inferior oblique

The oculomotor nerve begins within the oculomotor nucleus at the level of the superior colliculus. It travels between the PCA and SCA and enters the orbit through the superior orbital fissure. Notably, it does travel within the annulus of Zinn. It separates into a superior division and inferior division, with the superior division innervating the levator palpebrae and superior rectus, while the inferior division innervates the medial/inferior rectus and the inferior oblique.

Further Reading: Psarros. The Definitive Neurosurgical Board Review.

91. **C** Left trochlear nucleus

The trochlear nerve innervates the superior oblique muscle, and patients tend to tilt their head to the contralateral side of nerve injury to compensate. Also, the trochlear nerve is the only nerve to decussate outside of the CNS, and the only cranial nerve to exit dorsally from the brainstem. This patient tilts her head to the left, meaning she would have sustained damage to either the right trochlear nerve (postdecussation), or the left trochlear nucleus (predecussation).

Further Reading: Psarros. The Definitive Neurosurgical Board Review.

92. **A** Trigeminal nerve

The trigeminal nerve has a portio major (sensory afferents from the face) and a portio minor (motor efferents) that travels with V3. The motor branch of the trigeminal nerve innervates the muscles of mastication, including the tensor veli palatini, masseter, pterygoids, temporalis and anterior belly of the digastric. It also innervates the tensor tympani, which dampens sudden loud noises in the efferent arm of the auditory reflex.

Further Reading: Psarros. The Definitive Neurosurgical Board Review.

93. **D** Right abducens nucleus

The abducens nerve innervates the lateral rectus muscle and mediates lateral gaze of the ipsilateral eye. It is important to note that the abducens nucleus plays an important role in conjugate movement of the eyes. Signals initially reach the ipsilateral PPRF, which synapses on the ipsilateral abducens nucleus to mediate lateral gaze. The abducens nucleus also sends fibers to the contralateral oculomotor nucleus via the MLF to mediate conjugate medial deviation of the contralateral eye. Since this patient cannot cross midline with the left eye, the lesion must be within the abducens nucleus.

Further Reading: Psarros. The Definitive Neurosurgical Board Review.

94. **A** Efferent arm of the corneal reflex

The facial nerve contains a large motor branch as well as a smaller branch known as the nervus intermedius. The motor branch controls muscles of facial expression and forehead. The nervus intermedius carries parasympathetic fibers to the lacrimal gland through the GSPN and pterygopalatine ganglion, parasympathetic fibers to the submandibular gland via the submandibular ganglion, and taste afferents via the chorda tympani. The efferent arm of the corneal reflex is mediated by muscles of facial expression and is carried in the motor branch of the facial nerve.

Further Reading: Psarros. The Definitive Neurosurgical Board Review.

95. **B** Spiral–cochlear

Hair cells from the organ of Corti within the cochlea synapse on the spiral ganglion, which in turn connects to the cochlear nucleus in the brainstem via the cochlear nerve. Scarpa’s ganglion receives input from the receptors in the labyrinth of the saccule, utricle and semicircular canals. In turn, these fibers are transmitted to the vestibular nuclei of the brainstem via the vestibular nerve. Some fibers from Scarpa’s ganglion travel to the flocculonodular lobe of the cerebellum as mossy fibers, where they mediate balance.
Further Reading: Psarros. The Definitive Neurosurgical Board Review.

98.
C Posterior
The spinal accessory nerve has both a cranial and spinal point of origination. It innervates the sternocleidomastoid and trapezius muscles. The spinal portion passes posterior to the dentate ligament.

Further Reading: Psarros. The Definitive Neurosurgical Board Review.

99.
A Palatoglossus
The hypoglossal nerve exits the brainstem between the inferior olive and the pyramids. It exits the skull via the hypoglossal canal and innervates all intrinsic and extrinsic muscles of the tongue except for the palatoglossus, which is innervated by the vagus nerve.

Further Reading: Psarros. The Definitive Neurosurgical Board Review.

100.
D Rostral
The motor root of the trigeminal nerve most often arises rostral to the main sensory root of the trigeminal nerve.

101.
D Anterior atlanto-occipital membrane
The anterior atlanto-occipital membrane connects the anterosuperior border of C1 to the foramen magnum.

102.
B Notochord
The apical ligament is a single structure connecting the dens to the foramen magnum. It is a weak ligament that is an embryological remnant of the notochord.

103.
A Alar
The alar ligaments are paired ligaments that connect the tip of the dens to the foramen magnum near the occipital condyles. They are strong ligaments that limit rotation of the head.

104.
C Transverse ligament
The transverse ligament is a strong ligament that is very important in stability of the atlanto-axial joint. When the atlanto-dental interval is > 3 mm, this is highly suggestive of transverse ligament disruption and instability of the C1-2 joint. Surgical stabilization or prolonged collar immobilization will likely be required.

105.
B Posterior longitudinal ligament
The tectorial membrane is a broad ligament connecting the axis to the clivus/foramen magnum, and is a superior extension of the posterior longitudinal ligament.

106.
B Vertebral artery
The vertebral artery can have variant anatomy within the C2 vertebrae. Certain patients can have a “high-riding vertebral artery” where the vessel passes in close proximity to the C2 pedicle. In these patients it can be dangerous to attempt pedicle screws at C2, and pars screws or interlaminar screws should be considered. In most cases, a high riding vertebral artery can be discovered with a standard, non-contrast CT of the cervical spine in the pre-operative period.

107.
C Os odontoideum
Os odontoideum is either a congenital failure of fusion of the dens to the C2 vertebral body, or an unrecognized fracture at a young age. When the pseudoarthrosis is present inferior to the transverse ligament, atlantoaxial instability can result.

108.
B 9 weeks
The first ossification centers of the spine tend to occur at the cervicothoracic junction, and begin to appear at 9 weeks in utero.

109.
C 3 years
The atlas is composed of three main ossification centers, one anteriorly, and two posteriorly. It is common for the posterior ossification centers to persist until 3 years of age, while the anterior ossification center can persist even until 7 years of age. These ossification centers can easily be mistaken for acute fractures.
110.  
C 11 years  
The axis undergoes complicated ossification in 4 different ossification centers. The subdental synchondrosis, or the region where the dens attaches to the body of the axis is usually the last center to be visible on CT scans. It should be completely closed and no longer significantly visible by 11 years of age.  

111.  
B Sulcus limitans  
The developing embryo has both a basal plate and an alar plate. The basal plate develops into motor neurons, while the alar plate develops into sensory neurons. The structure dividing them is the sulcus limitans.  

112.  
A Dermal sinus tract  
During embryologic development, disjunction occurs when the surface ectoderm separates from the neural ectoderm. Failure of disjunction can lead to the development of dermal sinus tracts. Premature disjunction can lead to the development of spinal cord lipomas.  

113.  
B 19 to 21  
Somites form from paraxial mesoderm adjacent to the notocord. They begin initially in the cervical region and progress caudally. They begin forming between days 19 to 21 of development.  
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

114.  
C Vertebral column and spinal musculature  
Somites form from paraxial mesoderm adjacent to the notocord. They begin initially in the cervical region and progress caudally. They begin forming between days 19 to 21 of development. Ultimately they develop into the vertebral column and dorsal spinal musculature. Their rate of growth exceeds that of the spinal cord, which is why the cord ascends in the canal during development.  

115.  
B Secondary neurulation  
The sacral spinal cord (distal to S2) is formed during secondary neurulation. Failure of this process can lead to caudal regression syndromes.  

116.  
A Fasciculus cuneatus  
The fibers carrying sensory information travel within the dorsal columns. Fibers entering above T6 travel within the fasciculus cuneatus, just lateral to the fasciculus gracilis, which carries fibers from below T6.  

117.  
C Lamina VII  
Lamina VII (Zona intermedia) is the rexed lamina located between the dorsal and ventral horns. The dorsal horn contains lamina I-IV, which V and VI at its base. The ventral horn contains VIII-X.  
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.
118.  
A Lamina II  
The substantia gelatinosa is located in rexed lamina II and due to its lower density of myelinated fibers, it has a gelatinous appearance. It is one of two locations (the nucleus proprius being the other) where first order neurons of the spinothalamic tract synapse. 
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.  

119.  
C Lamina VII  
Lamina VII (Zona intermedia) is the rexed lamina located between the dorsal and ventral horns. Lamina VII contains the interomediolateral cell column and dorsal nucleus of Clarke.  
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.  

120.  
C Lamina VII  
Renshaw cells are special inhibitory interneurons of the spinal cord. They are mainly located in rexed laminae VII and VIII and they use glycine as a neurotransmitter.  
Further Reading: Psarros. The definitive neurological surgery board review.  

121.  
D Lamina IX  
Primary somatic motor neurons are located in lamina IX and are composed of medial and lateral groups. The medial group innervates axial musculature while the lateral group innervates appendicular musculature.  

122.  
B Lateral spinothalamic tract  
Pain and temperature information is transmitted to the CNS via the lateral spinothalamic tract, while the anterior spinothalamic tract conveys information about light touch.  

123.  
C Dorsal spinocerebellar tract  
The dorsal spinocerebellar tract contains sensory information originating in group Ia, Ib and II afferent fibers of the peripheral system. They synapse in the dorsal nucleus of Clarke (C8-L2) and travel to the cerebellum through the dorsal spinocerebellar tract where they enter the cerebellum via the inferior cerebellar peduncle and synapse within the vermis. They are involved in unconscious balance and proprioception mechanisms.  
Further Reading: Psarros. The definitive neurological surgery board review.  

124.  
B Spinotectal tract  
The spinotectal tract has its origins from lamina I and V of the dorsal horn and projects to the superior colliculus and periaqueductal grey in close proximity to the spinothalamic system. It is involved in reflexive head turning to focus on a source of painful stimulus.  
Further Reading: Psarros. The definitive neurological surgery board review.  

125.  
A 3%  
Only 3% of the corticospinal tract fibers originate from the giant pyramidal Betz cells in the motor cortex. Roughly 40% originate in the parietal lobe, roughly 30% originate in the supplementary motor area, and 30% originate in the primary motor cortex.  
Further Reading: Psarros. The definitive neurological surgery board review.  
126.
C Lamina VII
The majority of lateral corticospinal tract fibers synapse primarily on interneurons in lamina VII. Only a minority of fibers synapse directly on alpha motor neurons of the anterior horn.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

127.
B Rubrospinal tract
The rubrospinal tract contains fibers descending from the red nucleus and mediates flexor tone in the response to deep painful stimulus to the extremities. In a patient with decorticating (flexor) posturing, the red nucleus remains intact and flexor tone is maintained.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

128.
A Vestibulospinal tract
The vestibulospinal tract begins in Dieter's nucleus (vestibular nucleus) and descends to rexed lamina VII, VIII, and IX. Occasionally, fibers will synapse directly on alpha motor neurons. This nucleus and tract mediate extensor tone of the extremities and is usually under tonic inhibition by higher brain centers. With a lesion between the superior and inferior colliculi, the vestibular nucleus is released from its inhibition and extensor posturing (decerebrate) is observed.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

129.
D Tectospinal tract
The tectospinal tract carries information from the superior colliculus to all levels of the cervical cord. It mediates postural reflexes and movement of the upper body in response to visual and auditory stimuli.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

130.
C Anterior corticospinal tract
90% of descending pyramidal tract fibers travel in the lateral corticospinal tracts. A small number of uncrossed fibers travel in the anterior corticospinal tract, which is located near the median fissure of the cervical spinal cord. In the upper cervical levels they decussate via the anterior commissure and synapse within lamina VII.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

131.
B Medial
The dorsal columns of the spinal cord receive blood supply from the paired posterior spinal arteries, which lie medial to the dorsal roots, and generally originate from multiple posterior radicular arteries.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

132.
C Vertebral arteries
The anterior spinal arteries originate from the vertebral arteries and fuse in the midline to form the single anterior spinal artery traversing the cervical cord in the median fissure. It supplies the majority of the cervical spinal cord.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

133.
B T1-T4
The upper thoracic region (T1-T4) is the most susceptible region of the spinal cord to ischemic injury. It is followed by the first lumbar segment, which is the next most susceptible.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.
134.
C Left T10
The artery of Adamkiewicz is a large lower thoracic/upper lumbar anterior radicular artery that supplies the anterior spinal artery and the anterior spinal cord of the thoracic/lumbar regions. Injury to this artery can result in an anterior spinal artery infarct and paraplegia.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

135.
D Paraplegia, preserved pinprick sensation, bilateral loss of pain/temperature sensation
The artery of Adamkiewicz is a large lower thoracic/upper lumbar anterior radicular artery that supplies the anterior spinal artery and the anterior spinal cord of the thoracic/lumbar regions. Injury to this artery can result in an anterior spinal artery syndrome which includes paraplegia and loss of pain/temperature sensation with preserved pinprick sensation as the dorsal columns are supplied by the posterior spinal arteries.
Further Reading: Psarros. The Definitive Neurological Surgery Board Review.

136.
B L3-4
Pain to the knee and weakness of the quadriceps is usually due to a herniated lumbar disc at L3-4. These symptoms are 99% specific for a disc at this level.

137.
C L4-5
Pain to the ankle and weakness of ankle plantarflexion is usually due to a herniated lumbar disc at L4-5, and this constellation of symptoms is 70% specific for a disc at this level.

138.
D L5-S1
Pain to the ankle and weakness of ankle plan tarflexion is usually due to a herniated lumbar disc at L5-S1, and this constellation of symptoms is 95% specific for a disc at this level.

139.
B Paracentral L4-5
This constellation of symptoms is suggestive of L5 nerve root impingement. This is possible with a paracentral disc at L4-5, compressing the traversing root, or possible with a far lateral L5-S1 disc, compressing the exiting nerve root.

140.
D Far lateral L5-S1
This constellation of symptoms is suggestive of L5 nerve root impingement. This is possible with a paracentral disc at L4-5, compressing the traversing root, or possible with a far lateral L5-S1 disc, compressing the exiting nerve root.

141.
C C4-5
You must remember that in the cervical spine, nerve roots exit above the corresponding vertebral body, with the exception of C8, which exits under the C7 vertebral body. This patient has symptoms suggestive of a disc herniation compressing the C5 nerve root, meaning the herniation is likely to be located at the C4-5 space.

142.
B Right thumb
In this patient with a herniated disc at the C5-6 space, there should be compression of the exiting C6 nerve root. The sensory distribution of C6 includes the radial forearm and thumb as well as the 2nd finger.
143.  
B  Right wrist flexion  
In this patient with a herniated disc at the C6-7 space, there should be compression of the exiting C7 nerve root. C7 compression can lead to triceps weakness as well as weakness of wrist flexion.  

144.  
D  Right distal finger flexion  
In this patient with a herniated disc at the C6-7 space, there should be compression of the exiting C8 nerve root. C8 compression can lead to weakness of the distal finger flexors as well as paraesthesia of the 4th and 5th digits.  

145.  
C  Cervical MRI  
This patient presents with symptoms suggestive of pseudoclaudication, with leg pain/weakness when upright as well as evidence of spinal stenosis at L4-5 on MRI. On exam, he has the above mentioned weakness, but also has a positive Hoffman’s sign, a reflex suggestive of cervical compression. This patient should undergo cervical MRI to rule out presence of tandem stenosis. It may be that his symptoms are generated from cervical stenosis, and further workup is required.  

146.  
B  Batson’s plexus  
Batson’s plexus is a venous plexus in the epidural spinal compartment that is continuous with pelvic venous systems. It is unique in that this venous system does not contain valves. It is theorized that the lack of valves allow for easier transfer of both bacterial infections as well as metastatic lesions to affect the spine and spinal cord.  

147.  
C  Notochord  
The nucleus pulposus of the intervertebral disc is an embryological remnant of the notochord.


148.  
B  Ligamentum flavum  
The ligamentum flavum is a non-contiguous ligament that connects laminae between segments. It helps to provide tension when the spine is in flexion, to avoid flexion injuries under normal loads. It has a high proportion of elastin, and over time loses its elasticity, causing buckling and encroachment of the thecal sac.  

149.  
B  T4  
On average, T4 has the narrowest pedicle diameter and the shortest pedicle length  

150.  
A  Type I  
The annulus fibrosus is comprised of obliquely oriented type I collagen fibers. The nucleus pulposus is primarily comprised of type II collagen.  

151.  
B  Ligamentum flavum  
This image is a tubular discectomy and the blunt hook is elevating the yellow ligament, or ligamentum flavum, under which the dura can be seen.  

152.  
C  C6  
The vertebral artery enters the foramen transversarium at C6 in most patients. In some, with aberrant vertebral anatomy, it can enter at C5.  

C C6
The anterior tubercle of the sixth cervical vertebra is known as the carotid tubercle or Chassaignac tubercle. This separates the carotid artery from the vertebral artery and the carotid artery can be massaged against this tubercle to relieve the symptoms of supraventricular tachycardia.


154.
D Filum terminale
The filum terminale is a fibrous band extending inferiorly from the conus medullaris. It is often seen to have serpiginous vessels running along its course. It is often seen running through myxopapillary ependymomas. It is pictured in the intraoperative image above.


155.
A Dentate ligament
The dentate ligaments of the spine extend laterally in between the dorsal and ventral nerve roots. It is an extension of the pia mater which extends to the arachnoid and dura laterally. It provides stability to the spinal cord within the spinal canal.


156.
D Transverse ligament
The ligament depicted is the transverse ligament of the atlas. It is very important to assist with atlantoaxial stability. If there is a significant increase in atlantodental interval (> 3 mm), there is a high chance of transverse ligament injury and subsequent atlantoaxial instability.


157.
C 1.5 cm
On average, the vertebral artery is 14.6 mm from midline on the superior aspect of the C1 posterior arch.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 60.
162. 
D Hand sensation
The lateral cord is formed by the anterior divisions from the upper and middle trunks. The lateral cord divides into the musculocutaneous nerve and the lateral root of the median nerve. It is often described that the lateral cord contributions to the median nerve contain mostly sensory fibers traveling to the hand, while the medial cord contributions to the median nerve contain motor nerves controlling intrinsic hand function.
Further Reading: Psaaros. The definitive neurosurgical board review, page 60.

163. 
B Dorsal scapular nerve
The first branch off the brachial plexus is the dorsal scapular nerve, branching off the C5 nerve root, which supplies the rhomboids and the levator scapulae. Next, the long thoracic nerve branches to innervate the serratus anterior. Diminished function in these muscles can represent a clinical confirmation of proximal root injury to the plexus.
Further Reading: Psaaros. The definitive neurosurgical board review, page 60.

164. 
D Suprascapular nerve
The suprascapular nerve branches off the upper trunk and innervates the supraspinatus and infraspinatus muscles, responsible for initial shoulder abduction and external rotation. The patient likely has idiopathic brachial plexitis, or Parsonage-Turner syndrome.
Further Reading: Psaaros. The definitive neurosurgical board review, page 60.

165. 
C Brachioradialis
Innervation from the musculocutaneous nerve can be remembered as “BBC” Biceps, brachialis, and coracobrachialis. The brachioradialis is innervated by C6 through the radial nerve. The musculocutaneous nerve also gives a sensory branch to the lateral forearm via the lateral antebrachial cutaneous nerve.
Further Reading: Psaaros. The definitive neurosurgical board review, page 60.

166. 
D Medial antebrachial cutaneous nerve
The medial cord has 5 total branches, the medial pectoral nerve (supplying the pectoralis minor and some of the pectoralis major), the medial brachial cutaneous nerve (sensory information from medial upper arm), the medial antebrachial cutaneous nerve (sensory information from medial forearm), and the final two branches, the ulnar nerve and medial contribution to the median nerve. In the options listed above, the medial antebrachial cutaneous nerve (MABC) is the most distal along the medial cord.
Further Reading: Psaaros. The definitive neurosurgical board review, page 60.

167. 
B Posterior cord
The thoracodorsal nerve supplies the latissimus dorsi, and it branches as one of the five branches from the posterior cord (upper subscapular nerve, thoracodorsal nerve, lower subscapular nerve, axillary nerve, radial nerve).
Further Reading: Psaaros. The definitive neurosurgical board review, page 61.

168. 
A Teres minor
The axillary nerve branches from the posterior cord and mainly supplies the deltoid muscle. It also innervates the teres minor as well as a patch of skin overlying the shoulder.

169.
B Posterior interosseous nerve
The posterior interosseous nerve is a pure motor branch of the radial nerve in the forearm. It innervates the abductor pollicis longus, the extensor pollicis longus/brevis, extensor indices, extensor carpi ulnaris, extensor digitorum and extensor digiti minimi.
Further Reading: Psaaros. The definitive neurosurgical board review, page 61.

170.
A Anterior interosseous nerve
The anterior interosseous nerve is a pure motor branch of the median nerve. Compression of the anterior interosseous nerve gives the classic “flat OK” sign, since the patient has weakness of the flexor pollicis longus and the flexor digitorum profundus to the pointer finger.
Further Reading: Psaaros. The definitive neurosurgical board review, page 61.

171.
B Transverse carpal ligament
The patient is experiencing symptoms of carpal tunnel syndrome, where compression of the distal median nerve by the transverse carpal ligament causes the classic syndrome. Symptoms are worsened by the Phalen test (flexion of the wrist for extended periods of time), and there may be a positive Tinel’s sign over the carpal tunnel.

172.
A Volar carpal ligament
The patient is experiencing symptoms of ulnar tunnel syndrome, where compression of the distal ulnar nerve by the volar carpal ligament within Guyon’s canal. Note that the dorsal ulnar cutaneous nerve, which provides sensory innervation to the dorsum of the ulnar aspect of the hand branches approximately 6cm proximal to Guyon’s canal, so if sensory disturbance is present here, look more medially for compression, such as in the cubital tunnel.

173.
B Long thoracic nerve
The correct answer is the long thoracic nerve, which innervates the serratus anterior. Winged scapulae on exam suggests injury to this nerve, and can be an important exam finding that suggests proximal brachial plexus injury.

174.
D Musculocutaneous nerve
This sensory territory is that of the lateral antebrachial cutaneous nerve, a branch off the musculocutaneous nerve.

175.
B Thoracodorsal nerve
This test evaluates the strength of the latissimus dorsi, which is innervated by the thoracodorsal nerve, a branch from the posterior cord.

176.
A Dorsal scapular nerve
This examiner is testing rhomboid function, and the rhomboids are innervated by the dorsal scapular nerve.

177.
C Suprascapular nerve
This test examines the supraspinatous muscle, which is innervated by the suprascapular nerve. This muscle abducts the arm for the first 15 degrees from a straight hanging position.


178.
C Suprascapular nerve
This test examines the strength of the infraspinatous muscle, which primarily externally rotates the arm. It is innervated by the suprascapular nerve.


179.
B Radial nerve
This image depicts the quadrangular space on the back of the arm. The nerve that passes through this space is the axillary nerve as it travels to innervate the deltoid muscle.


180.
C Median nerve
This sensory innervation of the hand is provided by the median nerve. You can see the common digital branches as well as the palmar cutaneous branch, which branches prior to the carpal tunnel.


181.
C Inferior gluteal
The gluteus maximus is innervated by the inferior gluteal nerve. The superior gluteal nerve innervates the gluteus minimus/medius and the tensor fascia lata.

186.

**B Deep peroneal nerve**

The tibialis anterior is innervated by the deep branch of the common peroneal nerve. The superficial peroneal nerve innervates the muscles involved in foot eversion, the peroneus longus and brevis.


187.

**D Onuf’s nucleus**

Onuf’s nucleus is located within the conus medullaris and it is a grouping of motor neurons that send projections through the pudendal nerve, controlling urinary and fecal continence.


188.

**A Impaired foot eversion**

The superficial branch of the common peroneal nerve innervates the peroneus longus and brevis and controls foot eversion.


189.

**D Flexor digitorum brevis tendon**

The tarsal tunnel contains the tibial nerve, posterior tibial artery, posterior tibial vein, flexor hallucis longus tendon, flexor digitorum longus tendon and the tibialis posterior tendon.


190.

**B Deep peroneal nerve**

The extensor hallucis longus is innervated by the deep branch of the common peroneal nerve. Remember that the superficial branch, while providing sensory information to the majority of the dorsum of the foot, only innervates muscles involved in foot eversion (peroneus longus/brevis). The deep branch innervates the remaining foot extensors.


191.

**B Gluteus maximus**

The gluteus maximus muscle is innervated by the inferior gluteal nerve, and it extends the hip with the assistance of the hamstrings.


192.

**A Pudendal nerve**

Onuf’s nucleus is located within the conus medullaris and contains motor neurons that control urinary and fecal continence. Fibers are carried through the pudendal nerve.


193.

**C Sciatic nerve**

Fibers that innervate the peroneus longus originate in the peroneal component of the sciatic nerve.


194.

**C Sciatic nerve**

The flexor hallucis is innervated by the tibial nerve. Fibers innervating the flexor hallucis longus travel within the sciatic nerve before separating to become the tibial nerve.


195.

**A Sural nerve**

This image depicts the sensory innervation of the sural nerve.

196.  
C  Lateral femoral cutaneous nerve  
Sensory innervation from the anterolateral thigh is provided by the lateral femoral cutaneous nerve.  

197.  
C  Femoral nerve  
This examiner is evaluating the strength of the quadriceps muscle, which is innervated by the femoral nerve.  

198.  
A  Obturator nerve  
The obturator nerve innervates the adductors longus, brevis and magnus.  

199.  
C  Both  
This sensory innervation is from the genitofemoral nerve which supplies two regions as depicted in the image above. The femoral triangle region is innervated by the nerve branch that passes below the inguinal ligament, while the groin region is innervated by the branch that passes through the spermatic cord.  

200.  
B  Sacral plexus  
The lumbosacral trunk provides the connection between the lumbar plexus and the sacral plexus. It travels on the psoas muscle. It contributes to multiple sacral plexus nerves, including the superior and inferior gluteal nerves.  
1. **B** Anticholinergic
   Oxybutynin is an anticholinergic drug that works on M1-3 muscarinic receptors in the bladder wall, inhibiting the activity of acetylcholine at this receptor. This leads to bladder relaxation which can help limit bladder spasticity and frequent urination.

2. **B** Potassium
   Astrocytes serve multiple functions in the brain, but they actively sequester potassium from the extracellular space in order to keep extracellular potassium levels low, thus maintaining the gradient of potassium required for membrane depolarization.

3. **C** NMDA
   The NMDA receptor utilizes glutamate as a ligand and after glutamate binds to the receptor, ion channels permeable to Na, K, and Ca open. It has been found to be associated with gene expression, synaptic plasticity, and other signaling systems. It is associated with pain, and ketamine is an NMDA receptor antagonist that can treat pain.

4. **E** Supraoptic
   The supraoptic nucleus of the hypothalamus is one of the anterior nuclei and is associated with ADH secretion from the posterior pituitary.

5. **B** Paraventricular
   The supraoptic and paraventricular nuclei of the anterior hypothalamus are associated with secretion of ADH from the posterior pituitary. Of these two, the paraventricular nucleus also has diffuse connections to the spinal cord and brainstem.

6. **D** Stress shielding
   Wolf’s law states that bone will form along lines of stress, and alternatively, when normal stress loads are removed, bone will become osteopenic. This is important in fusion surgery as the goal is for bone to heal across the fusion segment. If fixed angle screws are used both above and below the fusion segment, the bone may not be allowed to settle and put stress on the graft (which can lead to higher rates of fusion). If there is no stress on the graft, it is said to be “stress shielded” and the likelihood of fusion decreases.

7. **A** cGMP deactivation, hyperpolarization
   Activation of rhodopsin is the final pathway in phototransduction. It deactivates cGMP via cGMP phosphodiesterase which has the effect of decreasing sodium ion movement across the cell membrane (occurs through cGMP associated Na channels). Ultimately this leads to hyperpolarization of the photoreceptor, and signal transduction.

8. **E** Layer VI
   There are six cortical layers and cortical layer VI is associated projection fibers back to the thalamus. Layer IV receives input from the thalamus and is heavily myelinated in the occipital cortex (known as the stria of Gennari, also giving the name striate cortex). Layer V contains the large pyramidal Betz cells that project to the spinal cord.
9. **D** Internal pyramidal

Betz cells of the cerebral cortex are large pyramidal neurons that project to the spinal cord. They are found in layer V, or the internal pyramidal layer of the cortex.


10. **B** Potassium

TEA is a toxic compound that can lead to ganglionic competitive inhibition of acetylcholine. It also is known to block voltage gated potassium channels in nerve tissue and skeletal muscle.


11. **A** Increased transmembrane resistance, decreased capacitance

Myelination of nerves helps to increase conduction velocity of the action potential. It increases the AP velocity by increasing transmembrane resistance and decreasing membrane capacitance.


12. **C** Primary GBM

PTEN mutations are often seen in primary glioblastoma rather than low grade gliomas or secondary glioblastoma. For this reason it is helpful when determining if the GBM is primary or is representative of malignant transformation.


13. **A** Granular layer

The mossy fibers of the cerebellum synapse in the granular layer, and further projections arise from intrinsic cerebellar cortical cells. Only climbing fibers have direct synapses on Purkinje cells.


14. **B** CA1–CA3

The intrinsic circuitry of the hippocampus is heavily tested. Mossy fibers connect the dentate gyrus to CA3, and the Schaffer collateral pathway interconnects the CA3 and CA1 regions.


15. **C** Entorhinal cortex–dentate gyrus

The perforant pathway of the hippocampus is the initial limb of the intrinsic hippocampal circuitry. It initiates in the entorhinal cortex and perforates across the subiculum to enter the dentate gyrus.


16. **C** Dopamine

The substantia nigra has two nuclei, pars reticulata and pars compacta. The pars compacta projects dopaminergic neurons to the striatum as part of the intrinsic basal ganglia circuitry.


17. **A** Glutamate

The initial projections into the basal ganglia circuitry include motor cortex projections to the striatum. These projections are glutamatergic for both the direct and indirect pathways of the basal ganglia.


18. **B** 3

The hippocampus has three layers which is considered archicortex, histologically older cortex than the cerebral cortex. The three layers are the molecular layer, the pyramidal layer, and the polymorphic layer.

This patient is experiencing poikilothermia, or variance of body temperature with surrounding temperature. This is due to bilateral destruction of the posterior thalamic nucleus.

20. C   Hyperphagia
The ventromedial nucleus is involved in satiety and when bilaterally damaged, hyperphagia and obesity can occur. This is a known complication of complex craniopharyngioma resection in children and is a feared complication as it is very difficult to control in the postoperative setting.

21. A   Anterior nucleus
The anterior hypothalamus is involved in cooling of the body and parasympathetic functions. The posterior nucleus is involved in sympathetic functions and heating.

22. E   D2
The medication you are using is haloperidol, a butyrophenone. It antagonizes both D1 and D2 receptors, but the D2 receptors are located in the frontal cortex, the limbic system, and the hippocampus. The D1 receptors are located in the striatum and are responsible for Parkinson-like effects of haloperidol.

23. D   Hypothalamus–intermediolateral cell column
Sympathetic innervation of the eye begins in the hypothalamus where first-order neurons project to the intermediolateral cell column. The second-order neuron connects the IML cell column to the superior cervical ganglion, and the third-order neuron connects the superior cervical ganglion to the radial musculature via long ciliary nerves.

24. C   Uncouples oxidative phosphorylation
Cyanide is a toxic compound that abolishes the proton gradient utilized during oxidative phosphorylation in the mitochondria. It leads to severe lactic acidosis and is highly toxic and ingestion is often fatal.

25. B   Thoracic and abdominal viscera
The vagus nerve has multiple nuclei with different functions. The dorsal motor nucleus of the vagus nerve supplies visceral motor innervation of the thoracic and abdominal viscera, having parasympathetic functions on the gut.

26. B   G-protein
cAMP is a second messenger system within the G-protein receptor pathway. G proteins have three major subunits—alpha, beta, and gamma. The alpha subunit is associated with the interior plasma membrane and usually is the aspect that interacts with the effector enzymes. For G-protein receptors, G proteins are activated after GDP is exchanged for GTP. The G-proteins then stimulate adenylyl cyclase to synthesize cAMP which has downstream effects after it interacts with PKA (cAMP-dependent protein kinase), which in turn phosphorylates serine and threonine residues.

27. B   Gα
This patient has cholera, and cholera toxin selectively activates Gα1, part of the G-protein signaling pathway.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 5.

28. D  
Inositol triphosphate (IP_3), is a messenger generated by DAG (along with phospholipase C), and is liberated from the plasma membrane through G-protein coupled messenger systems. IP_3 binds receptors in the mitochondria and ER causing Ca^{2+} to be released within the cytosol of the neuron.

Psarros. The Definitive Neurosurgical Board Review, page 5.

29. C  
Nitric oxide liberation is a downstream effect of activation of the NMDA receptor signaling mechanism. NO is lipid soluble and in turn stimulates the production of cyclic-GMP.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 5.

30. A  
Epidermal growth factor  
Tyrosine kinase receptors bind ligands including epidermal growth factor, nerve growth factor, etc. Ultimately, binding of the ligands to this receptor subtype results in phosphorylation of serine and threonine residues. EGF receptor is often seen on high grade glial neoplasms, specifically astrocytic subtypes.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 5.

31. A  
Alpha  
The ACh receptor system is comprised of four major subunit types, with five total subunits—two alpha, one beta, one gamma, and one delta. Each alpha subunit binds one molecule of ACh, therefore requiring two molecules to activate the receptor.


32. B  
Sodium influx into the cytosol  
Alpha-bungarotoxin inhibits the alpha subunit of ACh receptors and in turn inhibits the influx of sodium into the cytosol.


33. C  
Succinylcholine  
Succinylcholine is a depolarizing neuromuscular blocking agent often used for intubation during induction of anesthesia. All other listed options are nondepolarizing agents.


34. C  
Renshaw cells of the spinal cord  
Muscarinic receptors are G-protein coupled receptors from the metabotropic family. They are inhibited by atropine and scopolamine, and activated by bethanechol and pilocarpine. They are located throughout the CNS, including the cortex, striatum, cerebellum, autonomic nuclei, and Renshaw cells of the spinal cord.


35. D  
GABA_\beta  
The patient is suffering from baclofen withdrawal. Baclofen is a GABA agonist that works on the GABA_\beta channel. Picrotoxin inhibits the GABA_\alpha receptor.


36. C  
Neuregulin  
There are a number of proteins that have effects on ACh receptor clustering in the NMJ. Neuregulin
is responsible for increasing transcription of ACh receptors from within the muscle fiber, leading to increased concentration of these receptors in the NMJ.


37.
A Sarcoplasmic reticulum
After an action potential is generated at the NMJ, it propagates throughout the muscle cell and leads to release of Ca$^{2+}$ from the sarcoplasmic reticulum.


38.
C Z disk
Each sarcomere is connected to another sarcomere at the Z disk. Unfortunately, elements of the sarcomere are often tested on the neurosurgical written boards.


39.
B H zone
During muscle contraction, Ca$^{2+}$ facilitates crossbridges between actin/myosin fibrils. This leads to shortening of the H zone and the I band, while the A band remains the same size (this is because the actin fibrils move across the myosin fibrils and not the other way around).


40.
C Troponin C
Troponin C binds four molecules of Ca$^{2+}$ within the muscle cell. This causes the troponin/tropomyosin complex to release from the actin fibril. In turn, this allows myosin heads to freely bind actin, forming the crossbridges. Next, myosin, which has ATPase capability, rotates, pulling the actin fibril along its length, leading to muscle contraction. After this is complete, ATP binds myosin which re-cocks the myosin head, ready to grab the next actin binding site along the fibril.

44. C Growth hormone

This patient has a growth-hormone secreting adenoma and may have features consistent with acromegaly. You should not order IGF-1 in the immediate postoperative period because it is similar to HgbA1c in that it represents levels of growth hormone over an extended period of time. You should order growth hormone to determine success of the surgery, as the levels of GH should respond much more quickly.


45. B 50% reduction in cortisol levels after high dose DMZ suppression test

Patients with Cushing’s disease will have a random ACTH > 5 ng/L, they will have a 50% or more reduction in cortisol levels after high dose DMZ test, often will have a positive IPS sampling (at least in the textbooks), and will have a positive metyrapone test (rise in 17-OHCS in urine 70% above baseline, or increase in serum 11-deoxycortisol 400-fold above normal).


46. B Dynein

Retrograde axonal transport is considered fast transport, occurring at roughly 400 mm/day. It utilizes ATP and the protein dynein.


47. D Kinesin

There are several types of slow anterograde axonal transport that utilize both dynamin and actin/myosin complexes. Fast anterograde transport utilizes kinesin and ATP, and can cover 400 mm/day.


51. B Raphe nucleus
   Serotonergic neurons are located primarily within the raphe nucleus of the brainstem reticular formation.


52. D Histamine
   Glutamate, GABA, and glycine are amino acid neurotransmitters, while histamine is not.


53. C Glycine
   Glycine is utilized by inhibitory Renshaw cells of the spinal cord.


54. C Choline acetyltransferase
   Preganglionic autonomic neurons all utilize acetylcholine as their neurotransmitter, and acetylcholine is synthesized by the enzyme choline acetyltransferase.


55. D Nucleus basalis of Meynert
   The nucleus basalis of Meynert is located in the basal forebrain and contains connections throughout the cerebrum. Its primary neurotransmitter is ACh, and ACh has been found to be depleted in patients with dementia. Thus, pharmacologic management of dementia is focused largely on increasing levels of ACh within the cerebrum.


56. B Endothelial tight junctions
   The blood–brain barrier (BBB) is composed primarily of endothelial cell tight junctions. While astrocytic foot processes are involved with transport of molecules across the BBB, they stimulate the endothelial cells to form the BBB.


57. D Microglia
   Microglia are glial cells of the CNS that are involved in phagocytosis and antigen presentation within the CNS. They are from mesodermal origin.


58. C Axon hillock
   Nissl substance is a granular body of the cell containing rough endoplasmic reticulum and ribosomes involved in protein synthesis. The axon
hillock does not contain Nissl substance and it is the most excitable region of the axon owing to the fact that it has the highest concentration of sodium channels.


59.
A Endoplasmic reticulum
There are two major classes of neurotransmitters, small molecule neurotransmitters and neuroactive peptides. Small molecule neurotransmitters (dopamine, NE, histamine, etc.) are synthesized throughout the neuron, while the larger neuroactive peptides (substance P, enkephalins) are synthesized solely from within the endoplasmic reticulum.


60.
B Cleavage of synaptobrevin causing inhibition of synaptic transmission
The synaptic vesicle uses several proteins to fuse with the active zone of the presynaptic terminal. One of these proteins, synaptobrevin, is inhibited by tetanus toxin leading to inhibition of synaptic transmission. Botulinum toxin inhibits v-SNAREs with the same effect. Microtubule dysfunction is caused by certain chemotherapeutics, including vinblastine.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 5.

61.
C Subgranular layer
There are two known sites of neurogenesis in the adult brain, the subependymal zone in the lateral ventricle (neurons and glia are generated and migrate to the olfactory bulb), as well as the subgranular layer of the dentate gyrus within the hippocampus.

Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 5.

68.

**B** 18 cc/100 g/min
Normal blood flow to the brain is considered to be 50 cc per 100 g of tissue per minute. Electrical failure occurs when blood flow falls to 18 cc/100 g/min or below.


69.

**C** Phospholipase C
During cerebral ischemia, glutamate is released, causing influx of Na into the neuron. This results in cerebral edema and influx of Ca$^{2+}$. If the Ca$^{2+}$ levels are high enough, activation of phospholipase C occurs and further cell damage occurs, ultimately leading to apoptosis.


70.

**B** K$^+$
The resting membrane potential of the neuron is determined by diffusion of Na, K, and Cl ions across the plasma membrane. Each has its own equilibrium potential. Due to a much larger concentration of K$^+$ channels open during the resting state and a resultant increased movement of K$^+$ ions, the membrane potential is closest to that of K$^+$ (−75 mV).

II Answers


71. A 10,000 molecules
   Each synaptic vesicle contains a specific amount of neurotransmitters referred to as 1 quantum. For ACh, this is roughly 10,000 molecules. In the neuromuscular junction, only 1 quantum of ACh is required to generate an MEPP. This will not result in depolarization of the muscle cell, however.

72. A Ia
   The muscle stretch reflex is the only monosynaptic reflex in the body and it is mediated by muscle spindles and Ia sensory fibers.

73. D IV
   Type IV sensory fibers (slow/burning pain and some temperature from cutaneous free nerve endings) have the slowest conductance, at 0.4 to 2 m/s.

74. B Ib
   Golgi tendon organs are located in series with muscle cells (as opposed to muscle spindles which are organized in parallel). GTOs function to detect muscle tension at the muscle/tendon interface. They transmit via Ib sensory fibers.

75. C Norepinephrine
   COMT and MAO (monoamine oxidase) both metabolize norepinephrine in the cytosol of cells. These enzymes are inhibited by selegiline.
12 Neuropathology

1. **B** EGFR amplification

   The pathology slide demonstrates evidence of glioblastoma, notable for pseudopalisading necrosis. GBM often demonstrates amplification of EGFR, and this can also be a reason for tumor transition from anaplastic astrocytoma to GBM.

   Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 126.


2. **C** Loss of sex chromosome

   The pathology slide demonstrates an anaplastic astrocytoma, a WHO grade III glioma. Genetic mutations include P53 mutations and loss of sex chromosome. They often demonstrate GFAP positivity and occasionally S-100 positivity.

   Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 126.


3. **B** IDH mutant

   IDH mutations are becoming important for both glioma identification/characterization as well as prognostication. IDH mutations in primary GBM are very rare. IDH mutations are much more commonly found in WHO grade II-III lesions. If a GBM is found to have IDH mutations, it is likely that it transformed from a lower grade glial neoplasm.

   Further Reading: Cohen et al. IDH1 and IDH2 Mutations in Glioma. 2013.


4. **A** Prominent Rosenthal fibers

   This MRI is suggestive of a pilocytic astrocytoma, given the cystic component with an enhancing nodule. Histologically, these tumors demonstrate parallel arrangement of bipolar astrocytes with Rosenthal fibers and eosinophilic granular bodies.


5. **C** Seizures

   This pathology slide demonstrates eosinophilic granular bodies and a “storiform” pattern of cellular organization. This is common in pleomorphic xanthoastrocytoma. Intense reticulin staining can also be observed. These tumors often develop in the temporal lobe, have cystic components and present with seizures.


6. **A** Cortical malformations

   This pathology slide demonstrates gemistocytic type cells with a large eosinophilic cytoplasm and a large eccentric nucleus seen in subependymal giant cell astrocytomas. These tumors are seen in tuberous sclerosis, where cortical tubers can also be seen.


7. **D** 1p/19q co-deletion

   This pathology slide demonstrates classic “fried-egg” appearance of oligodendrogliomas. These tumors often demonstrate 1p/19q co-deletion, and this finding is helpful for both therapeutic and prognostic applications.


8. B EMA positivity
   This pathology slide demonstrates classic periventricular pseudorosettes and uniform cells with variable nuclear : cytoplasmic ratio commonly seen in ependymoma. These tumors often present in the ventricle, and are found to be GFAP, PTAH and EMA positive.


9. D Lack of gadolinium enhancement on MRI
   This pathology slide demonstrates classic subependymoma, showing small groups of cells with scant cytoplasm in a fibrillary background (islands of blue in a sea of pink). These tumors are often slow growing and can be completely asymptomatic, but due to their location in the 4th ventricle in most adults, they can present with hydrocephalus. On MRI, they classically are an intraventricular lesion that does not demonstrate enhancement with gadolinium.


10. B Steroids
    This slide demonstrates a cellular proliferation around small vascular channels/arterioles. This is highly suggestive of CNS lymphoma, and initial treatment can be carried out with steroids.


11. A Attached to septum pellucidum
    This slide demonstrates a central neurocytoma, with homogenous cells with round nuclei on a fibrillary background. These tumors are found within the lateral ventricle attached to the septum pellucidum.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 129.

12. A Arachnoid cap cells
    This slide demonstrates a classic meningioma. These tumors develop from arachnoid cap cells.


13. B Psammomatous
    This slide demonstrates a classic psammomatous meningioma. While multiple subtypes of meningiomas may demonstrate psammoma bodies, when there is a high concentration of these structures, the overall morphology is likely a psammomatous meningoma.


14. B Loss of chromosome 22
    The slide demonstrates a meningioma. The most common genetic malformation in meningioma is loss of chromosome 22.


15. B Rhabdoid
    Papillary, rhabdoid and anaplastic meningiomas are considered WHO grade III. Atypical and
chordoid meningomas are considered WHO grade II, and all others are considered WHO grade I.

17. A Vimentin
Meningiomas often have vimentin, EMA and occasionally S-100 positivity.

18. D Pineal
The tumor type depicted is a pineoblastoma. It is a poorly differentiated cancer of embryonal origin that demonstrates sheets of blue cells forming classic Flexner-Wintersteiner rosettes, pictured here. These are rosettes formed around cellular extensions rather than a blood vessel.
Further Reading: Psaaros. The Definitive Neurosurgical Board Review.

19. B gsp
The patient has signs of acromegaly, suggestive of a GH-secreting pituitary adenoma. 40% of GH-secreting adenomas exhibit a mutation of gsp.

20. A GH
Large, non-functioning pituitary adenomas can cause pituitary failure due to compression of the gland. GH is often the first peptide to be noticeably diminished in this setting.

21. C Papillary craniopharyngioma
The histologic slide demonstrates a papillary craniopharyngioma, the subtype more commonly found in adults. Adamantinomatous subtypes exhibit cholesterol clefts and scattered calcification.

22. B EMA negative
This slide demonstrates a hemangiopericytoma, with classic staghorn vessels. While both meningiomas and HPCs stain positive for vimentin, HPCs are EMA negative while meningiomas are EMA positive.

23. A Colloid cyst
This slide demonstrates a colloid cyst. The patient presented with headaches and likely low grade hydrocephalus. These lesions present within the third ventricle at the level of the foramen of Monro. They can transiently obstruct CSF flow leading to hydrocephalus. Histologically, they demonstrate a fibrous capsule with an inner epithelial layer and proteinaceous material within the cyst itself.

24. B Pars intermedia
This slide demonstrates a Rathke’s cleft cyst, as evident by the cleft as well as normal surrounding pituitary tissue. These masses arise from the pars intermedia of the pituitary gland.
25. B  Floor of the 4th ventricle
   The slide demonstrates perivascular pseudorosettes, columnar cells surrounding blood vessels. This is a classic finding for ependymoma, which is thought to arise from the floor of the 4th ventricle. Often times these tumors present with nausea compared to subependymomas.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 128.

26. B  Vimentin
   This slide demonstrates an ependymoma, classic with perivascular pseudorosettes. Ependymomas often have a loss of chromosome 22 and exhibit GFAP, PTAH and EMA positivity.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 128.

27. A  Subependymoma
   This patient had a subependymoma resected. These masses classically do not enhance on MRI, and pathology demonstrates “islands of blue in a sea of pink.”
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 128.

28. C  Paraganglioma
   The slide demonstrates a paraganglioma, with evidence of capillary networks and nests of chief cells. These lesions can secrete bioactive amines.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 129.

29. D  Lhermitte-Duclos disease
   This MRI demonstrates findings consistent with Lhermitte-Duclos disease, with evidence of hypertrophic cerebellar folia.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 129.

30. C  PTEN
   This MRI demonstrates findings consistent with Lhermitte-Duclos disease, with evidence of hypertrophic cerebellar folia. This finding can be seen in patients with Cowden’s syndrome, often caused by a mutation in PTEN.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 129.

31. B  Choroid plexus papilloma
   The slide demonstrates a choroid plexus papilloma, which often arises from the 4th ventricle in adults. They exhibit columnar epithelium in papillary extensions with an interior fibrovascular region.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 130.

32. A  P53
   The slide demonstrates a choroid plexus papilloma, which has been shown to be associated with Li-Fraumeni syndrome, a syndrome caused by germline mutations in P53. CPPs are vimentin, GFAP and S100 positive.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 130.

33. A  Antoni A
   This slide demonstrates a schwannoma with two distinct histologic areas. The black arrow is located within an area with prominent fascicles of spindle shaped cells, indicative of an Antoni-A area.
   Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 130.

34. C Verocay body
This slide demonstrates a schwannoma and prominently displays a Verocay body, classically described as “sequential nuclear palisading.”

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 130.


35. C Endoneurium
Neurofibromas are distinct from schwannomas and are thought to arise from the endoneurium of peripheral nerves.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 130.


36. D Neurofibroma
This slide demonstrates a neurofibroma, characterized by spindle-cells in a wavy pattern with large amounts of collagen and a myxoid background. They are often seen in NF1.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 130.


37. A Vimentin
This slide demonstrates a neurofibroma, characterized by spindle-cells in a wavy pattern with large amounts of collagen and a myxoid background. Classically they stain positive for S-100.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 130.


38. B MPNST
This slide demonstrates an MPNST, with the “storiform cellular pattern, prominent mitoses in a fascicular pattern.” Necrosis can also be seen on histology of MPNSTs.


39. A 3
This slide demonstrates a hemangioblastoma, with a dense network of vascular channels and lipid containing interstitial cells. These tumors are associated with von-Hippel Lindau syndrome, characterized by a mutation on chromosome 3.


40. C Epidermoid cyst
This slide demonstrates an epidermoid cyst, characterized by stratified squamous epithelium and significant keratin within the center.


41. D Chordoma
This slide demonstrates a chordoma, with “groups of cells with vacuolated cytoplasm” known as (physaliphorous cells). Glycogen deposits can also be seen. These tumors are locally aggressive, often present within the clivus or sacrum, and originate from remnants of the notochord.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 133.


42. C Dysembryoplastic neuroepithelial tumor
This slide demonstrates a DNET, and the history is helpful as well. DNETs occur most commonly in the temporal lobe and can be associated with refractory epilepsy. Histologically, there are multiple mucin containing cysts with glial nodules. These
masses are synaptophysin positive and neurofilament protein positive.

Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 129.

43.  
D  Group 5
This slide demonstrates findings consistent with medulloblastoma, including multiple, round, blue cells with scant cytoplasm. Occasional Homer-Wright rosettes (true rosette without central lumen or blood vessel) can be seen. There are 4 molecular subtypes of medulloblastoma, including Wnt, SHH, Group 3 and Group 4.
Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 129.

44.  
B  External granular layer of the cerebellum
This slide demonstrates findings consistent with medulloblastoma, and these tumors are though to arise from the roof of the 4th ventricle, specifically the granular layer of the cerebellum. This differentiates their origin from ependymomas of the 4th ventricle.
Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 129.

45.  
A  Placental alkaline phosphatase
This slide demonstrates findings consistent with germinoma, including "round neoplastic cells with prominent clear cytoplasm and large nuclei, occasionally with associated inflammation." CSF markers are important in pediatric suprasellar masses, and an elevated placental alkaline phosphatase can make the diagnosis of germinoma.
Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 130.

46.  
B  B-HCG
This slide demonstrates findings consistent with choriocarcinoma with evidence of syncytiotrophoblastic giant cells. Choriocarcinomas have elevated B-HCG levels.
Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 130.

47.  
C  AFP
This slide demonstrates findings consistent with a yolk sac tumor, with prominent schiller Duval bodies. Yolk-sac tumors are strongly positive for AFP on CSF analysis.
Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 130.

48.  
A  Mature teratoma
This slide demonstrates findings consistent with a mature teratoma, a cystic lesion that contains tissue from ectodermal, endodermal and mesodermal origin. CSF is often negative for aberrations in markers for mature teratomas.
Further Reading: Psaraos. The Definitive Neurosurgical Board Review, page 130.

49.  
A  Wnt
This slide demonstrates findings consistent with medulloblastoma, of which there are 4 subtypes, SHH, Wnt, Group 3 and Group 4. With current therapeutics, the Wnt subtype his the longest overall survival, followed by SHH, followed by Group 3/4 tumors.

50.  
B  Dermoid cyst
This slide demonstrates findings consistent with a dermoid cyst, containing sebaceous glands and keratin. Dermoid cysts are usually found in the midline.
51. C Electrolyte abnormalities
   This pathology slide demonstrates evidence of central pontine myelinolysis, or osmotic demyelination syndrome. It can occur with too rapid correction of chronic sodium abnormalities.
   Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 111.

52. D Hepatic encephalopathy
   This slide demonstrates Alzheimer's type II astrocytes, with scant cytoplasm and prominent marginated chromatin within a large nucleus. They are characteristic of hepatic encephalopathy. Given that the patient had asterixis as well, hepatic disease should be considered.
   Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 112.

53. B Gaucher's disease
   This slide demonstrates macrophages with "crinkled tissue paper" classic for Gaucher's disease. In it's juvenile neuropathic form, this disease presents with splenomegaly, myoclonic epilepsy and cognitive decline.
   Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 112.

54. A Abnormal very long-chain fatty acid metabolism
   This MRI demonstrates abnormal white matter throughout the deep hemisphere with sparing of the subcortical U fibers. This is classic for adrenoleukodystrophy, which occurs with deficits in very long chain fatty acid metabolism.
   Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 112.

55. B Multiple sclerosis
   This brain section demonstrates peri-ventricular demyelination, consistent with multiple sclerosis. These lesions on imaging are often referred to as "Dawson's fingers."

56. C Neurosarcoïdosis
   This MRI demonstrates cranial nerve enhancement, in this setting, the facial nerve enhances. This, along with non-caseating granuloma on sural nerve biopsy is highly suggestive of neurosarcoïdosis.
   Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 125.

57. A HLA B27
   This slide demonstrates multiple sclerosis, which is associated with alleles HLA DR2, A3, B7 and DR 15.

58. B Multiple sclerosis
   This MRI demonstrates multifocal demyelination, or Dawson's fingers, which could be consistent with lymphoma or multiple sclerosis. The transient nature of his deficits leads to the most likely diagnosis of multiple sclerosis.

59. D Tay-Sach's disease
   This slide demonstrates ballooned neurons that contain prominent stored gangliosides, and is consistent with a diagnosis of Tay-Sach's disease.
Further Reading: Psaros. The Definitive Neurosurgical Board Review, page 112.

60. B JC virus
This slide demonstrates evidence of progressive multifocal leukoencephalopathy, which results in multiple areas of demyelination on imaging, and foamy macrophages with large, pleomorphic astrocytes on histology. Oligodendrocytes can be seen with viral inclusions as well.


61. D Hexosaminidase A
Tay-Sachs disease is an autosomal recessive disorder caused by deficiency of hexosaminidase A. Patients have defective lipid metabolism in neurons.

Further Reading: Psaros. The Definitive Neurosurgical Board Review, page 112.

62. A Mucopolysaccharidoses
This slide demonstrates evidence of zebra cells, which is representative of stored mucopolysaccharides within cells. These cells are difficult to depict on standard histology given that they are highly water soluble.

Further Reading: Psaros. The Definitive Neurosurgical Board Review, page 112.

63. B Charcot-Marie-Tooth disease
The pathology demonstrates evidence of onion bulb formation within the peripheral nervous system. This, along with peripheral neuropathies and lower extremity deformities are classic for Charcot-Marie-Tooth disease.

Further Reading: Psaros. The Definitive Neurosurgical Board Review, page 112.

64. B Pyruvate dehydrogenase
This MRI demonstrates evidence of mamillary body degeneration. When taken with the clinical findings, this is indicative of Wernicke’s encephalopathy. This results from thiamine deficiency and impaired function of pyruvate dehydrogenase.

Further Reading: Psaros. The Definitive Neurosurgical Board Review, page 110.

65. A Nicotinic acid deficiency
The slide described has evidence of chromatolysis of Betz cells. When taken with the clinical triad of dermatitis, diarrhea and dementia, nicotinic acid deficiency causing pellagra should be considered.

Further Reading: Psaros. The Definitive Neurosurgical Board Review, page 110.

66. D Cutaneous vascular nevi
This picture demonstrates evidence of meningeal angiomatosis, a classic part of Sturge-Weber syndrome. Other findings include cutaneous vascular nevi of the face in the distribution of the trigeminal nerve, or the “Port-wine stain.”

Further Reading: Psaros. The Definitive Neurosurgical Board Review, page 110.

67. C This brain demonstrates polymicrogyria, a condition that can be asymptomatic, or cause severe mental retardation if the involvement is throughout the cortical surface of the brain.
Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 110.

68. A Pachygyria
This brain demonstrates pachygyria, a form of lissencephaly, or neuronal migration disorders. The gyri are enlarged and fewer in number than normal brain.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 110.

69. A Meckel-Gruber syndrome
This is an occipital encephalocele, and when present along with hepatic fibrosis and polycystic kidney disease, the underlying diagnosis is Meckel-Gruber syndrome. It is an autosomal recessive syndrome and is lethal syndrome.


70. C Carbon monoxide poisoning
This brain slice demonstrates evidence of bilateral basal ganglia destruction. The basal ganglia are particularly affected during carbon monoxide poisoning and are damaged in this condition. The findings are evident on imaging as well.


71. B Oil red O stain
Oil red O stain is used to highlight fat globules within the vasculature and can lead to a diagnosis of fat embolism, often after long bone fracture.


72. C Herpes encephalitis
This brain specimen demonstrates lymphocytic perivascular cuffing and a Cowdry type A inclusion body. This is highly suggestive of herpes simplex encephalitis. These patients should be started on acyclovir immediately if herpes encephalitis is suspected.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 121.

73. A Cytomegalovirus
This slide demonstrates an intranuclear inclusion body consistent with a viral infection. The presence of periventricular calcifications and chorioretinitis make CMV the most likely diagnosis.

Hall, Kim. Neurosurgical Infectious Disease, 2014, viral infections of the central nervous system.

74. D Cryptococcus neoformans
Meningitis in HIV positive patients is most commonly caused by cryptococcus infection.

Hall, Kim. Neurosurgical Infectious Disease, 2014, fungal infections of the central nervous system.

75. C S. milleri
Streptococcus milleri is the most common isolate from cerebral abscesses in adults.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 123.

76. B 3 to 7 days
Necrosis is first seen in the focal suppurative encephalitis phase (phase II) which occurs between 3-7 days. Initial encapsulation is Phase III.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 123.

77. 
C 8 to 14 days
This slide demonstrates an abscess with evidence of an early capsule. This occurs during early encapsulation, days 8 to 14.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 123.

78. 
B M. tuberculosis
This slide demonstrates an abscess with evidence of a multinucleated giant cell. The presence of the giant cell makes Mycobacterium tuberculosis the most likely diagnosis.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 123.

79. 
C Mucormycosis infection
This picture demonstrates a frontal lobe mass that appears to be emanating from the floor of the anterior fossa, possibly from the paranasal sinuses. In the setting of uncontrolled diabetes, mucormycosis is the most likely diagnosis and is highly fatal.
Hall, Kim. Neurosurgical Infectious Disease, 2014, fungal infections of the central nervous system.

80. 
B Aspergillus infection
This slide demonstrates evidence of fungal hyphae that are both branching acutely and invading a blood vessel, consistent with aspergillosis. The brain is often seeded from the lung, and the fungus invades the blood vessels.
Hall, Kim. Neurosurgical Infectious Disease, 2014, fungal infections of the central nervous system.

81. 
B Cavernous malformation
This slide demonstrates evidence of a cavernoma. The dilated blood filled spaces represent an abnormality at the capillary level. There is no brain between the blood vessel walls, distinguishing it from an AVM. Often times these lesions present with seizures.

82. 
A 3
Familial cavernomatosis is an inherited condition predisposing to multiple cavernous malformations throughout the brain. It is thought to be caused by gene mutations on chromosomes 3 and 7.

83. 
C Seizures
This slide demonstrates a cavernoma. Often times cavernomas present with seizure activity after hemorrhage events.

84. 
B Arteriovenous malformation
This slide demonstrates an arteriovenous malformation. Note the presence of vascular channels with vessel walls containing prominent internal elastic laminae. This compares to cavernous malformations where dilated capillaries are the cause.
Further Reading: Psarros. The Definitive Neurosurgical Board Review, page 118.

85. 
B Internal elastic laminae
Intracranial aneurysms do not have the elastic lamina and muscularis layer present in normal blood vessels.
Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 118.

86.  
D Candidiasis  
Candidiasis is the most common mycotic infection of the CNS, but this is not common in otherwise healthy patients. CNS involvement is one of the last aspects of this systemic disease.
Hall, Kim. Neurosurgical Infectious Disease, 2014, fungal infections of the central nervous system.

87.  
D Candidiasis  
Candidiasis is the most common mycotic infection of the CNS, but this is not common in otherwise healthy patients. CNS involvement is one of the last aspects of this systemic disease. Histologically, it presents with budding yeast and hyphae.
Hall, Kim. Neurosurgical Infectious Disease, 2014, fungal infections of the central nervous system.

88.  
A Ruptured aneurysm  
This CSF sample demonstrates erythrocytes, which would only be seen in a case of subarachnoid hemorrhage from a ruptured aneurysm.

89.  
C Giant cell arteritis  
This ultrasound demonstrates evidence of giant cell arteritis. Note the multiple granulomas within the vessel wall with evidence of thickening. It is often seen on temporal artery biopsy in patients with associated malaise, fever and diffuse myalgias. It is associated with polymyalgia rheumatica. If untreated, blindness can occur.
Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 117.

90.  
C Blindness  
This specimen demonstrates evidence of giant cell arteritis. Note the multiple granulomas within the vessel wall. It is often seen on temporal artery biopsy in patients with associated malaise, fever and diffuse myalgias. It is associated with polymyalgia rheumatica. If untreated, blindness can occur.
Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 117.

91.  
B SOD-1  
ALS is a motor neuron degenerative condition caused by mutations in superoxide dismutase (SOD 1) gene in 25% of cases.

92.  
D XII  
ALS causes motor neuron loss in cranial nerve XII, the hypoglossal nerve. This is identified by fasciculations of the tongue. Generally, ALS spares cranial nerves III, IV and VI.

93.  
C Parkinson’s disease  
This slide demonstrates Lewy bodies, which can be identified as inclusion bodies containing an eosinophilic core with a pale halo surrounding the core. They stain for ubiquitin. Lewy bodies are seen in Parkinson’s disease.
94. Parkinson’s disease

C This slide demonstrates a Lewy body in its classic form, an eosinophilic intracytoplasmic inclusion body with a clear halo surrounding it.


95. Friedrich’s ataxia

D This slide demonstrates evidence of diffuse atrophy, most notable in the gracilis column, the cuneate column, the spinocerebellar tracts and Clarke’s column. These findings, when present with cardiomyopathy, are suggestive of Friedrich’s ataxia, caused by a mutation in the frataxin gene on chromosome 9q.


96. Nucleotide duplication

C This brain demonstrates evidence of caudate atrophy. In the setting of choreiform movements, Huntington’s disease is the underlying diagnosis. This is due to mutations in the huntingtin gene on chromosome 4. It is a trinucleotide repeat disorder that demonstrates anticipation.


97. Acetylcholine

C This beta amyloid stained slide demonstrates senile plaques consistent with Alzheimer’s disease. It is associated with loss of acetylcholine within the basal nucleus of Meynert.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 120.

98. Basal nucleus of Meynert

D The slide demonstrates a Hirano body, a eosinophilic cytoplasmic inclusion body that consists of actin-associated proteins in patients with Alzheimer’s disease. Medications for this condition are used to increase the concentration of acetylcholine in the basal nucleus of Meynert.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 120.

99. Phosphorylated tau protein

B This slide demonstrates a neurofibrillary tangle, seen in Alzheimer’s dementia. It is made of phosphorylated tau protein.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 120.

100. Creutzfeldt-Jakob disease

A This slide demonstrates spongiform change and subsequent vacuolation of the neural cells. These are hallmark findings in a patient with CJD.

Further Reading: Psaaros. The Definitive Neurosurgical Board Review, page 121.
13 Neuroimaging

1. C Glioma
   This MR spectroscopy (MRS) image demonstrates an area of abnormality in the left insula. On MRS, the choline peak is much higher than the N-acetylaspartate (NAA) or creatine peak. This is suggestive of glioma.

2. B Infarction
   MRS can be used to determine what an abnormality may be when seen on MRI. The classic choline peak is suggestive of glioma. When the lactate peak is elevated, ischemic stroke is suggested, given that the brain has switched over to anaerobic metabolism.

3. D Radiation necrosis
   MRS can be difficult to determine the difference between radiation necrosis and recurrent glioma. However, in recurrent glioma, a choline peak would be suggested, while in radiation necrosis, a significant NAA peak can be seen.

4. D IDH-1 wild type
   This MRI is suggestive of a glioblastoma (GBM), based on ring enhancement of a “butterfly” lesion. Most primary GBMs are IDH-1 wild type and, when found to be IDH-1 mutant, may be suggestive of a malignant transformation from a lower grade glioma.

5. A Glioblastoma
   This MRI demonstrates evidence of a malignant GBM.

6. B Meningioma
   This MRI demonstrates a classic appearance of a meningioma with associated dural tails.

7. B WHO grade II
   This MRI demonstrates a classic appearance of a meningioma with associated dural tails. If pathology determined this to be chordoid type, it would make it an atypical, or WHO grade II lesion.

8. C Hemangiopericytoma
   This MRI demonstrates an invasive lesion that appears to be associated with the meninges. It has a look of a meningioma, but in this case was a hemangiopericytoma. When these tumors are based in the meninges, they can closely resemble meningiomas, but may appear much more vascular and may have more associated cerebral edema.

9. B Gray–white matter junction
   This MRI demonstrates evidence of multiple metastatic lesions. These lesions most often are located at the gray–white matter junction as this is the level of the small capillaries that tend to filter out cells as they metastasize.
10.  
**A** Skin  
This MRI demonstrates a cerebral metastasis with significant edema and a fluid–fluid level within the mass suggestive of hemorrhage. The hemorrhagic nature of this mass makes it most likely to be melanoma out of the choices listed above. Renal cell metastases are also known to hemorrhage.  

11.  
**D**  
This MRI demonstrates bilateral vestibular schwannomas. This is very common in patients with NF2, caused by a chromosomal abnormality on chromosome 22.  

12.  
**B** Epidermoid cyst  
This diffusion-weighted MRI demonstrates a cerebellopontine (CP) angle mass that is bright on diffusion images. This finding is consistent with an epidermoid cyst of the CP angle. The diffusion scans are important to evaluate with CP angle masses to rule out epidermoid cysts, as they are the mass in this region that are bright on diffusion.  

13.  
**D** Ependymoma  
This gadolinium-enhanced MRI demonstrates an expansile mass with heterogenous enhancement within the fourth ventricle. It also extends laterally through the foramen of Luschka. This, along with the history of nausea at presentation, makes ependymoma the most likely diagnosis. Ependymomas are known to extend laterally, enhance, and cause nausea at presentation. There is also an association between these tumors and NF2.  

14.  
**B** Luschka  
This gadolinium-enhanced MRI demonstrates an expansile mass with heterogenous enhancement within the fourth ventricle. It also extends laterally through the foramen of Luschka. This, along with the history of nausea at presentation, makes ependymoma the most likely diagnosis. Ependymomas are known to extend laterally, enhance, and cause nausea at presentation. There is also an association between these tumors and NF2.  

15.  
**B** Subependymoma  
This gadolinium-enhanced MRI demonstrates a mass within the fourth ventricle that does not enhance. This is a classic picture for a subependymoma. While ependymomas can also present in the fourth ventricle, they generally have a heterogenous enhancement pattern.  

16.  
**D** PICA aneurysm  
This T2 sequence axial MRI demonstrates a large mass in the posterior fossa. There is T2 hypointensity within the mass in a somewhat layered form. Given the location and the appearance on T2, this should be concerning for a posterior fossa aneurysm.  

17.  
**C** Cavernous malformation  
These MRI sequences demonstrate a mass within the brainstem consistent with a cavernous malformation. Cavernomas often appear very dark on gradient-echo (GRE) sequences owing to bleeding events.  
18. D Persistent trigeminal artery
   This lateral DSA of the ICA demonstrates filling of both the ICA and posterior circulation simultaneously. There is a persistent trigeminal artery connecting the ICA to the basilar artery. It is the most common persistent connection between the ICA and basilar systems. A fetal PCA would be an enlarged posterior communicating artery with an absent ipsilateral P1 segment.

19. B Carotid-ophthalmic aneurysm
   This DSA of the ICA demonstrates an aneurysm of the ophthalmic segment of the ICA. It is superiorly projecting, which makes it most likely a carotid ophthalmic aneurysm. Superior hypophyseal aneurysms can arise in the same location, but tend to project inferomedially rather than superolaterally.

20. B Intracranial/extradural
   This angiogram of the ICA demonstrates a petrous/cavernous segment fusiform aneurysm, making it intracranial, but extradural. This makes these aneurysms much more stable and in some cases, they do not require treatment (mainly for stable cavernous segment aneurysms). When they rupture, a direct/indirect CC fistula can occur and patients can present with paralysis of the eye, as well as chemosis, proptosis, and venous congestion on the ipsilateral eye.

21. B Anastomotic vein of Labbé
   The arrows in this magnetic resonance venography (MRV) are demonstrating the inferior anastomotic vein (of Labbé). It is an important structure as damage the vein of Labbé can lead to venous infarction of the temporal lobe.

22. C Size greater than 1.0 cm
   This coronal MRI demonstrates a pituitary macroadenoma given that the size of the adenoma is greater than 1.0 cm.

23. C Tuberculum meningioma
   This enhanced MRI demonstrates a suprasellar mass. It is most consistent with a tuberculum meningioma due to the dural tail.

24. A Neurofibromatosis type 1 (NF1)
   This MRI demonstrates enlargement of the optic nerve in a pediatric patient consistent with an optic pathway glioma. These tumors are highly associated with neurofibromatosis type 1 (NF1).

25. C 9
   This MRI demonstrates a homogenously enhancing mass at the level of the foramen of Monro most consistent with a subependymal giant cell astrocytoma. These tumors are found in tuberous sclerosis, which can be caused by a mutation in tuberous sclerosis 1 (TSC1) on chromosome 9.

26. D Internal cerebral veins
   In this coronal MRI, the white arrowheads are pointing to the paired internal cerebral veins within the third ventricle.
27. Hippocampus
   D This coronal MRI is T2 weighted, and number
   18 demonstrates the hippocampal formation. It is
   important to identify the hippocampus, especially
   in patients in whom there is concern for mesial
   temporal sclerosis and seizures.

Further Reading: Cataltepe, Jallo. Pediatric Epilepsy
Surgery, 2010, resective surgical techniques in
temporal lobe epilepsy: transsylvian selective
amygdalohippocampectomy.

28. Posterior reversible encephalopathy syndrome
   C This MRI demonstrates T2 hyperintensities
   within the parieto-occipital lobes bilaterally.
   This, associated with seizures on presentation, is
   classic for posterior reversible encephalopathy
   syndrome (PRES).

Further Reading: Harbaugh, Shaffrey, Couldwell,
Berger. Neurosurgery Knowledge Update, 2015,
posterior reversible encephalopathy syndrome.

29. Start acyclovir
   A This MRI demonstrates hyperintensities within
   the anterior temporal lobes bilaterally. In the sett-
   ing of a rapidly declining patient with seizures,
   herpes encephalitis should be strongly considered
   and acyclovir should be initiated.

Further Reading: Hall, Kim. Neurosurgical Infect-
ious Disease, 2014, radiology of central nervous
system infections.

30. Neurocysticercosis
   B This MRI demonstrates multiple lesions with-
   in the cerebrum. Each lesion demonstrates T2
   hyperintensities within the central core as well as
   a hypointense region within the cyst, the classic
   “cyst with a dot sign.” This MRI is consistent with
   neurocysticercosis.

Further Reading: Hall, Kim. Neurosurgical Infect-
ious Disease, 2014, radiology of central nervous
system infections.

31. CMV encephalitis
   B This CT scan demonstrates diffuse periventric-
   ular calcifications and hydrocephalus, findings
   associated with CMV encephalitis in the pediatric
   population.

Further Reading: Hall, Kim. Neurosurgical Infect-
ious Disease, 2014, microbiological diagnosis of
central nervous system infections.

32. Multiple sclerosis
   A This MRI demonstrates the classic periventric-
   ular hyperintensities, “Dawson’s fingers” asso-
   ciated with multiple sclerosis. The intermittent
   nature of the deficits helps point toward the diag-
   nosis of MS.

Further Reading: Forsting, Jansen. MR Neuroim-
aging: Brain, Spine, Peripheral Nerves, 2017, multi-
ple sclerosis and related diseases.

33. Tumefactive multiple sclerosis
   C This MRI demonstrates an acute, fulminant
demyelinating process causing severe mass effect
consistent with tumefactive MS. There is incom-
plete ring enhancement and decreased perfusion
to the region, making GBM less likely.

Further Reading: Forsting, Jansen. MR Neuroim-
aging: Brain, Spine, Peripheral Nerves, 2017, multi-
ple sclerosis and related diseases.

34. Very long chain fatty acid synthesis
   A This MRI demonstrates white matter edema
   that appears to spare the subcortical U-fibers. This
   can be seen in X-linked adrenoleukodystrophy,
   which is caused by an abnormality in very long
   chain fatty acid synthesis.

Further Reading: Forsting, Jansen. MR Neuroim-
aging: Brain, Spine, Peripheral Nerves, 2017, meta-
bolic disorders.

35. Cerebral abscess
   B This CT demonstrates a cortical ring enhancing
   mass with significant surrounding edema. Given
   the clinical history, cerebral abscess should be high
   on the differential. Metastatic lesions can cause
   this much edema, but GBM often does not present
   with this much perilesional edema.

Further Reading: Forsting, Jansen. MR Neuroim-
aging: Brain, Spine, Peripheral Nerves, 2017, infec-
tions.

36. Streptococcus milleri
   A This MRI demonstrates a cortical ring enhanc-
   ing mass with significant surrounding edema.
Given the clinical history, cerebral abscess should be high on the differential. The most common isolate from primary cerebral abscesses listed here is Streptococcus milleri.


37. D Lymphocytic hypophysitis
This sagittal MRI demonstrates an enlarged pituitary gland as well as an enlarged infundibular stalk, both of which enhance with contrast. Given the female gender and history of recent pregnancy, lymphocytic hypophysitis should be strongly considered. This condition is often self-limited.


38. D Give hydrocortisone
This MRI demonstrates pituitary hemorrhage, and in this patient, consistent with Sheehan's syndrome, a pituitary infarction caused by large-volume blood loss during delivery. After necrosis of the pituitary gland, hemorrhage can occur. These patients can decompensate quickly due to further hypotension given a complete lack of cortisol. Hydrocortisone should be given immediately and, next, consideration of pituitary decompression should be considered to save vision.


39. C Neurosarcoidosis
This skull base MRI demonstrates diffuse, homogenous enhancement of cranial nerves and the leptomeninges. This finding, with cranial neuropathies, can be consistent with neurosarcoidosis.


40. B Dopamine
This MRI demonstrates the substantia nigra, which uses dopamine as its primary neurotransmitter.


41. C Frontotemporal dementia
This MRI demonstrates atrophy of the frontal lobe with sparing of the parietal lobes. These findings, along with socially disruptive behavior and personality changes, are consistent with frontotemporal dementia. This term is becoming antiquated, and behavioral variant FTLD (frontotemporal lobe degeneration) is being used. It has also been termed Pick's disease, but this should refer only to patients with histologically proven Pick's bodies.


42. A Isointense
Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).


43. B Hyperintense
Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).

II Answers

44. C Hypointense

Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).


45. C Hypointense

Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).


46. B Hyperintense

Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).


47. C Hypointense

Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).


48. B Hyperintense

Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).


49. C Hypointense

Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).


50. C Hypointense

Blood products on MRI are highly testable and annoying to memorize. Several mnemonics exist, but consider the classic mnemonic I Be, iDDy, BiDy, BaBy, DooDoo. Hyperacute (< 24 hours) = I B (T1/T2) or T1 isointense and T2 hyperintense. Acute (1–3 days) = DD (T1 dark, T2 dark), early subacute (3–7 days) = BD (T1 bright, T2 dark), late subacute (7–14 days) = BB (T1 bright, T2 bright), chronic (> 14 days) = DD (T1 dark, T2 dark).

13 Neuroimaging

Further Reading: Dickman, Fehlings, Gokaslan. Spinal Cord and Spinal Column Tumors, 2006, radiologic imaging of tumors of the spine, spinal cord, and peripheral nerves.

56. C Myxopapillary ependymoma
   This sagittal MRI demonstrates classic findings for myxopapillary ependymoma. A uniform, enhancing mass in close approximation to the conus medullaris is most often consistent with myxopapillary ependymoma.

57. A NF1
   This MRI demonstrates a spinal cord astrocytoma. There is diffuse T2 signal throughout the cord and patchy enhancement within the spinal cord itself. Spinal cord astrocytomas can be associated with neurofibromatosis type 1.

58. B Astrocytoma
   This MRI demonstrates expansion of the thoracic spinal cord with T2 hyperintensity. This is most consistent with spinal cord astrocytoma. Astrocytomas of the spine are the second most common intramedullary tumor behind ependymomas; however, ependymomas are usually more circumscribed and homogenously enhancing.

59. D Osteoid osteoma
   This CT scan demonstrates the hyperdense lesion with hypodense halo consistent with osteoid osteoma. Oftentimes, these masses cause pain that is more severe at night and relieved by aspirin.

65. C Elastin
This MRI demonstrates lumbar stenosis, consistent with the patient presentation as well. The level with the yellow arrow demonstrates a disk bulge as well as ligamentum flavum hypertrophy, common in lumbar spinal stenosis. The ligamentum flavum is comprised of 80% elastin, which allows it to stretch in flexion and not buckle in extension. As patients age, the elastin is replaced with collagen and the yellow ligament loses its elasticity, causing it to buckle in extension and compress the neural elements.


66. C Right L5
This MRI demonstrates disk-herniation at L4–L5 on the right side. Given that it is a paracentral disk herniation, this patient would most likely experience symptoms from compression of the right L5 nerve root as it is traversing at this level. The right L4 nerve root has already exited the foramen.


67. C Right extensor hallucis longus weakness
This MRI demonstrates disk herniation at L4–L5 on the right side. Given that it is a paracentral disk herniation, this patient would most likely experience symptoms from compression of the right L5 nerve root as it is traversing at this level. The right L4 nerve root has already exited the foramen. The L5 nerve is easily assessed by examining the extensor hallucis longus on the ipsilateral side.


68. B Right quadriceps weakness
This MRI demonstrates disk herniation at L3–L4 on the right side, but it demonstrates a far lateral/foraminal disk herniation. This is different from a paracentral herniation in that foraminal/far lateral disk herniations affect the exiting root at that level.
rather than the traversing root. In this case, the right L3 root would be compressed, causing quadriceps weakness.


69.
A Right L3
This MRI demonstrates disk herniation at L3–L4 on the right side, but it demonstrates a far lateral/foraminal disk herniation. This is different from a paracentral herniation in that foraminal/far lateral disk herniations affect the exiting root at that level rather than the traversing root. In this case, the right L3 root would be compressed, causing quadriceps weakness.


70.
B Lumbar spondylolisthesis
This X-ray demonstrates L4–L5 spondylolisthesis of the lumbar spine, resulting in likely spinal stenosis.


71.
B Lumbar spine MRI
The flexion/extension X-rays demonstrate spondylolisthesis at L4–L5. The patient has pain that may correlate with these findings. A lumbar spine MRI should be performed to better determine any areas of spinal stenosis and help with treatment planning. Long-cassette X-rays could be considered if there is concern for sagittal imbalance.


72.
B Contrast-enhanced lumbar spine MRI
A contrast-enhanced MRI scan of the lumbar spine should be ordered as this is the best way to demonstrate the difference between scar tissue and recurrent disk. Recurrent disks tend to have some peripheral enhancement with central hypointensity, whereas scar tissue is generally homogenously enhancing.


73.
C Spondyloptosis
This CT scan demonstrates complete anterolisthesis of the lumbar spine from the sacrum, known as spondyloptosis.


74.
D Spondylolysis
This CT scan demonstrates a disruption of the pars interarticularis, which is termed spondylolysis.


75.
B Transverse ligament
This MRI demonstrates a periodontoid pannus formation in a patient with rheumatoid arthritis. There is also associated laxity of the transverse ligament. Abnormal motion can increase the mass formation and even lead to significant stenosis causing compression of the cord. In some cases, decompression and fusion of the atlantoaxial joint can decrease or completely eliminate this pannus without direct decompression.

Further Reading: Goel, Cacciola. The Craniovertebral Junction: Diagnosis, Pathology, Surgical Techniques, 2011, radiological investigations.

76.
B CT scan of the cervical spine
This MRI demonstrates multilevel narrowing of the cervical spine by very hypointense, contiguous soft-tissue posterior to the vertebral bodies. This should concern you for the presence of ossification of the posterior longitudinal ligament (OPLL), and a CT scan to confirm this is warranted. OPLL can cause erosion of the dura, and without knowing a patient has OPLL, a simple anterior procedure could cause disastrous CSF leak complications.

77. A Ossification of the posterior longitudinal ligament
   This X-ray and CT scan demonstrate contiguous bone formation posterior to the vertebral body consistent with OPLL.

78. A Right C6
   This MRI demonstrates a cervical disk herniation likely causing this patient’s radiculopathy. In the cervical spine, nerve roots exit above their corresponding level, meaning that the right C6 nerve root would be compressed in this patient at this level.

79. B Right thumb
   This MRI scan demonstrates a cervical disk herniation at C5/C6, meaning that C6 will be compressed. This would lead to a sensory radiculopathy affecting the right thumb.

80. C Epidural lipomatosis
   This MRI exaggerated fat within the epidural space notable on this T1 image. This is consistent with epidural lipomatosis.

81. B Synovial cyst
   This MRI demonstrates a T2-hyperintense mass emanating from the left synovial joint impinging on the traversing nerve root. This is most consistent with a synovial cyst.

82. C Spinal arteriovenous malformation
   This MRI demonstrates evidence of T2 signal changes within the cervical cord as well as the presence of multiple flow voids dorsal to the cord. This is most consistent with a spinal cord arteriovenous malformation (AVM). While spinal dural arteriovenous fistulas (AVFs) can also have multiple flow voids, it is rare for there to be an intramedullary component. This is more often seen in spinal cord AVMs.

83. C Conventional angiogram
   This MRI demonstrates evidence of T2 signal changes within the cervical cord as well as the presence of multiple flow voids dorsal to the cord. This is most consistent with a spinal cord AVM. A conventional spinal angiogram should be performed next to better characterize the AVM.

84. C Conventional angiogram
   This MRI demonstrates evidence of T2 signal changes within the spine as well as the presence of multiple flow voids dorsal to the cord. Since there is no appreciable intramedullary component with mass effect, this MRI is most consistent with a spinal dural AVF (dAVF). A conventional angiogram should be performed next to better determine the abnormal connection location.

85. B Spinal dural arteriovenous fistula
   This angiogram demonstrates congestion of the spinal cord veins and evidence of a direct fistula arising from the left L4 root. This would be consistent with a type I spinal AVM (dAVF).
86. C CT myelogram
In patients who are pacemaker dependent or cannot undergo MRI for other reasons, a CT myelogram of the lumbar spine can be used to determine the level of compression.

87. B Hardware failure
This X-ray demonstrates fusion hardware failure of the pedicle screw at the inferior aspect of the construct. Hardware failure can be a cause for pseudoarthrosis and return of significant pain.

88. B Pseudoarthrosis
This patient has screw pullout and plate dislodgement after an attempted anterior cervical disectomy and fusion (ACDF). The hardware failure in this case would very likely lead to pseudoarthrosis and worsened pain.

89. B Diffuse idiopathic hyperostosis
This MRI and CT scan demonstrate flowing bony osteophytes anterior to the cervical spine. This is consistent with a diagnosis of diffuse idiopathic skeletal hyperostosis (DISH).

90. C HLA-B27
This MRI/CT scan demonstrates flowing bony osteophytes anterior to the cervical spine. This is consistent with a diagnosis of DISH, which is associated with HLA-B27.

91. C HLA-B27
This CT scan demonstrates the classic ankylosed “bamboo spine.” This is consistent with a diagnosis of ankylosing spondylitis, which is associated with HLA-B27.

92. A Ankylosing spondylitis
This CT scan demonstrates the classic ankylosed “bamboo spine.” This is consistent with a diagnosis of ankylosing spondylitis.

93. A Ankylosing spondylitis
This X-ray demonstrates the classic ankylosed “bamboo spine.” This is consistent with a diagnosis of ankylosing spondylitis. Patients can also experience fusion of the sacroiliac (SI) joints.

94. D Transverse myelitis
This MRI scan demonstrates T2 signal change within the spinal cord in the setting of an otherwise patent spinal canal. The sudden onset nature of her symptoms are suggestive of transverse myelitis rather than tumor.

95. C Diskitis/osteomyelitis
This MRI scan demonstrates increased T2 signal within the disk space as well as endplate destruction at the bordering vertebral bodies. These findings, in the setting of a patient with history of IV drug use, are most consistent with diskitis/osteomyelitis.
Further Reading: Khanna. MRI Essentials for the Spine Specialist, 2014, the lumbar and thoracic spine.
II Answers

96.  
B  *Staphylococcus aureus*  
This MRI scan demonstrates increased T2 signal within the disk space as well as endplate destruction at the bordering vertebral bodies. These findings, in the setting of a patient with history of IV drug use, are most consistent with diskitis/osteomyelitis. The most common pathogen is *Staphylococcus aureus*.  

99.  
B  **Schmorl’s nodes**  
This X-ray and MRI demonstrate disk herniation through the endplate, which are termed Schmorl’s nodes. Unless they form acutely, they are generally not associated with back pain. They are part of the diagnosis of Scheuermann’s disease, but they are found in up to 75% of autopsies as well.  

100.  
A  **Scheuermann’s disease**  
This X-ray demonstrates kyphosis and wedging of multiple thoracic vertebral bodies. This is consistent with Scheuermann’s kyphosis, often seen in pediatrics (~ 5% incidence), and is diagnosed based on the Sorensen classification (thoracic kyphosis > 40 degrees; thoracolumbar kyphosis > 25 degrees). Or multiple thoracic vertebral bodies wedged > 5 degrees.  
14 Fundamental Skills

1. B 8%
   In a normal 70-kg man, approximately 67% of fluid is intracellular and 33% is extracellular. Of the extracellular fluid, a further 25% is interstitial, and the remaining approximately 8% is intravascular.

2. C Shunt externalization/removal
   This patient has evidence of a large pleural effusion on the side where the syringopleural shunt has been placed. In this case, the shunt should be externalized or removed completely. General/thoracic surgery can address the pleural effusion, but further treatment of the syrinx will have to be performed via another approach.
Further Reading: Procedures: Syringopleural Shunting, Thieme eNeurosurgery.

3. B Pulmonary capillary wedge pressure (PCWP) greater than 18 mm Hg
   In patients with cardiogenic pulmonary edema, the PCWP is elevated beyond 18 mm Hg. In acute or adult respiratory distress syndrome (ARDS), the PCWP is less than 18 mm Hg.

4. B Dobutamine
   Of the listed medications, only dobutamine has positive effects in patients with severe ARDS. Its inotropic effects can increase cardiac output and thus oxygen delivery.

5. A Narrow complex tachycardia
   Adenosine briefly interrupts transmission through the His–Purkinje system and causes asystole for several seconds. It can be useful for treating supraventricular tachycardia (a narrow complex tachycardia).

6. B Lidocaine infusion
   This patient has a stable, wide complex tachycardia. She could undergo elective, synchronized cardioversion, or infusion of lidocaine, which can treat wide complex tachycardia. The other options are not reasonable in a stable patient.

7. D 6
   The GCS is a commonly used scale for neurotrauma. Points are assigned for motor, verbal and eye-opening responses. This patient gets 3 points for flexor posturing, 2 points for eye opening to pain, and 1 point for no verbal response.

8. A Normal physiologic response
   This patient is exhibiting hippus, a normal physiologic response where the pupils dilate and contract seemingly randomly. It can also be seen during recovery of oculomotor nerve injury.

9. C Suprachiasmatic nucleus
   This patient is experiencing sundowning, where delirium worsens in the evening and at night. It is thought that this is at least partially due to degeneration of the suprachiasmatic nucleus of the hypothalamus, and dysregulation of melatonin release and the circadian rhythm.
10.  
E  Gamma  
Opioid receptors have four classes, mu, delta, kappa, and N/OFQ. Gamma is not an opioid receptor subtype. There is interest in the kappa receptor as a target for pain medication as it may also have neuroprotective effects in traumatic brain injury.  

11.  
D 9  
Warfarin inhibits vitamin K–dependent factors, including factors II, VII, IX, and X and proteins C and S.  

12.  
E 24+ hours  
IV vitamin K has excellent bioavailability and a rapid onset; however, the vitamin K–dependent coagulation factors have long half-lives, with factor II having a half-life of 65 hours. Therefore, it can take between 24 to 72 hours for IV vitamin K to reverse the INR.  

13.  
D Xa  
Heparin binds to antithrombin, and this combination has a high affinity for factor Xa, inhibiting its function and causing anticoagulation. It is monitored using activated partial thromboplastin time (aPTT).  

14.  
B Dabigatran  
Dabigatran is in the class of direct thrombin inhibitors, which can be used for anticoagulation in patients with HIT. Dabigatran is cleared by the kidney, however, and it should be avoided in patients with renal failure. Argatroban is cleared by the liver, and would be a better choice.  

15.  
A 30 minutes  
The half-life of aspirin is very short, only 30 minutes. It has lasting effects, however, due to the irreversible inhibition of platelets, which survive for 7 days. The effect of aspirin will no longer be evident in most patients by 5 to 7 days after the last dose.  

16.  
B P2Y₁₂ receptor binding inhibiting ADP mediated platelet aggregation (GPIIb/IIIa)  
Clopidogrel (plavix) inhibits platelet function by binding to the P2Y₁₂ receptor and inhibiting ADP-mediated GPIIb/IIIa complex formation. It is irreversible and its effects last until new platelets are formed.  

17.  
B 0.5 to 1.0 mL/kg/h  
Urine output can be a useful determining factor of overall volume status in the postoperative patient. Often, volume resuscitation is targeted to a urine output of 0.5 to 1.0 mL/kg/h.  

18.  
A Prothrombin complex concentrates  
In this patient with heart failure and a need for immediate reversal, PCCs should be used to decrease the overall fluid volume utilized during resuscitation as to not worsen the heart failure.  

19.  
C 3 months  
For patients with an unprovoked deep vein thrombosis (DVT) who are on anticoagulation, the recommended initial treatment period is 3 months. After 3 months, further imaging will be performed to determine if treatment needs to be extended.  
20. A IV heparin
This patient has evidence of a cerebral venous sinus thrombosis. Regardless of the presence of intracerebral hemorrhage (ICH), this patient should receive IV heparin administration in an attempt to dissolve the clot. The presence of hemorrhage is not a contraindication for heparin.

21. D 20 mm Hg
It is thought that with a brain tissue partial pressure of oxygen below 20 mm Hg, anaerobic respiration predominates, which can lead to secondary brain injury.

22. C 8 or less
According to these guidelines, a GCS of 8 or less is considered severe head injury, and these patients should be considered for intubation if there is clinical concern for airway protection

23. C 90 minutes
Rocuronium is a paralytic agent used for intubation. The duration can be 30 to 90 minutes.

24. B Increased pH
Hyperventilation increases the pH in the brain due to increased ventilation and blowing off of CO₂. This increase in pH causes vasoconstriction, which can decrease blood volume in the brain and subsequently decrease ICP.

25. C Pons
This breathing pattern is apneustic breathing, suggestive of destruction to the pons.

26. C 50 mL/100 g/min
CBF in the normal, healthy adult is thought to be around 50 mL/100 g/min.

27. E 100 mL/100 g/min
Pediatric patients have elevated cerebral blood flow, and it can be as high as 108 mL/100 g/min and it can stay this elevated through the teenage years.

28. B Small cell lung cancer
Small cell lung cancer has the ability to form peptide hormones, including antidiuretic hormone (ADH), which can lead to syndrome of inappropriate antidiuretic hormone secretion (SIADH) and hyponatremia.

29. B CSF antineuronal antibodies
Neuropsychiatric SLE can manifest with multiple symptoms. The diagnosis can be made by testing for ANA in the cerebrospinal fluid (CSF).
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 221.

30. B CADASIL
This MRI demonstrates findings classic for cerebral autosomal dominant arteriopathy with subcortical infarcts. This is thought to occur due to regional hypometabolism due to a genetic abnormality on chromosome 19. Patients have a progressive declining course and often die between 50 and 70 years of age.
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 220.

31. A Inflammation
This patient has giant cell arteritis, also known as temporal arteritis. Blindness is a feared complication when this condition is left untreated, and it occurs via inflammation and progression of disease to include the ciliary arteries and central retinal artery. When inflamed, they can lead to ischemic optic neuropathy and blindness.

32. C Prednisone
Giant cell arteritis is an inflammatory vasculitis and blindness can be a complication of this condition. These patients should be treated with prednisone initially.

33. C 320
Mannitol should no longer be administered in patients who have a serum osmolality of 320 or greater as the risk of ATN increases substantially.

34. D Calcified cephalohematoma
This CT scan demonstrates evidence of a calcified cephalohematoma, a bleed located between the periosteum and the skull. It becomes bound by suture lines. In the majority of cases, these resolve in 1 to 3 days; however, they can persist and calcify, sometimes requiring surgery.

35. A Further observation
At this point, the child is stable and more observation should be recommended. The hematoma may continue to resolve over time. Needle aspiration should be avoided unless there is concern for infection due to the risk of iatrogenic infection.

36. B < 70 minutes
According to current evidence, decompression should be achieved within 70 minutes of the onset of pupillary changes in patients with EDH, highlighting the emergent nature of this condition.

37. B 12-mm thick/6-mm midline shift
According to current guidelines, any acute subdural hematoma that measures greater than 10 mm in thickness and is associated with greater than 5 mm of midline shift should be surgically evacuated regardless of GCS.

39. B NSAIDs
There is currently no role for steroids in the treatment of brachial neuritis. These patients are managed conservatively and NSAIDs can be used for shoulder pain.
40.  
D 90%  
Brachial neuritis is managed conservatively, and most patients experience a full recovery at 3 years. The rate of recovery is around 90%. Supportive care and extensive physical therapy should be utilized in this condition.  

41.  
C Bradycardia  
Precedex is an alpha-2 agonist in the CNS that can be used for sedation. It has dose-dependent effects on blood pressure and heart rate, specifically causing hypotension and bradycardia.  

42.  
D Locus coeruleus  
Precedex is a central alpha-2 agonist that is thought to exert its effects on the locus coeruleus in the brainstem, mediating arousal and sleep–wake cycles. Decreasing transmission of the neurons in this nucleus that are primarily noradrenergic causes sedation and diminishes agitation.  

43.  
D 24 hours  
Currently, the FDA has only approved continuous infusion of Precedex for 24 hours given the risk of rebound hypertension and tachycardia after cessation of administration.  

44.  
B New right bundle branch block  
Propofol infusion syndrome is thought to occur in patients receiving high-dose propofol infusion for more than 48 hours. The exact mechanism is unknown but thought to be due to metabolic derangements in the mitochondria. Initial findings can include a right bundle branch block. It can go on to include hypotension, bradycardia, metabolic acidosis, rhabdomyolysis, and hypokalemia. Propofol should be stopped.  

45.  
B Etomidate  
Etomidate is an anesthetic agent that decreases CMRO₂ and cerebral blood flow. It also causes adrenocortical axis suppression and decreases the concentration of ACTH.  

46.  
A Patent foramen ovale  
The sitting position can be useful in neurosurgery, but there is an increased risk of venous air embolism. A patient with a PFO is a relative contraindication for the use of the sitting position due to the risk of a right-sided air embolism becoming a left-sided embolism.  

47.  
E Methohexital  
Methohexital is an anesthetic agent that lowers the seizure threshold. It is sometimes used during electrocorticography for surgical treatment of epilepsy.  

48.  
D ~ 60%  
In patients with refractory temporal lobe epilepsy (TLE), surgical treatment can lead to 60% seizure freedom at 1 year post-op, compared to 8% seizure freedom in patients undergoing medical management alone.  
49. **B** Temporary motor deficit
   Multiple subpial transections can be performed as a palliative epilepsy surgery in patients with medically refractory epilepsy. It severs the horizontal intracortical connections, but preserves neurons due to the vertical columnar orientation. These patients should expect to have transient neurologic deficit for several months postoperatively.

50. **C** Temporal lobe
    The rising epigastric sensation and déjà vu can be associated with TLE.

51. **D** Throbbing pain
    Type I, or classic TN, usually presents with sharp, lancinating unilateral pain with pain-free intervals. In studies on the subject, type I patients were more likely to have arterial compression at surgery as well as better long-term outcomes than type II patients, which tend to have persistent, burning/aching/throbbing pain that can be bilateral, and may be associated with other pathologies, such as multiple sclerosis.

52. **D** 85%
   According to current literature, up to 84% of patients with type I TN pain will experience excellent to good pain control with microvascular decompression surgery.

53. **B** 65%
   Patients with atypical type II TN may still benefit from microvascular decompression. Up to 65% of these patients will have “excellent to good” pain control long term.

54. **D** Medical management
   This patient has TN and has not yet undergone any treatment. Initial management should be with carbamazepine, as 80% of patients will experience nearly immediate relief (within 24–48 hours) with this medication. The pain relief diminishes over time, and over the long term, only 50% of patients may have continued relief on carbamazepine. Up to 10% of patients may not tolerate carbamazepine.

55. **C** Lateral
    The distribution of the V1, V2, and V3 divisions of the trigeminal nerve is oriented in the foramen ovale in a superomedial to inferolateral direction. Therefore, to best treat V3 pain, the catheter should be placed lateral within the foramen.
57. B A 55-year-old male alcoholic
   This image demonstrates central pontine myelinolysis (CPM), also known as osmotic demyelination syndrome. Patients with alcoholism can experience severe alterations in electrolytes, which could lead to CPM.

58. B Hyperkalemia
   Hyperkalemia can cause tall, peaked or spiked T waves on ECG.

59. B Hypocalcemia
   Hypocalcemia can be associated with lengthening of the PR interval on ECG.

60. C Multifocality
   Hypomagnesemia can cause multifocality on ECG.

61. A Cortical-based tumor
   The presence of an intracranial tumor, aneurysm or arteriovenous malformation (AVM) is absolute contraindication to the administration of IV rtPA for acute ischemic stroke.

62. B Choroidal point
   PICA originates from the vertebral artery and supplies the brainstem and cerebellum. After the choroidal point, PICA is supplying only cerebellum and if needed could be taken with minimal side effects. Proximal to this point, a medullary infarct will likely occur.

63. A Superior thyroid
   The superior thyroid artery is the first branch of the external carotid artery. It is commonly seen and needs to be controlled during carotid endarterectomy.

64. D Sphenopalatine
   The sphenopalatine artery is the primary vascular supply to the nasal cavity.

65. A 4%
   Patients with aneurysmal subarachnoid hemorrhage (SAH) with an unsecured aneurysm are at risk of rebleed, which can have devastating consequences. The risk in the first 24 hours is roughly 4%.

66. B 15 to 20%
   There is an elevated risk of aneurysm rebleed in the first 2 weeks after rupture if the aneurysm remains unsecured. That risk is approximately 15 to 20%. The mortality of aneurysm rebleed is near 75%.

67. B Catecholamine surge
   Neurogenic pulmonary edema can occur after aneurysmal SAH and close pulmonary monitoring should occur in these patients. While pulmonary edema can occur from iatrogenic fluid overload, neurogenic pulmonary edema is thought to be due to an acute catecholamine surge experienced after the bleeding event.

68. A Hyponatremia

The most common electrolyte disturbance in SAH is hyponatremia, which can occur via two mechanisms, either cerebral salt wasting (CSW) or SIADH. It is important to determine volume status to differentiate between SIADH and CSW.


69. C Anterior communicating artery

Occasionally patients with SAH can present with hypernatremia, caused by diabetes insipidus. This may be suggestive of an anterior communicating artery aneurysm due to destruction of hypothalamic pathways involved in the production and release of ADH.


70. D Early enteral nutrition

Intubated SAH patients have high rates of gastrointestinal (GI) stress ulcer formation and should all be placed on GI prophylactic medications. Early enteral nutrition via either percutaneous gastrostomy or nasogastric tube can allow for early feeding, thus decreasing stress ulcer formation.


71. D Poor outcome and decreased ICP

The DECRA trial was performed in Australia in 2011 and demonstrated that patients who underwent decompressive craniectomy (DC) had improvement in their ICP and shorter intensive care unit (ICU) stays, but overall had poorer outcomes than standard care. The trial has been criticized for having too aggressive a surgical arm with refractory ICP defined as 20 mm Hg for more than 15 minutes. This may have led to more patients being operated than necessary. The Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intracranial Pressure (RESCUEicp) trial is ongoing and has increased the time frame required to determine refractory ICP elevation.


72. B Decreased hematoma volume; no clinical effect

The INTERACT trial aimed to determine if intensive blood pressure control had significant effects on clinical outcome. Intensive blood pressure control (systolic blood pressure [SBP] < 140) decreased overall hematoma size, but it did not have any effect on clinical course. INTERACT 2 is ongoing.


73. B 5 times

According to current literature, baseline hypertension with SBP > 160 leads to a 5.5 times higher risk of spontaneous ICH compared to patients with good blood pressure control.


74. B 20%

ICH can be a devastating event, and many patients develop neurologic deficits following this event. The rate of functional independence 3 months after the bleeding event occurs is roughly 20%.


75. E 100%

This patient has suffered a devastating cerebellar hemorrhage that will have a 100% 30-day mortality according to the ICH score. Points are awarded for age older than 80 years, infratentorial location, IVH, hematoma volume greater than 30 mL, and 1 point for GCS 5 to 12. This gives her 5 of a total of 6 points. Patients with an ICH score of
5 or 6 have a 100% 30-day mortality. Patients with a score of 4 have a 97% 30-day mortality.


76.  
C Superficial cortical (< 1 cm from the surface) location

In the initial STICH trial, there was no benefit from surgical resection of spontaneous cerebral hemorrhage when compared to standard medical therapy. Upon subgroup analysis, there may be a benefit to resecting a cerebral hemorrhage with a superficial location and significant mass effect. STICH II examined cases of lobar hemorrhage, however, and found no improvement in outcome between the surgical and medical arms of treatment.


77.  
A Hypertension

This CT scan demonstrates a cerebellar hemorrhage with intraventricular extension. The most common underlying cause for this disorder is uncontrolled hypertension.


78.

C 50%

This patient has a spontaneous cerebellar hemorrhage and the data suggest that there is a 50% chance of good outcome (Glasgow Outcome Score 4 or 5, meaning no requirement for assistance in activities of daily living) in patients treated surgically for this condition.


79.

D Hydrocephalus

According to American Heart Association (AHA)/American Stroke Association (ASA) ICH guidelines, the presence of neurological deterioration, brainstem compression and/or the presence of hydrocephalus should make you strongly consider surgical resection of the hematoma and decompression of the posterior fossa. CSF diversion should also be utilized during the surgery. EVD placement alone without hematoma resection is not recommended.


80.

C 3 cm

Three centimeters has been identified as a rough cutoff whereby patients with a hematoma smaller than 3 cm in dimension are less likely to deteriorate and require surgical intervention compared to patients with a hematoma greater than 3 cm. This is not a hard and fast rule, however, and many other factors, including location, brainstem compression, medical comorbidities, and other systemic characteristics, play into the surgical decision making from patient to patient.


81.

C Vasculitis

This pathologic specimen demonstrates arterial wall necrosis and monocytic infiltration of the vessel walls. There is associated granuloma formation. These findings are consistent with vasculitis. Conventional angiogram may demonstrate arterial nicking.


82.

E Decreased ventricular compliance

NPH is characterized by ambulatory difficulties, cognitive impairment, and urinary incontinence in patients with ventriculomegaly but normal CSF pressure. The full underlying mechanism is not well understood, but thought to be due to poor craniospinal compliance of the ventricular system, at least in part.

83.  
D  Improved gait after high-volume LP  
In patients with suspected NPH, high-volume lumbar puncture (LP) should be performed (30–50 mL removed), and gait analysis should be performed immediately after this procedure. Patients who had gait improvement after LP had the highest rate of overall symptom improvement after permanent VP shunt placement.  

84.  
D  Arachnoid cyst  
This patient has an arachnoid cyst of the right sylvian fissure. The cyst contents have the same signal intensity as CSF and this is helpful for the diagnosis.  

85.  
E  No improvement in ICP, no clinical improvement, increased systemic complications  
Similar to adult TBI, there is no role for systemic steroids in pediatric patients that have severe TBI. Clinical and ICP outcomes show no difference and patients are exposed to systemic risk with steroid administration.  

86.  
B  24 to 26 weeks of gestation  
Currently, fetal surgery for the repair of myelo meningocele occurs at 24 to 26 weeks of gestation.  

87.  
D  Further imaging  
This is a young patient with no significant risk factors for spontaneous ICH. The age, lack of risk factors, and odd location of this hemorrhage should make you concerned for an underlying vascular malformation or aneurysm. A CT angiogram (CTA) should be obtained as a start, and likely a formal catheter angiogram to follow depending on the CTA findings.  

88.  
C  Hereditary hemorrhagic telangiectasia  
The catheter angiogram demonstrates a cerebral AVM. Of the listed choices, HHT is associated with AVM formation.  

89.  
A  <10%  
With successful indirect or direct bypass in patients with moyamoya disease, the 5-year rate of stroke drops from 67 to 90% to less than 10%.  

90.  
B  Optic chiasm involvement  
Optic gliomas in patients with NF1 can be surgically resected en bloc (or nearly en bloc) if it is obvious that there is normal optic nerve on either side of the involved area. In these cases, the tumor can be resected with the optic nerve (and orbit); however, if there is tumor invasion into the optic chiasm, the mass cannot be completely excised without unacceptable risk of bilateral blindness postop.  

91.  
A  Moment arm  
Spine biomechanics can be helpful to understand when evaluating traumatic injury to the spine. Forces are applied to the spine in force vectors. When one of these vectors is applied at a given distance from an axis of rotation, a moment arm is created. This moment arm depicts a lever that starts from the IAR to the force application. This property helps explain compression fractures versus burst fracture pathology.

92. B Force applied per unit area

Stress is defined as force applied per unit area. Strain is defined as change in unit length compared to original length.


93. B The slope of the most linear region of the force deformation curve

Stiffness of the implant is defined as the slope of the line on the force deformation curve.


94. C Yield point

The point on the force deformation curve where the implant begins to deform but has not yet undergone complete failure is called the elastic zone. The point where the device enters the elastic zone is termed the yield point.


95. E 95%

Development of spondylosis in the spine is a normal aspect of aging, and approximately 10% of patients aged 25 years will have spondylosis on imaging, with this percentage increasing to 95% by 65 years of age.


96. C Excitation of recurrent sinuvertebral nerve endings

Discogenic axial back pain is a controversial issue, especially regarding treatment options, but is thought to occur due to excitation of the sinuvertebral nerve (a branch from the anterior ramus) that innervates the posterior longitudinal ligament (PLL) and annulus. In patients with spondylosis, irritation, and inflammation of the various structures of the ventral canal are thought to excite these fibers and generate pain.


97. C Posterior spinal nerve ramus

Facetogenic axial back pain is controversial, but pain from the facet joints is thought to arise from innervating fibers from the posterior ramus of the associated spinal nerve.


98. C 1,200-mg calcium, 1,000-IU vitamin D

According to NOF guidelines, women older than 50 years should receive 1,200 mg of calcium on a daily basis as well as 1,000 IU of vitamin D.


99. B Inhibits osteoclasts

Calcitonin antagonizes parathyroid hormone and therefore inhibits osteoclast activity. This decreases bone resorption and helps strengthen bones.


100. C Increased risk of DVT

Raloxifene is a selective estrogen receptor modifier that is used for bone health. It simultaneously decreases risk of breast cancer and inhibits bone resorption. Patients should be aware of the increased risk of DVT with the administration of raloxifene.

101. B NSAIDs
In patients with inflammatory spondyloarthropathies, patients can be treated with NSAIDS that both decrease associated pain and modify the disease process, through a process that is not entirely known, but likely involves decreasing inflammation.

102. A Hemangioblastoma
Intramedullary spinal cord tumors can have an associated syrinx. The most common intramedullary tumors associated with a syrinx are hemangioblastoma and ependymoma.

103. D Detrusor hyperreflexia
Tethered cord syndrome can have orthopedic, neurologic, and urologic problems. Of the urologic problems, detrusor hyperreflexia is the most common.

104. C 65%
Bone is made of 20% water, but the dry weight of bone is 35% organic material and 65% inorganic material.

105. A Calcium phosphate
Calcium phosphate compounds make up 85% of inorganic bone material.

106. C Osteoblasts
Parathyroid hormone works to enhance bone resorption, but it does this by stimulating osteoblasts. In turn, the osteoblasts release osteoclast stimulating factor, which activates the osteoclastic resorption process.

107. B Osteogenesis
Osteogenesis refers to the cellular component of bone fusion, and osteogenesis gives the bone graft the ability to form new bones.

108. A Osteoconduction
Osteoconduction refers to providing a solid matrix for new bone formation.

109. C Osteoinduction
Osteoinduction refers to the process of fusion where precursor or immature cells are induced to differentiate into mature bone-forming cells.

110. C Common peroneal
In this posterior location, the sciatic, common peroneal, and tibial nerves are at risk. When the laceration is just above the knee in a lateral position, it would be more likely for the patient to have suffered a common peroneal nerve injury as the peroneal and tibial nerves have bifurcated from the sciatic.

111. C Vascular surgery consult
With a confirmed nerve injury in a sharp laceration such as depicted above, you should strongly consider a vascular surgery consult given that nerves often run in close approximation with major blood vessels. There is also an associated
hematoma apparent in the wound. You would not want to expose the nerve and discover a major vascular injury that you were not prepared for. Further Reading: Harbaugh, Shaffrey, Couldwell, Berger. Neurosurgery Knowledge Update, 2015, page 565.

112. C Presence of nerve continuity
The presence or absence of peripheral nerve continuity is the most important initial factor to determine when evaluating a traumatic nerve injury as it governs potential for recovery. If the nerve is in continuity, it should be given time to heal and serial electromyograms (EMGs) will be performed to determine if there are nerve potentials across the area of damage. If present, conservative management will likely be recommended. If the nerve is completely severed, earlier surgical reconstruction will likely be performed.


113. C 3 weeks
Gunshot wounds to the peripheral nerves often cause neurologic deficit via indirect or pressure-wave-related phenomena. In 85% of cases, the nerve remains intact. In the case where the nerve has been severed, the surgeon should wait 3 to 4 weeks to perform a nerve graft repair. If another surgical team is planning to explore the wound, the two ends of the severed nerve should be tagged for easier identification and to decrease retraction for the definitive secondary repair. Waiting for 3 to 4 weeks allows the injured nerve tissue to degenerate and then at reoperation the nerve can be resected back to healthy tissue to facilitate a repair.


114. E Detailed neurological examination
The diagnosis of brain death can be both controversial and difficult, but generally speaking the only requirement for the diagnosis of brain death is a detailed neurologic examination making sure multiple factors are met prior to the performance of the examination.


115. A PaCO₂ > 60 mm Hg (or 20 mm Hg greater than baseline)
There are several aspects to the brain death evaluation, and the apnea test is one of the tests. The patient should be preoxygenated and a blood gas should be drawn. The ventilator is then stopped for 8 to 10 minutes or until hypoxia and/or hypotension occurs. Another blood gas is drawn and if the PaCO₂ is greater than 60 mm Hg or has risen more than 20 mm Hg above baseline, the test is positive.


116. C No change in mortality, improved hearing
Corticosteroids have been studied as an adjunct during treatment of meningitis. A Cochrane review demonstrated no change in overall mortality, but that there was a reduction in hearing loss.


117. B Albumin concentration
You can use serum albumin concentration to help determine volume status in patients that you are trying to determine CSW versus SIADH. Patients with SIADH will have normal albumin concentrations, while patients with CSW will be hypovolemic and will have increased albumin concentrations.


118. C Seizures
This patient has posterior reversible encephalopathy syndrome (PRES), and along with significant encephalopathy, these patients have high rates of seizures and hypertension.

119. D Unopposed vagal tone
   Neurogenic shock is thought to arise after spinal cord injury due to sympathetic deafferentation, which leads to unopposed tone from the vagal nerve, causing hypotension and bradycardia. Further Reading: Siddiqi. Neurosurgical Intensive Care, 2017, page 103.

120. B Heart rate
   In neurogenic shock, there is hypotension and bradycardia, whereas in hemorrhagic shock, you would expect to see hypotension and tachycardia. Further Reading: Siddiqi. Neurosurgical Intensive Care, 2017, page 103.

121. B < 48 hours
   The STICH II trial randomized patients to early surgery (< 48 hours) for superficial ICH and the characteristics listed in the question stem. There was a small survival benefit with surgery, but no change in morbidity. The patient and/or family members should be counseled regarding the outcome of surgical resection of ICH. Further Reading: Siddiqi. Neurosurgical Intensive Care, 2017, page 116.

122. B No change in good functional outcome
   The CLEAR III trial demonstrated that intraventricular distillation of rtPA in cases of IVH does not lead to any more patients with a good functional outcome. Subset analysis demonstrated that in patients who had 20 mL of evacuated blood, there was a 10% increase in good functional outcome. Further Reading: Siddiqi. Neurosurgical Intensive Care, 2017, page 116.

123. B Pentobarbital
   This EEG demonstrates a burst-suppression pattern. Of the listed medications, pentobarbital is the most likely to be utilized in a patient to achieve this EEG pattern. Further Reading: Siddiqi. Neurosurgical Intensive Care, 2017, page 177.

124. C Hydralazine
   Hydralazine is an antihypertensive that causes direct arteriolar vasodilation as a mechanism of action, and therefore would not be a good choice of antihypertensive in a patient with elevated ICP. Further Reading: Siddiqi. Neurosurgical Intensive Care, 2017, page 248.

125. E ~ 50%
   There is an increased energy demand after severe neurologic injury. Some studies have suggested that the basal energy expenditure in TBI patients is 46% higher than normal expected values. Patients require elevated levels of nutritional support while recovering from neurologic injury. Further Reading: Siddiqi. Neurosurgical Intensive Care, 2017, page 276.

126. C Calcium channel blockade
   Nicardipine is a calcium channel blocker used for control of hypertension. Further Reading: Greenberg. Handbook of Neurosurgery, 8th edition, page 126.

127. A True
   Nitroglycerin is a vasodilator and has been shown to raise intracranial pressure (ICP). Further Reading: Greenberg. Handbook of Neurosurgery, 8th edition, page 126.

128. B False
   Labetalol is an alpha-1 selective and beta non-selective blocker that either maintains ICP or reduces it. It has not been shown to increase ICP. Further Reading: Greenberg. Handbook of Neurosurgery, 8th edition, page 126.

129. A Phenylephrine
   Phenylephrine is a pure alpha agonist that has no beta inotropic effects and therefore it constricts arterioles. It tends to decrease cardiac output and can decrease renal blood flow. It should be avoided in spinal cord injuries unless absolutely necessary. Better choices would be a medication with inotropic effects.

130.  
C B1  
The B1 receptor, when activated, leads to increased cardiac contractility and therefore increased cardiac output based on + inotropy.  

131.  
B Warfarin  
Omeprazole is a proton pump inhibitor (PPI) that inhibits certain P450 enzymes in the liver that can alter the metabolism of warfarin. Care should be taken when prescribing omeprazole to patients on anticoagulation with warfarin.  

132.  
B False  
Remifentanil is a rapid acting formulation of fentanyl that crosses the blood–brain barrier (BBB) in less than 1 minute. It lowers ICP.  

133.  
B Locus coeruleus  
Dexmedetomidine (Precedex) is an alpha-2 agonist that acts primarily in the locus coeruleus.  

134.  
C Proteins C + S  
In the initial days of warfarin therapy, patients can actually become hypercoagulable owing to the inhibition of proteins C + S, which are vitamin K–dependent anticoagulation factors. Therefore, bridging therapy should be considered in at-risk patients initiating warfarin therapy.  

135.  
C 60%  
Protamine can be used to reverse enoxaparin, and should be given as 1-mg protamine per 1 mg of Lovenox. This dose will reverse approximately 60% of active circulating Lovenox.  

136.  
B Decreases  
CO₂ is a potent cerebral vasodilator, and therefore during hyperventilation, the PaCO₂ drops and cerebral blood flow decreases.  

137.  
A 7%/1 degree  
Hypothermia decreases the cerebral metabolic rate of oxygen (CMRO₂) by approximately 7% per 1 degree of temperature decrease.  

138.  
C Nitric oxide  
All of the inhalational neuroanesthetic drugs decrease cerebral metabolism except for nitric oxide.  

139.  
A True  
True, the inhalational anesthetic agents disturb cerebral autoregulation and cause vasodilation, which increases ICP.  

140.  
C > 2 hours  
It is thought that use of inhalational anesthetic agents for more than 2 hours can lead to increased production of CSF, exacerbating any potential ICP issues.  

141.  
C Nitric oxide  
Nitric oxide is 34 times more soluble than nitrogen, and in cases where pneumocephalus or air embolism can occur, nitric oxide should be avoided
as it can expand as it is evolved out of the bloodstream and greatly increase the pressure within a confined space, causing tension pneumocephalus or further embolism.


142.
A Isoflurane
Isoflurane is a halogenated inhalational anesthetic agent.


143.
A 10 minutes
Nitric oxide can cause tension pneumocephalus as it evolves out of the bloodstream in an enclosed space. It should be discontinued at least 10 minutes before the dural is closed in a watertight fashion.


144.
A Isoflurane
Isoflurane is a halogenated inhalational anesthetic that can be used to create an isoelectric EEG without reaching levels causing metabolic toxicity.


145.
D Sevoflurane
Sevoflurane is a halogenated inhalational anesthetic that can have decreased cardiac inotropic effects, decreasing cardiac output.


146.
B Hypotension
Propofol will cause a dose-dependent decrease in blood pressure and ICP.


147.
B Methohexital
Methohexital is a barbiturate anesthetic that can be used for induction. It can lower the seizure threshold, so it should be used sparingly in patients with seizure disorders.


148.
B False
Etomidate is an imidazole anesthetic agent that can be used for induction of anesthesia. It has anesthetic and amnestic effects, but it is important to remember that it does not have any analgesic effects.


149.
B Intrinsic renal disease
Etomidate is an imidazole anesthetic agent that can be used for induction of anesthesia. It has anesthetic and amnestic effects, but it is important to remember that it does not have any analgesic effects. It is known to impair renal function and should be avoided in patients with known renal disease.


150.
C NMDA receptor
Ketamine is a dissociative anesthetic that works on the NMDA receptor.


151.
C Histamine release
Synthetic narcotics (fentanyl and derivatives) differ from nonsynthetic narcotics in that they do not cause release of histamine.


152.
D Lidocaine
Lidocaine can be given IV, which can suppress laryngeal reflexes, decreasing the ICP spikes during intubation.

153.  
A True  
Succinylcholine is the only depolarizing paralytic agent used during anesthetic induction.  

154.  
C Muscle rigidity  
While the initial symptom may be an increase in end-tidal CO$_2$, the classic symptom is muscle rigidity.  

155.  
A Dantrolene  
Dantrolene IV infusion is used to treat malignant hyperthermia and can be titrated to decreased symptoms up to 10 mg/kg.  

156.  
B Compliance  
Cardiac ventricular compliance is the ability of the ventricular wall to distend at a given volume. The same principles apply to CSF ventricular compliance.  
Further Reading: Marino. The ICU Book, page 5.  

157.  
B Decreased compliance  
Cardiac ventricular compliance is the ability of the ventricular wall to distend at a given volume. The same principles apply to CSF ventricular compliance.  

158.  
C Afterload  
Afterload is considered the sum of all forces that decrease cardiac ventricular emptying. This sum of forces is essentially made from the impedance caused by the aorta and large arteries.  

159.  
A True  
Arterial oxygen content is entirely dependent on saturation of hemoglobin with oxygen. Therefore, a 50% reduction in hemoglobin will lead to a 50% reduction in arterial oxygen content, while a 50% reduction in PaO$_2$ may only lead to a 20% reduction in arterial oxygen content.  
Further Reading: Marino. The ICU Book, page 11.  

160.  
B False  
Stress ulcers of the GI mucosa are primarily caused by decreased or impaired blood flow, not gastric acidity. The ulcerations are confined to the surface mucosa and tend to be different from ulcers caused by peptic ulcer disease, which are deeper ulcerations, sometimes deep enough to erode through the wall of the GI tract completely.  
Further Reading: Marino. The ICU Book, page 96.
163. D 90%
There is evidence of early gastric erosion in up to 90% of patients admitted to the ICU by the third day. Patients at higher risk include those with burns affecting 30% of the body surface area and those with head injuries.
Further Reading: Marino. The ICU Book, page 96.

164. B Mean arterial pressure
The mean arterial pressure is the best measurement to determine true pressure for peripheral blood flow. It does not change as the waveform progresses distally, and is less affected by distortions from recording systems.
Further Reading: Marino. The ICU Book, page 151.

165. C Diastolic pressure + one-third of pulse pressure
Oftentimes, the mean arterial pressure is calculated electronically by modern recording systems, but it can be estimated manually by using the diastolic pressure and adding one-third of the pulse pressure. This calculation is based on a heart rate of 60 beats per minute, and may be incorrectly estimating mean arterial pressure in patients with tachycardia.
Further Reading: Marino. The ICU Book, page 151.

166. A 10%
The average male has approximately 48 L of total body fluid, and only 10% is located in the intravascular space.
Further Reading: Marino. The ICU Book, page 207.

167. B 5 L
The average 80-kg male has approximately 5 L of whole blood.
Further Reading: Marino. The ICU Book, page 207.

168. B 750 mL
Class I hypovolemia is clinically asymptomatic hypovolemia, and this is often seen with 1 to 15% of total intravascular volume loss. At approximately 15% or more, clinical symptoms will present, and this is often resting tachycardia.
Further Reading: Marino. The ICU Book, page 209.

169. B Resting tachycardia
Oftentimes, the first clinical symptom from acute blood loss/hypovolemia is resting tachycardia.
Further Reading: Marino. The ICU Book, page 209.

170. B 20%
When patients are hypovolemic, the body will move interstitial fluid into the intravascular space to compensate. When IV crystalloid is given, a significant portion of the salt content moves into the interstitial space, and the fluid follows. Therefore, only approximately 20% of crystalloid fluid volume will remain in the intravascular space.
Further Reading: Marino. The ICU Book, page 220.

171. D 80%
Due to oncotic pressure, approximately 80% of colloid volume given through a peripheral IV will remain in the intravascular space.
Further Reading: Marino. The ICU Book, page 220.
C 154
The concentration of sodium in 0.9% NaCl is 154 mEq.

Further Reading: Marino. The ICU Book, page 229.

A 130
Lactated Ringer’s solution contains the cations potassium and calcium to better approximate plasma concentrations. It also contains lactate. In order to remain electrically neutral, there must be a reduction in sodium concentration, to 130 mEq.


B False
Twenty-five-percent albumin has a plasma volume expansion ratio of four to five times and while intravascular volume can be repleted, a significant decrease in interstitial fluid volume can occur and the patient may remain significantly hypovolemic even though the parameters normalize.


B False
Albumin solutions are heat treated and therefore there is not risk of viral transmission through the use of albumin.


D > 150 BPM
Rate control is more important than rhythm control in atrial fibrillation, and when there is a persistent tachycardia greater than 150 bpm, electrical cardioversion should be considered, especially in the setting of corresponding hypotension.

Further Reading: Marino. The ICU Book, page 322.
C > 46 mm Hg

Hypercapnia is diagnosed when the PaCO₂ is greater than 46 mm Hg, but it must not be artificially elevated as is the case of a compensatory response to metabolic alkalosis.


182.

A Increased pulmonary shunting

The three main sources of hypercapnia are increased dead space, hypoventilation, and increased metabolic CO₂ production.

Further Reading: Marino. The ICU Book, page 351.

183.

B False

While many are taught that ARDS represents an acute accumulation of watery edema into the lungs, it is truly an inflammatory process where the alveolar spaces are filled with WBCs, RBCs, and protein debris.


184.

C 7 to 10 mL/kg

While previously tidal volumes of 11 to 15 mL/kg were used during mechanical ventilation, out of concern for barotrauma standard tidal volumes are now 7 to 10 mL/kg.

Further Reading: Marino. The ICU Book, page 381.

185.

B Positive end-expiratory pressure

Positive end-expiratory pressure (PEEP) can be used to increase arterial oxygen saturation by keeping the alveoli from collapsing at the end of expiration. It is also useful in ARDS.

Further Reading: Marino. The ICU Book, page 381.

186.

A True

Positive pressure ventilation can reduce ventricular filling due to positive intrathoracic pressure and compression of pulmonary blood vessels.

Further Reading: Marino. The ICU Book, page 424.

187.

B False

Previously, large inflation volumes (10–15 mL/kg) were used in an attempt to keep the alveoli open, but this led to worsened respiratory conditions due to barotrauma. Currently, lower inflation volumes are used with PEEP to keep the alveoli open.

Further Reading: Marino. The ICU Book, page 424.

188.

D Respiratory rate

End-inspiratory peak pressure is an important factor in mechanical ventilation, and it is calculated by using the inflation volume, the flow resistance, and the elastic recoil of the lung tissue.


189.

A True

Assist control (A/C) mode on the ventilator allows the patient to trigger breaths but delivers a set inflation volume. If the patient does not trigger a breath in a set amount of time, the ventilator will deliver a breath based on a backup rate.

Further Reading: Marino. The ICU Book, page 434.
190. A True
A/C mode on the ventilator allows the patient to trigger breaths but delivers a set inflation volume. If the patient does not trigger a breath in a set amount of time, the ventilator will deliver a breath based on a backup rate.

191. B A patient breathing rapidly
A/C mode on the ventilator allows the patient to trigger breaths but delivers a set inflation volume. If the patient is breathing rapidly, the ventilator will continue to deliver set volumes and this can lead to hyperventilation and severe alkalosis or hyperinflation injury.

192. C Pressure support
Pressure support ventilation allows the patient to trigger breaths as well as determine the respiratory cycle and inflation volume. It assists with providing inspiratory pressure to augment the inflation volume if necessary. This setting is often used to help wean patients from the ventilator since it allows the patient to demonstrate their capacity to breathe on their own.

193. A Distal airway collapse
PEEP is used to keep the alveoli open during expiration to avoid the end-expiratory pressure from reaching zero, which causes distal airway collapse. By propping open the alveoli, there is better ventilation throughout the respiratory cycle.

194. A Continuous positive airway pressure
CPAP is very useful to keep upper airways open during negative pressure inspiration in patients with obstructive sleep apnea.

195. B Bilevel positive airway pressure
Bilevel positive airway pressure is a useful adjunct for noninvasive ventilation in patients with mild hypercapnia. It provides positive pressure timed in accordance with the change in inspiratory/expiratory pressure in order to keep the distal airways open and improve ventilation.

196. A Inspiration
Almost 90% of patients have laryngeal edema after extubation, but only approximately 2% have severe enough obstruction to require reintubation. Stridorous breathing noted on inspiration is an ominous sign for impending obstruction given that the negative pressure during inspiration is causing dynamic worsening of upper airway obstruction. Reintubation should be strongly considered.

197. A Reintubation
Severe upper airway obstruction can be dangerous, and if there is significant concern, immediate reintubation should be performed, followed by possible tracheostomy. IV steroids do not have any effect on improving acute obstruction, and racemic epinephrine has only been shown to work in children.
Further Reading: Marino. The ICU Book, page 479.
198. B False

Fever is a qualitative response to inflammation, not infection, and there is no association between fever and degree of infection.

Further Reading: Marino. The ICU Book, page 487.

199. B False

Early postoperative fever is often attributed to atelectasis, but it has been demonstrated that there is no correlation between the two entities. Even after upper abdominal surgery, where atelectasis is nearly 100% in the first week, only 15% of patients will exhibit an early postoperative fever.

Further Reading: Marino. The ICU Book, page 489.

200. B False

Steroids were commonly used in the past for septic shock but have shown no benefit, and have even demonstrated harm in some cases. They should be avoided in cases of septic shock.

Further Reading: Marino. The ICU Book, page 509.

201. B *Pseudomonas* sp.

*Pseudomonas* is the most common cause of nosocomial, ventilator-associated pneumonia. This differs from community-acquired pneumonia, which is often caused by *streptococcus pneumonia*. ICU-/ventilator-associated pneumonia is often gram negative.

Further Reading: Marino. The ICU Book, page 517.

202. B 0.25%

Needle stick injuries with blood from an HIV-infected patient carries a risk of transmission of approximately 0.25%.

Further Reading: Marino. The ICU Book, page 547.

203. A 0.09%

As a care provider if you are exposed to blood from a patient with HIV to a mucous membrane, your risk of transmission is quite low, coming in at approximately 0.09%.

Further Reading: Marino. The ICU Book, page 547.

204. C Nephrotoxicity

Amphotericin is a powerful antifungal agent used for severe infections. It is accompanied by mild side effects in up to 70%. The most significant major complication is nephrotoxicity, and therefore amphotericin is administered with saline flushes and close monitoring of renal function labs.

Further Reading: Marino. The ICU Book, page 566.

205. A Seizures

Imipenem is a very powerful broad spectrum antibiotic, and the major complication is the development of generalized seizures, which can occur in up to 3% of patients.

Further Reading: Marino. The ICU Book, page 566.

206. B 30%

The survival rate of cardiopulmonary resuscitation (CPR) is low, at 30% overall. There is only a 10% return to baseline function in patients that have CPR performed.

207.

B True negative

True negative is when the test you are performing accepts the null hypothesis and the individual has a negative result on the test. For example, your patient tests negative for tuberculosis (TB) and actually does not have TB.


208.

D False negative

False negative is when the test you are performing accepts the null hypothesis and the individual does not satisfy the null hypothesis. For example, your patient tests negative for TB but actually does have TB.


209.

A Sensitivity = TP/ (TP + FN)

Sensitivity is the chance of testing positive among the community of patients with the condition. It is defined as TP/ (TP + FN), or 1–type II error.


210.

B Specificity = 1 − type I error

Specificity is the chance of testing negative among the community of patients without the disease. It is defined as TN/ (TN + FP), or 1–type I error.


211.

C PPV = TP/ (TP + FP)


212.

D NPV = TN/ (TN + FN)

Negative predictive value is the chance of not having the condition among patients who test negative for the condition. It is defined as TN/ (TN + FN).


213.

C Type I error = FP/ (FP + TN)

Type I error (alpha) is the chance of testing positive among patients who do not have the condition. It is defined as FP/ (FP + TN), or 1–specificity.


214.

B Type II error = 1 − sensitivity

Type II error (beta) is the chance of testing negative among patients who do have the condition. It is defined as FN/ (FN + TP), or 1–sensitivity.


215.

A NNT = 1/absolute risk reduction

Number needed to treat can be a helpful calculation to make statistics generalizable to patient populations in clinic. It is calculated by using the formula 1/absolute risk reduction (ARR). The ARR is calculated by ARR = (control event rate) − (experimental event rate).


216.

B Power = 1 − type II error

Statistical power is used to decrease the rate of type II error (false negatives). It is calculated using the formula 1 − type II error.


217.

B Perform a medical examination

A hospital must perform an initial medical examination to ensure patient stability prior to transferring the patient to another hospital regardless of ability to pay.

Further Reading: https://www.acep.org/news-media-top-banner/emtala/.

218.

A True

According to EMTALA, you are required to accept this transfer as the intake hospital does not have subspecialty coverage for this type of emergency and the patient needs to be transferred
to your facility for further management and stabilization.

Further Reading: https://www.acep.org/news-media-top-banner/emtala/.

219.  B  False

According to EMTALA, you are required to accept a transfer when a local hospital or ED does not have subspecialty coverage. However, when there are other facilities closer to the hospital in question, the patient should be transferred to the closest facility with appropriate coverage, and you do not have to accept this transfer over such a long distance as there are multiple capable facilities between you and the patient.

Further Reading: https://www.acep.org/news-media-top-banner/emtala/.

220.  A  True

The intake hospital must provide stabilizing care to a patient prior to transfer to a different facility. If a patient is unstable, a physician must certify that the expected benefits outweigh any risks of transfer.

Further Reading: https://www.acep.org/news-media-top-banner/emtala/.

221.  B  False

While all 50 states and the District of Columbia have some form of the Good Samaritan law, specifics can vary. It is important to know that it is designed to encourage health care workers to render emergency aid, but does not provide blanket liability. You can still be charged with gross negligence if you are not providing at least reasonable standard of care in an emergency situation. An example would be initiating emergency care (CPR), but then walking away before emergency medical technicians (EMTs) arrive.


222.  B  False

There are three provisions required for the Good Samaritan law to be in effect. It must be an emergency, you must not be on hospital grounds, and care must be voluntary.


223.  B  False

In this situation, you are covered under the Good Samaritan law and you should provide emergency care that you think is required. If the patient is awake and responsive, it is appropriate and required that you ask for consent. If the patient is unconscious, you can provide emergency care without obtaining prior consent.


224.  B  False

According to the Stark Law against self-referral, physicians are not able to refer patients to facilities in which they have a direct financial benefit from the referral. This law was enacted to decrease resource utilization and conflicts of interest when providing medical care.

Further Reading: http://starklaw.org/.

225.  B  False

According to the Anti-Kickback Statute, it is a criminal offense to provide or promise any financial incentive or anything of value to promote referrals.


226.  B  False

Sending patient information over text messaging in an unsecured violation with specific information is a Health Insurance Portability and Accountability Act of 1996 (HIPAA) violation and should be avoided unless the hospital has provided encrypted capabilities for messaging.

III  Stand-Alone
Questions are randomized but follow the ABNS (American Board of Neurological Surgery) content category breakdown.

**Question Breakdown:**
- Neuroanatomy—49 questions
- Neurosciences—30 questions
- Neuropathology—43 questions
- Neuroimaging—57 questions
- Clinical Neurology—40 questions
- Neurosurgery—84 questions
- Critical Care/Fundamental Clinical Skills—65 questions
- Core Competencies—7 questions

1. A 34-year-old woman with a history of medically intractable epilepsy currently failing two AEDs has been admitted to the epilepsy monitoring unit for seizure classification. On the video monitor, you observe her having a seizure. On the video, before her seizure begins, she reports a rising feeling in her epigastric region, as well as the smell of burnt rubber. She begins seizing, and after 15 seconds, the semiology appears to change, and she adopts the classic fencer’s posture, with her contralateral arm abducted, externally rotated, and flexed at the elbow. What white matter tract did the seizure propagate along?
   A. Corpus callosum
   B. Uncinate fasciculus
   C. Fronto-occipital fasciculus
   D. Fasciculus retroflexus

2. A neurologist is checking the reflexes of a patient with myelopathy and diffuse hyperreflexia. When the patellar tendon is struck, the muscle organ that mediates the myotatic reflex fires. This organ is innervated by what type of motor nerve?
   A. Alpha
   B. Beta
   C. Gamma
   D. Theta

3. A 12-year-old boy presents with a history of headaches and is found to have a cystic mass in the hypothalamus. He undergoes successful resection and the final pathology slides are demonstrated below. These slides show a characteristic finding for this particular tumor type; what are the characteristic findings?

   A. Rosenthal fibers
   B. Axonal spheroids
   C. Bunina bodies
   D. Verocay bodies
Questions

4. What is the best treatment for the abnormality demonstrated in the image below?

A. Embolization  
B. Surgical resection  
C. Observation  
D. Stereotactic radiosurgery

5. Which of the following is most characteristic of neuromyelitis optica?

A. 64F with increased T2 signal covering two-thirds of the cross-section of the spinal cord at one level  
B. 58M with circumscribed increased T2 signal localized to the posterior columns at multiple levels  
C. 60F with increased T2 signal covering the entire cross-section of the spine with associated hemorrhage at two levels  
D. 62M with increased T2 signal and spinal cord enlargement spanning more than three levels

6. While on call, you evaluate a 66-year-old woman who fell and sustained a compression fracture of the upper lumbar spine. She does not require surgery for this fracture, but you notice that she does have a mobile spondylolisthesis at L4–L5 with pseudoclaudication pain, and you feel that a fusion procedure could benefit her in the future. As a part of her presurgical workup, you order a DEXA scan, and her T score returns at −1.8. How would her bone density be classified?

A. Osteopenic  
B. Osteoporotic  
C. Normal  
D. Low-normal bone mineral density

7. You are called to the bedside of a 32-year-old man who is currently in the emergency department and began having a generalized, tonic-clonic seizure that has now lasted for 60 seconds. The emergency department has not yet performed any interventions or obtained any lab studies; they called for your assistance. What is the best initial step in management?

A. Administer lorazepam  
B. Check blood glucose level  
C. Obtain head CT  
D. Secure airway  
E. Administer thiamine/glucose

8. You are evaluating a 73-year-old man who has evidence of 70% stenosis of his right internal carotid artery. At this time, he has not had any neurological symptoms related to his right ICA stenosis. What medication has been shown to reduce the incidence of transition from asymptomatic to symptomatic carotid stenosis?

A. Simvastatin  
B. Metoprolol  
C. Aspirin  
D. Hydrochlorothiazide  
E. Lisinopril
9. The abnormality depicted below is associated with what syndrome?

A. Arnold–Chiari type I malformation
B. Arnold–Chiari type II malformation
C. Arnold–Chiari type III malformation
D. Arnold–Chiari type IV malformation
E. Arnold–Chiari type 0 malformation

10. The aneurysm depicted below would be classified as what type of aneurysm?

A. Posterior communicating
B. Superior hypophyseal
C. Carotid–ophthalmic
D. Anterior communicating
E. ICA terminus

11. You are operating on a patient with left-sided persistent dystonia, utilizing a deep brain stimulation electrode targeting the globus pallidus internal segment. If the electrode is advanced too deep, what side effect would you expect the patient to report during intraoperative stimulation?

A. Facial pulling
B. Phosphenes
C. Paresthesias
D. Worsened dystonia
E. Double vision

12. The resting membrane of the neuron is closest to the equilibrium potential of what ion?

A. Sodium
B. Potassium
C. Chloride
D. Magnesium
E. Calcium

13. You resect a tumor in a 12-year-old boy utilizing an interhemispheric approach to the lateral ventricular system. When you open into the ventricle, the tumor appears to be coming from the midline septum rather than the lateral ventricular wall. The final pathology is demonstrated below. What is the most likely diagnosis?

A. Oligodendroglioma
B. Neurocytoma
C. Pilocytic astrocytoma
D. Hemangioblastoma
E. Glioblastoma
14. You are treating a 45-year-old man with a large facial mass and imaging demonstrated below. After subtotal resection, what further treatment method is contraindicated?

A. Observation  
B. Repeat surgery  
C. Radiation  
D. Chemotherapy

15. Patients with CJD display what characteristic finding on EEG?

A. Diffuse sharp waves  
B. 1- to 2-Hz spike and wave activity  
C. 3-Hz spike and wave activity  
D. Hypsarrhythmia  
E. Burst suppression

16. You are called to the neonatal intensive care unit (NICU) to evaluate a newborn with a myelomeningocele. The NICU team is performing all appropriate initial treatments. You schedule the patient for repair the next morning. The child’s parents ask you what percentage of children with myelomeningocele is able to ambulate into adolescence; what do you tell them?

A. 10%  
B. 25%  
C. 33%  
D. 50%  
E. 75%

17. You are set to perform a routine lumbar microdiskectomy. Immediately after you flip the patient into the prone position, the CRNA reports that they are having some “issues.” When you ask what is happening, they state that the end-tidal CO₂ has just increased significantly. Anesthetic induction was uneventful and they utilized succinylcholine for induction and intubation. What is the best treatment for this condition?

A. Desmopressin  
B. Cold saline administration  
C. Dantrolene  
D. Immediate reversal  
E. Immediate extubation

18. You are performing a craniotomy for a patient with a carotid-ophthalmic aneurysm. In order to better expose the neck of the aneurysm and its relationship to the ophthalmic artery, you decide to remove the anterior clinoid process. If you continue to drill medially when the clinoid process has been removed, what structure will you enter into?

A. Sella turcica  
B. Ethmoid sinus  
C. Sphenoid sinus  
D. Maxillary sinus  
E. Middle fossa

19. What segment of the internal carotid artery gives rise to the meningohypophyseal trunk?

A. Cervical  
B. Petrous  
C. Lacerum  
D. Cavernous  
E. Clinoidal
20.
You evaluate a patient with the facial abnormality depicted in the image below. The parents ask if any further children are at risk of being born with this condition, and whether it is inheritable. What do you tell them?

A. Autosomal dominant
B. Autosomal recessive
C. X-linked recessive
D. Sporadic
E. Mitochondrial

21.
You are treating a patient with a recurrent pituitary adenoma status postsurgical resection 2 years prior. You have elected to perform stereotactic radiosurgery to treat the recurrence. While planning, you are carefully adjusting the dose in order to protect the optic chiasm. What is the maximum safe dose that can be delivered to the optic apparatus?

A. 6 Gy
B. 10 Gy
C. 12 Gy
D. 14 Gy
E. 16 Gy

22.
What ventilator setting listed below has the highest risk of ventilator-induced barotrauma?

A. Pressure support
B. Simultaneous intermittent mandatory ventilation
C. Volume support
D. Pressure control-inverse ratio ventilation

23.
You are called to the bedside to evaluate a 72-year-old woman who is in the postanesthesia care unit having just recovered from a routine, uncomplicated L3–L5 laminectomy for spinal stenosis. You notice on the monitor that her heart rate is 145, and you review an ECG strip that does not demonstrate any P waves. Her blood pressure is 145/85. What is the best medication to control her heart rate?

A. Diltiazem
B. Metoprolol
C. Procainamide
D. Sotalol
E. Digoxin

24.
You are evaluating a 12-year-old male with findings of myelopathy and the imaging demonstrated below. Ultimately, the lesion was resected and the intraoperative images are also demonstrated. If this lesion was formed by an embryologic abnormality, what stage of embryogenesis did this abnormality occur?

A. Disjunction
B. Primary neurulation
C. Closure of the anterior neuropore
D. Foregut–notochord separation
E. Secondary neurulation
25. What ion blocks the pore of the NMDA channel during the resting phase?
   A. Na  
   B. K  
   C. Mg  
   D. Ca  
   E. Cl

26. You are evaluating a 34-year-old man with a known history of HIV infection who presented with persistent headaches. Imaging is demonstrated below. What is the best initial treatment for these lesions?

   ![Imaging](image)

   A. Gross total resection  
   B. Stereotactic radiosurgery  
   C. Methotrexate  
   D. Observation

27. You resected a tumor through a skull base approach and the final pathology is demonstrated below. What nerve is this tumor associated with in the majority of cases?

   ![Pathology](image)

   A. Inferior vestibular  
   B. Facial  
   C. Cochlear  
   D. Abducens  
   E. Greater superficial petrosal

28. What is the name of the artery that enters the internal acoustic meatus to supply the cranial nerves and cochlea?
   A. Basilar perforators  
   B. Labyrinthine artery  
   C. Anterior inferior cerebellar artery  
   D. Posterior inferior cerebellar artery  
   E. Superior cerebellar artery

29. What would you expect to see on final pathologic specimen after resection of the mass pictured below (panels A/B preoperative, panel C postoperative)?

   ![Pathology](image)

   A. Verocay bodies  
   B. Whorls  
   C. Pseudopalisading necrosis  
   D. Dry keratin  
   E. Homer Wright rosettes

30. You resect a calcifying, partially enhancing circumscribed mass near the cortical surface on a 55-year-old man who presented with seizures. CT scan demonstrated scattered calcification in the mass. What molecular pattern would you expect to see on final pathology?
   A. PTEN mutation  
   B. 1P/19Q co-deletion  
   C. Loss of sex chromosome  
   D. IDH mutation  
   E. MGMT methylation
31. You are called emergently to the bedside of a patient who is postoperative day 1 from clipping of a right anterior communicating artery aneurysm. The nursing staff tells you that the patient suddenly became unconscious. You notice on the ECG strip that the patient has a wide complex tachycardia. Systolic blood pressure is 70 mm Hg. What is the next best step?

A. Head CT  
B. Epinephrine administration  
C. Defibrillation  
D. Obtain electrolyte panel  
E. Start diltiazem infusion

32. You decide to perform an epidemiological study regarding development of multiple sclerosis in a defined population. You elect to perform a cohort study. What is the best statistical association method to use for your cohort study?

A. Odds ratio  
B. Relative risk  
C. Power  
D. Absolute risk reduction  
E. Number needed to treat

33. Exposure to what toxic agent causes wrist drop?

A. Lead  
B. Arsenic  
C. Iron  
D. Manganese  
E. Mercury

34. You are called by the pediatric team to come and see a child with the abnormality pictured below (preoperative and intraoperative pictures). They are asking about preoperative care. You suggest that they keep the child laying on his abdomen, cover the lesion with a sterile dressing, and start what prophylactic antibiotic regimen?

A. Vancomycin/cefepime  
B. Ampicillin/gentamicin  
C. Erythromycin monotherapy  
D. Fluconazole  
E. Dicloxacillin

35. You are evaluating a 73-year-old man who has right leg pain that goes down the side of his leg to the top of the foot. The pain is significantly worse when he is up and walking around. It is relieved by leaning forward. You are concerned that he has lateral recess stenosis affecting his L5 nerve root. What structure causes direct compression of the nerve root?

A. Inferior articulating process  
B. Superior articulating process  
C. Pedicle  
D. Lamina  
E. Spinous process

36. Which of the following syndromes can be distinguished from the others by a normal IQ?

A. Apert's syndrome  
B. Pfeiffer's syndrome  
C. Crouzon's syndrome  
D. Patau's syndrome
37. What is the abnormality pictured here?  
- A. Metastatic disease  
- B. Osteoid osteoma  
- C. Eosinophilic granuloma  
- D. Hemangioma  
- E. Aneurysmal bone cyst

38. You are evaluating a peripheral nerve biopsy slide that demonstrates “onion bulb” histologic appearance. You believe this is due to a hereditary neuropathy, specifically Charcot–Marie–Tooth disease type III. What type of neuropathy does this disease cause?  
- A. Demyelinating  
- B. Axonal  
- C. Toxic  
- D. Traumatic

39. What protein is involved in fast retrograde axonal transport?  
- A. Dynamin  
- B. Dynein  
- C. Kinesin  
- D. Tropomyosin  
- E. Synaptobrevin

40. The lateral geniculate nucleus is fed by what blood vessel?  
- A. Lateral lenticulostriates  
- B. Medial lenticulostriates  
- C. Anterior choroidal  
- D. Posterior choroidal  
- E. Thalamic perforators

41. The abnormality pictured here is caused by an error in what stage of embryogenesis?  
- A. Nondisjunction  
- B. Premature disjunction  
- C. Primary neurulation  
- D. Secondary neurulation  
- E. Gastrulation

42. Mossy fibers entering the cerebellum traverse what structure?  
- A. Brachium conjunctivum  
- B. Brachium pontis  
- C. Restiform body  
- D. Juxtarestiform body

43. Cells in what phase of the cell cycle are most resistant to the destructive effects of radiation?  
- A. G0  
- B. G1  
- C. M  
- D. S
44. A Hirano body, made of actin-associated protein, is demonstrated in what disease process?
   A. Progressive supranuclear palsy  
   B. Alzheimer’s disease  
   C. Parkinsonism  
   D. Metachromatic leukodystrophy  
   E. Rabies

45. You are evaluating a 12-year-old male with a history of persistent seizures. Brain imaging is demonstrated. What is the most likely diagnosis and inheritance pattern for this condition?
   A. Tuberous sclerosis, autosomal dominant  
   B. Tuberous sclerosis, autosomal recessive  
   C. Neurofibromatosis type I, autosomal dominant  
   D. Neurofibromatosis type II, autosomal dominant  
   E. Sturge–Weber syndrome, sporadic

46. You are observing the EEG patterns of a sleeping patient in the sleep study lab. You determine the patient is in stage III sleep. What EEG wave pattern are you observing that leads to this determination?
   A. Alpha  
   B. Beta  
   C. Theta  
   D. Delta  
   E. Sleep spindles and K complexes

47. Which of the following metal implant mixtures will lead to the highest rate of galvanic corrosion?
   A. Stainless steel–stainless steel  
   B. Stainless steel–cobalt-chromium alloy  
   C. Cobalt-chromium alloy–Titanium  
   D. Titanium–titanium  
   E. Cobalt-chromium alloy–cobalt-chromium alloy

48. What medication has been shown to decrease rates of early subacute aneurysmal rebleeding events in patients who have suffered a subarachnoid hemorrhage?
   A. Heparin  
   B. Aspirin  
   C. Tranexamic acid  
   D. Nimodipine  
   E. Prothrombin complex concentrates

49. This intraoperative photograph demonstrates a mucor brain abscess. What patient is this most likely to have developed in?
   A. A 34-year-old man with a history of IV drug use  
   B. A 14-year-old woman with poorly controlled type I diabetes mellitus  
   C. An 85-year-old man with a history of chronic lymphocytic leukemia  
   D. A 76-year-old woman who takes rituximab for a chronic skin condition

50. What is the ideal agent to use to break reentry supraventricular tachycardia?
   A. Procainamide  
   B. Diltiazem  
   C. Sotalol  
   D. Adenosine  
   E. Lidocaine
51. What characteristics does the Meissner corpuscle exhibit?
   A. Rapid adaptation, small receptive field
   B. Rapid adaptation, large receptive field
   C. Slow adaptation, small receptive field
   D. Slow adaptation, large receptive field

52. What histopathologic factor is used to distinguish a WHO grade III astrocytoma from a WHO grade II astrocytoma?
   A. Microvascular proliferation
   B. Pseudopalisading necrosis
   C. High mitotic activity
   D. IDH status
   E. Microcystic change

53. What type of Arnold–Chiari malformation is depicted here?
   A. Chiari 0
   B. Chiari I
   C. Chiari II
   D. Chiari III
   E. Chiari IV

54. What underlying tumor type is demonstrated in this MRI from a 3-year-old girl?
   A. Germ cell tumor
   B. Glioma
   C. Metastatic tumor
   D. Primitive neuroectodermal tumor (PNET)
   E. Atypical teratoid/rhabdoid tumor (AT/RT)

55. What MRI finding is most consistent with nerve root avulsion in a patient who was involved in a motorcycle accident who presents with a flail arm?
   A. Perineural edema
   B. Neuroma-in-continuity
   C. Distal muscle atrophy
   D. Pseudomeningoceles
   E. Coexistent vascular injury

56. You are called to see a 75-year-old man with long-standing hypertension who suddenly became unresponsive and was brought by family into the emergency department. The patient is comatose with pinpoint pupils and has a labored breathing pattern. He appears to have a long inspiratory phase, followed by a prolonged pause prior to initiation of the expiratory phase. If his coma is due to intracerebral hemorrhage, what is the most likely location of the hemorrhage based on his clinical findings?
   A. Bithalamic
   B. Midbrain
   C. Pons
   D. Medulla
   E. Cerebellum
57. You are evaluating a 53-year-old woman with evidence of spinal stenosis both clinically and on MRI. She appears to have significant stenosis at L3–L5. As you are considering what type of surgery to perform, you notice that she seems to have a decreased overall lumbar lordosis. You do not have long-cassette X-rays to evaluate her overall spine alignment, but what quick measurement can you perform to evaluate her overall alignment?

A. Sacral slope ± 9 degrees = pelvic incidence
B. Pelvic incidence ± 9 degrees = pelvic tilt
C. Lumbar lordosis ± 9 degrees = sacral slope
D. Lumbar lordosis ± 9 degrees = pelvic tilt
E. Pelvic incidence ± 9 degrees = lumbar lordosis

58. What suture is abnormal in this patient with craniosynostosis?

A. Metopic
B. Sagittal
C. Coronal
D. Lambdoid
E. Mastoid

59. You are asked to evaluate an 18-year-old woman with a brain abnormality depicted in the MRI. She was playing soccer and lost consciousness after performing a header. A concussion was diagnosed, and a CT scan in the emergency department demonstrated an abnormality. This was further imaged with an MRI. What is the best initial treatment for this lesion?

A. Ventriculoperitoneal shunting
B. Surgical excision
C. Chemotherapy
D. Stereotactic radiosurgery
E. Observation

60. You are called to evaluate a 34-year-old man with a known history of IV drug use who has become hypotensive. Blood cultures have grown 3+ staphylococcus aureus in all four bottles. Currently he is in distress, tachypneic, tachycardic with a heart rate of 128, and hypotensive with a systolic blood pressure that is 73 mm Hg. He has already received 3 L of crystalloid and the 4th liter is hanging and running in at the fastest rate. What should be the next medication administered?

A. Dopamine
B. Epinephrine
C. Norepinephrine
D. Phenylephrine
E. Isoproterenol
61. You are evaluating a 52-year-old woman who has noticed cramping pain in her elbow and paresthesias of the hand every time she is using her right hand. It has been worsening over the last 5 weeks. If these symptoms are due to nerve compression by an abnormal ligament of Struthers, what muscle listed below would you expect to be weak on motor examination?

A. First interosseous
B. Abductor pollicis longus
C. Abductor pollicis brevis
D. Flexor digitorum superficialis to the fourth and fifth digits
E. Ventral interossei

62. What neurotransmitter does the basal nucleus of Meynert utilize predominantly?

A. Norepinephrine
B. Acetylcholine
C. Serotonin
D. Glutamate
E. GABA

63. You resect a tumor that appears to be associated with the conus medullaris in a 24-year-old woman. Final pathology slides are demonstrated. What is the diagnosis?

A. Myxopapillary ependymoma
B. Metastatic renal cell carcinoma
C. Primary spinal cord astrocytoma
D. Schwannoma

64. This tumor was resected from a 16-year-old boy. What did he most likely present with?

A. Hemorrhage
B. Headache
C. Blurry vision
D. Weakness
E. Seizures

65. What further imaging study might help you diagnose this skull lesion?

A. Contrast enhanced CT scan
B. Diffusion weighted MRI
C. T2 weighted MRI
D. PET scan
E. AP skull radiograph
66. The injury demonstrated in the image studies can be associated with what condition?

A. Trisomy 13  
B. Trisomy 18  
C. Duchenne's muscular dystrophy  
D. Kallmann's syndrome  
E. Trisomy 21  

67. You are operating with intraoperative somatosensory evoked potential (SSEP) monitoring. Suddenly, the EMG technician tells you that the N11 wave is abnormal and extended significantly. What region is most likely affected by your recent surgical maneuver?

A. Brachial plexus  
B. Posterior columns  
C. Anterior horn cells  
D. Lateral corticospinal tract  
E. Parietal cortex  

68. You are operating on a 56-year-old man with a 1.1-cm, growing, pure intracanalicular vestibular schwannoma via a middle fossa approach in order to identify the facial nerve and protect it early in the operation. During the exposure for this approach, if you are not careful to identify the relevant anatomy, you risk injuring a structure that will cause what postoperative deficit?

A. Decreased salivation  
B. Decreased lacrimation  
C. Ipsilateral Horner's syndrome  
D. Ipsilateral hyperacusis  
E. Ipsilateral dystonia  

69. According to the Spetzler–Martin scale for AVMs, what would be the risk of unfavorable outcome after resecting this AVM?

A. 0 to 9%  
B. 13 to 22%  
C. 31 to 37%  
D. 48 to 57%  
E. 67%  

70. What percentage of patients with medially refractory epilepsy experiences adequate seizure control when adding a third antiepileptic medication to their antiseizure regimen?

A. 4%  
B. 12%  
C. 23%  
D. 33%  
E. 38%  

71. What nerve is at risk during a lateral transpsoas approach for fusion of the lumbar spine?

A. Sciatic  
B. Inferior gluteal  
C. Femoral  
D. Obturator  
E. Superior gluteal
I Questions

72. You are evaluating a 44-year-old man in the trauma bay who was involved in a bar fight. He was struck on the left side of the head with a bottle, and appears to have sustained a depressed skull fracture in the left frontal region. Initially his GCS was 14, but suddenly he has become unresponsive and his eyes are deviated to the right. What is the next best step?
A. Give Ativan
B. Proceed to OR
C. MRI
D. Give naloxone
E. Obtain EEG

73. What is the mechanism of action of protamine?
A. Binds antithrombin III
B. Inactivates antithrombin III
C. Binds protein C
D. Binds heparin
E. Binds protein S

74. You are treating a 28-year-old man with a high, complete spinal cord injury requiring pressors and now intubation. What would be a disadvantage of higher levels of PEEP in this patient?
A. Risk of barotrauma
B. Hypoxemia
C. Increased work of breathing
D. Ventilator dyssynchrony
E. Decreased preload

75. You are performing a radiofrequency ablation in a 58-year-old woman with V3 distribution type I trigeminal neuralgia. The radiofrequency electrode is in position. You turn on test stimulation, and the patient experiences paresthesias in the high mandibular region, with no effect on her pain. What direction should you move the electrode?
A. Inferolaterally
B. Inferomedially
C. Superolaterally
D. Superomedially

76. Which of these fibers do not synapse directly on the Purkinje cell of the cerebellum?
A. Climbing fibers
B. Basket cell fibers
C. Granule cell fibers
D. Mossy fibers

77. The tumor depicted in this pathology slide is most likely to harbor what gene mutation?
A. 1p/19q co-deletion
B. PTEN mutation
C. Loss of heterozygosis on chromosome 22
D. Duplication of chromosome 3
E. Loss of sex chromosome

78. What is the best initial management in a patient with septic shock?
A. Colloid infusion
B. Hetastarch infusion
C. Crystalloid infusion
D. Free water infusion

79. Which of the following antibiotics has the highest risk of significantly increasing the creatinine?
A. Vancomycin
B. Isoniazid
C. Penicillin
D. Erythromycin
E. TMP/SFX
80. 
You are evaluating a 78-year-old patient with long-standing atrial fibrillation who suddenly presented with aphasia and right-sided weakness. A CT angiogram is demonstrated. It has been determined that this patient could benefit from mechanical thrombectomy. How long from onset of symptoms does mechanical thrombectomy remain a viable treatment option?
A. 3 hours
B. 4.5 hours
C. 6 hours
D. 8 hours
E. 10 hours

81. 
What is the rate of Engel I seizure control after surgical resection of structural temporal lobe epilepsy in children?
A. 25%
B. 50%
C. 67%
D. 75%
E. 90%

82. 
What anticoagulant does the agent idarucizumab effectively reverse?
A. Lepirudin
B. Dabigatran
C. Rivaroxaban
D. Apixaban

83. 
You are caring for a 28-year-old woman who was thrown from a horse and suffered a depressed skull fracture, severe brain trauma, and elevated intracranial pressure now status post hemicraniectomy. She has had no nutritional intake for the last 3 days and you have elected to start TPN. Her caloric intake should be what compared to her predicted basal energy expenditure?
A. 60%
B. 100%
C. 140%
D. 180%

84. 
The lateral olfactory stria terminates in what cortical region?
A. Cribriform plate
B. Subiculum
C. Basal nucleus of Meynert
D. Septal area
E. Pyriform cortex

85. 
Astrocytes are responsible for mediating the extracellular levels of what ion?
A. Sodium
B. Potassium
C. Calcium
D. Chloride
E. Magnesium

86. 
You resect the tumor depicted here from a 28-year-old woman. The procedure was uncomplicated. The final pathology report states “nests of cells that are diffusely positive for chromogranin A.” What is the diagnosis?
A. Paraganglioma
B. Myxopapillary ependymoma
C. Metastatic tumor
D. Schwannoma
E. Neurofibroma
87. The final pathology of a tumor resected from a 42-year-old woman's cervical spine is depicted here. If this tumor is due to an inherited condition, what other tumor might you see in this patient?

A. Optic glioma  
B. Meningioma  
C. Parathyroid carcinoma  
D. Renal cell carcinoma  
E. Subungual fibromas

88. What developmental abnormality is pictured here?

A. Alobar holoprosencephaly  
B. Hydranencephaly  
C. Anencephaly  
D. Lobar holoprosencephaly  
E. Semilobar holoprosencephaly

89. What segment of the vertebral artery is at risk during exposure of the superior aspect of the C1 posterior arch?

A. V1  
B. V2  
C. V3  
D. V4  
E. V5

90. Triphasic waves on EEG are seen with what underlying disorder?

A. Lennox–Gastaut syndrome  
B. West's syndrome  
C. Cruetzfeld–Jakob disease  
D. Rasmussen's encephalitis  
E. Hepatic encephalopathy

91. The transverse ligament connects what two structures?

A. Petrous bone to clivus  
B. C1 lateral mass to occiput  
C. C1 lateral masses  
D. Dens to basion  
E. C1 lamina to C2 spinous process

92. Non-REM sleep is mediated in part by what hypothalamic structure?

A. Ventrolateral preoptic nucleus  
B. Paraventricular nucleus  
C. Supraoptic nucleus  
D. Posterior region  
E. Ventromedial region

93. The structure known as Bill's bar separates what nerves?

A. Facial and cochlear  
B. Superior vestibular and inferior vestibular  
C. Inferior vestibular and cochlear  
D. Superior vestibular and facial  
E. Inferior vestibular and facial
94. The patient pictured here most likely suffers from what underlying abnormality?

A. Ipsilateral olfactory groove meningioma  
B. Retinoblastoma  
C. Carotid cavernous fistula  
D. Optic glioma  
E. Thyrotoxicosis

95. What blood vessel variant is demonstrated in this angiogram?

A. Fetal PCA  
B. Enlarged posterior communicating  
C. Persistent trigeminal artery  
D. Persistent otic artery  
E. Persistent hypoglossal artery

97. Which of these structures is extremely sensitive to ischemia?

A. Cerebellar Purkinje cell layer  
B. CA2  
C. Dentate gyrus  
D. Dentate nucleus  
E. Cerebellar granule cells

98. You are called to evaluate a newborn with the findings demonstrated in the images. What should be the next imaging step?

A. Full neuraxis MRI  
B. Lumbar MRI  
C. Lumbar CT scan  
D. Lumbar ultrasound  
E. Head CT

99. The pulmonary capillary wedge pressure best approximates the pressure in what cardiac chamber?

A. Right atrium  
B. Right ventricle  
C. Left ventricle  
D. Left atrium  
E. Coronary artery
100. You decided to improve your knowledge regarding high-grade internal carotid artery stenosis and its treatment, and you begin by reading the results of the classic NASCET study. They state: "As shown in the first row of Table 2, the life-table estimate of the risk of any fatal or nonfatal ipsilateral stroke by 24 months after randomization was 26 percent for the medical patients and only 9 percent for the surgical patients." You agree that these are impressive results, but you are trying to incorporate them into your thinking as a surgeon who performs carotid endarterectomies. How many patients that meet these criteria will you need to operate on to prevent one "fatal or nonfatal ipsilateral stroke by 24 months after diagnosis"?

A. 1.0
B. 3.7
C. 5.9
D. 7.3
E. 11.1

101. You are caring for a 65-year-old woman who suffered an H&H grade III subarachnoid hemorrhage from a 1.2-cm anterior communicating artery aneurysm. She is now postbleed day 6. You have been trending her daily sodium levels and they have been 138, 132, and 127 over the last 3 days, respectively. What clinical factor is helpful in determining the correct reason for her hyponatremia?

A. Volume status
B. Magnesium level
C. Mental status
D. Heart rate
E. Urine volume

102. You are evaluating a patient in the trauma bay who was not wearing her seatbelt and was thrown from a vehicle during a high-velocity motor vehicle accident. She is comatose with anisocoria, left greater than right. This CT scan was obtained approximately 75 minutes after the accident. The risk of dangerous expansion of this hematoma is greatest at what time after injury?

A. 1 to 6 hours
B. 6 to 12 hours
C. 12 to 24 hours
D. 24 to 48 hours

103. You resect the lesion demonstrated on these MRI images. Final pathology is consistent with glioblastoma with MGMT promoter methylation. The methylation of the MGMT promoter region suggests what?

A. Increased susceptibility to radiation
B. Increased local recurrence rate
C. Decreased progression-free survival
D. Increased susceptibility to alkylating agents
E. Secondary GBM

104. Which of the following conditions is inherited in an autosomal recessive pattern?

A. Neurofibromatosis type I
B. Tuberous sclerosis
C. Sturge–Weber syndrome
D. Leber's hereditary optic neuropathy
E. Friedrich's ataxia

105. What is the most likely diagnosis for this mass discovered in a 28-year-old woman with symptoms of progressive saddle anesthesia and urinary incontinence?

A. Schwannoma
B. Paraganglioma
C. Myxopapillary ependymoma
D. Spinal cord astrocytoma
E. Spinal cord arteriovenous malformation
106. What Brodmann's region are the frontal eye fields?
A. 8  
B. 6  
C. 4  
D. 3  
E. 1

107. The neuropeptide substance P is responsible for what type of neurological process?
A. Postganglionic sympathetic transmission  
B. Preganglionic parasympathetic transmission  
C. Pain transmission  
D. Excitation of alpha motor neurons  
E. Inhibition of cerebellar output

108. You are seeing a patient in clinic who presented with headaches. Imaging is demonstrated. What immunohistochemical feature would you use on final pathology to determine whether this tumor is a meningioma or a hemangiopericytoma?
A. GFAP  
B. EMA  
C. Vimentin  
D. Chromogranin  
E. Cytokeratin

109. The optic nerve is made up of axons of what type of retinal cell?
A. Bipolar cells  
B. Amacrine cells  
C. Horizontal cells  
D. Photoreceptor cells  
E. Ganglion cells

110. What ion is the highest concentration in endolymphatic fluid?
A. Na  
B. K  
C. Cl  
D. Ca  
E. Mg

111. What is the most likely location for the tumor depicted here to present?
A. Temporal lobe  
B. Cerebellum  
C. Sacrum  
D. Planum  
E. Filum terminale
112. These images were obtained in an 11-year-old boy with back pain. These findings are most consistent with what process?

A. Aneurysmal bone cyst
B. Chordoma
C. Idiopathic scoliosis
D. Eosinophilic granuloma
E. Degenerative scoliosis

113. You are evaluating the MR spectroscopy results in a patient that you suspect has recurrent glioblastoma versus radiation necrosis. You notice that the choline peak is significantly elevated compared to the NAA peak. What cellular process does the elevated choline peak represent?

A. Energy metabolism
B. Cell membrane turnover
C. Neuronal integrity
D. Glial marker

114. You are evaluating the MRI of a 53-year-old patient who is now 1 year status post resection of a left frontal lobe mass that was confirmed to be glioblastoma on final pathology. He underwent chemotherapy with temozolomide and radiation. He returns with the MRI and MR perfusion studies as shown. What is the most likely diagnosis?

A. Recurrent tumor
B. Postoperative inflammation
C. Radiation necrosis
D. Infarction

115. Absence seizures exhibit what classic EEG pattern?

A. 1- to 2-Hz spike and wave pattern
B. Generalized 3-Hz spike and wave pattern
C. Triphasic waves
D. Diffuse sharp waves
E. Hypsarrhythmia

116. On neurology rounds you evaluate a patient who is exhibiting right/left disorientation, finger agnosia, agraphia, and acalculia. You correctly diagnose Gerstmann's syndrome. What region of the brain is affected in this syndrome?

A. Dominant parietal lobe
B. Nondominant parietal lobe
C. Left occipital lobe
D. Dominant frontal lobe
E. Nondominant frontal lobe
117. What is the most common causative organism in pediatric shunt infections?
   A. *Propionibacterium acnes*
   B. *Haemophilus influenzae*
   C. *Staphylococcus aureus*
   D. Coagulase-negative *Staphylococcus*
   E. *Enterococcus*

118. You are called to the emergency department to evaluate an 8-month-old infant with the CT reconstruction demonstrated. He is also exhibiting a cock-robin deformity. If this condition is due to Grisel’s syndrome, what is the best treatment?
   A. Surgical debridement and fusion
   B. NSAIDS and Philadelphia collar
   C. Antibiotics and Philadelphia collar
   D. Cervical traction

119. Which of the following is a common side effect of chemotherapy with temozolomide?
   A. Myelosuppression
   B. Peripheral neuropathy
   C. Diarrhea
   D. Alopecia
   E. Mood disorders

120. At what stage of wound healing does initial wound contraction occur?
   A. 24 hours
   B. 5 days
   C. 14 days
   D. 30 days
   E. 60 days

121. Which of the following does not increase the serum osmotic gap?
   A. Mannitol
   B. Ethanol
   C. Hypertriglyceridemia
   D. 3% saline
   E. Hypergammaglobulinemia

122. Which of the following criteria suggest that a patient with Guillain–Barré syndrome should be intubated?
   A. Ascending weakness
   B. Facial diplegia
   C. Forced vital capacity 9 mL/kg
   D. Forced vital capacity 33 mL/kg
   E. Presence of GQ1b antibody
123. You are performing an endoscopic third ventriculostomy and you successfully perforate the floor of the third ventricle. To ensure adequate CSF flow, you also perforate through an arachnoid membrane that is apparent ventral to the floor of the third ventricle. After disruption of this membrane, CSF can freely flow between what cisterns?

A. Prepontine–perimesencephalic  
B. Chiasmatic–prepontine  
C. Perimesencephalic–chiasmatic  
D. Quadrigeminal–perimesencephalic  
E. CP angle–prepontine

124. You are called to the emergency department to evaluate a child with headaches and a known shunt for long-standing obstructive hydrocephalus. He was wrestling with his older brother 2 days ago and has now developed headaches over the last 24 hours. X-ray is demonstrated. What is the best course of action?

A. Shunt tap/culture  
B. Observation  
C. Decrease the shunt valve setting  
D. Distal shunt revision  
E. Proximal shunt revision
125. You are evaluating a patient with left-sided intention tremor and dysmetria. The MRI scan is demonstrated. What gene is likely abnormal in this patient?

A. PTEN  
B. EGFR  
C. Schwannomin  
D. SHH  
E. WNT

126. You are evaluating a 14-year-old boy who was at football practice and made a tackle after which he had the onset of immediate neck pain and a brief shock sensation going through all four extremities. The X-ray is demonstrated. What is the likely mechanism for this injury?

A. Hyperextension  
B. Axial loading  
C. Flexion compression  
D. Hyperflexion  
E. Flexion/rotation

127. CNS melanocytes are found in what regions?

A. Dura mater  
B. Substantia nigra  
C. Cervical leptomeninges  
D. Sommer’s sector  
E. Purkinje’s cell layer

128. The Renshaw cell of the spinal cord is found in what Rexed’s laminae?

A. II—substantia gelatinosa  
B. I—marginal nucleus  
C. V—reticular nucleus  
D. VII—Clarke’s intermediolateral nuclei  
E. IX—lateral motor nuclei
129. What nerve innervates the infraspinatus muscle?
A. Musculocutaneous
B. Suprascapular
C. Dorsal scapular
D. Long thoracic
E. Thoracodorsal

130. You are evaluating a 22-year-old man who has noticed a bump in the right parietal region of his head. On palpation, it is hard like cortical bone, and the scalp moves over it freely. CT imaging demonstrates a hyperdense lesion without bony destruction. The radiology report suggests osteoma of the skull as the diagnosis. The patient is not currently bothered by the mass. What is the next best step?
A. MRI
B. Stereotactic radiosurgery
C. Surgical resection
D. Observation
E. Treatment with aspirin

131. Axons originating from the dentate nucleus project to what thalamic nucleus?
A. VPL
B. VLp
C. Pulvinar
D. Laterodorsal
E. Anterior

132. Which of the following proteins activates protein kinase C?
A. DAG
B. IP3
C. Phospholipase C
D. Arachidonic acid
E. Adenylyl cyclase

133. What symptoms can occur with rupture of this neoplasm?

A. Bacterial meningitis
B. Seizures
C. Superficial siderosis
D. Hearing loss
E. Aseptic meningitis

134. What is the most likely diagnosis in this 86-year-old patient with progressive cognitive decline over the last 3 to 5 years?
A. CJD
B. Pick's disease
C. Familial cavernomatosis
D. Amyloid angiopathy
E. Hereditary hemorrhagic telangiectasia

135. Which of the following antiepileptic drugs has the highest risk of Stevens-Johnson syndrome?
A. Levetiracetam
B. Valproic acid
C. Zonisamide
D. Phenytoin
E. Phenobarbital
136. Wave V of the brainstem auditory evoked response is associated with signals passing through what structure?
A. Cochlear nucleus
B. Trapezoid body
C. Superior olive
D. Inferior colliculus
E. Cranial nerve

137. What coagulation parameters would you expect in a patient with von Willebrand's disease?
A. Normal PT, normal aPTT, normal bleeding time
B. Normal PT, normal aPTT, prolonged bleeding time
C. Normal PT, prolonged aPTT, prolonged bleeding time
D. Prolonged PT, prolonged aPTT, prolonged bleeding time
E. Prolonged PT, normal aPTT, normal bleeding time

138. You are taking care of a patient with Cushing's disease who is now postoperative day 1 after resection of a functioning pituitary adenoma. The morning after surgery, she does not feel well, is nauseated, and nursing reports that her blood pressure is low. You suspect she had adequate resection of the mass, and is now experiencing adrenal insufficiency. What metabolic parameters might you see in this patient?
A. Hypokalemic metabolic acidosis
B. Hyperkalemic metabolic acidosis
C. Hypokalemic metabolic alkalosis
D. Hyperkalemic metabolic alkalosis

139. You are caring for a 26-year-old man who was thrown from his motorcycle at 30 mph without wearing a helmet while intoxicated. He was found to have a transverse fracture of the clivus. He is now postinjury day 7 and he is noted to have a persistent fever. His mental status has decreased, and you are concerned for the development of meningitis. What is the most common causative organism of meningitis in patients with skull base fractures?
A. *Neisseria meningitidis*
B. Group B streptococci
C. *Staphylococcus aureus*
D. *Streptococcus pneumoniae*
E. *Pseudomonas aeruginosa*

140. You have decided to administer a unit of PRBCs to a patient with a hemoglobin of 6.8 who is symptomatic after an extensive thoracolumbar spine fusion. She reports to you that she has had multiple febrile transfusion reactions in the past. What type of blood products should she receive?
A. Not safe to administer blood to this patient
B. Washed PRBCs
C. Irradiated/leukoreduced PRBCs
D. O-Negative Only
E. Whole Blood

141. You have just admitted a 52-year-old woman with the sudden onset of the worst headache of her life. Initial CT scan is demonstrated. You admit her to the neurological ICU for monitoring. You are called suddenly to the patient's bedside by nursing because the patient has suddenly become unresponsive. What is the next best step?
A. Intubate
B. Ventriculostomy
C. Emergent angiogram
D. Emergent surgical decompression
E. Opioid reversal
Questions

142. The administration of succinylcholine leads to what metabolic abnormality?
A. Metabolic acidosis
B. Hypokalemia
C. Hyperkalemia
D. Hyponatremia
E. Hypernatremia

143. A 32-year-old woman develops symptoms every time she turns her head more than 30 degrees to the right side. If her syndrome is caused by a lateral disk/osteophyte complex at C5–C6, what symptoms would you expect her to present with?
A. Paresthesias of the hand
B. Hand weakness
C. Hemifacial spasm
D. Syncope
E. Amaurosis fugax

144. Which of the following structures is supplied by the anterior choroidal artery?
A. Caudate
B. Ventral anterior nucleus of the thalamus
C. Putamen
D. Posterior limb of the internal capsule
E. Anterior limb of the internal capsule

145. This pathologic specimen is most consistent with what underlying process?
A. CMV infection
B. Glioblastoma
C. HIV infection
D. Rabies infection
E. Pleomorphic xanthoastrocytoma

146. These pathologic slides demonstrate what type of reaction?
A. Radiation reaction
B. Chemotherapy reaction
C. Local recurrence
D. Ischemia
E. Vasogenic edema

147. The subthalamic nucleus uses what type of neurotransmitter?
A. Dopamine
B. GABA
C. Glycine
D. Glutamate
E. Substance P

148. The vagus nerve passes through what structure?
A. Pars nervosa of the jugular bulb
B. Pars vascularis of the jugular bulb
C. Hypoglossal canal
D. Foramen magnum
E. Internal acoustic meatus
149. Axonal spheroids are seen in what pathological condition?
A. Glioblastoma
B. Metastatic intracranial tumor
C.Binswanger’s disease
D. Diffuse axonal injury
E. Cisplatin chemotherapy

150. This pathologic specimen demonstrates a finding that is seen in what underlying CNS process?

A. Fungal infection
B. Bacterial infection: early cerebritis
C. Bacterial infection: early capsule
D. Ischemia
E. Viral infection

151. The inset at the upper right of this pathologic slide demonstrates findings consistent with what intracranial process?

A. Nuclear atypia
B. Fungal infection
C. DNA virus infection
D. Diffuse axonal injury
E. Abscess formation

152. You are asked to evaluate the MRI scan in an 18-year-old man who is known to have a T-cell count of less than 200. What is the best treatment for this condition?

A. Steroids
B. Albendazole
C. Vancomycin/cefepime
D. Pyrimethamine
E. Methotrexate

153. This tumor was resected from a 24-year-old man with headaches. An interhemispheric approach to the lateral ventricle was utilized as an approach. What syndrome does this patient most likely have?

A. Neurofibromatosis type I
B. Neurofibromatosis type II
C. Sturge–Weber syndrome
D. Tuberous sclerosis
E. Tay–Sachs disease
154. 
What layer of the cerebral cortex is responsible for connecting the hemispheres across the corpus callosum?
A. I  
B. II  
C. III  
D. IV  
E. V

155. 
You are asked to evaluate a newborn who has a small patch of skin abnormality over its lower back. There also appears to be a small opening that tracts into the deep tissues. A picture is demonstrated. If this is found to be a dermal sinus tract, this abnormality developed due to what abnormal embryologic process?
A. Premature disjunction  
B. Nondisjunction  
C. Early gastrulation  
D. Defect in primary neurulation  
E. Defect in secondary neurulation

156. 
You are evaluating a 28-year-old female patient with the assistance of the endocrinology team. She has headaches and on imaging was found to have a pituitary tumor. Her prolactin level is 450. What is the best initial treatment for this patient?
A. Surgical resection  
B. Bromocriptine  
C. Radiation  
D. Observation  
E. Metyrapone

157. 
In neurosurgery clinic you are seeing a patient who had a shoulder dislocation approximately 2 months ago and has had shoulder weakness since that time. He can abduct the shoulder the first 15 degrees, but then bends at the waist in the opposite direction in an attempt to increase the shoulder abduction beyond the 15-degree mark. He is not able to simulate putting the phone up to his ear. You suspect an axillary nerve injury. If the patient has no evidence of reparation on EMG and you decide to offer a nerve transfer, what donor nerve should you use to recover deltoid function?
A. Suprascapular branches to supraspinatus  
B. Lateral cord fascicle  
C. Radial nerve branches to triceps  
D. Musculocutaneous branches to biceps  
E. Medial pectoral nerve

158. 
What nerve innervates the first dorsal interosseous muscle?
A. Superficial ulnar nerve  
B. Deep branch of the ulnar nerve  
C. Radial nerve  
D. Median nerve, recurrent motor branch  
E. Anterior interosseous nerve

159. 
Which of the following clinical findings is not consistent with cardiac tamponade?
A. Jugular venous distension  
B. Distant heart sounds  
C. Pulsus paradoxus  
D. Decreased cardiac output  
E. Pronounced apical impulse

160. 
You are evaluating a patient with severe spasticity that is significantly limiting her activities of daily life and causing pain. You elect to start a medication to reduce her symptoms of spasticity. Where does this medication work in the CNS?
A. GABA A receptor  
B. GABA B receptor  
C. Chloride channels  
D. Acetylcholine receptor  
E. NMDA receptor
161. Which anesthetic agent increases cerebral blood flow and cerebral metabolic rate?
A. Isoflurane  
B. Etomidate  
C. Phenobarbital  
D. Ketamine  
E. Remifentanil

162. Which of the following is a known side effect of carbamazepine?
A. Leukocytosis  
B. SIADH  
C. Peripheral neuropathy  
D. Hyperglycemia  
E. Weight gain

163. You are evaluating a patient in the emergency department who is an intrathecal pump in place for treatment of spasticity. She has pruritus, hyperthermia, and is diaphoretic. What is the most likely cause for her symptoms?
A. Catheter fracture  
B. Pocket fill  
C. Medication dosing too high  
D. Catheter infection  
E. Intracranial hemorrhage

164. You are asked to review the imaging findings in a newborn with elevated head circumference and neurologic deficits. What grade germinal matrix hemorrhage is evident on these images?

A. Grade I  
B. Grade II  
C. Grade III  
D. Grade IV  
E. Grade V

165. If the tumor demonstrated in this MRI is a functioning tumor, what is the most likely hormone being produced?

A. Prolactin  
B. ACTH  
C. LH/FSH  
D. GH  
E. ADH

166. You are asked to evaluate a 17-year-old adolescent boy with persistent, complex partial seizures with the imaging demonstrated. He has been treated with a combination of carbamazepine and valproic acid, but is developing side effects and seizure control on these medication is not adequate. What is the next best step to attempt Engel class I seizure control?

A. Add levetiracetam  
B. Lesionectomy  
C. Craniotomy with cortical grid placement and monitoring  
D. Radiation  
E. Chemotherapy
167. What is the biggest neurologic risk during placement of and utilization of a vagal nerve stimulator?
A. Bradycardia
B. Hoarseness
C. Dysphagia
D. Worsened seizures
E. Lower extremity weakness

168. Discogenic pain is transmitted via what nerve?
A. Segmental nerve
B. Sinuvertebral nerve
C. Radicular nerve
D. Parasympathetic chain
E. Intraosseous nerve

169. Which of the sphingolipidoses has supranuclear palsy as part of its presentation?
A. Fabry's disease
B. Gaucher's disease
C. Tay–Sach's disease
D. GM1 gangliosidoses
E. Niemann–Pick disease

170. The tumor demonstrated in this MRI scan would most likely stain positive for what agent?

A. Synaptophysin
B. Chromogranin A
C. GFAP
D. Cytokeratin
E. CD34

171. Which of the following muscles is not innervated by the facial nerve?
A. Stylohyoid
B. Stylopharyngeus
C. Orbicularis oculi
D. Anterior belly of the digastric
E. Posterior belly of the digastric

172. What type of tumor is demonstrated in this MRI?

A. Schwannoma
B. Paraganglioma
C. Meningioma
D. Hemangioma
E. Epidermoid

173. Ictal SPECT imaging demonstrates what in patients with medically refractory epilepsy?
A. Increased perfusion in epileptic focus
B. Decreased perfusion in epileptic focus
C. Increased metabolism in epileptic focus
D. Decreased metabolism in epileptic focus

A. Increased perfusion in epileptic focus
B. Decreased perfusion in epileptic focus
C. Increased metabolism in epileptic focus
D. Decreased metabolism in epileptic focus
174. You are evaluating a pediatric patient in the epilepsy monitoring unit. You observe the following pattern on EEG shown in Fig. 56. What is the best medical treatment of this condition?

A. Clonazepam
B. Valproic acid
C. Etomidate
D. ACTH
E. Levetiracetam

175. You are evaluating an overweight patient who works as a security guard. He wears a belt for work, and at the end of his shift he notices burning pain and paresthesias on the anterolateral aspect of his thigh. He has tried conservative management and has been referred to you for evaluation and management. You suspect meralgia paresthetica. What is best initial treatment in this patient?

A. Neurectomy
B. Inguinal ligament release
C. Weight loss/activity modification
D. Steroid injection
E. Nerve transfer

176. What nerve passes through the area directed by the white arrows?

A. Facial nerve
B. Glossopharyngeal nerve
C. Vagus nerve
D. Spinal accessory nerve
E. Hypoglossal nerve

177. What structure makes up the superior border of the anteromedial triangle of the skull base?

A. Oculomotor nerve
B. Trochlear nerve
C. Ophthalmic division of trigeminal nerve
D. Maxillary division of trigeminal nerve
E. Greater superficial petrosal nerve

178. BMP is contraindicated in patients with what condition?

A. Bacteremia
B. Soft-tissue sarcoma
C. Cervical kyphosis
D. Diabetes
E. Heart failure
179. What is used to treat polymorphic ventricular tachycardia?
A. Potassium
B. Magnesium
C. Defibrillation
D. Ventricular pacing
E. Diltiazem

180. What is the most sensitive method for detecting venous air embolism?
A. Precordial Doppler
B. Transesophageal echocardiogram
C. Chest X-ray
D. Pulmonary capillary wedge pressure
E. Decreased end-tidal CO₂

181. Which of the following anesthetic agents can be used to obtain an isoelectric EEG?
A. Ketamine
B. Isoflurane
C. Halothane
D. Remifentanil

182. A lesion compressing the cauda equina would lead to what type of bladder dysfunction?
A. Bladder hyperreflexia
B. Bladder atony
C. Spastic bladder
D. Inappropriate voiding

183. You are tasked with taking care of the patient pictured in this image post-op. Based on the deformity, what respiratory abnormality would you expect to exist in this patient?

A. Decreased compliance
B. Decreased resistance
C. Increased obstruction
D. Decreased obstruction
E. High tidal volumes

184. What is the currently accepted best deep brain stimulation target for patients with dystonia?
A. Subthalamn nucleus
B. VIM thalamus
C. VOA thalamus
D. Globus pallidus internal segment
E. Globus pallidus external segment
185. You are evaluating a 3-year-old patient who was found to have diplopia by a primary care physician. The MRI is demonstrated. What is the best treatment option?

A. Retrosigmoid craniotomy and debulking
B. Suboccipital craniotomy and debulking
C. Stereotactic needle biopsy
D. Observation
E. Retrosigmoid craniotomy and biopsy

186. You are on your neuroradiology rotation and evaluate this MRI in a patient with altered mental status. What toxic agent was this patient most likely taking prior to the onset of this condition?

A. Carbon monoxide
B. Arsenic
C. Mercury
D. Alcohol
E. Lead

187. The spinal injury demonstrated here most likely occurred via what force mechanism?

A. Flexion compression
B. Axial compression
C. Flexion rotation
D. Extension compression
E. Flexion extension

188. Which of the following ions does not pass through the NMDA channel?

A. Sodium
B. Potassium
C. Calcium
D. Chloride

189. What cytoarchitectural layer of the cerebral cortex are the striae of Gennari made up of?

A. Layer I
B. Layer II
C. Layer III
D. Layer IV
E. Layer V

190. What structure does not pass through the carpal tunnel?

A. Abductor pollicis longus tendon
B. Flexor digitorum superficialis
C. Flexor pollicis longus tendon
D. Median nerve
191. Which basal ganglia tract travels through the internal capsule?
A. Ansa lenticularis  
B. Lenticular fasciculus  
C. Thalamic fasciculus  
D. Pallidosubthalamic fibers

192. From what blood vessel does the substantia nigra pars compacta receive its blood supply?
A. ICA perforators  
B. Lateral lenticulostriates  
C. Anterior choroidal  
D. PCA perforators  
E. Basilar perforators

193. What should you expect to see upon surgical exploration of the patient demonstrated in the image?
A. Empyema  
B. Arachnoid cyst  
C. Dural laceration  
D. Necrotic brain  
E. Fungal infection

194. What is the most likely diagnosis in this patient?
A. Glioblastoma  
B. Lymphoma  
C. Marburg’s variant multiple sclerosis  
D. Bacterial abscess  
E. Dermoid cyst

195. What is the most likely offending vessel in this patient undergoing a percutaneous procedure for facial pain?
A. Posterior cerebral  
B. Superior cerebellar  
C. Anterior inferior cerebellar  
D. Posterior inferior cerebellar  
E. Basilar
196. You are caring for a patient in the epilepsy monitoring unit who has been admitted for seizure classification. During her classic seizure, her head turns to the right side, her right arm extends, and her left arm flexes and abducts. Where is the most likely cortical location for her seizure focus?
A. Orbitofrontal cortex  
B. Posterior frontal cortex  
C. Parietal cortex  
D. Occipital cortex  
E. Mesial temporal lobe

197. You are evaluating a patient with poorly controlled diabetes. What nerve of the lower extremity is most likely to be affected by an acute, painful mononeuropathy?
A. Sciatic  
B. Femoral  
C. Obturator  
D. Tibial  
E. Peroneal

198. Which of the following is a common diagnosis in patients with achondroplasia?
A. Foramen magnum stenosis  
B. Epidural lipomatosis  
C. Thoracolumbar kyphosis  
D. Sacral agenesis  
E. Ankylosing spondylitis

199. You are evaluating a 19-year-old overweight woman with chronic headaches. Her neurologist noted papilledema and appropriately ordered a lumbar puncture that demonstrated elevated opening pressures. You suspect idiopathic intracranial hypertension. If this condition in this patient is due to medication use, what condition might she be taking medication for?
A. Hypertension  
B. Depression  
C. Anxiety  
D. Acne vulgaris  
E. Trichomonas vaginitis

200. You are called emergently to the bedside of a patient in the neurosciences ICU who is postoperative day 1 from clipping of a complicated anterior communicating artery aneurysm. The nurse is very concerned because his heart rate is 158; he is diaphoretic and extremely altered. His systolic blood pressure is 96 mm Hg. The rhythm strip demonstrates a wide complex tachycardia. What is the next best step?
A. Epinephrine  
B. Norepinephrine  
C. Defibrillation  
D. Dopamine  
E. Procainamide

201. Which of the following anesthetic agents decrease endogenous release of ACTH?
A. Ketamine  
B. Isoflurane  
C. Halothane  
D. Etomidate  
E. Methohexital

202. What is the etiology of hydrocephalus on the patient demonstrated in these MR images?
A. Aqueductal stenosis  
B. Superficial siderosis  
C. Elevated protein  
D. Pineal region tumor  
E. Aneurysmal subarachnoid hemorrhage

203. How old should a pediatric patient be to adequately tolerate helmeting after repair of craniosynostosis?
A. 2 months  
B. 4 months  
C. 6 months  
D. 8 months  
E. 1 year
204. Which organism is the most common causative agent in infection of a ventriculoperitoneal shunt?
A. *Staphylococcus aureus*
B. *Streptococcus pneumoniae*
C. *Propionibacterium acnes*
D. *Staphylococcus epidermidis*
E. *Enterococcus*

205. Which nucleus is likely damaged in a patient with intention tremor?
A. Subthalamic nucleus
B. Nucleus ambiguous
C. Dentate nucleus
D. Basal nucleus of Meynert
E. Nucleus accumbens

206. What underlying spinal pathology this sagittal MRI and CT demonstrate?
![MRI images](image)
A. Ankylosing spondylitis
B. Diffuse idiopathic skeletal hyperostosis
C. Osteoporosis
D. Osteopetrosis
E. Vertebra plana

207. You are evaluating a patient with persistent epilepsy and the images demonstrated below. The seizure inducing pathology is most likely found in what region?
![MRI images](image)
A. CA1
B. CA2
C. CA3
D. Subiculum
E. Fornix

208. Due to failure of what embryological stage of development is the abnormality on imaging demonstrated here most likely?
![MRI image](image)
A. Primary neurulation
B. Disjunction
C. Secondary neurulation
D. Neuronal migration
E. Gastrulation
209. Sour taste is mediated by what chemical messaging system?
A. Potassium influx  
B. H+ ion influx  
C. cAMP  
D. Na+  

210. O-linked glycosylation of proteins occurs in what organelle?
A. Lysosome  
B. Endoplasmic reticulum  
C. Nucleus  
D. Microtubule  
E. Golgi’s apparatus  

211. In what embryologic region is the nucleus of the solitary tract located?
A. Basal plate  
B. Alar plate  
C. Telencephalon  
D. Diencephalon  
E. Metencephalon  

212. What structure connects the amygdala to the septal nuclei?
A. Stria medullaris  
B. Stria terminalis  
C. Ventral amygdalofugal pathway  
D. Medial forebrain bundle  
E. Uncinate fasciculus  

213. Which of the following muscles is innervated by branches of C6 through the radial nerve?
A. Biceps  
B. Brachialis  
C. Brachioradialis  
D. Triceps  
E. Flexor digitorum profundus  

214. You decide randomly that you are going to run a marathon in your local city. At 0.25 mi, you start sweating profusely. What neurotransmitter is responsible for sweating?
A. Norepinephrine  
B. Epinephrine  
C. Acetylcholine  
D. Glutamate  
E. GABA  

215. The tumor depicted in this pathological specimen arises from what?
A. Dura mater  
B. Pia mater  
C. Arachnoid cap cells  
D. Ependymal cells  
E. Schwann cells  

216. The following mass was resected from the middle temporal gyrus. What chromosomal abnormality might you see in this patient?
A. Chromosome 3  
B. Chromosome 6  
C. Chromosome 10  
D. Chromosome 12  
E. Chromosome 15
217. You are evaluating a patient with the lesion depicted in the attached image. She is complaining of significant night pain. What medication can be used to decrease these symptoms?

![Image](image.png)

A. Beta blocker  
B. Aspirin  
C. Gabapentin  
D. Acetaminophen  
E. Levetiracetam

218. What is the primary treatment method for patients with unilateral, severe headaches associated with tearing and flushing on one half of the face?

A. Metoprolol  
B. Aspirin  
C. Verapamil  
D. Valproic acid  
E. Gabapentin

219. Which of the following inherited conditions is associated with the development of cerebral abscesses?

A. Neurofibromatosis type I  
B. Neurofibromatosis type II  
C. Sturge-Weber syndrome  
D. Hereditary hemorrhagic telangiectasia  
E. Tay–Sach disease

220. You are operating on a likely vestibular schwannoma in a 56-year-old patient with a growing IAC mass and hearing loss. As you open the dura, you see a large mass in the CP angle. You begin to stimulate to identify the facial nerve. What are the most likely locations of the facial nerve displacement by tumor?

A. Superior then inferior  
B. Anterior then superior  
C. Posterior then inferior  
D. Posterior then superior  
E. Superior then anterior

221. You are evaluating a 34-year-old spine surgeon who is noticing cramping of his right hand that he has to “shake out.” The pain is worse overnight, and he has a positive Phalen’s test. What study helps make the diagnosis?

A. Increased motor latency (>3.5 ms) across the wrist  
B. Abductor pollicis longus weakness  
C. Hypothenar atrophy  
D. Increased sensory latency (>3.5 ms) across the wrist  
E. Adductor pollicis weakness

222. You are caring for an 18-year-old comatose patient who appears to have suffered diffuse axonal injury after being thrown from a vehicle during an accident. He has been on the ventilator for the last 5 days and you have been utilizing prophylactic antibiotics to prevent ventilator-associated pneumonia (VAP). What is the most common causative agent of VAP?

A. *Streptococcus agalactiae*  
B. *Enterococcus faecalis*  
C. *Pseudomonas aeruginosa*  
D. *Listeria monocytogenes*  
E. *E. coli*
223. Which of the following conditions is associated with the tumor demonstrated in the image?

A. Multiple endocrine neoplasia type I
B. Multiple endocrine neoplasia type IIA
C. Multiple endocrine neoplasia type IIB
D. Neurofibromatosis type I
E. Tuberous sclerosis

224. Which of the following medications has a significant inotropic effect?

A. Phenylephrine
B. Low-dose dopamine
C. Isoproterenol
D. Albuterol
E. Hydralazine

225. A neurosurgery resident is interested in evaluating the effectiveness of transverse sinus (TS) stenting for cases of idiopathic intracranial hypertension. He performs a literature review and analyzes multiple case series looking at the effectiveness of TS stenting for relief of symptoms and papilledema. He publishes a manuscript demonstrating a 95% rate of improvement in symptoms and an 88% rate of resolution of papilledema after transverse sinus stenting. What type of bias is affecting the results in his manuscript?

A. Publication bias
B. Selection bias
C. Lead-time bias
D. Detection bias
E. Attrition bias

226. You are asked to evaluate a 78-year-old woman who fell down a set of stairs at her home. She had the onset of severe back pain without neurological symptoms. Ultimately, an MRI was ordered and the findings are demonstrated. What does the MRI show?

A. Spinal cord epidural hematoma
B. Spinal cord subdural hematoma
C. Chance fracture
D. Posterior ligamentous disruption
E. Massive central disk herniation

227. What is the first intradural branch of the internal carotid artery?

A. Caroticotympanic artery
B. Meningohypophyseal trunk
C. Ophthalmic artery
D. Superior hypophyseal artery
E. Posterior communicating artery
I Questions

228. What is the most likely diagnosis for the abnormality demonstrated in these images?

A. Vestibular schwannoma
B. Ependymoma
C. Subependymoma
D. Meningioma
E. Epidermoid

229. What imaging characteristics is the lesion demonstrated in the pathology slide most likely to have?

A. Brightly enhancing ventricular mass
B. Poorly enhancing ventricular mass
C. T1-bright mass in the foramen of Monro
D. CP angle mass bright on diffusion weighted imaging (DWI)
E. Cystic mass at the gray–white matter junction

230. What cell provides the primary output of the cerebellar cortex?

A. Golgi’s cell
B. Basket cell
C. Stellate cell
D. Granule cell
E. Purkinje’s cell

231. What nerve is most at risk during the treatment of the pathology demonstrated in this angiogram?

A. Phrenic nerve
B. Axillary nerve
C. Hypoglossal nerve
D. Spinal accessory nerve
E. Vagus nerve

232. What structure connects the cochlear nucleus to the superior olive?

A. Trapezoid body
B. Juxtarestiform body
C. Restiform body
D. Brachium conjunctivum
E. Lateral lemniscus

233. The pulvinar receives sensory information and projects to what region of the brain?

A. Broca’s area 8
B. Broca’s area 1
C. Broca’s areas 5, 7
D. Broca’s areas 18, 19
E. Broca’s areas 41, 42

234. The dura mater forms from what embryologic layer?

A. Neural tube
B. Neural crest
C. Alar plate
D. Basal plate
E. Mesoderm
235. What is the main output pathway of the structure exposed in this temporal craniotomy for a patient with epilepsy?

A. Stria terminalis  
B. Fornix  
C. Stria medullaris  
D. Fasciculus retroflexus  
E. Arcuate fasciculus

236. What is a likely complication after rupture of the aneurysm depicted in the angiogram below?

A. Subarachnoid hemorrhage  
B. Hydrocephalus  
C. Intraparenchymal hematoma  
D. Chemosis  
E. Third nerve palsy

237. What metabolic derangement does hyperaldosteronism lead to?

A. Hyperkalemic metabolic acidosis  
B. Hypokalemic metabolic acidosis  
C. Hyperkalemic metabolic alkalosis  
D. Hypokalemic metabolic alkalosis  
E. None of the above

238. What ECG findings would you most expect to see in a patient with an acute pulmonary embolism?

A. Peaked T waves  
B. T-wave inversion  
C. Prolonged PR interval  
D. Diffuse ST changes  
E. Prolonged QRS interval

239. You are caring for a 36-year-old female smoker who developed a severe headache and has had some word-finding difficulties. On CT imaging, there are some hyperdensities in left posterior inferior occipital cortex associated with the transverse sinus and you see an empty delta sign. What is the best next treatment for this pathology?

A. Daily 81-mg aspirin dose  
B. Heparin anticoagulation  
C. Start warfarin  
D. TPA  
E. TXA

240. What is the most common causative organism in cases of intracerebral abscesses?

A. Microaerophilic streptococcus  
B. *Staphylococcus aureus*  
C. *Pseudomonas aeruginosa*  
D. *Listeria monocytogenes*  
E. *Enterococcus coli*

241. You are caring for a 23-year-old man who was thrown from a motorcycle while not wearing a helmet. He is now post-op day 3 after left-sided hemicraniectomy for an acute subdural hematoma. He has severe TBI and has remained intubated. The nurses are reporting color tinged sputum and he has a fever. Ultimately, he is diagnosed with pseudomonas VAP. What prophylactic measure has been shown to decrease rates of VAP?

A. Compression stockings  
B. Stress ulcer prophylaxis  
C. Chlorhexidine oral swabs  
D. Increased PEEP  
E. NG tube placement
The neurosurgical service pager that you are covering receives a call from a local nursing facility regarding an 86-year-old woman who was just discharged to their location. They report that she is starting to have rhythmic movements that are not consistent with seizures. She was discharged on multiple medications listed below. What medication that she is taking may be involved in her new onset movement disorder?

A. Oxycodone  
B. Famotidine  
C. Levetiracetam  
D. Metoclopramide  
E. Docusate sodium

The measurement “sagittal vertical axis less than 5 cm” is used in what type of neurosurgery?

A. Traumatic craniocervical junction surgery  
B. Ruptured aneurysm surgery  
C. Adult degenerative scoliosis surgery  
D. Insular glioma surgery  
E. Stereotactic radiosurgery

The findings on the demonstrated images are associated with what syndrome?

A. Trisomy 13  
B. Trisomy 18  
C. Trisomy 21  
D. Sturge–Weber syndrome  
E. Tuberous sclerosis

This MRI was obtained in a 23-year-old woman with a history of progressively worsening headaches and blurry vision. What is the most likely diagnosis?
246. Which of the following spectroscopy peaks would you expect to be elevated in this 36-year-old patient with a past medical history significant for regular IV drug use and new onset headache?

A. Myo-inositol
B. NAA
C. Choline
D. Creatine
E. Lactate

247. Which of the following has been found to be synthesized in the pineal gland?

A. Histamine
B. Epinephrine
C. Dopamine
D. Norepinephrine
E. Substance P

248. What examination finding is used to determine whether or not a patient has a deficit involving the L5 nerve root or the common peroneal nerve?

A. Foot eversion
B. Foot inversion
C. Foot dorsiflexion
D. Foot plantar flexion
E. Extensor hallucis longus extension

249. Korsakoff's psychosis involves destruction of what thalamic nucleus?

A. Lateral dorsal
B. Lateral posterior
C. Ventral lateral posterior
D. Lateral geniculate
E. Mediodorsal

250. Which of the following passes through the orbital ring?

A. Lacrimal nerve
B. Frontal nerve
C. Trochlear nerve
D. Superior ophthalmic vein
E. Nasociliary nerve

251. Disruption of what white matter tract leads to a conductive aphasia?

A. Uncinate fasciculus
B. Superior longitudinal fasciculus
C. Arcuate fasciculus
D. Stria terminalis
E. Stria medullaris

252. The dorsal spinocerebellar tract enters the cerebellum via what pathway?

A. Restiform body
B. Juxtarestiform body
C. Brachium conjunctivum
D. Brachium pontis
E. Fasciculus retroflexus

253. The paramedian pontine reticular formation is associated with what anatomic movement of the eye?

A. Elevation
B. Depression
C. Intorsion
D. Abduction
E. Adduction
Questions

254. The protein involved in this malformation discovered in the pyramidal neurons of the hippocampus has what function in normal, healthy neurons?

A. Condensing DNA  
B. N-linked glycosylation  
C. Stabilization of microtubules  
D. Synaptic vesicle fusion  
E. Protein breakdown

255. The toxic compound strychnine affects transmission of what?

A. Acetylcholine  
B. Dopamine  
C. Chloride  
D. Norepinephrine  
E. Sodium

256. This pathologic specimen was most likely biopsied from a patient with what neurocutaneous syndrome?

A. Sturge–Weber syndrome  
B. Tuberous sclerosis  
C. von Hippel–Lindau disease  
D. Neurofibromatosis type I  
E. Neurofibromatosis type II

257. What tumor type listed below is most likely to lead to leptomeningeal carcinomatosis?

A. Primary CNS lymphoma  
B. Gliosarcoma  
C. Metastatic prostate cancer  
D. Metastatic breast cancer  
E. Metastatic renal cell carcinoma

258. You are evaluating a patient who presented with persistent headache and had an MRI performed (demonstrated). What is the most likely diagnosis?

A. Glioblastoma  
B. Ependymoma  
C. Central neurocytoma  
D. Metastatic renal cell carcinoma  
E. Primary CNS lymphoma

259. You are monitoring a 34-year-old man with complex epilepsy after experiencing autoimmune encephalitis. If you were to perform an interictal PET study on this patient, what would you expect to see in the primary seizure focus?

A. Increased perfusion  
B. Decreased perfusion  
C. Increased metabolic activity  
D. Decreased metabolic activity
260. This pathologic specimen (H&E stain [left], NeuN stain [right]) was removed from a patient who likely presented with what symptoms?

A. Intracranial hemorrhage  
B. Gelastic seizures  
C. Hemiparesis  
D. Headache  
E. Anosmia

261. What toxic agent causes a Parkinsonism-like syndrome?

A. Mercury  
B. Arsenic  
C. Manganese  
D. Cyanide  
E. Carbon monoxide

262. You are operating on the tumor demonstrated in the associated image via a bifrontal craniotomy. As you work along the floor of the anterior fossa, you encounter brisk bleeding that appears to be coming from vessels that directly feed the tumor. What arteries are you likely dealing with?

A. Superior hypophyseal  
B. Ophthalmic arteries  
C. Ethmoidal arteries  
D. Posterior branch of the middle meningeal  
E. Anterior cerebral arteries

263. You are evaluating a patient with chemosis of the eye and the findings demonstrated on angiogram. She has continued to have symptoms despite 6 months of observation. What would be the best method to treat this abnormality?

A. Carotid sacrifice  
B. Direct bypass  
C. Endovascular transarterial coiling  
D. Endovascular transvenous coiling  
E. Surgical clipping

264. You have just resected a pituitary adenoma in a patient with acromegaly. In order to determine whether or not a cure has been achieved, what hormone should you check the morning following surgery?

A. Cortisol  
B. TSH  
C. GH  
D. IGF-1  
E. ACTH

265. You are scheduled to perform an elective ACDF in a 65-year-old man with C5–C6 cervical stenosis. During the preoperative evaluation, he reports that on his drive in to the hospital, he stopped at a fast food restaurant and had a sausage/egg bagel and coffee. He was really hungry and nervous about surgery. How long will you have to wait before anesthesia can be safely initiated?

A. 2 to 4 hours  
B. 4 to 6 hours  
C. 6 to 8 hours  
D. 8 to 10 hours  
E. 10 to 12 hours
Questions

266.
You are operating on the following pathology via an endoscopic approach. The surgery is uncomplicated and the patient is recovering well. You are called by the PACU nurse saying the patient is becoming tachypneic and feeling chest pain. A chest X-ray demonstrates shift of the trachea to the left of midline. What is the best method to treat the complication being experienced by the patient?

A. Needle decompression
B. Oxygen administration
C. Obtain troponin levels
D. Administer Ativan
E. Elevate blood pressure

267.
What is the best initial treatment for a patient with traumatic brain injury that is becoming hypotensive and you suspect the development of septic shock?

A. Hetastarch
B. Colloid
C. Crystalloid
D. Hypertonic saline
E. Metoprolol

268.
Which of the following antiretroviral agents has the highest incidence of myopathy?

A. Darunavir
B. Zidovudine
C. Etravirine
D. Tenofovir
E. Efavirenz

269.
Which of the following statistical terms is dependent on disease prevalence for its determination?

A. Sensitivity
B. Specificity
C. Number needed to treat
D. Positive predictive value
E. Power

270.
The abnormality demonstrated on the following angiogram is associated with what other finding?

A. Meningioma
B. Glioblastoma
C. Aneurysm
D. Cavernous malformation
E. Dural fistula
271. The following angiograms demonstrate all aspects of the Suzuki staging of a particular disease process causing progressive intracranial carotid artery stenosis. Of the following indirect bypass techniques, what is a disadvantage of the encephalomyosynangiosis technique?

A. Seizures  
B. Decreased rate of collateralization  
C. Mass effect  
D. CSF leak  
E. Higher risk of infection

272. Stage I sleep represents a shift between what type of EEG patterns?

A. Alpha to theta  
B. Beta to theta  
C. Beta to alpha  
D. Alpha to delta  
E. Delta to beta

273. Which of the following antiepileptic medications would be a good option in a patient that is currently admitted on the transplant service with an elevated MELD score?

A. Valproic acid  
B. Levetiracetam  
C. Phenytoin  
D. Gabapentin  
E. Lamotrigine

274. You are evaluating a patient who had previously undergone spinal fusion and comes back with new back pain. The X-rays are demonstrated below. You remember that implant failure rate is based on structural factors including the Young’s modulus of the material itself. Which of the following implants has the highest Young’s modulus?

A. Stainless steel  
B. Titanium  
C. Cobalt chromium  
D. PEEK

275. You are taking care of a 22-year-old woman who was involved in a motor vehicle accident and has severe traumatic brain injury. You have a subarachnoid bolt in place, which is reading elevated ICPs despite maximum medical management and you have been asked to consider decompressive hemicraniectomy. Based on the results of the DECRA trial, how should you counsel the family?

A. Surgery will improve ICP and outcome  
B. Surgery will improve ICP but worsen outcome  
C. Surgery will worsen ICP but improve outcome  
D. Surgery will worsen ICP and outcome
276. You are evaluating a patient who experienced a severe headache and the local emergency department obtained an MRI scan demonstrating a right posterior communicating artery aneurysm. You are trying to determine if the aneurysm ruptured. What MRI sequence can help you?
A. T1 weighted
B. T2 weighted
C. GRE
D. Diffusion
E. Gadolinium-enhanced T1 weighted

277. During a skull base approach, drilling in what region can give you better exposure of the pons?
A. Oculomotor triangle
B. Infratrochlear triangle
C. Anterolateral triangle
D. Glasscock's triangle
E. Kawase's triangle

278. You are evaluating a 67-year-old man with a history of lung adenocarcinoma and the new findings demonstrated in the MRI scans. Addition of whole brain radiation to surgical resection will lead to what outcome in this case?
A. Improved local and distant control
B. Improved local but no change in distant control
C. Improved distant control but no change in local control
D. No change in local or distant control

279. What donor nerve is commonly used to reinnervate the brachialis muscle and help reanimate flexion at the elbow?
A. Musculocutaneous nerve
B. Ulnar nerve
C. Axillary nerve
D. Medial antebrachial cutaneous nerve
E. Radial nerve

280. What finding on radiographic evaluation would be considered a contraindication to performance of a cervical laminoplasty?
A. Cervical lordosis
B. Facet fracture
C. Cervical kyphosis
D. Diffuse idiopathic skeletal hyperostosis
E. Multilevel cervical stenosis
281. The tumor depicted in these images is most likely fed by branches of what artery?

A. Inferolateral trunk
B. Caroticotympanic artery
C. Meningohypophyseal trunk
D. Posterior meningeal artery
E. Posterior branch of the middle meningeal artery

282. What brainstem nucleus mediates the jaw-jerk reflex?

A. Mesencephalic nucleus
B. Spinothalamic nucleus
C. Principal sensory nucleus
D. Gasserian ganglion
E. Nucleus of the solitary tract

283. Isthmic spondylolisthesis refers to a defect in what aspect of spinal anatomy?

A. Superior articulating process
B. Lamina
C. Inferior articulating process
D. Pars
E. Spinous process

284. The thoracodorsal nerve arises from what region of the brachial plexus?

A. Upper trunk
B. Posterior cord
C. Lateral cord
D. Medial cord
E. Middle trunk

285. The blood–brain barrier is made up of what structures?

A. Astrocytic foot process
B. Endothelial tight junctions
C. Ependymal gap junctions
D. Glial membrane
E. Arachnoid villae

286. What is the only excitatory cell of the cerebellum?

A. Purkinje’s cell
B. Granule cell
C. Golgi’s cell
D. Basket cell
E. Stellate cell

287. What is the neurotransmitter associated with sympathetic postganglionic fibers?

A. Dopamine
B. Acetylcholine
C. Norepinephrine
D. GABA
E. Glycine

288. You are evaluating a 42-year-old man who was involved in a motorcycle accident at highway speeds and was not wearing a helmet. His admission CT scan does not demonstrate any intracranial hemorrhages or fractures of the skull, but he is still comatose on postinjury day 3. If you were to obtain an MRI scan, where might you expect to see microhemorrhages in this patient?

A. Cortical surface
B. Corpus callosum
C. Basal ganglia
D. Hippocampus
E. Cerebellum
I Questions

289. With what symptoms does the patient with the following findings on lateral skull X-ray most likely present?

A. Headache  
B. Multiple cranial neuropathies  
C. Seizures  
D. Metastatic lesions  
E. Intracranial hemorrhage

290. Which of the following describes the bovine aortic arch?

A. Left common carotid from brachiocephalic trunk  
B. Left common carotid from aortic arch  
C. Right common carotid from brachiocephalic trunk  
D. Left subclavian from brachiocephalic trunk  
E. Right subclavian from aortic arch

291. The aneurysm depicted in the images most likely formed due to what etiology?

A. Dissection  
B. Infection  
C. Herniation  
D. Degenerative  
E. Increased shear stress

292. The abnormality depicted in the pathology slide is made of what protein?

A. Actin-associated protein  
B. AB amyloid  
C. Tau protein  
D. Alpha synuclein  
E. Microtubules
293. The following image was obtained during a standard prenatal workup. What finding would you expect to see on further testing?

A. Split cord malformation  
B. Elevated maternal serum alpha fetoprotein  
C. Trisomy 21  
D. Sacral agenesis  
E. Dextrocardia

294. Which of the following syndromes most often presents with seizures?

A. Tuberous sclerosis  
B. Neurofibromatosis type I  
C. Tay–Sachs disease  
D. Nieman–Pick disease  
E. Neurofibromatosis type II

295. What is an ideal treatment for a patient with medically refractory unilateral epilepsy after recovering from Rasmussen's encephalitis and hemiplegia?

A. Multiple subpial transections  
B. Vagal nerve stimulator  
C. Functional hemispherectomy  
D. Further AED management  
E. Motor cortex stimulator

296. Which of the following can help distinguish multiple sclerosis from spinal cord astrocytoma?

A. Myelopathy  
B. Polyphasic symptoms  
C. Contrast enhancement  
D. Spinal cord enlargement  
E. Monophasic symptoms

297. You are taking care of a 62-year-old man who reports fullness in the right ear for several months. He occasionally experiences a low, hissing sound in the ear that sounds like escaping steam. What is the most likely diagnosis?

A. Benign paroxysmal positional vertigo  
B. Meniere's disease  
C. Vestibular schwannoma  
D. Hearing loss  
E. Vestibular neuritis

298. You are performing a carotid endarterectomy and have applied the cross clamp to the common carotid, and you have control of the distal ECA and ICA, which also have been clamped. You perform your arterectomy and you encounter brisk, pulsatile bleeding. What is the most likely cause of the bleeding you are dealing with?

A. Internal jugular vein injury  
B. Inadequate common carotid clamp  
C. Back-wall ascending pharyngeal artery  
D. Superior thyroid artery avulsion

299. You have been consulted by the orthopedic team on a 78-year-old woman who just had a hip replacement and was started on unfractionated heparin for a DVT/PE in the postoperative period. She received 1,400 units of unfractionated heparin and became sleepy. Imaging demonstrates a right frontal intraparenchymal hematoma. What dose of protamine should be given for reversal?

A. 1.4 mg  
B. 14 mg  
C. 140 mg  
D. 1,400 mg  
E. 1,400 μg

300. Which of the following diseases has a higher propensity for the development of malignant hyperthermia with inhalational anesthetics?

A. Neuroleptic malignant syndrome  
B. Serotonin syndrome  
C. Central core disease  
D. Duchenne's muscular dystrophy  
E. Tuberous sclerosis
I Questions

301. You are in the ICU caring for a patient who is postoperative day 1 from a large T2–pelvis fusion procedure. You have elected to administer blood for hemoglobin of 6.7. About 5 minutes into the transfusion, the patient has the sudden onset of back pain and an impending sense of doom. You suspect a transfusion reaction. This type of transfusion reaction is most likely due to what?
A. Allergic reaction
B. ABO incompatibility
C. Reaction to donor leukocytes
D. Sepsis
E. Febrile hemolytic reaction

302. Which of the following agents inhibits the degradation of warfarin?
A. Phenobarbital
B. Rifampin
C. Phenytoin
D. HCTZ
E. Cimetidine

303. You are caring for a patient that has evidence of PML and has been admitted for monitoring and treatment to the neurosciences ICU. This patient is most likely to have a coinfection with what?
A. HBV
B. Influenza
C. RSV
D. St. Louis encephalitis
E. Herpes simplex I

304. What factor listed below can be determined from a cross-sectional study design?
A. Prevalence
B. Incidence
C. Number needed to treat
D. Number needed to harm
E. Sensitivity

305. Pregnancy is most likely to affect the symptoms in a patient with what tumor type?
A. Glioblastoma
B. Ependymoma
C. Meningioma
D. Lung metastases
E. Melanoma

306. The patient with the associated imaging presents with myelopathy that is progressive including significant weakness. What is the best likely approach to management?
A. Multilevel anterior disectomy and fusion
B. Posterior laminectomy and fusion
C. Epidural steroids
D. EMG
E. Physical therapy
307. A 58-year-old woman presents to your office with the following X-ray. She reports severe lower back and leg pain that is worsened by walking and improved by sitting down and/or leaning forward. MRI of the region demonstrates multilevel stenosis of the lumbar spine. What is an appropriate next step for evaluation of this patient?

A. Lumbar laminectomy  
B. Obtain 36-in standing scoliosis films  
C. Lumbar ultrasound  
D. Cervical MRI  
E. Flexion–extension X-rays

308. What is appropriate management in an 89-year-old man with congestive heart failure and a history of multiple myocardial infarctions who fell down at his nursing home and presented with this X-ray?

A. Odontoid screw  
B. Posterior atlantoaxial fusion  
C. Posterior atlanto-occipital fusion  
D. Cervical collar  
E. No treatment

309. What is a commonly used pathological stain to identify central neurocytoma?

A. GFAP  
B. Synaptophysin  
C. EMA  
D. Cytokeratin  
E. CD34

310. The subthalamic nucleus has glutamatergic projections to what other nucleus of the basal ganglia?

A. Globus pallidus externa  
B. Globus pallidus interna  
C. Putamen  
D. Thalamic fasciculus  
E. Caudate
1. You are evaluating a 67-year-old woman with an intrathecal pain pump for chronic, cancer-related pain. She had a refill of her system 4 days ago. She is in the emergency department with altered mental status, shallow breathing, and pinpoint pupils. What might help you identify the cause for her condition?
   A. X-ray of pump system
   B. Ultrasound of pump pocket
   C. MRI of lumbar spine
   D. Interrogate pump system
   E. Pump explantation

2. You are caring for a 72-year-old man who is post-op day 1 from a large thoracolumbar deformity correction. The nurse calls you and reports that he is nauseated and she noticed some bright red blood in his vomitus, but he has only vomited twice. What is the likely source of this bright red blood?
   A. Mallory–Weiss tear
   B. Duodenal ulcer
   C. Gastric ulcer
   D. Endotracheal tube trauma

3. You are asked to evaluate a 75-year-old man who was involved in a motor vehicle accident. He is a C6 American Spinal Injury Association (ASIA) A on your examination. What is the best long-term management of this patient?
   A. Fusion
   B. Cervical collar
   C. Halo
   D. Conservative management
   E. Steroids

4. You are evaluating a 9-year-old boy who presented with headaches and has the following MRI findings. What would you recommend as initial treatment in this patient?
   ![MRI images]
   A. Supracerebellar, infratentorial resection
   B. Endoscopic third ventriculostomy
   C. Endoscopic third ventriculostomy and biopsy
   D. Shunt implantation
   E. Chemotherapy

5. You are performing an oblique lateral, prepsos approach to fuse intervertebral disk pathology at the L3–L4 interspace. You are approaching from the left side. What structure lies just medial to the psoas muscle during this approach?
   A. Vena cava
   B. Aorta
   C. Ureter
   D. Femoral nerve
   E. Sympathetic chain
316. You are evaluating a 13-year-old adolescent girl with medically refractory epilepsy that appears to be originating from a nonresectable focus. You offer a left-sided vagal nerve stimulator (VNS). Her mother asks you what chance of success there is with VNS. What do you tell her?
A. 50% chance of seizure freedom
B. 100% chance of seizure freedom
C. 50% chance of 50% reduction in frequency
D. 100% chance of 50% reduction in frequency
E. 30% chance of 50% reduction in frequency

317. Which of the following factors is most important when evaluating potential for ambulation in a patient with myelomeningocele?
A. Involved level
B. Motor examination
C. Hydrocephalus
D. Infection
E. Gender

318. How is pelvic incidence calculated?
A. Distance between C7 plumb line and posterior superior corner of sacrum
B. Angle between line drawn from sacral midpoint to femoral head and vertical line
C. Angle between line drawn from sacral midpoint to femoral head and line perpendicular to sacral endplate
D. Cobb's angle between L1 and L5 endplates

319. You are evaluating an 86-year-old patient who has right-sided nystagmus causing dizziness. You believe that this nystagmus is peripheral in origin. What examination finding helps determine that this pathology is lateral and not central.
A. Extinction with visual fixation
B. Lack of torsional component to nystagmus
C. Skew deviation
D. Direction of nystagmus changes with gaze

320. You are asked to evaluate a 32-year-old construction worker who has weakness of the right arm. He reports that about 1 week ago, after a long day of work, he noticed extreme pain in the right shoulder but did not notice any weakness at that time. He took Tylenol and ibuprofen and the pain resolved after 2 days. Starting yesterday, he noticed right shoulder weakness; he is not able to put his cell phone up to his ear on the right side. He also seems to have some mild elbow flexion weakness. What is the most likely etiology?
A. Shoulder trauma
B. Cervical disk herniation
C. Brachial neuritis
D. Amyotrophic lateral sclerosis
E. Thoracic outlet syndrome

321. Which of the following embryological events occurs first?
A. Neural tube edges meet
B. Anterior neuropore closes
C. Posterior neuropore closes
D. Disjunction occurs
E. Notochord develops

322. You are performing deep brain stimulation of the subthalamic nucleus in a patient with Parkinsonism. The lead has been placed and you are performing test stimulation. When you turn on the current, the patient experiences facial pulling. The lead is placed too far in what direction?
A. Anterior
B. Posterior
C. Medial
D. Superior
E. Inferior
323. The structure labeled “1” in this image gives off fibers that innervate what gland?

A. Submandibular gland  
B. Lacrimal gland  
C. Parotid gland  
D. Sublingual gland

324. The artery of Adamkiewicz is most likely to be found in what region?

A. Left T5–T8  
B. Right T5–T8  
C. Left T9–T12  
D. Right T9–T12  
E. Left L1–L4

325. What type of nerve mediates the afferent arm of the myotatic reflex?

A. Alpha motor nerve  
B. Type Ia sensory nerve  
C. Type Ib sensory nerve  
D. Type II sensory nerve  
E. Gamma motor nerve

326. Which of the following is most likely to be uniquely found in a glioblastoma that transformed from what was initially a low-grade glioma?

A. EGFR amplification  
B. PTEN mutation  
C. p53 mutation  
D. IDH wild type

327. This MRI was obtained in a 34-year-old man with progressive decline in cognition and intellectual ability. He has been having hallucinations and evidence of early dementia. What is the most likely diagnosis?

A. Alexander’s disease  
B. Multiple sclerosis  
C. Progressive multifocal leukoencephalopathy  
D. Metachromatic leukodystrophy  
E. Acute disseminated encephalomyelitis

328. The following pathological specimen was obtained during autopsy. What is the most likely cause of death?

A. Progression of systemic cancer burden  
B. Artery to artery embolism  
C. Trauma  
D. Advanced dementia  
E. Toxic exposure
18 Stand-Alone 375-Question Examination

329. What is the most likely diagnosis in this 7-week-old newborn with a skull mass?

A. Eosinophilic granuloma
B. Skull epidermoid
C. Calcified cephalohematoma
D. Osteochondroma
E. Growing skull fracture

330. PET scanning is based on detection of subatomic particles that are produced after annihilation of a positron used during the imaging session. What particle is released during annihilation of the positron that allows for this imaging modality?

A. Electron
B. Proton
C. Neutron
D. Photon
E. Quark

331. What type of pathological structure is seen in anterior horn cells of patients with amyotrophic lateral sclerosis?

A. Negri's bodies
B. Bunina's bodies
C. Lafora's bodies
D. Lewy's bodies
E. Hirano's bodies

332. You are performing deep brain stimulation electrode implantation in a patient with essential tremor. You are targeting the ventral intermediate (VIM) nucleus of the thalamus. During test stimulation, the patient notices ipsilateral paresthesias that are persistent and do not improve with time. The lead should be moved in what direction?

A. Anterior
B. Posterior
C. Superior
D. Medial
E. Lateral

333. If the underlying tumor depicted in this pathological specimen is of the primary variety rather than secondary, what mutation status would you expect?

A. IDH wild type
B. IDH mutant
C. p53 mutant
D. Loss of heterozygosity on chromosome 10
I Questions

334. What is the pathological abnormality depicted in this slide composed of?

A. Ubiquitin
B. Amyloid
C. Alpha synuclein
D. Tau protein

335. Which of the following patients would be best suited for a vagal nerve stimulator?

A. 42M with complex partial epilepsy who has failed two AEDs
B. 58F with drop attacks refractory to three AEDs
C. 22M with generalized seizures originating in an unresectable location
D. 38F with absence seizures

336. You are caring for a 35-year-old man who is currently in the neurosciences intensive care unit (ICU) after developing a symmetric ascending weakness syndrome with preserved sensation. He initially had symptoms of an upper respiratory tract infection 2 weeks ago and has been noticing weakness in his legs that has worsened over time. He is in the ICU for monitoring and possible mechanical ventilation. What is the best treatment if his condition continues to worsen?

A. Interferon
B. IVIG
C. Methylprednisolone
D. Antiretrovirals
E. Dexamethasone

337. You are asked to consult on an 8-month-old infant’s MRI that shows expansion of the subarachnoid space. What outcome would observation in this patient most likely lead to?

A. Shunt-dependent hydrocephalus
B. Idiopathic intracranial hypertension
C. Normal pressure hydrocephalus
D. Mild macrocephaly, normal development
E. Mild macrocephaly, depressed IQ

338. You successfully resect a posterior fossa mass in a 16-year-old adolescent girl that was cystic with a mural nodule. Final pathology comes back consistent with hemangioblastoma. What should be your next step in management?

A. Craniospinal radiation
B. Eye, kidney, pancreas screen, and genetics consult
C. Temozolomide chemotherapy
D. Full neuraxis MRI
E. Observation

339. You are taking a neonate to the operating room to repair a myelomeningocele 48 hours after birth. During the procedure, you are meticulously dissecting the placode away from the associated skin. You take care during this portion of the procedure since failure to fully separate the skin from the placode in the correct plane may result in what development?

A. Higher risk of infection
B. Worsened hydrocephalus
C. Higher risk of spinal cord tethering
D. More difficult watertight closure
E. Inclusion dermoid
340. You are performing a Chiari decompression in the sitting position, and while you are performing your craniectomy, the anesthesiologist reports that the precordial Doppler is suggesting the presence of air embolism. You irrigate the wound with saline and use bone wax on the edges of the craniectomy, but the air persists. What should be your next step?
A. Left Trendelenburg positioning
B. Right Trendelenburg positioning
C. Open the dura
D. Quickly finish the case
E. Close the wound and abort the procedure

341. You are caring for a 54-year-old woman who has a World Federation of Neurological Surgeons (WFNS) grade III SAH from the aneurysm demonstrated. On postbleed day 2, she develops severe pulmonary edema and reports chest pain. Labs demonstrate elevated troponins. What is the best next step in management?
A. Immediate cardiac catheterization
B. Echocardiogram
C. Beta blocker administration
D. TPA administration
E. Heparinization

342. Which of the following ventilator settings demonstrate a patient most suitable to be weaned from the ventilator?
A. FiO$_2$ 70%, PEEP 10, negative inspiratory force (NIF) –12 cm H$_2$O
B. FiO$_2$ 40%, PEEP 10, NIF –18 cm H$_2$O
C. FiO$_2$ 20%, PEEP 5, NIF –20 cm H$_2$O
D. FiO$_2$ 30%, PEEP 5, NIF –26 cm H$_2$O
E. FiO$_2$ 60%, PEEP 5, NIF –28 cm H$_2$O

343. You are caring for a patient with severe brain trauma who has been intubated and sedated. Currently, you have chosen 14 breaths per minute (BPM). The patient attempts to trigger the ventilator at 19 BPM and appears uncomfortable. What should you do?
A. Paralyze the patient
B. Increase the PEEP to 10
C. Increase the ventilator rate to 19
D. Increase the FiO$_2$
E. Decrease the tidal volume

344. What technique would be useful during microsurgical clipping of an ophthalmic artery aneurysm?
A. Intradural posterior clinoidectomy
B. Frontal sinus cranialization
C. Anterior clinoidectomy
D. Cisterna magna decompression
E. Frontotemporal orbitozygomatic approach

345. According to a recently published randomized trial (A Randomized trial of Unruptured Brain Arteriovenous malformations), how is a young patient with a grade I, frontopolar AVM best managed?
A. Observation
B. Embolization
C. SRS
D. Surgical resection
346. Based on large studies, what is the approximate chance of a patient experiencing a shunt failure requiring revision within 1 year of receiving a ventriculoperitoneal shunt?

A. 10%
B. 30%
C. 50%
D. 70%
E. 90%

347. You have been asked to see a patient who suffered a gunshot wound to the forearm (pictured) and has evidence of a complete transection of the radial and ulnar nerves on examination. If you were to perform EMG distal to the injury on postinjury day 1, what would you expect to see?

A. Normal MUAPS
B. Fibrillations
C. Normal distal conduction
D. Insertional sharp waves

348. You are seeing a 4-year-old boy with a skull mass that is demonstrated in the X-ray. What do you think is the most likely diagnosis?

A. Epidermoid
B. Dermoid
C. Eosinophilic granuloma
D. Osteosarcoma
E. Meningioma

349. You are walking on the treadmill as you are reading your ABNS preparation review book. You start to sweat. What neurotransmitter is responsible for the production of sweat?

A. Acetylcholine
B. Dopamine
C. Norepinephrine
D. Glutamate
E. Nitric oxide

350. The sulcus limitans defines borders between what structures?

A. Layers of trilaminar disk
B. Basal plate and alar plate
C. Anterior and posterior neuropores
D. Neural crest from neural tube
E. Neuroectoderm from skin ectoderm

351. Which of the following is not required for transfer of a patient under the emergency medical treatment and labor act?

A. Transferring hospital has provided maximum care
B. Insurance covers receiving hospital
C. Benefits of transfer outweigh risks
D. Accepting hospital agrees to accept patient
E. Transfer occurs with qualified personnel and equipment

352. You are a physician/researcher and you have completed an industry-funded trial regarding complication rates after the use of BMP during cervical spine surgery. You received remuneration from industry for completion of the trial. You have been asked to partake in formulating a consensus statement on cervical spine fusion techniques by the national organization. What should you do?

A. Nothing. Help formulate the statement
B. Disclose your financial agreement and participate
C. Recuse yourself from the discussion
D. Send another researcher without a financial agreement
353. You are caring for an intubated patient in the neurosciences intensive care unit. The patient is requiring high levels of FiO₂ and elevated ventilator settings. You have determined that the pulmonary capillary wedge pressure is 22 mm Hg. What is the most likely underlying diagnosis?
A. ARDS
B. Cardiogenic pulmonary edema
C. Tension pneumothorax
D. Bronchospasm
E. COPD

354. Which of the following have been shown to be effects of STN deep brain stimulation for Parkinsonism?
A. Decrease “on” time
B. Decrease “off” time
C. Increase “off” time
D. No change in medication dosing
E. Elimination of symptoms

355. What structure is labeled “6” in the corresponding image of the third ventricular floor?
A. Mammillary bodies
B. Lamina terminalis
C. Anterior commissure
D. Optic chiasm
E. Tuber cinereum

356. What is the relationship of the cochlea to the facial nerve?
A. Anterior
B. Posterior
C. Medial
D. Lateral
E. Superior
I Questions

357. Which of the following helps differentiate between amyotrophic lateral sclerosis and cervical spondylotic myelopathy?
A. Positive Hoffman's sign
B. Hand weakness
C. Tongue fasciculations
D. Thenar fasciculations
E. Lower extremity weakness

358. You are seeing a 14-year-old adolescent boy back in follow-up after completing a direct STA–MCA bypass approximately 3 months ago for moyamoya disease. Imaging demonstrates that the graft is open and he has recovered from surgery well. What do you recommend for follow-up?
A. Observation
B. MRI/MRA if ischemic symptoms develop
C. MRI/MRA yearly for 5 years
D. Graft Doppler every 6 months
E. SPECT study now and in 1 year

359. The following angiogram was obtained in a 28-year-old woman with progressive myelopathy. If this is a type 1, where is the location of the abnormal connection?

![Angiogram Image]
A. Nerve root sleeve
B. Pial surface
C. Ventral dura
D. Central canal
E. Intraparenchymal

360. What cell type would you expect to see in an active multiple sclerosis plaque?
A. B lymphocyte
B. T lymphocyte
C. Red blood cell
D. Neutrophil
E. Plasma cell

361. You are asked to evaluate a 13-year-old adolescent girl who initially fell and had back pain. An X-ray demonstrated an abnormality that was further evaluated on MRI (shown). What is the best initial course of management for this lesion?

![MRI Image]
A. Observation
B. Embolization
C. Radiation
D. Surgical resection
E. PET scan

362. Which of the following disorders demonstrates T-cell infiltration into individual muscle fibers on pathology?
A. Viral myositis
B. Bacterial myositis
C. Trichinosis myositis
D. Dermatomyositis
E. Polymyositis
363. Via what mechanism does glucose enter the brain?
A. Diffusion
B. Active transport
C. Facilitated diffusion
D. Osmosis
E. Voltage-gated transport

364. The following MRI was obtained in a 42-year-old woman after she was involved in a motor vehicle accident at highway speeds. What does this MRI demonstrate?
A. Compression fracture
B. Jumped facets
C. Posterior ligamentous complex disruption
D. Spinal cord compression
E. Spinal vascular malformation

365. A patient who has experienced an ASIA B spinal cord injury is most likely to have what neurologic dysfunction?
A. Preserved sensation
B. Preserved motor strength
C. Detrusor hyperreflexia
D. Detrusor areflexia
E. Normal voiding

366. This image is taken from a muscle biopsy in a normal gastrocnemius muscle. The muscle specimen has been stained with ATPase. The region labeled “S” is positive. What muscle type does “S” represent?
A. Type I
B. Type IIa
C. Type IIb
D. Type III
E. Type IV

367. An MRI and CT were obtained in a 67-year-old patient with hypertension as a follow-up after being hospitalized for an intraparenchymal hemorrhage resulting in minor visual field cut. Based on the imaging, what is the approximate stage of this hematoma?
A. Hyperacute
B. Acute
C. Early subacute
D. Late subacute
E. Chronic
Questions

368. The pterion is the junction of what bones of the skull?
A. Frontal, parietal, temporal, and lesser sphenoid wing
B. Frontal, occipital, parietal, and greater sphenoid wing
C. Frontal, parietal, temporal, and greater sphenoid wing
D. Parietal, temporal, occipital, and greater sphenoid wing
E. Frontal, temporal, parietal, and occipital

369. You are evaluating a 60-year-old woman who had blurry vision and underwent an MRI that is demonstrated. The vision abnormality has resolved and she is at her baseline. What is the best initial management of this patient?
A. Observation
B. Fractionated radiation
C. Stereotactic radiation
D. Surgical resection
E. Antihypertensive treatment

370. What is the most important factor in achieving a good outcome after spinal fusion for spondylolisthesis?
A. Optimal pedicle screw placement
B. Adequate bony fusion
C. Wide decompression
D. Indirect foraminal decompression
E. Reduction of spondylolisthesis

371. You are performing an endoscopic third ventriculostomy on a patient with obstructive hydrocephalus. You have entered the lateral ventricle and your scope is focused on the foramen of Monro. What structure is just anterior to the foramen of Monro?
A. Caudate
B. Thalamus
C. Thalamostriate vein
D. Forniceal column
E. Choroid plexus

372. Decompression of a patient with malignant epidural spinal cord compression at one level caused by a radioresistant tumor will lead to what postoperative outcome?
A. No prolongation of life expectancy
B. Two-week prolongation of life expectancy
C. Four-week prolongation of life expectancy
D. Two-month prolongation of life expectancy
E. Six-month prolongation of life expectancy

373. You are evaluating a 63-year-old man with COPD and medication controlled heart failure who is found to have a 1.2-cm intracanalicular acoustic neuroma on the left side that has demonstrated interval growth. He has a 30% reduction in hearing on the left compared to the right. Facial nerve function is HB grade I. What do you recommend for a next step in management?
A. Observation
B. Stereotactic radiosurgery
C. Translabyrinthine surgical debulking
D. Retrosigmoid surgical resection
E. Chemotherapy
374. You are caring for a patient in the intensive care unit who is receiving the massive transfusion protocol for abdominal hemorrhage. Twelve liters of crystalloid and 8 units of pRBCs have been administered to this point. You notice that the labs are demonstrating low fibrinogen. What should be added to the transfusion regimen?

A. Platelets
B. FFP
C. Colloid
D. Hetastarch
E. Whole blood

375. What type of heart block is characterized by progressive elongation of the PR interval until a beat is dropped?

A. First degree
B. Second degree (Mobitz type I)
C. Second degree (Mobitz type II)
D. Third degree
1. **B Uncinate fasciculus**
   
   The uncinate fasciculus is a white matter tract that connects the anterior temporal lobe to the orbitofrontal cortex. It has been implicated in temporal lobe epilepsy as a potential seizure propagation pathway from the temporal lobe to the frontal lobe. The question tells you that the patient started with olfactory hallucinations (classic temporal lobe epilepsy) and propagated to a fencing posture, which is common in frontal lobe epilepsy, specifically seizures occurring in the SMA region.

   Further Reading: Leite, Castillo. Diffusion Weighted and Diffusion Tensor Imaging, 2016, pages 42–43.

2. **C Gamma**
   
   The myotatic reflex occurs when a hammer strikes the patellar tendon. This activates the muscle spindle, which is located in series with the muscle fibers, and causes contraction of the quadriceps muscle (in this case). The muscle spindle is innervated by type la sensory nerves (the afferent arm of the reflex) and gamma motor nerves. The gamma motor nerves innervate the static and dynamic bag fibers. During muscle contraction, the spindle is unloaded and loses sensitivity. The static fibers contract (after firing of gamma motor neurons) in order to shorten the spindle and maintain sensitivity even in the contracted states.


8. **A** Simvastatin

The introduction of statin therapy has revolutionized best medical management in cases of carotid stenosis. Statins have been shown to limit progression of the plaque, and decrease rates of conversion from asymptomatic to symptomatic disease. They have also demonstrated improved perioperative outcomes in both symptomatic and asymptomatic patients. There is a fivefold decrease in perioperative mortality in patients taking a statin who undergo CEA. Bottom line is that patients who meet NASCET (North American Symptomatic Carotid Endarterectomy Trial) or ACAS (symptomatic Carotid Atherosclerosis Study) criteria should be on a statin medication.


9. **C** Arnold–Chiari type III malformation

A high cervical spina bifida with herniated hindbrain contents is consistent with an Arnold–Chiari type III malformation. While it is commonly thought that the occipital encephalocele is associated with Chiari type III malformations, it is actually a different entity. Arnold–Chiari type III malformations are very rare, and are associated with other abnormalities including severe neurologic and developmental abnormalities. Neurosurgery plays a minor role in treatment, mainly ensuring that there is skin covering the herniation defects and that no spinal cord tethering is present.


10. **C** Carotid–ophthalmic

This 3D reconstruction of a lateral digital subtraction angiogram demonstrates an aneurysm of the internal carotid artery. There are two hints as to the classification of this aneurysm. First, it is in close proximity to the takeoff of the ophthalmic artery, although it is also in close proximity to the takeoff of the superior hypophyseal artery. In order to determine between these two separate classifications, the direction of aneurysm projection is often helpful. Carotid–ophthalmic aneurysms tend to project superiorly, while superior hypophyseal aneurysms project inferomedially.

11. **B** Phosphenes

Patients with dystonia generally benefit from GPi stimulation. It is important to understand the anatomical relationship of electrodes to structures surrounding the target in order to identify misplaced electrodes. In the case of GPi electrode placement, phosphenes (bright flashing lights in the visual field) are seen when the electrode is placed too deep, as the optic tract runs inferior to the GPi. Medial placement would result in stimulation of the internal capsule and facial pulling or muscle twitching.


12. **C** Chloride

The resting membrane potential of the neuron is approximately –70 mV. This is determined by the permeability of the membrane to potassium, sodium, and calcium. The equilibrium potential of potassium is approximately –90 mV, and the equilibrium potential of chloride is approximately –70 mV. The other three choices have positive equilibrium potentials.


13. **B** Neurocytoma

The pathology slides demonstrate a cellular tumor that has abundant cytoplasm. There are only two answer choices that have this appearance, oligodendroglioma and neurocytoma. They both appear similar on final pathology, but the intraventricular nature and septum origin make neurocytoma much more likely than oligodendroglioma.

17.  
C  Dantrolene  
This patient is experiencing malignant hyperthermia, which is associated with the use of halothane and succinylcholine. Often the first feature recognized is a sudden, abrupt increase in end-tidal CO₂. The offending agent should be removed, but in the case of succinylcholine, this is not readily possible. Dantrolene sodium should be administered during cases of malignant hyperthermia. Rhabdomyolysis and DIC can follow, so the patient should be closely monitored.  

18.  
C  Sphenoid sinus  
While it may seem like the ethmoid sinus is entered medial to a removed anterior clinoid process, it is in fact the sphenoid sinus that extends superiorly and would be entered medial to the anterior clinoid process.  

19.  
D  Cavernous  
The meningohypophyseal trunk arises from the cavernous segment of the internal carotid artery. It gives rise to the tentorial artery, which is commonly implicated in petrous meningiomas and some tentorial dural arteriovenous fistulae.  

20.  
D  Sporadic  
This patient has a classic port-wine stain in the V₁ distribution (bilaterally in this case, although often unilateral). This is characteristic of Sturge-Weber syndrome, which is also associated with leptomeningeal angiomatosis, seizures, and the tram-track sign on skull X-ray. It has a sporadic inheritance pattern.  

21.  
B  10 Gy  
Stereotactic radiosurgery (SRS) can be used to treat recurrent pituitary adenomas after an initial surgical resection. Due to the close proximity of the optic chiasm, care should be taken to avoid elevated doses to the optic apparatus. Currently, a dose of 10 Gy or less is considered safe to avoid visual deterioration after SRS. Some authors have suggested 8 Gy should be the limit, but multiple studies have determined that 10 Gy is an acceptable limit with very low rates of visual deterioration. For patients that may require further radiosurgery, a dose of 8 Gy or less is recommended.  

22.  
D  Pressure control-inverse ratio ventilation  
Ventilator-induced barotrauma is a concern for patients requiring mechanical ventilation. While PEEP can lead to barotrauma, it is more often associated with decreased cardiac output. Inverse ration ventilation increases the inspiratory phase but significantly decreases the expiratory phase compared to normal breathing. This allows air to remain trapped and patients can start stacking breaths, leading to increased pressure, or “auto-PEEP.” If this pressure becomes high enough, barotrauma or pneumothorax can occur.  

23.  
A  Diltiazem  
This patient has atrial fibrillation, which is not uncommon immediately after surgery due to fluid shifts and electrolyte disturbances. Many cases of postoperative atrial fibrillation will spontaneously revert to normal sinus rhythm with fluid administration and electrolyte replacement. This patient, however, has a rapid ventricular response, given that her heart rate is 145 BPM. For these patients, rate control is best performed by utilizing calcium channel blockers, such as diltiazem.
24. D Foregut–notochord separation

This image demonstrates a neurenteric cyst. It is a classic depiction of an embryologic inclusion cyst, in this case consistent with a neurenteric cyst. The cyst contents are remnants of persistent endodermal cell rests that remained attached to ectoderm. They often present with back pain, weakness, gait changes, or other findings of myelopathy. Occasionally, the cyst can rupture and cause chemical meningitis. A key clue that this is a neurenteric cyst is its ventral location.


25. C Mg

The NMDA channel is a glutamate receptor that is permeable to Na, K, and Ca. At the resting state, the ion channel is blocked by an Mg ion. When the membrane is depolarized, the Mg ion is expelled from the channel and select ions are allowed to traverse the channel. The NMDA channel also requires glycine as a cofactor as well as glutamate.


26. C Methotrexate

This MRI demonstrates a classic appearance of primary CNS lymphoma, and the history of HIV infection in this patient is another clue. These lesions are very radiosensitive and also sensitive to methotrexate chemotherapy. Gross total resection is not indicated in this case as the postoperative morbidity would be severe. Stereotactic radiosurgery is not ideal due to the diffuse nature of this pathology. Whole brain radiotherapy would be more beneficial. Of the options, methotrexate would be the best initial treatment method.


27. A Inferior vestibular

The image demonstrates a schwannoma, with a Verocay body demonstrated by the black arrowheads and arrow. This is the underlying pathology behind acoustic neuromas. Acoustic neuromas, or vestibular schwannomas, often originate from the inferior vestibular nerve. Schwannomas can originate from the other listed nerves, but they are much rarer than a schwannoma of the inferior vestibular nerve.


28. B Labyrinthine artery

The labyrinthine artery is a branch of AICA that traverses the internal acoustic meatus and supplies the vestibular and facial nerves as well as the cochlea.


29. B Whorls

This MRI scan depicts a petroclival meningioma occupying the CP angle. It has a broad base and dural attachments. On pathology, you would expect to see whorls that are characteristic of meningiomas.


30. B 1P/19Q co-deletion

This question is suggestive of an oligodendroglioma. These masses tend to present near the cortical surface, occur in patients 50 to 60 years old, and more commonly in men. They tend to calcify, and this can be seen on CT scan. They are partially enhancing to fully enhancing. Oligodendrogliomas often have 1P/19Q co-deletions on analysis of molecular markers, and this deletion confers an improved response to chemotherapy.


31. C Defibrillation
   This patient is unstable and unconscious in wide complex tachycardia. In this situation, the patient should undergo immediate defibrillation.
32. B Relative risk
   Relative risk is the correct answer, as it is the most useful association method when performing a cohort study. Cohort studies are designed to determine the incidence of developing a disease over time, and this is best studied using the relative risk. This compares to a case-control design where patients with the disease are selected and compared to controls without the disease to look at exposures and compare exposure to risk factors between patients with and without the disease. Case-control studies utilize the odds ratio for statistical association.
33. A Lead
   Lead toxicity (plumbism) occurs when lead levels reach greater than 10 μg/dL, and can have several noxious effects, specifically pure motor peripheral neuropathy manifesting as wrist drop. Patients can also develop a gingival “lead line.” Treatment is chelation therapy if the lead level is greater than 70 μg/dL, utilizing BAL.
34. B Ampicillin/gentamicin
   This patient has a myelomeningocele, and surgery to close the defect should be performed as soon as feasible. There are several things that should be performed prior to or while waiting for surgery. The patient should be kept on their abdomen to keep pressure off the fluid abnormality. It should be covered in a sterile dressing, and prophylactic antibiotics (ampicillin/gentamicin) should be administered.
35. B Superior articulating process
   Lateral recess stenosis is a common cause of radicular leg pain. This is often caused by a hypertrophic facet and subsequent bone overgrowth. The bony structure that causes direct compression of the nerve root is the superior articulating process from the vertebrae below.
36. C Crouzon's syndrome
   Apert's, Pfeiffer's, and Crouzon's syndromes are all craniofacial syndromes that often present with midface anomalies and craniosynostosis. Of the presented syndromes, only Crouzon's syndrome patients have normal IQs.
37. E Aneurysmal bone cyst
   This image demonstrates an aneurysmal bone cyst. These lesions are benign, but can grow rapidly and cause bony destruction and kyphotic deformity. They classically have multiple fluid-fluid levels on imaging. Surgical resection and spinal reconstruction is often recommended.
Answers

38. A Demyelinating
   This patient has CMT type III, or Dejerine–Sottas disease. This is a demyelinating peripheral neuropathic process due to a mutation on chromosome 17 that causes myelin to become unstable. This leads to repetitive demyelination and remyelination processes, causing the “onion-bulb” appearance on pathology. It is a motor sensory peripheral neuropathy that is often coexistent with orthopedic deformities, which helps distinguish it from other causes of neuropathy.

39. B Dynein
   Dynein is involved in fast retrograde axonal transport, occurring at 100 mm/d. Kinesin is fast anterograde transport at roughly 400 mm/d, and they both travel along microtubules utilizing ATP.

40. C Anterior choroidal
   The lateral geniculate nucleus receives the optic tract fibers and receives its blood supply from the anterior choroidal artery.

41. B Premature disjunction
   The image above demonstrates a spinal cord lipoma, which is often associated with spinal cord tethering. It is formed by premature disjunction during embryogenesis. The lipoma itself is made from mesodermal tissue that is allowed entry into the incompletely closed neural tube. This occurs because the neural ectoderm prematurely separates from the cutaneous ectoderm before the neural tube is completely fused, allowing mesodermal tissue to migrate into the neural tube, leading to formation of a lipoma.

42. B Brachium pontis
   There are two major input pathways into the cerebellum, the mossy fibers that synapse in the granular cell layer on granule cells and modify the activity of many Purkinje's cells and climbing fibers from the inferior olive that synapse directly on Purkinje's cells. The mossy fibers enter the cerebellum mainly through the brachium pontis, also known as the middle cerebellar peduncle.

43. D S
   Cells are susceptible to the effects of radiation during the G1 and M phases of the cell cycle, and most resistant during the S phase, when DNA repair mechanisms are fully active.

44. B Alzheimer's disease
   A Hirano body is an eosinophilic formation of actin-associated protein that is found in the neurodegenerative condition Alzheimer's disease. It has a characteristic trapezoidal shape.
45. A Tuberous sclerosis, autosomal dominant

These imaging studies demonstrate multiple periventricular masses that demonstrate hyperdensity on CT scan. There are also focal cortical malformations. The combination of these two findings should lead to the diagnosis of tuberous sclerosis, which is an autosomal dominant condition. The periventricular masses are subependymal giant cell astrocytomas and the cortical lesions are cortical malformations, or cortical tubers.


46. D Delta

Stage III sleep is characterized by delta activity on the EEG. Stage IV sleep also has predominant delta waves. Stage II is characterized by sleep spindles and K complexes.


47. B Stainless steel–cobalt–chromium alloy

Galvanic corrosion is just one mechanism by which metal implants fail over time. Galvanic corrosion occurs when two dissimilar metals are placed in contact. Over time, electrochemical destruction occurs and the metal weakens. The highest rate of galvanic corrosion occurs with cobalt–chromium alloy combined with stainless steel. Often this is not clinically relevant as the fusion mass is generally stable before this occurs, but medicolegally the surgeon should be aware of these electrochemical properties and try to not mix dissimilar metals if at all possible.

Further Reading: http://www.orthobullets.com/basic-science/9062/material-properties.

48. C Tranexamic acid

TXA is an antifibrinolytic that can be used after aneurysmal subarachnoid hemorrhage to decrease the rates of rebleeding prior to definitive treatment. Studies have demonstrated statistically significant decreases in rebleed rates; however, they have also demonstrated increased rates of vasoospasm and delayed cerebral ischemia. For this reason, it is recommended to utilize TXA for up to 72 hours to decrease the chance of rebleed while arranging for definitive treatment of the aneurysm.


49. B A 14-year-old woman with poorly controlled type 1 diabetes mellitus

This abscess is caused by mucor species, an invasive fungal organism. It often affects patients with diabetes and can extend into the brain from paranasal sinuses, which is what occurred in this patient with poorly controlled juvenile diabetes mellitus.


50. D Adenosine

Supraventricular tachycardia is a narrow complex tachycardia with page waves present, although it can be difficult to distinguish the page waves if the heart rate is fast enough. In the stable patient, vagal maneuvers can initially be attempted, followed by administration of adenosine, which blocks conduction through the AV node for several seconds. The patient can become asystolic with the administration of adenosine, but this is an effective method for treating SVT. If the patient is unstable, consider synchronized cardioversion.


51. A Rapid adaptation, small receptive field

The Meissner corpuscle is a skin receptor that exhibits rapid adaptation and has a very small receptive field. It transmits discriminative touch due to its small receptive field. It is also sensitive for flutter. Vibration sense is carried by the Pacinian corpuscles, which are also rapidly adapting, but have a larger receptive field.

52. C High mitotic activity
   The difference between a WHO grade II and WHO grade III astrocytoma is clinically important, but the differences can be subtle and disagreed upon by pathologists. Generally, a grade III astrocytoma will display nuclear atypia and high mitotic rate. It will not have microvascular proliferation and/or pseudopalisading necrosis as these are characteristics of WHO grade IV astrocytoma.

53. B Chiari I
   This image demonstrates tonsillar herniation and an associated holocord syringomyelia. This constellation of findings is most likely to be found in Chiari type I malformations.

54. B Glioma
   This MRI is characteristic of a diffuse intrinsic pontine glioma. Many of these diagnoses are made purely based on imaging as obtaining tissue for biopsy causes significant morbidity and does not aid in the treatment or prognosis of this unfortunate tumor.

55. D Pseudomeningoceles
   When evaluating brachial plexus injuries, the presence of nerve root avulsion is important to identify. In patients with confirmed nerve root avulsion, the only options are nerve transfers, tendon transfers, or muscle transfers. Nerve root avulsion can be diagnosed by EMG and imaging studies. Classically, CT myelograms would demonstrate pseudomeningoceles in cases of nerve root avulsion, but pseudomeningoceles can also be demonstrated on MRI. The presence of pseudomeningoceles is not a confirmation of avulsion as rootlets can remain intact, but it can be a helpful clue to consider nerve root avulsion when pseudomeningoceles are present.

56. C Pons
   This patient is exhibiting an apneustic breathing pattern, which is characterized by a prolonged pause following the inspiratory phase, and this localizes to lesions of the pons, the likely location of hemorrhage in this patient. The pinpoint pupils also help localize to the pons, although they can be seen in other lesions of the brainstem as well.

57. E Pelvic incidence ± 9 degrees = lumbar lordosis
   Spinopelvic parameters and overall alignment are important factors to consider when deciding what surgical procedure is appropriate for certain patients. In many cases of lumbar pathology, only lumbar X-rays and/or lumbar MRI are available. Sagittal vertical axis cannot be calculated from a lumbar only X-ray, as it requires a long cassette film to calculate. You can utilize a lumbar X-ray to calculate the lumbar lordosis/pelvic incidence ± 9 degrees match however. If these two parameters are off by more than 9 degrees, it is recommended that long cassette films are obtained to better evaluate the overall spinopelvic alignment.

58. A Metopic
   This image demonstrates trigonocephaly, with the classic pointed forehead. This is due to craniosynostosis of the metopic suture.
59. **E** Observation

This is a middle fossa arachnoid cyst that has been discovered incidentally. Over 80% of arachnoid cysts are stable and asymptomatic. Some may grow and lead to headaches or other symptoms and may require treatment. Several treatment paradigms exist, from simple fenestration into the basal cisterns or cystoperitoneal shunting. Initial treatment should likely consist of observation with repeat imaging in the future to determine interval stability.


60. **C** Norepinephrine

This patient is in septic shock, a form of distributive shock. Initially, the patient should receive multiple liters of crystalloid in an attempt to support the blood pressure. The drug of choice in septic shock is norepinephrine, and that should be administered in order to support the blood pressure and cardiac output despite the current tachycardia.


61. **C** Abductor pollicis brevis

A ligament of Struthers is an abnormal tissue band connecting a supracondylar process to the medial epicondyle and compressing the median nerve as it passes through this abnormal tunnel. Of the muscles listed, only the abductor pollicis brevis (abduction of the thumb perpendicular to the plane of the palm) would be affected as it is the only median innervated muscle listed.


62. **B** Acetylcholine

The basal nucleus of Meynert is located below the globus pallidus in the innominate substance. It receives subcortical input from the limbic/paralimbic cortex and projects to all regions of the cortex. Ninety percent of cells in this nucleus are cholinergic.


63. **A** Myxopapillary ependymoma

This pathology slide demonstrates a myxopapillary ependymoma, a tumor commonly associated with the conus medullaris. These tumors can often be completely resected in their entirety by identifying and cutting the filum terminale above and below the lesion. Care should be taken not to violate the capsule in order to avoid spilling the tumor contents into the spinal canal. Occasionally, these tumors can be adherent to the conus, and in these circumstances, aggressive resection including subpial resection of the conus should not be performed. Leaving tumor is preferable to giving the patient permanent bowel/bladder incontinence.


64. **E** Seizures

This pathology slide demonstrates findings classic for DNET (dysembryoplastic neuroepithelial tumor). The pathological slides demonstrate evidence of “floating neurons” that require high power to view. These tumors present often in the temporal lobe and are very epileptogenic.


65. **B** Diffusion weighted MRI

This skull lesion represents an epidermoid tumor of the skull. Epidermoid tumors appear bright on DWI MRI and this will lead to the correct diagnosis. There are several lesions that can affect the skull with different imaging characteristics on plain radiographs and MRI.

66. E Trisomy 21

The images demonstrate evidence of atlanto-occipital dislocation.


67. B Posterior columns

SSEP monitoring is very useful during spine surgery as it provides real-time monitoring of the dorsal column system. The N11 waveform roughly corresponds to the stimulation traversing the dorsal columns, and when there is increased latency, there could be a surgical problem causing compression of the spinal cord. Erb’s point near the shoulder is used for monitoring of the brachial plexus. SSEPs do not monitor motor function.


68. B Decreased lacrimation

The middle fossa approach encounters the greater superficial petrosal nerve during the exposure. The GSPN leaves the geniculate ganglion en route to the lacrimal ducts. Damage to the GSPN can cause an ipsilateral dry eye.


69. C 31 to 37%

This image demonstrates a high-grade AVM based on the Spetzler–Martin grading system. It is a very large AVM clearly in eloquent cortex. Venous drainage may be entirely cortical, although there is drainage into the transverse sinus and some may consider there to be deep venous drainage for this AVM. Regardless, it is at least a grade IV avm, placing it in the high-grade category. Based on recent literature of 1,500 combined cases, the risk of unfavorable outcome in surgical resection of these high-grade AVMs was 31 and 37%, respectively.


70. A 4%

Patients with medically refractory epilepsy should undergo surgical evaluation as there is a significant decrease in seizure control with the addition of further AEDs. In AED naïve patients, the addition of a first AED controls seizures in roughly 50% of patients. A further 15% are controlled with the addition of a second AED. Only around 4% obtain good seizure control with the addition of a third AED, and therefore medically intractable epilepsy is declared after failure of two adequate AED trials.


71. C Femoral

The lateral transpsoas approach has been used to access the lumbar spine for fusion procedures. When traversing the psoas muscle, care should be taken to avoid compression of the femoral nerve or genitofemoral nerve. The lateral femoral cutaneous nerve can be injured during exposure as well. For these reasons, often an electrical probe is utilized to split the psoas muscle, and the retractor should only be open for the minimal required time. Some patients may experience transient hip flexor weakness postoperatively.

72. A Give ativan
This patient has suffered a depressed skull fracture with likely damage to the left frontal region. Causes of decompensation could be vascular injury with hematoma formation or seizure activity. In this case, the eyes have deviated to the opposite side, which occurs when seizures originate from the left frontal eye fields. This is compared to eyes deviated toward the lesion, which occurs with destruction of the ipsilateral frontal eye fields. This patient will require surgery, but Ativan should be given to break the seizure first.

73. D Binds heparin
Protamine is useful for reversing unfractionated heparin, and 1 mg of protamine will inactivate 100 U of heparin. It does this by directly binding heparin and forming a stable, nonreactive salt. Protamine has a half-life of 7 minutes, and the maximum dose is 50 mg.

74. E Decreased preload
PEEP is useful for intubated patients, but at a price. It increases end expiratory pressure to keep the alveoli open. In order to keep the alveoli open, positive pressure is required. This has the effect of increasing intrathoracic pressure and decreasing preload. This could be dangerous in this patient who already is having episodes of hypotension requiring pressors. Consider the elevation of intrathoracic pressure when utilizing PEEP.
Further Reading: Frontera. Decision Making in Neurocritical Care, 2009, page 239.

75. A Inferolaterally
There are several techniques that can be utilized to treat trigeminal neuralgia. Radiofrequency ablation often occurs with the patient awake in order to confirm that test stimulation is in the right region of the trigeminal nerve. In this patient, test stimulation is eliciting symptoms in the V2 region. Since the electrode is positioned medial to the nerve, the electrode should be moved inferolaterally in order to better target V3.

76. D Mossy fibers
The Purkinje cell of the cerebellum is the only output cell of the cerebellar cortex. It receives inputs from several cells, including climbing fibers, basket cell fibers, granule cell fibers, and indirectly via mossy fibers.

77. B PTEN mutation
This pathology slide demonstrates classic GBM with nuclear atypia, microvascular proliferation, and pseudopalisading necrosis. These tumors are associated with a PTEN gene mutation on chromosome 10. It is also more likely that primary GBMs have a PTEN mutation than secondary GBMs.

78. C Crystalloid infusion
According to early goal-directed therapy, infusion of crystalloid to support the central venous pressure should be administered in patients with septic shock. Even though a higher percentage of colloid will remain in the blood vessels, the initial management should begin with crystalloid infusion.

79. A Vancomycin
Of the above choices, vancomycin has been associated with renal dysfunction and elevation of creatinine. Creatinine should be monitored during prolonged vancomycin infusions.
80. **D** 8 hours

Mechanical thrombectomy has been utilized for select patients up to 8 hours after symptom onset. 4.5 hours is the threshold for IV-tPA, 6 hours for intra-arterial thrombolysis, and 8 hours is the threshold for mechanical thrombectomy.


81. **D** 75%

The Engel classification system is useful in determining clinical outcome after seizure surgery. Patients with Engel class I seizure control are completely free of disabling seizures. In pediatric patients with structural temporal lobe epilepsy who undergo surgical resection, approximately 74% will have Engel class I seizure control at a mean follow-up of 67 months.


82. **B** Dabigatran

Idarucizumab is a monoclonal antibody that can be used to reverse dabigatran, a direct thrombin inhibitor. Patients receive 5 g of idarucizumab, and this effectively reverses the effect of dabigatran in 88 to 98% of patients.


83. **C** 140%

This patient has suffered a severe traumatic brain injury and requires TPN administration. Due to her trauma, she should receive 140% of her predicted basal energy expenditure in calories from supplemental nutrition during the first 2 weeks after injury.


84. **E** Pyriform cortex

The lateral olfactory stria projects directly to primary olfactory cortex, the pyriform area.


85. **B** Potassium

Astrocytes have been found to have ion channels and it is suggested that astrocytes sequester extracellular potassium so that extracellular concentrations remain low.


86. **A** Paraganglioma

While this image appears classic for myxopapillary ependymoma, the pathology report reads “nests of cells that stain for chromogranin A.” This is consistent with a filum paraganglioma. The nests of cells are called Zellballen, and they do not resemble pathologic findings in myxopapillary ependymoma.


87. **D** Renal cell carcinoma

This pathologic slide demonstrates a hemangioblastoma, which is common in patients who have von Hippel–Lindau disease, with genetic abnormalities on chromosome 3. It is associated with retinal hemangioblastomas, pheochromocytomas, endolymphatic sac tumor, pancreatic islet cell tumors, and renal cell carcinomas.


88. **E** Semilobar holoprosencephaly

The three holoprosencephalies are not distinct entities as much as variable formations on a spectrum of neuronal dysgenesis. In semilobar holoprosencephaly, there is often absence of an anterior interhemispheric fissure, but presence of a posterior interhemispheric fissure. The thalami are often fused with a dysmorphic monoventricle.

89. C V3
There are four segments of the vertebral artery. V1 is the vertebral artery from its origin to the point it enters the foramen transversarium at C6. V2 is the vertebral artery in the foramen transversarium from C6 through the inferior aspect of C1. V3 is the segment of the vertebral artery after it courses out of the transverse to passage through the dura. V4 is the intradural segment of the vertebral artery. The V3 segment is at risk during superior exposure of the superior C1 lamina.

90. E Hepatic encephalopathy
Hepatic encephalopathy can be a cause of coma. On EEG, it can manifest as triphasic waves. Neuropathology slides in patients with hepatic encephalopathy can demonstrate Alzheimer's type II astrocytes.

91. C C1 lateral masses
The transverse ligament of the atlas connects the C1 lateral masses and holds the tip of the dens in place. It is very important for stabilizing the atlantoaxial joint. When disrupted, the atlantoaxial joint stability is compromised and C1–C2 fusion should be considered if possible.

92. A Ventrolateral preoptic nucleus
The VLPO is a cluster of hypothalamic neurons that are believed to be involved with mediating several aspects of the sleep cycle, including NREM sleep. In rats when the VLPO is disrupted, there is a 70% decrease in delta wave activity and a 60% decrease in NREM sleep time.

93. D Superior vestibular and facial
Bill's bar separates the facial nerve (anterior and superior) from the superior vestibular nerve (superior and posterior). The transverse crest separates the facial/superior vestibular from the cochlear/inferior vestibular nerves.

94. C Carotid cavernous fistula
This patient demonstrates proptosis, chemosis, dilated and tortuous conjunctival veins, and exophthalmos. Of the listed differential diagnosis, carotid cavernous fistula is most likely with this constellation of symptoms. You are not able to determine if this is a direct or indirect fistula based on this clinical picture alone; a conventional angiogram should be obtained.

95. C Persistent trigeminal artery
This angiogram demonstrates a persistent trigeminal artery (PTA). It is often seen as an abnormal connection between the posterior cavernous ICA to the basilar artery approximately two-thirds from its origin. It can compress local cranial nerves causing symptoms. Patients with PTAs should not undergo Wada testing as medication administration can cause the patient to become comatose.
97. A Cerebellar Purkinje cell layer
   There are three regions of the brain that are extremely sensitive to ischemia. They are the Purkinje cell layer of the cerebellum, the CA1 region of the hippocampus (Sommer's sector), and the cerebral cortex (layers III, V, and VI of the parietooccipital region).


98. D Lumbar ultrasound
   This child has evidence of a possible dermal sinus tract, and the presence of this abnormality should make you consider the possibility that other lumbar spine (or other) abnormalities exist. An excellent initial screening tool is a lumbar ultrasound in this newborn as it may help determine if there is a mass lesion associated with the dermal tract or other abnormality. Ultimately an MRI will likely be obtained, but given the difficulty required in obtaining an MRI in this newborn, ultrasound would be the preferred initial imaging study.


99. D Left atrium
   The pulmonary artery catheter utilizes a balloon to create a “wedge” within the blood vessel wall, halting any blood flow in that particular vessel. This creates a stable column of blood going from the end of the catheter directly to the left atrium, allowing for accurate pressure recordings. Since the left ventricular end-diastolic pressure should equal the left atrial pressure, it can also calculate this. Preload is LV end diastolic volume, but this is not directly measured by the pulmonary catheter; only LV end diastolic pressure is. Therefore, preload can only be calculated accurately by PCWP in cases of normal left ventricular compliance; the measurement of preload may be inaccurate in stiff, diseased left ventricles.


100. C 5.9
   This question is asking you to calculate the number needed to treat (NNT). This is done by determining the absolute risk reduction (ARR) and then calculating 1/ARR. In this case, the rate of stroke decreased from 26 to 9%, an ARR of 17%, or 0.17. Next, 1/0.17 = 5.88; therefore, the number of patients needed to treat to prevent one stroke in this interval is approximately 5.9.


101. A Volume status
   This patient could be experiencing either SIADH or cerebral salt wasting, and it is important to determine which of these conditions the patient has, since they have different treatments. In SIADH, volume restriction may be employed as part of the treatment regimen, but in patients with cerebral salt wasting, volume replacement is utilized as these patients tend to be profoundly dehydrated. Volume status is the key to making the diagnosis in this condition.


102. A 1 to 6 hours
   This CT scan demonstrates a left-sided epidural hematoma associated with multiple skull fractures. The patient is comatose and has a larger left pupil. This patient should be intubated and taken to the OR for evacuation. In less severe epidural hematomas, close monitoring should still be performed with early repeat CT scans to determine interval stability. Epidural hematomas can significantly expand in the first 6 hours after injury, and a seemingly stable patient can suddenly deteriorate due to expansion of blood products and associated brain herniation.


103. D Increased susceptibility to alkylating agents
   MGMT promoter methylation makes high-grade glial tumors more susceptible to alkylating agents, such as temozolomide. In one study of patients who underwent resection of GBM and treatment with temozolomide, 46% of patients whose tumors harbored an MGMT promoter methylation were alive 2 years later, compared to 22% of those patients without the MGMT promoter methylation.

104. E  Friedrick's ataxia
Friedrick's ataxia is an autosomal recessive spino-cerebellar ataxia that is caused by a mutation in the frataxin gene. This gene is implicated in iron transport into mitochondria. These patients develop trunk and limb ataxia, nystagmus, sensory loss, and spasticity with hyporeflexia. They often die by 40 years of age.

105. C Myxopapillary ependymoma
This MRI demonstrates a soft-tissue mass associated with the conus medullaris at L2–L3. The most common tumor with this appearance is a myxopapillary ependymoma, arising from the filum terminale. While paraganglioma is possible, it is rarer than a myxopapillary ependymoma in this region.

106. A 8
The frontal eye fields are responsible for contralateral saccadic eye movements, and they are classified as Brodmann's area 8.

107. C Pain transmission
Substance P is a neuropeptide that has been implicated in pain signal transduction.

108. B  EMA
Hemangiopericytomas (HPCs) can look similar to meningiomas on imaging and even intraoperatively. Final pathology utilizes immunohistochemical stains to determine the difference in complex cases. HPCs are immunoreactive for CD34 and negative for EMA, while meningiomas have the opposite staining pattern.


109. E  Ganglion cells
The optic nerve is made of axons of ganglion cells, and is the output pathway from the retina.

110. B  K
The inner ear has two fluid types: perilymph has similar characteristics to serum, with high concentrations of Na and low concentrations of K. Endolymph fills the scala media of the cochlea, and is highest in concentration of potassium, the opposite of the perilymph.

111. C  Sacrum
This pathologic slide demonstrates physaliphorous cells that classically appear in chordomas. These tumors arise from primitive notochord remnants, thus making the sacrum the most likely location of presentation for chordoma. They can also be seen emanating from the clivus.

112. D  Eosinophilic granuloma
This patient has vertebra plana with kyphotic deformity. The differential diagnosis of patients with vertebra plana can include leukemia, metastatic neoplasm, tuberculosis infection, and Langherans histiocytosis, also known as eosinophilic granuloma. With bony involvement in LCH/eosinophilic granuloma, pathologic compression fractures can occur.
113. B Cell membrane turnover
   Magnetic resonance spectroscopy (MRS) can be used to try and differentiate tumor from ischemia, metabolic disorders, or radiation necrosis. In practice, MRS has issues with reliable, accurate prediction, but it is a tested detail on the neurosurgery boards. The choline peak is elevated in tumors, and is a marker for cell membrane turnover.
   Further Reading: Jain, Essig. Brain Tumor Imaging, 2015, page 141.

114. C Radiation necrosis
   MR perfusion is starting to be utilized in attempts to differentiate recurrent tumor from pseudoprogression and radiation necrosis. In this case, there is contrast enhancement in the resection cavity 1 year after resection and chemoradiation. While this may be concerning for recurrent tumor, the perfusion study does not demonstrate any increased perfusion in the resection cavity, and ultimately, radiation necrosis was diagnosed.
   Further Reading: Jain, Essig. Brain Tumor Imaging, 2015, page 42.

115. B Generalized 3-Hz spike and wave pattern
   Absence seizures are characteristic on EEG, demonstrating 3-Hz generalized spike and wave activity. Clinically patients appear to lose consciousness or have a blank stare for several seconds, followed by immediate return to preseizure function and task. They do not experience a Todd postictal phenomenon.

116. A Dominant parietal lobe
   Gerstmann’s syndrome is found in patients with lesions of the dominant parietal lobe, specifically the angular and supramarginal gyri. They demonstrate right/left disorientation, finger agnosia, agraphia, and acalculia. Lesions of the nondominant parietal lobe tend to cause dressing apraxia.

117. D Coagulase-negative Staphylococcus
   The most common causative organism in shunt infections is coagulase-negative Staphylococcus, staph epidermidis. While all of the other organisms are implicated in shunt infections, staph epidermidis is the most common, occurring in 50 to 72% of shunt infections.

118. C Antibiotics and Philadelphia collar
   Grisel’s syndrome is a torticollis and atlantoaxial subluxation associated with inflammation due to tonsillitis, mastoiditis, otitis media, or retropharyngeal abscess. The patients often present with an abnormally rotated head in flexion (cock-robin deformity). Treatment involves resolution of the infection with antibiotics, and bracing with either a halo or a cervical collar. Of 50 patients, only 2 required surgical debridement and fusion.

119. A Myelosuppression
   Alkylating agents, such as temozolomide, can have myelosuppressive effects among others, and routine monitoring utilizing regular complete blood counts while on therapy should be undertaken.

120. B 5 days
   Wound healing progresses in stages. Wound contraction occurs when myofibroblasts are present and begin proliferating, which happens at postinjury day 5.
121.
D 3% saline
Of the medications listed, 3% saline is the medication that does not increase the osmotic gap. The medication most commonly used in neurosurgery that has an effect on osmotic gap is mannitol, and osmolality should be monitored during administration.


122.
C Forced vital capacity 9 mL/kg
Patients with Guillain–Barré syndrome may require prophylactic or emergent intubation for impending respiratory failure. Negative inspiratory force and forced vital capacity (FVC) should be monitored every 6 hours. If FVC drops below 10 mL/kg, the patient should be intubated. The 10 to 15 mL/kg range is dangerous, and intubation could be considered for patients with an FVC less than 15 mL/kg. An easy bedside test is to see if the patient can count to 10 on one breath. If not, they should be intubated.


123.
C Perimesencephalic–chiasmatic
This membranous structure is Liliequist’s membrane, which separates the chiasmatic from perimesencephalic cisterns. It should be divided during an ETV procedure to ensure adequate CSF flow into the basal cisterns. When the basilar artery and branches are seen plainly without overlying arachnoid, the membrane has been adequately perforated.


124.
D Distal shunt revision
This skull X-ray demonstrates an area of shunt discontinuity, likely a shunt fracture. The patient has headaches, and a CT could be obtained to prove an increase in ventricular size is present, although this is likely not necessary given the history, examination, and X-ray findings. This patient should be taken as soon as feasible for a distal shunt revision.


125.
A PTEN
This MRI demonstrates dysplastic gangliocytoma of the cerebellum, or Lhermitte–Duclos disease. It is characterized by cerebellar cortical enlargement with diminished white matter. Patients often present with signs and symptoms of an enlarging posterior fossa mass. This disorder is associated with Cowden’s disease, a PTEN mutation on chromosome 10. These lesions are benign, but may require surgical debulking as they have a propensity to grow.


126.
D Hyperflexion
This X-ray demonstrates C4 on C5 subluxation with bilateral jumped facets. This injury mechanism occurs with hyperflexion injuries. Unilateral locked facets occur with flexion/rotation injuries. He should be put in cervical traction to reduce the injury.


127.
C Cervical leptomeninges
CNS melanocytes are found in the meninges of the ventral medulla and cervical spinal cord. The substantia nigra contains pigmented cells, but not actual CNS melanocytes.


128.
D VII–Clarke’s intermediolateral nuclei
Renshaw’s cells are inhibitory interneurons of the spinal cord. They inhibit alpha motor neuron synergist muscles and inhibit the inhibitors of antagonist muscles. This serves to help make the motor signal more accurate. They are located primarily in Rexed’s lamina VII.

II Answers

129.  
B Suprascapular  
The infraspinatus muscle is involved in external rotation of the arm at the shoulder, and it is innervated by the suprascapular nerve.  

130.  
D Observation  
This patient has a skull osteoma, a benign mass comprised of mature cortical bone. These lesions can grow, but rarely enough to cause a problem outside of cosmetic abnormalities. If the patient does not mind the mass, simple observation is recommended. If there is cosmetic concern, the mass can be drilled out and cranial plating can be utilized to improve the contour of the skull.  

131.  
B VLp  
The thalamus has multiple relay nuclei and is heavily tested on neurosurgical board examinations. The dentate nucleus of the cerebellum has axons that project to the ventral anterior and the ventral lateral (including ventral lateral posterior) nuclei. It does not project to the VPL (ventral posterolateral), which is the main sensory relay nucleus.  

132.  
A DAG  
Protein kinase C is activated by the protein DAG as a part of an intracellular signaling mechanism. For this particular pathway, phospholipase C breaks PIP2 into IP3 and DAG. IP3 goes on to release calcium ions into the cytosol, while DAG activates protein kinase C.  

133.  
E Aseptic meningitis  
These images demonstrate a CP angle epidermoid cyst. If the cyst ruptures, it can cause aseptic meningitis. This is in comparison to a dermoid cyst, which tends to occur in the midline, and can cause bacterial meningitis when ruptured.  

134.  
D Amyloid angiopathy  
This elderly patient has evidence of white matter ischemic vascular disease as well as multiple cortical-based hemorrhages that are apparent on susceptibility-weighted imaging. This is most suggestive of cerebral amyloid angiopathy.  

135.  
C Zonisamide  
Of the listed medications, zonisamide has the highest risk of development of the skin condition Stevens–Johnson syndrome.  

136.  
D Inferior colliculus  
BAERs are useful for posterior fossa surgery and also for diagnosing certain conditions in the ICU setting. Wave V of the BAER response localizes to the inferior colliculus in the auditory pathway.  
137. C Normal PT, prolonged aPTT, prolonged bleeding time
von Willebrand’s disease can be congenital (autosomal dominant) or acquired and consists of deficiency of vWF (von Willebrand factor), and leads to abnormal platelet adhesion as well as abnormal intrinsic coagulation pathway function due to deficient factor VIII. It causes prolongation of the bleeding time and aPTT with normal bleeding time. Treatment can be DDAVP or cryoprecipitate.

138. B Hyperkalemic metabolic acidosis
This patient is exhibiting adrenal insufficiency from sudden loss of ACTH secretion by the tumor. Her adrenal function has not accelerated fast enough to secrete enough steroids and she is becoming symptomatic. Due to the lack of aldosterone, she will retain potassium in the kidney and develop a metabolic acidosis.

139. D Streptococcus pneumoniae
This patient appears to have meningitis from a skull base fracture, and the organism most often associated with this process is Streptococcus pneumoniae. S. pneumoniae is also the most common causative organism in older infants through adults for spontaneous meningitis.

140. C Irradiated/leukoreduced PRBCs
Patients that have a history of multiple, febrile transfusion reactions should receive leukoreduced blood products. Recent blood products have usually been filtered to decrease the WBC count in attempts to decrease this reaction, but care should be taken in patients with a history of this type of reaction. Washed blood products are for patients that have a history of allergic transfusion reactions with anaphylaxis.

141. A Intubate
This patient has a likely aneurysmal subarachnoid with evidence of hydrocephalus on admission CT. There should be a low threshold for ventriculostomy in this patient. Now that the patient has suddenly become unresponsive, she has likely decompensated from worsened hydrocephalus or potentially an aneurysmal rebleed. While ventriculostomy will be required, this patient clearly needs to be intubated first.

142. C Hyperkalemia
Succinylcholine is a depolarizing neuromuscular blocking agent used for induction of anesthesia. Care must be taken when using succinylcholine in patients with spinal cord injury as this medication can cause a sudden, dangerous hyperkalemia.

143. D Syncope
This patient has bow-hunter’s syndrome, which is characterized by near syncopal episodes when a patient turns their head to one side, causing dynamic compression of the vertebral artery. In these patients, the affected vertebral artery is dominant, and there is minimal, if any, collateral flow from the anterior circulation. There are multiple points of compression, and the compression can occur from disk osteophyte complexes, fibrous bands, or enlarged anterior scalene/longus colli muscles.

144. D Posterior limb of the internal capsule
The anterior choroidal artery arises from the distal internal carotid artery and makes a sharp superior turn at the plexal point. This makes it easy to distinguish on angiogram. It supplies the posterior limb of the internal capsule, part of the optic tract, and the lateral geniculate body. It is at risk of injury during amygdalohippocampectomy.
145. HIV infection
   This pathologic specimen demonstrates evidence of a multinucleated giant cell, consistent with HIV encephalitis.

146. Radiation reaction
   This pathologic slide demonstrates necrosis surrounded by inflammatory reaction. This occurs months after radiation and is considered subacute radiation reaction.

147. Glutamate
   The subthalamic nucleus is part of the indirect basal ganglia pathway, and receives GABA input from the GPe. In turn, it provides excitatory input to the GPi utilizing glutamate. This increases the tonic inhibition of the thalamus provided by GABAergic cells of the GPi.

148. Pars vascularis of the jugular bulb
   The jugular foramen splits into two portions, the pars nervosa (anteromedial compartment), which contains cranial nerve IX and the inferior petrosal sinus, and the pars vascularis (posterolateral compartment), which contains the vagus and accessory nerves, as well as the proximal jugular bulb.

149. Diffuse axonal injury
   Axonal spheroids are evident on pathologic specimens of patients who have severe cerebral trauma. When an axon is disrupted, neurotransmitters and proteins continue to be transported from the cell body down the damaged axon. This leads to ballooning of the proximal axonal stump, which appears as a swollen, eosinophilic body on pathology. The distal stump also swells as retrograde transmission continues in the early postinjury period.

150. Viral infection
   This pathologic specimen demonstrates a microglial nodule, or “babes” nodule. It is characteristic of viral infection of the CNS.

151. DNA virus infection
   This pathologic slide demonstrates Cowdry type A inclusion bodies, which are nuclear inclusion bodies surrounded by a characteristic halo. They are indicative of DNA virus infection, and are most often seen in herpes virus infection.

152. Pyrimethamine
   This patient has AIDS and is immunocompromised with a T-cell count of less than 200. He has multiple mass lesions in the basal ganglia as well as near the cortical surface. Two of the main causes of mass lesions in patients with AIDS are toxoplasmosis and primary CNS lymphoma. Of these two, toxoplasmosis is more common. Toxoplasmosis infection involves the basal ganglia and subcortical regions, whereas lymphoma tends to be primarily periventricular. In some cases, toxoplasmosis will demonstrate targetoid lesions on imaging. Treatment is with pyrimethamine.
153.  
D  Tuberous sclerosis  
This pathologic specimen demonstrates tumor containing cells with significant eosinophilic inclusions in the cytoplasm. The question stem also tells you that the resection was carried out in the ventricle, making this most likely to be a subependymal giant cell astrocytoma, a tumor that is seen in patients with TS.  

154.  
C  III  
The cerebral cortex has six layers. Layers I and II tend to have interneurons connecting areas of cortex in the same hemisphere. Layer III has association fibers that cross the corpus callosum. Layer IV is the primary input layer from the thalamus. In the occipital cortex, it is enlarged and myelinated, leading to the characteristic stria of Gennari, which also gives this region the name “striate cortex.” Layer V contains Betz’s cells, the large pyramidal cells seen in the motor cortex. Layer VI mainly contains output cells to the thalamus.  

155.  
B  Nondisjunction  
This patient has a dermal sinus tract and very likely has underlying spinal dysraphism. A dermal sinus tract that connects to the spinal column occurs with nondisjunction. As the neural tube closes, disjunction occurs, separating neural ectoderm from surface ectoderm. In areas of focal nondisjunction, an abnormal persistent connection between surface and neural ectoderm persists, leading to a dermal sinus tract. When present, these should be resected due to the possibility of recurrent meningitis.  

156.  
B  Bromocriptine  
This patient has an elevated prolactin level at 450 in the setting of a pituitary tumor, making the diagnosis of prolactinoma likely. In many of these cases, initiation of bromocriptine/cabergoline will lead to decrease in tumor size, and this may even cause surgery to not be required. It should be trialed first. Since the prolactin level is higher than 200, this is not stalk effect and likely represents a true prolactinoma.  

157.  
C  Radial nerve branches to triceps  
Axillary nerve damage can lead to deltoid paresis and difficulty with shoulder abduction. A common nerve transfer used to reconstruct deltoid function is taking a medial branch of the radial nerve to the triceps muscle and performing an end-to-end anastomosis with the motor branch of the axillary nerve.  

158.  
B  Deep branch of the ulnar nerve  
The first dorsal interosseous muscle functions to adduct the thumb in the plane of the palm and is innervated by the deep branch of the ulnar nerve.  

159.  
E  Pronounced apical impulse  
Cardiac tamponade causes three classic findings, jugular distension, distant heart sounds, and pulsus paradoxus. It is also associated with decreased cardiac output, but it is not associated with a more pronounced apical impulse.  

160.  
B  GABA B receptor  
Baclofen is an agent commonly used in patients with severe spasticity. It is an agonist of the GABA B receptor, which leads to increased influx of K+ ions.  
161. A Prolactin

The imaging demonstrates a pituitary adenoma. The most common functioning pituitary tumors are prolactin-secreting adenomas.


162. B Lesionectomy

This patient has a classic appearance of a dysembryoplastic neuroepithelial tumor in imaging, and has medically refractory epilepsy. The utility of adding a third AED is less than 5% chance of Engel class I seizure control. This patient does not need craniotomy with grid implantation; he needs a resection of the lesion itself.


163. A Catheter fracture

This patient likely has an intrathecal catheter for administration of IT baclofen. Her symptoms are consistent with baclofen withdrawal, and this could be due to catheter fracture. She should receive IV baclofen and should undergo X-ray evaluation to determine if the catheter is intact or damaged. The pump should be interrogated as well. Patients with baclofen withdrawal can develop seizures, and often present as “itchy, twitchy and bitchy.”


164. D Grade IV

This patient has a grade IV germinal matrix hemorrhage, as evident by intraventricular hemorrhage with hydrocephalus as well as hemorrhagic destruction of adjacent brain matter. There is no grade V hemorrhage.


165. A Prolactin

The imaging demonstrates a pituitary adenoma. The most common functioning pituitary tumors are prolactin-secreting adenomas.


166. B SIADH

Carbamazepine is a useful medical treatment option for patients with trigeminal neuralgia. It has several side effects, including agranulocytosis and SIADH (hyponatremia). CBC and serum sodium should be monitored in patients on carbamazepine.


167. A Catheter fracture

This patient likely has an intrathecal catheter for administration of IT baclofen. Her symptoms are consistent with baclofen withdrawal, and this could be due to catheter fracture. She should receive IV baclofen and should undergo X-ray evaluation to determine if the catheter is intact or damaged. The pump should be interrogated as well. Patients with baclofen withdrawal can develop seizures, and often present as “itchy, twitchy and bitchy.”


168. B Sinuvertebral nerve

Discogenic back pain is a controversial topic, but pain generated from the disk is thought to propagate along the sinuvertebral nerve, which is created from a branch of the ventral rami that fuses with a branch of the sympathetic trunk and innervates the posterolateral annulus fibrosus as well as the posterior longitudinal ligament.

169. E Niemann–Pick disease
   The sphingolipidoses are caused by mutations that cause aberrations in the sphingolipid metabolic pathway. They often present by the age of 2 years and cause severe mental retardation and developmental delays. Of these disorders, the Niemann–Pick disease presents with supranuclear palsy. It is caused by a deficiency in sphingomyelinase.

170. B Chromogranin A
   This image study and pathologic specimen demonstrate the classic appearance of a glomus tumor (paraganglioma) of the skull base. The pathologic specimen demonstrates “Zellballen” or nests of cells. These tumors stain vigorously for chromogranin A.

171. D Anterior belly of the digastric
   Of the choices listed, the trigeminal nerve innervates the anterior belly of the digastric muscle. The other muscles are innervated by the facial nerve and glossopharyngeal nerve (stylopharyngeus)

172. A Schwannoma
   This T2-weighted MRI demonstrates a small tumor originating in the IAC, associated with the vestibular nerve. It is most likely a vestibular schwannoma. While meningioma and epidermoid tumors are on the differential for CP angle masses, a pure canalicular tumor is almost certainly a schwannoma.

173. A Increased perfusion in epileptic focus
   Both SPECT and PET imaging are used in seizure imaging. Ictal PET is very difficult owing to the time required to inject the tracer and obtain the images, so PET scanning is usually used for interictal scanning. SPECT scans demonstrate changes in blood flow to regions of the brain and can be obtained during a seizure. The ictal SPECT scan demonstrates increased perfusion to the epileptic focus.

174. D ACTH
   This EEG demonstrates hypsarrhythmia, which is seen in patients with infantile spasm (West’s syndrome). It is treated with ACTH.

175. C Weight loss/activity modification
   This patient has compression of the lateral femoral cutaneous nerve as it traverses underneath the inguinal ligament. Surgical release and/or neurectomy are options, and often have excellent results; however, this patient should first attempt weight loss and activity modification to determine if the nerve pain improves without the need for surgery. If this fails, surgery can be offered.
II Answers

178. B Soft-tissue sarcoma

BMP is thought to function by recruiting mesenchymal cells to differentiate into chondroblasts as well as directly into osteoblasts. It is a very powerful bone forming substance. It should be avoided in any patients with a history of soft-tissue sarcoma as it may worsen the tumor burden in these patients.


183. A Decreased compliance

This patient has a severe scoliotic deformity of the spine. This often leads to restrictive lung disease and can cause a decrease in overall lung compliance given the small expansion space for the lungs.


184. D Globus pallidus internal segment

Some patients with dystonia may be amenable to deep brain stimulation. The region most commonly targeted for patients with dystonia is the internal segment of the globus pallidus.


185. D Observation

This patient has a diffuse intrinsic pontine glioma, which is classic on the provided imaging studies. At the current time, these tumors are directed immediately to chemotherapy and radiation if reasonable, and surgery is avoided unless an attempt is being made to obtain tissue for molecular studies or further research. There is no role for surgical debulking of this tumor.


186. D Alcohol

This MRI demonstrates degeneration of the mediodorsal thalamic nucleus and is consistent with Wernicke’s encephalopathy, likely caused by prolonged alcohol use and thiamine deficiency.

Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 337.
187. B Axial compression
This image study demonstrates a burst fracture of the thoracolumbar spine, as evidenced by the disruption of both the anterior and middle columns of the spine. This fracture pattern occurs with axial compression, and often develops at the thoracolumbar junction primarily because in this region the axial force vector travels directly through the vertebral body as compared to anterior or posterior to the vertebral body in other regions.


188. D Chloride
The NMDA channel is a complicated ion channel, requiring both a ligand (glutamate) and electrochemical forces to open (membrane depolarization leads to expulsion of the magnesium ion blocking the channel). It is permeable to sodium, potassium, and calcium, but not chloride.


189. D Layer IV
The striae of Gennari are located in the striate (visual) cortex, and are made up of heavily myelinated fibers entering layer IV of the cortical cytoarchitecture. Layer IV generally receives input from the thalamus, and in this case likely from the lateral geniculate nucleus.


190. A Abductor pollicis longus tendon
The carpal tunnel is made of the bones of the wrist and the transverse carpal ligament. It contains the median nerve, the tendons of the FDS and FDP as well as the tendon of the FPL. The abductor pollicis longus tendon is responsible for thumb abduction in the plane of the palm, and it does not pass through the carpal tunnel.


191. B Lenticular fasciculus
There are several output tracts from the basal ganglia. The lenticular fasciculus (FFH2) crosses the internal capsule from the GPi. The ansa lenticularis curves around the internal capsule and connects with FFH2 to form the thalamic fasciculus (FFH1) entering the thalamus.


192. D PCA perforators
The substantia nigra pars reticulata is located between the cerebral peduncles and the junction of the peduncles to the midbrain. It is fed by perforators from the PCA.


193. C Dural laceration
The image demonstrates a leptomeningeal cyst, also known as a growing skull fracture. They occur in young children with a skull fracture and an underlying dural laceration. Surgical intervention should focus on repair of the dural defect.


194. D Bacterial abscess
This MRI demonstrates a ring-enhancing mass in the corpus callosum. There is one image that seals the diagnosis, and that is the diffusion MRI. The center of the mass is very bright on diffusion weighted imaging, consistent with an abscess. Always check the diffusion study.

Further Reading: Tsiouris, Sanelli, Comunale. Case-Based Brain Imaging, 2nd edition, 2013, page 188.
195.
B Superior cerebellar
This lateral X-ray demonstrates a patient undergoing a percutaneous balloon compression of the trigeminal nerve for facial pain, also known as trigeminal neuralgia. This condition can be multifactorial, but in many patients a loop of a blood vessel is found compressing the trigeminal nerve as it exits the brainstem. For trigeminal neuralgia, the superior cerebellar artery is the most common compressing vessel.

196.
B Posterior frontal cortex
This patient is exhibiting a “fencer’s posture,” which is classic for posterior frontal (motor strip) seizure onset.

197.
B Femoral
Patients with poorly controlled diabetes can develop a lumbosacral radicular neuropathy that is asymmetric and painful. Weakness tends to involve muscles innervated by the femoral nerve.

198.
C Thoracolumbar kyphosis
Patients with achondroplasia can have multiple abnormalities of the spinal column, but one of the most commonly observed abnormalities is exaggerated and abnormal thoracolumbar kyphosis. This leads to increased rates of spinal stenosis.

199.
D Acne vulgaris
This patient has idiopathic intracranial hypertension, commonly seen in overweight adolescent females. It can also be associated with medication use, notably vitamin A, isotretinoin, and tetracycline, antibiotics used to treat acne.

200.
C Defibrillation
This patient has an unstable ventricular tachycardia, and immediate defibrillation is indicated in the patient who is unconscious. Even in the conscious patient, synchronized cardioversion should be performed in the unstable state.

201.
D Etomidate
Of the anesthetic agents listed, etomidate causes depression of ACTH release.

202.
A Aqueductal stenosis
This MRI demonstrates an aqueductal web, causing aqueductal stenosis and hydrocephalus. The lateral and third ventricles are dilated, but the fourth ventricle is normal in caliber, leading to the diagnosis of aqueductal stenosis.

203.
B 4 months
Cranial molding helmets are used in the postoperative period after craniosynostosis surgery. Patients should be older than 4 months prior to utilization of a postoperative helmet, and this is often why surgery for craniosynostosis is delayed until after 4 months.
204. D *Staphylococcus epidermidis*

Shunt infections are often caused in both the early and late stages by the organism *Staphylococcus epidermidis*. This is most likely due to the ability of this organism to form biofilms on foreign material.


205. C Dentate nucleus

The dentate nucleus is one of the deep cerebellar nuclei and is heavily involved in coordinated movement of the extremities. Destruction can lead to decomposition of movement and intention tremor.


206. B Diffuse idiopathic skeletal hyperostosis

These imaging studies demonstrate the classic “flowing bone” or candle-wax bone that is consistent with DISH. While these patients are bone formers, they can have brittle bone that is susceptible to damage easily.


207. A CA1

These images demonstrate mesial temporal sclerosis as the underlying etiology for this patient’s seizures. The abnormal foci within the hippocampus are often in regions CA1 and CA4, the regions most susceptible to hypoxia.


208. D Neuronal migration

This patient has gray matter heterotopia, which can be very epileptogenic. These abnormalities are most likely due to aberrant neuronal migration during development, where nests of cortical neurons remain within the white matter rather than reaching the cortical surface.


209. B H⁺ ion influx

Taste is mediated by different chemical messaging systems. Of these, sour taste is mediated by acids and is associated with concentration of H⁺ ions.


210. E Golgi’s apparatus

O-linked glycosylation occurs when a sugar molecule is added to an oxygen atom in an amino acid residue in a protein. This occurs in the Golgi apparatus, compared to N-linked glycosylation, which occurs in the endoplasmic reticulum.


211. B Alar plate

The basal plate and alar plate are embryological regions that are separated by the sulcus limitans. Motor nuclei are located in the basal plate and sensory nuclei are located in the alar plate.


212. B Stria terminalis

The amygdala is connected to the septal area by the stria terminalis. This pathway generally connects the lateral aspect of the amygdala to the septal area, and the medial aspect is connected to the hypothalamus by the ventral amygdalofugal pathway.


213. C Brachioradialis

The radial nerve (via C6) innervates the brachioradialis, which can be observed when the patient flexes the arm in the pronated position.

214.
C  Acetylcholine
Sweat glands are innervated by postganglionic acetylcholine nerves, and therefore, acetylcholine is the neurotransmitter responsible for sweating.

215.
C  Arachnoid cap cells
This pathological specimen demonstrates a meningioma, which arises from arachnoid cap cells.

216.
A  Chromosome 3
The pathologic specimen demonstrates a cavernous malformation, as evident by multiple vascular channels next to each other. This should be differentiated from an AVM because a classic AVM will have intervening brain parenchyma. Familial cavernomatosis syndrome is associated with abnormalities on chromosomes 3 and 7.

217.
B  Aspirin
This image demonstrates an osteoid osteoma, with the classic targetoid presentation on imaging. These patients can have significant night pain and are often treated with aspirin, which is thought to decrease the surrounding inflammation causing the pain.

218.
C  Verapamil
The patient has a cluster headache and can be treated with high-flow oxygen for acute attacks or calcium channel blockers for prophylaxis, which have been shown to decrease frequency of cluster headaches.

223.
A  Multiple endocrine neoplasia type I
This pathologic slide demonstrates a pituitary tumor. It is apparent given the acinar appearance of the cells with large amounts of cytoplasmic inclusions. Pituitary adenomas can be seen in patients with MEN type I as well as tumors of the parathyroid and pancreas.

224.
C  Isoproterenol
Isoproterenol is a nonselective beta agonist that has significant inotropic effects on the heart. It also causes vasodilatation with beta 2 agonist properties. It can be used in cases of atropine-resistant bradycardia. Low-dose dopamine does not have significant inotropic effects.

225.
A  Publication bias
In this scenario, the resident is gathering together case series demonstrating the effectiveness of the technique and then publishing the aggregated results. This type of study is subject to significant publication bias. Since the manuscript is made up of previously published studies, it is extremely likely that only positive results were published previously, and therefore the outcome of the aggregate analysis will likely be positive. When performing reviews of multiple case series, the researcher should be aware of potential publication bias.

226.
D  Posterior ligamentous disruption
This MRI scan demonstrates a compression fracture with significant edema in the posterior ligamentous complex. It is also apparent that there is likely a disruption of the supraspinous ligament posteriorly. This should concern the evaluator that this patient may have a potentially unstable spinal fracture and operative intervention should be considered.

227.
C  Ophthalmic artery
The first intradural branch of the ICA is the ophthalmic artery.

228.
E  Epidermoid
This fourth ventricular mass has mixed density on the FLAIR scan, but is very bright on DWI, making epidermoid the most likely tumor in this patient. Epidermoid tumors are often thought to arise in the CP angle, but they can be seen as primary fourth ventricular tumors as well.

229.
B  Poorly enhancing ventricular mass
This pathologic slide demonstrates a subependymoma, and this is apparent by the “islands of blue in a sea of pink,” classic picture. These lesions are often in the lateral ventricular wall and do not enhance in many cases.

230.
E  Purkinje's cell
The cerebellar cortex contains several cell types. Of these, the Purkinje cell is the only output cell of the cerebellar cortex. The Purkinje cell projects to the deep cerebellar nuclei and is GABAergic.

231.
C  Hypoglossal nerve
The angiogram demonstrates greater than 90% stenosis of the ICA in this patient, and they would very likely undergo a carotid endarterectomy. During the exposure for a carotid endarterectomy, the hypoglossal nerve traverses the ICA and is observed in patients with a high-riding bifurcation.
II Answers

Care should be taken to avoid damaging the hypoglossal nerve.

232.  
A Trapezoid body  
The trapezoid body is a white matter tract of the brainstem that connects the cochlear nuclei to the superior olive. The lateral lemniscus then ascends bilaterally to the inferior colliculi.

233.  
D Broca's areas 18, 19  
The pulvinar is the large posterior thalamic nucleus that receives visual input and projects to the secondary visual cortex of the occipital lobe (Broca's areas 18, 19).

234.  
E Mesoderm  
The dura mater arises from mesoderm. The mesodermal layer also forms the skull and vertebrae.

235.  
B Fornix  
This surgical exposure through the temporal lobe demonstrates the hippocampal formation. The main output pathway of the hippocampus is the fornix, as part of the circuit of Papez, connecting the hippocampus to the mammillary bodies via the fornix.

236.  
D Chemosis  
This angiogram demonstrates a giant aneurysm of the cavernous sinus. These aneurysms are often stable as they are contained within the cavernous sinus. Rupture does not lead to subarachnoid hemorrhage, but it can create a carotid cavernous fistula, leading to ocular abnormalities, visual changes, proptosis, and chemosis.

237.  
D Hypokalemic metabolic alkalosis  
Aldosterone works in the kidney to retain sodium in exchange for potassium. In patients with hyperaldosteronism, potassium loss is significant, and patients develop a hypokalemic metabolic alkalosis.

238.  
D Diffuse ST changes  
The most common ECG finding in acute PE are diffuse ST changes.

239.  
B Heparin anticoagulation  
This patient likely has suffered an acute sinus thrombosis, most likely the left transverse sinus (TS) due to the associated hyperdensities and empty delta sign on CT. Left TS thrombosis can be associated with word-finding difficulties and aphasia. Seizures are also common after venous strokes from sinus thrombosis, much more common (40%) than in arterial strokes (5%). Anticoagulation with heparin is the first-line medical therapy.

240.  
A Microaerophilic streptococcus  
The most common causative organism isolated from intracerebral abscesses is microaerophilic streptococcus (including Streptococcus milleri). This is a commonly tested topic on the written boards.
241. C Chlorhexidine oral swabs
   Ventilator-associated pneumonia (VAP) can be seen in patients with prolonged intubation. Often-
etimes, *Pseudomonas* species are implicated. It can be seen in patients that are completely supine owing to aspiration of oral secretions. Patients should be placed in the semirecumbent position and chlorhexidine swabs should be used to keep the oral cavity clean and decrease the risk of VAP.

242. D Metoclopramide
   Metoclopramide (Reglan) is an agent sometimes used for patients with gastroparesis or GERD-like symptoms. It can have extrapyramidal side effects including a secondary Parkinsonism syndrome, and should be used carefully, especially in the elderly.

243. C Adult degenerative scoliosis surgery
   Adult degenerative scoliosis surgery is correct as the SVA is a useful measurement tool for global spine alignment. A plumb line is drawn from the midpoint of the C7 vertebral body and compared to the posterosuperior corner of the sacrum. The distance between the sacral point and the plumb line is the SVA, and for the best outcome this value should be less than 5 cm.

244. A Trisomy 13
   This X-ray demonstrates dextrocardia, which is associated with trisomy 13 and none of the other listed syndromes. The CT scan demonstrates sinusitis, and that finding is not helpful in this case. This syndrome (Patau’s syndrome) is also associated with polydactyl, cleft lip/palate, and holoprosencephaly.

245. B Central neurocytoma
   This is a heterogeneous mass that appears to arise from the septum pellucidum and causes obstruction of the foramen of Monro and subsequent hydrocephalus. Given the presentation and appearance on MRI, this is most likely a central neurocytoma.

246. E Lactate
   The MRI demonstrates a contrast-enhancing, cortically based mass with significant edema in a drug-using young patient. This is very likely to be an abscess. MR spectroscopy readings from the center of the necrotic mass will be high in lactate and amino acids, and these findings are not consistent with tumor.

247. D Norepinephrine
   The pineal gland is thought to synthesize serotonin, melatonin, and norepinephrine.

248. B Foot inversion
   An L5 radiculopathy can be distinguished from a common peroneal nerve abnormality by inversion of the foot. Foot inversion is innervated by L5, but it does not reach its destination via the common peroneal nerve, which controls foot dorsiflexion and eversion.

249. E Mediodorsal
   Korsakoff’s psychosis is a feared complication of acute thiamine deficiency seen in alcoholics. After persistence of thiamine deficiency beyond Wernicke’s syndrome, destruction of the mediodorsal thalamic nucleus and mammillary bodies
can lead to Korsakoff’s psychosis, with permanent memory impairment.  

250.  
E Nasociliary nerve  
The tendinous orbital ring of Zinn contains all structures except the LFTs (lacrimal nerve, frontal nerve, trochlear nerve, and superior/inferior ophthalmic veins). It is a commonly tested topic.  

251.  
C Arcuate fasciculus  
Pure conductive aphasia manifests clinically as inability to repeat phrases stated by the examiner. Patients will be able to name and converse appropriately, but repetition alone will be affected.  

252.  
A Restiform body  
The dorsal spinocerebellar tract is involved in proprioception, touch, and pressure from the lower limbs. They arise from the Golgi tendon organs and muscle spindles. They travel to Clarke’s nucleus in the spinal cord and then into the dorsal spinocerebellar tract. They enter the cerebellum through the inferior cerebellar peduncle via the restiform body.  

253.  
D Abduction  
The PPRF is closely associated with the abducens nucleus and is considered a lateral gaze center. The ipsilateral PPRF stimulates the ipsilateral abducens nerve to abduct the eye, and also sends fibers via the MLF to the contralateral oculomotor nucleus leading to conjugate adduction of the contralateral eye.  

254.  
C Stabilization of microtubules  
This formation demonstrates a neurofibrillary tangle of the hippocampus, made primarily of Tau protein. Tau protein functions to stabilize microtubules in the normal healthy neuron.  
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 121.

255.  
C Chloride  
Strychnine affects the glycine receptor as a competitive antagonist. This blocks the transmission of chloride, which is the ion transmitted by the glycine receptor.  

256.  
D Neurofibromatosis type I  
This pathologic specimen demonstrates evidence of a plexiform neurofibroma. You can discern the normal nerve as well as the multiple regions of plexiform neuroma surrounding the nerve. This tumor is associated with NF1.  

257.  
D Metastatic breast cancer  
Leptomeningeal carcinomatosis is a form of metastatic cancer spread where the tumor grows along the leptomeninges, leading to diffuse thickening of the dura. It is most commonly seen in breast and lung cancers.  
**258.**
A  Glioblastoma

This MRI demonstrates a classic, butterfly glioma. There is a rim-enhancing lesion that extends across the corpus callosum. While lymphoma is possible, this is a classic appearance of glioblastoma and remains the most likely diagnosis.


**259.**
D  Decreased metabolic activity

PET studies can be useful in seizure localization, but it is difficult to obtain an ictal PET study. Interictal PET studies demonstrate a decrease in metabolic activity of the seizure focus. Perfusion is demonstrated by SPECT studies.


**260.**
B  Gelastic seizures

This pathologic specimen demonstrates a hypothalamic hamartoma, as evidenced by two neuronal types, both a large ganglion cell and smaller neurocytes in a neuropil background. The NeuN stain helps identify neurons in both cell types. These tumors present in the hypothalamus and these patients present with behavioral abnormalities and gelastic seizures.


**261.**
C  Manganese

Toxic levels of the element manganese can lead to a Parkinsonism-like syndrome with rhythmic movements and bradykinesia. It is often seen in welders who inhale toxic fumes. The Parkinsonism-like syndrome is due to manganese deposition in deep gray nuclei.

Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 303.

**262.**
C  Ethmoidal arteries

This is an olfactory groove meningioma and oftentimes these tumors receive significant blood supply from the anterior and posterior ethmoidal arteries (arising from the ophthalmic artery, but the ophthalmic artery is not directly feeding the tumor in this case).


**263.**
D  Endovascular transvenous coiling

This angiogram demonstrates an indirect carotid cavernous fistula (CCF). It can be seen that the fistula is arising from small ICA branches rather than the ICA itself. Some of these indirect fistulas will close spontaneously, but others require treatment. Transvenous coiling is the most preferred approach since the endovascular catheters cannot traverse the small branches to enter the cavernous sinus. This differs from direct CCFs where a transarterial approach is preferred as the catheter can directly cross the defect in the ICA.


**264.**
C  GH

Acromegaly is caused by functioning pituitary adenomas that release growth hormone. Ultimately, growth hormone stimulates the production of IGF-1, but IGF-1 lasts much longer in serum than growth hormone (think HgbA1c for glucose). In order to determine if the tumor has been significantly reduced or completely removed, check a growth hormone.


**265.**
C  6 to 8 hours

According to the national guidelines put forth by anesthesiologists, after a solid food meal, patients should wait between 6 and 8 hours before induction of anesthesia to prevent aspiration of gastric contents.


**266.**
A  Needle decompression

This patient underwent a transcavitary endoscopic approach to a thoracic disk and they are experiencing tension pneumothorax in the PACU. They should undergo immediate needle decompression and chest tube placement to relieve the intrathoracic pressure.
II Answers


267.  
C Crystalloid  
This patient with TBI has septic shock and the best initial management is with administration of crystalloid solutions to support the blood pressure in this patient with distributive shock. There is some controversy regarding colloid versus crystalloid, but colloid solutions can have detrimental effects in patients with severe TBI; thus, crystalloid is a better option.  

268.  
B Zidovudine  
Myopathy can be a component of HIV infection but can also be caused by the administration of HAART for AIDS. It is most often seen in patients taking zidovudine.  

269.  
D Positive predictive value  
The positive predictive value of a test is useful for clinicians to determine how likely it is for a patient with a particular positive test to have the disease. It factors in the overall disease prevalence in the population being tested.  
Further Reading: https://www.med.uottawa.ca/sim/data/Sensitivity_and_Prevalence_e.htm.

270.  
D Cavernous Malformation  
This angiogram demonstrates a developmental venous anomaly in its classic appearance. They should not be resected as they can lead to venous strokes in eloquent cortex. They can be seen in patients with cavernous malformations.  

271.  
C Mass effect  
The encephalomyosynangiosis technique involves directly placing the temporalis muscle on the surface of the brain, allowing for collateralization of flow directly to the hemisphere. Major disadvantages include cosmetic deformities and mass effect on the brain.  

272.  
A Alpha to theta  
Stage I sleep represents a change from background alpha activity to a more low, rhythmic theta rhythm.  

273.  
B Levetiracetam  
This patient has liver failure, and levetiracetam is an excellent choice as it is metabolized by the kidney. Valproic acid should be avoided in liver failure.  

274.  
C Cobalt–chromium  
The young's modulus of an implant is the slope of the line on its stress/strain curve. Cobalt–chromium has the highest slope of the choices listed here. This means it is the stiffest construct of the mentioned possibilities. It is the most resistant to deformation at equal stress loads.  

275.  
B Surgery will improve ICP but worsen outcome  
The DECRA trial was published in 2011 and sought to determine efficacy of decompressive hemicraniectomy in patients with diffuse, severe TBI and elevated ICPs. Ultimately, it was found that decompression decreased ICPs and ICU time, but led to a worsened overall outcome compared to maximum medical management. This remains a controversial issue, and is undergoing further study. The DECRA trial has several methodological issues, and further surgical trials are ongoing.
Cervical kyphosis
Cervical laminoplasty is a technique designed to treat cervical stenosis while attempting to preserve posterior ligamentous complex integrity. It is contraindicated in patients with kyphotic deformity, and patients with kyphotic deformity have worse outcomes after undergoing laminoplasty compared to other procedures, including ACDF/corpectomy.

Meningohypophyseal trunk
This is a tentorial and petrous apex meningioma. In many cases, these tumors are fed by the tentorial artery (artery of Bernasconi and Cassinari), a branch of the meningohypophyseal trunk.

Improved local and distant control
There is level I evidence that patients who undergo surgical resection, followed by whole brain radiation have decreased rates of local recurrence and distal recurrence. There are cognitive deficits that develop after WBRT, starting generally at 4 months, so this should be considered during treatment. Multiple studies are currently evaluating SRS versus WBRT alone or in combination.

Pars
A defect in the pars can be very destabilizing. Isthmic spondylolisthesis occurs with bilateral pars defects.

Ulnar nerve
To restore elbow flexion, many surgeons will perform the Oberlin procedure, whereby a donor fascicle from the ulnar nerve (that innervates the flexor carpi ulnaris) is dissected free and coapted with a branch to the brachialis as close to the muscle as possible in order to decrease reinnervation time.
II Answers

Further Reading: Mackinnon, Yee. Nerve Surgery, 2015, page 439

285. B Endothelial tight junctions
The blood–brain barrier is made primarily of
 capillary tight junctions. It is permeable to lipid
 soluble compounds, oxygen, CO₂, and water.
Further Reading: Citow, Macdonald, Refai. Comprehen-

286. B Granule cell
There are multiple cell types in the cortex of the
cerebellum, but the only excitatory cell is the gran-
ule cell. These are inhibitory.
Further Reading: Citow, Macdonald, Refai. Comprehen-

287. C Norepinephrine
Sympathetic postganglionic fibers of the nerv-
ous system use norepinephrine as the neu-
rotransmitter for nerve transmission.
Further Reading: Greenstein, Greenstein. Color

288. B Corpus callosum
This patient likely has diffuse axonal injury,
damage caused by shearing forces applied to the
brain tissue. Oftentimes, these patients remain
comatose despite adequate resuscitation and a
“relatively” negative head CT. MRI can confirm the
diagnosis of DAI, oftentimes demonstrating diffuse
microhemorrhages, but obvious involvement of
the corpus callosum.
Further Reading: Anzai, Fink. Imaging of Traumatic
Brain Injury, 2015, page 22.

289. B Multiple cranial neuropathies
This patient demonstrates cortical thickening
with evidence of remodeling of bone and irregular
calcification. It is classic for Paget’s disease of bone.
These patients often present with multiple cranial
neuropathies as the foramina tend to hypertrophy
and cause compression of the nerves.
Further Reading: Meyers. Differential Diagnosis in

290. A Left common carotid from brachiocephalic
trunk
The classic “bovine arch” occurs when the left
common carotid artery arises from the brachioce-
phalic trunk rather than directly from the aortic
arch in normal anatomy.
Further Reading: Prestigiacomo, Duffis, Gandhi. Sur-
gical Endovascular Neuroradiology, 2015, page 84.

291. B Infection
This is a distal MCA aneurysm, and often aneu-
rysms that are in the distal circulation are mycot-
ic aneurysms due to an infection, often caused by
staph aureus.
Further Reading: Spetzler, Kalani, Nakaji. Neuro-

292. C Tau protein
This pathology slide demonstrates a neuro-
fibrillary tangle, which is an abnormality com-
posed of tau protein, seen in Alzheimer’s disease.
Further Reading: Borsody, Comprehensive Board

293. B Elevated maternal serum alpha fetoprotein
This fetal ultrasound demonstrates biconcav-
ity of the frontal bones and a banana sign (mal-
formation) of the brain. These two findings are
consistent with a diagnosis of probable myelome-
ningocele with a high sensitivity and specificity.
Further testing would demonstrate elevated MSAF.
Further Reading: Albright, Pollack, Adelson. Prin-
ciples and Practice of Pediatric Neurosurgery, 3rd

294. A Tuberous sclerosis
Tuberous sclerosis is a neurocutaneous syn-
drome that is associated with subependymal giant
cell astrocytomas as well as cortical malformations
(tubers) and seizures.

295.
C Functional hemispherectomy
Rasmussen's encephalitis often involves one hemisphere and can lead to severe volume loss in one hemisphere as well as medically refractory epilepsy. Often patients have severe weakness or plegia of the contralateral limbs. Functional hemispherectomy can help decrease the seizure rates in these patients.


296.
B Polyphasic symptoms
In some patients, it can be difficult to determine whether a region of contrast enhancement or T2 signal intensity on MRI is due to stenosis, spinal cord astrocytoma, or multiple sclerosis. One of the keys to determining that a patient has multiple sclerosis is the polyphasic nature of the symptoms.


297.
B Meniere's disease
This patient exhibits classic symptoms of Meniere's disease, which can lead to unilateral ear fullness, hissing tinnitus that is often low pitched. Vertigo can also be present. Initial treatment includes low salt diet, diuretics, and meclizine.


298.
C Back-wall ascending pharyngeal artery
Occasionally, the ascending pharyngeal artery can arise from the back side of the carotid bifurcation and may not be seen or controlled by the exposing surgeon. When the arteriotomy is performed, if the ascending pharyngeal artery is arising from the back wall and is not seen, pulsatile flow can occur after the arteriotomy.


299.
B 14 mg
This patient needs to have her heparin reversed with protamine. The dose for protamine reversal is 1 mg of protamine for 100 U of heparin given over the last 3 hours.


300.
C Central core disease
Of the mentioned syndromes, central core muscle disease is very closely associated with malignant hyperthermia and these patients have an elevated risk of developing malignant hyperthermia after use of inhalational anesthetics.


301.
B ABO incompatibility
This patient is experiencing a classic, severe transfusion reaction caused by ABO incompatibility of blood products. This causes rapid cell lysis and can be fatal. Patients report an impending sense of doom and many report back pain. The transfusion should be stopped immediately.


302.
E Cimetidine
All of the listed agents are potent inducers of warfarin metabolism except for cimetidine, which inhibits the degradation of warfarin, potentiating its effects.


303.
A HBV
There is a high rate of coinfection with HBV in patients with HIV, as high as 70 to 80% of HIV patients demonstrate past or active infection with HBV.

304.
A Prevalence

Prevalence is a statistical term that is used to identify the number of patients with a disease at a specific point in time and within a group of a specific, defined number of individuals. This compares to incidence, which is the propensity to develop a disease over a time interval.


308.
D Cervical collar

This lateral X-ray demonstrates evidence of an odontoid fracture, likely a type II injury. A CT scan of the cervical spine should be obtained to better clarify the diagnosis. In an older patient with multiple comorbidities, surgery should be avoided if possible and treatment should include a cervical collar. Some patients treated with cervical collar do not fuse. For this patient, decreasing the risk of iatrogenic injury is key. There is controversy regarding appropriate age/comorbidity status warranting surgical fixation and via what approach.

Further Reading: Goel, Cacciola. The Craniovertebral Junction: Diagnosis, Pathology, Surgical Techniques, 2011, page 40

305.
C Meningioma

Meningiomas have progesterone receptors in their nuclei and during periods of hormonal influence seen in pregnancy, some meningiomas can exhibit increased growth rates.


309.
B Synaptophysin

Central neurocytomas are enhancing masses that often arise from the septum pellucidum of the lateral ventricle. Pathologically they stain for synaptophysin and this can be a differentiating factor from other ventricular tumors such as meningioma or subependymoma.


310.
B Globus pallidus interna

The STN is part of the indirect pathway of the basal ganglia, and it has excitatory, glutamatergic output to the medial globus pallidus, or the GPI.

311.  
B  Ultrasound of pump pocket  
This patient is exhibiting symptoms of opioid overdose, in this case likely due to a pocket refill. The provider mistakenly filled the pump pocket instead of the pump itself, leading to absorption and opioid overdose. Ultrasound would identify this fluid collection and help make the diagnosis.  

312.  
C  Gastric ulcer  
This patient had a prolonged surgery and prolonged intubation. Long surgery and intubation can lead to gastric ulcers and upper GI bleeding. This should be considered in a patient with these symptoms.  

313.  
A  Fusion  
This patient has evidence of DISH and a very unstable fracture. He has a complete spinal cord injury, but not treating this type of three column injury could result in worsening of his functional condition. Fusion should be performed.  

314.  
C  Endoscopic third ventriculostomy and biopsy  
This patient has a third ventricular tumor with hydrocephalus. There should be two goals for initial management of this patient. First, treat the hydrocephalus; second, obtain tissue for diagnosis. In some pediatric tumors (namely, germinoma), radiation and chemotherapy can adequately treat the tumor without debulking. An ETV with biopsy both treats the hydrocephalus and obtains tissue for diagnosis and is an excellent initial treatment choice.  

315.  
B  Aorta  
The oblique lateral, prepsaos approach allows access to the lumbar spine for intervertebral disk surgery. Approach should come from the left side to avoid vascular injury to the vena cava. Coming from the left side, the aorta lies just medial to the psoas muscle during this approach.  

316.  
C  50% chance of 50% reduction in frequency  
A vagal nerve stimulator (VNS) is a palliative option for disabling seizures. An easy-to-remember outcome measure for VNS implantation is that around 50% of patients experience a 50% or greater reduction in seizure frequency.  

317.  
B  Motor examination  
The most important factor in determining ambulatory status in patients with myelomeningocele is initial motor examination rather than involved level on imaging. It is important to obtain a full motor examination before repair of the myelomeningocele. Up to 89% of patients in their preadolescent years will ambulate, but this drops to 50% in adolescence.  

318.  
C  Angle between line drawn from sacral midpoint to femoral head and line perpendicular to sacral endplate  
The pelvic incidence is a useful spinopelvic parameter that should be considered when performing deformity surgery. It is not a mobile measurement and is based on the patient’s native anatomy. It is calculated as the angle between two lines, one drawn perpendicular to the sacral endplate and the other drawn from the sacral endplate to the femoral head.  
with visual fixation, a peripheral etiology is more likely.

320. C Brachial neuritis
This patient likely has brachial neuritis, also known as Parsonage–Turner syndrome. It is a rare condition that presents initially with severe shoulder pain that resolves, followed by weakness of muscles associated with one or more nerve distributions. It can be associated with recent infection, surgery, or exercise. It is thought to be benign and self-limited, with 90% of patients having full recovery by 3 years.

321. E Notochord develops
Of the following listed events, notochord development occurs first, during the gastrulation stage. The notochord allows the embryo to organize in a rostral-caudal orientation and helps induce formation of the neural tube. The other answers listed here all deal with neural tube development and differentiation.

322. A Anterior
This patient is experiencing tonic muscle contraction from excitation of the corticobulbar tract, which is located just anterior to the STN. Facial pulling can be seen when the lead is too anterior or lateral. The lead should be moved posterior in this case.

323. C Parotid gland
In this figure, the structure labeled “1” is the otic ganglion, and it supplies innervation to the parotid gland. Innervation of the parotid gland is via the glossopharyngeal nerve through the otic ganglion.

324. C Left T9–T12
The artery of Adamkiewicz is a radicular artery that is the main supplier of the thoracolumbar anterior spinal cord. It is seen on the left side between T9 and T12 in roughly 75% of patients.

325. B Type Ia sensory nerve
The myotatic reflex (stretch reflex) is the only monosynaptic reflex in the body, and afferent impulses are sent via type Ia sensory nerves from muscle spindles. They synapse on alpha motor neurons of the anterior horn cells.

326. C p53 mutation
p53 mutations can be seen in glioblastoma, but they are often present in patients who initially had a low-grade glioma that transformed into a higher grade neoplasm over time. This is similar to IDH mutations in that IDH mutant glioblastomas are more likely to have undergone malignant transformation than IDH wild-type GBMs, often seen in de novo GBMs.

327. D Metachromatic leukodystrophy
This MRI demonstrates diffuse FLAIR signal throughout the white matter of both hemispheres. You can appreciate that the subcortical U fibers are spared in this case, and of the answer choices, only metachromatic leukodystrophy spares the subcortical U fibers, making it the correct answer.
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 313.
328.
B Artery to artery embolism
This slide demonstrates classic red, dead neurons. They are shrunken and eosinophilic, which gives them the name red dead neurons. They occur after ischemia, and in this patient, artery to artery embolism resulting in cerebral infarction was the cause of death.

329.
C Calcified cephalohematoma
This CT scan demonstrates evidence of a calcified cephalohematoma, which can originally occur in neonates due to shearing forces of the galea during delivery. The vast majority of cephalohematomas resolve, but occasionally they will persist and calcify. Surgical decompression/resection is indicated in patients where there is documented calcification of a hematoma such as demonstrated here.

330.
D Photon
PET scanning is based on the annihilation of a positron when it interacts with an electron in the matter it passes through. When this occurs, two photons are released in opposite directions. The PET scintillators pick up both photons and determine they came from the same annihilation event. This is part of the basic fundamentals behind PET imaging.
Further Reading: Jain, Essig. Brain Tumor Imaging, 2015, page 156.

331.
B Bunina’s bodies
The Bunina body is a small, eosinophilic body located in the cytoplasm of anterior horn cells in patients with ALS.

332.
A Anterior
During test stimulation of VIM DBS, persistent paresthesias suggest that the lead is too far posterior, in Vc, and should be moved anteriorly.

333.
C p53 mutant
This pathological specimen demonstrates evidence of glioblastoma. Primary glioblastomas are most often IDH wild type, rather than glioblastomas that arise from malignant change occurring in lower grade gliomas, which can be IDH mutant, P53 mutant, and have LOH on chromosome 10.

334.
C Alpha synuclein
The structure demonstrated is a Lewy body, and it is composed primarily of alpha synuclein.
Further Reading: Kanekar. Imaging of Neurodegenerative Disorders, 2016, page 150.

335.
C 22M with generalized seizures originating in an unresectable location
Vagal nerve stimulation (VNS) has some efficacy in decreasing the frequency of seizures in patients with refractory epilepsy. It is often quoted that 50% of patients will experience a 50% or greater reduction in seizure frequency. VNS can be useful in patients with medically refractory epilepsy originating from a focus that is not surgically resectable.

336.
B IVIG
This patient has the AIDP variant of Guillain-Barré syndrome, a symmetric motor neuropathy that is ascending oftentimes following infection. Up to 30% of patients may require mechanical ventilation, but there is a less than 5% mortality. Methylprednisolone or dexamethasone should not be used as steroids have no efficacy in Guillain-Barré syndrome. IVIG or plasmapheresis should be utilized if his condition worsens.
337. **D** Mild macrocephaly, normal development

This patient has a condition that has been described as benign expansion of the subarachnoid space. It has not been shown to ultimately lead to hydrocephalus unless there is an underlying infection. These patients can be observed and often this condition results in mild macrocephaly with normal development/IQ.


338. **B** Eye, kidney, pancreas screen, and genetics consult

A posterior fossa hemangioblastoma should immediately make you think of VHL, which has associated tumors in other regions of the body, including the kidneys, the eyes, and the pancreas, among others. A genetics consult should be obtained as well.


339. **E** Inclusion dermoid

When closing a myelomeningocele, it is very important to dissect the placode free from the surrounding skin tissue. If skin tissue remains with the placode and then the placode is brought together to reconstitute the neural tube, the skin tissue may persist and lead to an inclusion dermoid in the future, requiring further surgical treatment.


340. **A** Left Trendelenburg positioning

Air embolism can occur in cases where the head is above the heart. Venous channels, especially located in bone, can remain open and start to draw in air. After irrigating and using bone wax, the patient should be put in the left Trendelenburg position, which traps the air in the right heart, decreasing the chance for the air embolus to enter the left heart and lead to ischemic stroke. The anesthesiologist can then draw the air out of the right heart via central catheters.


341. **B** Echocardiogram

This patient most likely suffered neurogenic cardiomyopathy, or Takotsubo’s cardiomyopathy. This can be seen after SAH and is thought to occur due to sudden, massive release of sympathetic factors causing calcium overload and decreased contractility of the myocardium. It is also termed stunned myocardium. It can lead to transient heart failure and pulmonary edema. Management is supportive as this process resolves in several days. Diagnosis is easily made with echocardiogram. The patient may require intubation, so should be monitored closely.


342. **D** FiO₂ 30%, PEEP 5, NIF–26 cm H₂O

There are several criteria for weaning a patient from the ventilator, and most patients are placed on a T-piece or other technique for trial of extubation to ensure that they will succeed and not require emergent reintubation. Easy figures to remember for ventilator weaning are as follows: FiO₂ <50%, PEEP 5, NIF <–25 cm H₂O.


343. **C** Increase the ventilator rate to 19

This patient is attempting to trigger the ventilator at 19 BPM, higher than your set rate of 14 BPM. The ventilator rate should be increased to the patient’s rate unless the breathing is so rapid that it leads to inadequate ventilation. If the patient has severe tachypnea, other causes of tachypnea should be evaluated, including discomfort, PE, infection, etc.

344.
C  Anterior clinoidectomy
   The origin of the ophthalmic artery needs to be understood during microsurgical clipping of an ophthalmic artery aneurysm. Its origin as well as the proximal aspect of the aneurysm can be obscured by the anterior clinoid process and therefore this structure should be removed in order to better expose the aneurysm for treatment.

345.
A  Observation
   The ARUBA trial was designed to compare medical management/observation with interventional strategies for brain AVMs. There are several methodological concerns with the trial and the results, but it did demonstrate a decreased rate of adverse outcome in patients treated medically. In the patient in question, a low-grade, frontopolar AVM could be observed, and that is likely the best initial management. This AVM, however, would have a very low risk of surgical resection.

346.
B  30%
   Based on two studies comprising almost 2,000 shunted patients, the risk of shunt failure requiring revision within 1 year is approximately 30%. Younger age (<2 years) has a higher risk.

347.
C  Normal distal conduction
   Immediately after nerve injury, distal conduction remains normal until Wallerian degeneration has had enough time to occur. There will be no MUAPs, but fibrillations and sharp waves will not have had enough time to develop.

348.
C  Eosinophilic granuloma
   This X-ray demonstrates evidence of an eosinophilic granuloma, often seen as a punched out lesion of the skull. It does not possess sclerotic margins like a skull epidermoid would. It can be easily excised surgically as long as the entirety of the mass is removed.

349.
A  Acetylcholine
   Acetylcholine is a very prominent neurotransmitter and it is utilized in all preganglionic nerves as well as the nerves innervating sweat glands.

350.
B  Basal plate and alar plate
   In the developing embryo, the sulcus limitans defines the border between the basal and alar plates. The basal plate contains the motor nuclei, and the alar plate contains the sensory nuclei.

351.
B  Insurance covers receiving hospital
   EMTALA is a law that governs patient care often in emergency room settings. It becomes important for neurosurgeons when they are working at facilities that may need to accept a patient due to a neurosurgical condition that the sending hospital cannot take care of. The law is meant to protect patients by disallowing hospitals to reject patients based on ability to pay, and therefore, insurance coverage does not factor into the process.

352.
B  Disclose your financial agreement and participate
   You have been asked to participate in formulating this statement, but you do have a conflict of interest that should be known to other members and documented officially. You should disclose your financial agreement to the group and continue to participate if it is deemed acceptable by the meeting committee.

353.
B  Cardiogenic pulmonary edema
   This patient has an elevated PCWP, at 22 mm Hg, which suggests heart failure and cardiogenic
pulmonary edema. The PCWP seen in ARDS is often less than 18 mm Hg.


354.
B Decrease “off” time
There are two current targets for DBS in Parkinsonism, STN, and GPi. Currently, many patients undergo STN stimulation as it requires lower current and it can have the effect of decreasing medication dosages by 50%. It also prolongs the “on” time and decreases the “off” time that is characterized by bradykinesia.


355.
D Optic chiasm
This image depicts the floor of the third ventricle and its associated structures. The optic chiasm is labeled “6” in this image. “8” corresponds to the ideal location for perforation during ETV.


356.
A Anterior
The cochlea lies just anterior to the facial nerve in the temporal bone. As the facial nerve gives off the GSPN, the “Y” that is created by the main trunk of the facial nerve and the GSPN houses the cochlea.


357.
C Tongue fasciculations
ALS and cervical myelopathy have similar presenting symptoms; however, ALS can cause bulbar palsies, such as tongue weakness and fasciculations, whereas cervical spondylotic myelopathy would not cause tongue weakness.


358.
C MRI/MRA yearly for 5 years
This patient is several months after direct STA-MCA bypass and has recovered well. The nature of this disease involves progression, and even though the patient is doing well, he should undergo yearly MRI/MRA for 5 years to observe for worsening of intracranial stenosis as well as monitoring of the contralateral hemisphere for development of ischemia.


359.
A Nerve root sleeve
This spinal angiogram demonstrates a dural arteriovenous fistula (dAVFs) of the spine. Type I spinal dAVFs arise from an abnormal connection that originates in the nerve root sleeve.


360.
B T lymphocyte
Active multiple sclerosis plaques demonstrate significant T-cell infiltration, since they are activated by proteins in myelin. This occurs before macrophage infiltration.


361.
A Observation
This X-ray/MRI demonstrates a hemangioma of bone. They can cause back pain or rarely nerve root compromise, at which point they should be treated. They also can lead to microfractures of the vertebral body. If consistently symptomatic, they can be treated with embolization or radiation; however, radiation should be avoided in children if possible.


362.
E Polymyositis
Polymyositis is a condition that causes symmetric, proximal muscle weakness that is painless. It also can cause dysphagia. It is seen in patients that are 30 to 50 years old and more predominately in females. On pathology, there is T-cell infiltration into individual muscle fibers, compared to dermatomyositis, where the infiltrate is perifascicular in nature.

19 Stand-Alone 375-Question Examination

363.
C Facilitated diffusion
Glucose is transported into the brain via facilitated diffusion. The GLUT 1 transporter is involved in FDG uptake into the brain for PET studies. Neurons do not require insulin for glucose uptake due to the facilitated diffusion across the GLUT family of receptors.

364.
C Posterior ligamentous complex disruption
This MRI STIR image demonstrates edema within the posterior ligamentous complex as well as evidence of disruption of the ligamentum flavum. This patient should be maintained in a cervical collar and very likely undergo stabilization surgery depending on the presence of other injuries of the spine and/or neurologic symptoms.

365.
C Detrusor hyperreflexia
Patients with incomplete spinal cord injuries often experience detrusor hyperreflexia, owing to the intact bladder reflex arc but disrupted inhibition from the pontine micturition center. This can lead to reflexive emptying of the bladder and urge incontinence.

366.
A Type I
ATPase helps identify type I (slow twitch) from type II (fast twitch) muscle fibers. Slow-twitch fibers are aerobic and utilize ATPase, while fast-twitch muscles are fatigable and utilize anaerobic metabolism.

367.
D Late subacute
This MRI demonstrates hyperintensity on both T1- and T2-weighted MRI scans. This places the hematoma in the late subacute stage, approximately 4 days to 1 month after the initial hemorrhage.

368.
C Frontal, parietal, temporal, and greater sphenoid wing
The Pterion is a junction point of the frontal, parietal, squamous temporal, and greater wing of the sphenoid bone. It is an external landmark that can often be seen. It is a helpful landmark for identifying the correct location for a keyhole burr hole.

369.
A Observation
This patient has a brain stem cavernous malformation with an associated developmental venous anomaly. At this point, she is back to her neurologic baseline and should be simply observed. There is controversy regarding radiation to cavernous malformations and their efficacy, and at this point the natural history of these lesions is not well enough understood to determine the risk/benefit ratio of radiation to the brainstem. This lesion also does not readily come to the surface, which would make surgery challenging and dangerous. Observation is recommended.

370.
B Adequate bony fusion
The most significant factor when deciding to perform a fusion for spondylolisthesis is achieving a good bony fusion at the operative levels. Bone fusion at follow-up is associated with the best long-term outcome in patients.

371.
D Forniceal column
Just anterior to the foramen in the lateral ventricle is the column of the fornix. Care should be taken during ETV to avoid too much anterior force by the scope, which could cause pressure against the fornix.
372.
C  Four-week prolongation of life expectancy
   In patients with single-level malignant epidural spinal cord compression, surgical decompression leads to higher rates of ambulation post-op as well as prolongation of life expectancy from 100 to 126 days. Many factors need to be considered prior to surgery, including stability, life expectancy, and radiosensitivity of the specific tumor type.

373.
B  Stereotactic radiosurgery
   This patient has a small but symptomatic acoustic neuroma. He has medical comorbidities making surgical resection complicated. There is some controversy regarding conservative management versus treatment, but this patient is symptomatic and radiosurgery provides an excellent treatment with low complication rates and high rates of preservation of facial nerve function.

374.
B  FFP
   This patient is exhibiting dilutional coagulopathy during massive transfusion. Fibrinogen levels should be monitored during resuscitation and FFP should be administered to avoid ongoing coagulopathy.

375.
B  Second degree (Mobitz type I)
   This ECG description refers to second-degree heart block, Mobitz type I, also known as Wenkebach. It is characterized by progressive lengthening of the PR interval until a beat is dropped.