Chapter e72: Evaluation of Neurological Illness

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KEY CONCEPTS

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1. Accurate diagnosis of neurological disorders leads to effective pharmacotherapy.
2. The clinical neurologic history and examination are the cornerstones of neurologic diagnosis and management.
3. History and examination should be modified for the pediatric patient as appropriate.
4. The neurologic history and examination are directed at localizing the disease process to derive a differential diagnosis.
5. After forming the differential diagnosis, appropriate testing helps pinpoint the correct diagnosis.
6. Accurate diagnosis leads to appropriate therapy and management of neurologic conditions.
7. Specific neurologic history and examination are useful for monitoring and evaluating the pharmacotherapeutic plan.
8. Lumbar puncture (LP) should only be performed when it can be done safely. Relative contraindications may include increased intercranial pressure, mass lesions, papilledema, and coagulopathies.

BEYOND THE BOOK

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Watch the video entitled "The Neurologic Screening Exam" in AccessPharmacy by Daniel H. Lowenstein.
https://accesspharmacy.mhmedical.com/MultimediaPlayer.aspx?MultimediaID=12986884

This 9-minute video provides a brief overview of the neurologic examination including all five components. This visual depiction will aid in student understanding of the examination. The information collected in the neurologic examination is used in the COLLECT and FOLLOW-UP steps in the patient care process.

INTRODUCTION

1 2 Accurate diagnosis of neurological disorders leads to effective pharmacotherapy. This diagnosis is built upon history, a detailed neurological examination, and appropriate testing. To contribute most effectively to the care of patients with neurologic illness, one must understand the tools used in the diagnosis and management of these patients. In addition, clinicians must be able to gather their own data through patient history and targeted neurologic examination to ensure optimal pharmacotherapy. Despite technological advances and development of sensitive diagnostic tests,

the clinical neurologic history and examination are still the cornerstones of diagnosis and management.[1]

SIGNS AND SYMPTOMS OF NEUROLOGIC DISORDERS

As in all of medicine, obtaining an accurate and complete history is of utmost importance in the evaluation of neurologic diseases. In many instances, the differential diagnosis can be made on the basis of the history, and the neurologic examination can be tailored to optimally evaluate the patient and confirm the diagnosis.[1] Open-ended questions allow the patient to provide the salient history without leading the patient toward preconceived diagnoses. Obtaining an accurate history may be difficult because a number of neurologic diseases potentially affect communication and memory. The details obtained from family or other observers support and further expand patient reported history; additionally, family medical history can be helpful in diagnosis.[1] Through patient history, one can determine the main symptoms, location, onset (acute, subacute, or chronic), progression over time (maximal at onset or steadily gaining intensity), and associated illnesses or risk factors for neurologic disease.[2] The history should also identify factors that might precipitate or ameliorate the symptoms.[2] Each patient complaint should be thoroughly investigated while taking the history. See Table e72-1 for questions to assist the clinician in obtaining the neurologic history.

TABLE e72-1

Questions to Ask Regarding Neurologic Symptoms

For each symptom:

- How would you describe the symptom (quality, severity)?
- Where is the symptom?
- When did it begin?
- Did it start suddenly or slowly?
- Has it stayed the same/improved/worsened?
- Does anything make the symptom occur?
- Does anything improve/worsen the symptom?

Data from Reference 2.

Special attention should be given to the medication history including current medications, doses, dosing schedule (times, relationship to other medications and meals), duration, and adherence. Adverse effects should be recorded in detail. Past and recently discontinued medications as well as any medications used previously, including reasons for discontinuation, to treat the main complaints are important. Clinicians should also consider if the patient's symptoms may be medication-induced.

3 Additional history is necessary for pediatric patients. The child should be allowed to provide as much history as he/she is developmentally able to do so. Because of the differing developmental stages of children, the amount of information the child is able to provide will vary with age. History may be obtained from the patients, guardians, or caretakers rather than the child in most cases.[3] Family history is particularly important because some pediatric neurological illnesses have a genetic cause.[3] History of the pregnancy, including maternal illnesses, medication or toxin exposures, and complications, should be noted.[3] The details of labor and delivery including duration, method of delivery, and complications may also be important.[3] Developmental history requires a comparison of the child's developmental stage to standard age-related developmental milestones.[3]

THE NEUROLOGIC EXAMINATION

4 A general physical examination is important because it can reveal evidence of systemic disease that may secondarily affect the nervous system.[2] The neurologic examination is one component of a complete general physical examination. A detailed neurologic examination is an extremely important tool for localizing a lesion within the nervous system.

The neurologic examination consists of seven main components: higher cortical function (mental status), cranial nerves, motor function, reflexes,

cerebellar function, sensory function, and gait.[2] Table e72-2 describes the common approaches to assessing each of the seven domains and includes examples of the diseases in which abnormal findings are common. Readers are encouraged to consult other references to better understand the intricacies of the neurologic examination.[4,5]

TABLE e72-2

Neurologic Complaints and Corresponding Examination

Domain	Common Complaints	Example Tests or Assessment	Example Diseases with Abnormal Findings
Mental status	Confusion, forgetfulness, disorientation, speech difficulties, calculation difficulties, lack of facial recognition	While obtaining the history: general mental and emotional status, speech, memory, alertness, abstract reasoning, ability to follow commands (motor integration), ability to communicate	Dementias, stroke, metabolic encephalopathies
Cranial nerves	Blurred vision, ptosis, diplopia, anosmia, dysgeusia, dysarthria, dysphagia, facial asymmetry, tinnitus	Visual acuity, visual fields, eye movements, jaw strength, corneal reflex, facial symmetry, auditory acuity, gag reflex, shoulder and neck strength	Myasthenia gravis, stroke, ALS, Bell palsy
Motor function	Weakness, muscle cramps, muscle twitches, dropping items, muscle wasting, shaking	Motor strength with and without resistance tremors, atrophy, fasciculations, hypertonia, hypotonia	Stroke, myasthenia gravis, Parkinson disease, ALS, essential tremor
Reflexes		Deep tendon reflexes, plantar response, superficial cutaneous reflexes (eg, abdominal)	Stroke, spinal cord lesions, peripheral neuropathy, ALS, multiple sclerosis
Sensation	Tingling, numbness, burning, throbbing	Asymmetry or decreased sensation to pinprick, vibration, temperature, position	Stroke, peripheral neuropathy, spinal cord lesions
Cerebellar function	Unsteady gait, incoordination, tremor, speech abnormalities	Nystagmus, saccades, coordination (rapid alternating movements, finger-to-nose test, heel-to-shin test, finger tapping)	Stroke, posterior fossa tumors, alcoholic cerebellar degeneration
Gait	Unsteadiness, falls, tripping, freezing, slow gait, poor balance	Walking (tandem, on heels, on toes), standing (Romberg test—closing eyes tests proprioception)	Stroke, Parkinson disease, spinal cord lesions, multiple sclerosis

ALS, amyotrophic lateral sclerosis.

Data from Reference 2.

3 5 6 7 The neurologic examination of pediatric patients should be adapted for age and developmental stage. Some adaptations of the standard examination techniques may include observing walking and playing for cerebellar and motor function or observing facial expressions, withdrawal, and responses to tactile sensory stimulation to assess sensory function.[6] Assessment of the weight, height, and head circumference and evaluated with reference to age- and gender-adjusted charts to identify any abnormalities.[7] In infants, the fontanels should be assessed for size and noted as to whether they are open or closed.[6] Specific pediatric neurology texts may be consulted for more detailed examination techniques for

children.[3,8] The clinician must synthesize the results of the history and physical examination to arrive at an anatomic localization of the lesion and create a differential diagnosis, then use appropriate testing to help pinpoint the correct diagnosis. Accurate diagnosis leads to appropriate therapy and management of neurologic conditions. Repeat assessment of the history and examination are essential to customizing, monitoring, and evaluating a pharmacotherapeutic plan for an individual patient. For example, motor examination techniques can assist with evaluating the usefulness of Parkinson's disease therapy.

LABORATORY FINDINGS FOR NEUROLOGIC DISORDERS AND THEIR INTERPRETATION

8 Laboratory testing should be guided by the differential diagnosis for each patient; examples include treponemal testing for neurosyphilis, creatine kinase for myopathy, or vitamin B_{12} for peripheral neuropathy. One of the most neurologic-specific laboratory tests is the examination of the cerebrospinal fluid (CSF). Lumbar puncture (LP) is used to obtain CSF for further evaluation. It is used most often as an evaluation for markers of central nervous system infections, such as meningitis and encephalitis, but it is also useful in diagnosing subarachnoid hemorrhage or multiple sclerosis.[2] A long needle is inserted between the vertebrae of the lumbar spine and CSF is drained through the needle into collection vials (Fig. e72-1).[9] Opening pressure, blood cell count and differential, glucose concentration, total protein concentration, Gram stain, culture, and sensitivity are measured routinely. Normal CSF laboratory values are given in Table e72-3.[9,10] A space-occupying lesion in the brain with mass effect is a relative contraindication to LP because herniation of the brainstem could result.[9,10] Before performing an LP, the patient should be checked for papilledema, which may indicate increased intracranial pressure. Additionally, coagulopathies are a relative contraindication because of the difficulty of compressing the site of the LP.[9]

FIGURE e72-1

Lateral decubitus position for lumbar puncture. The lumbar puncture needle is usually inserted in the L3-L4 or L4-L5 space. (*Adapted from Investigative studies. In: Simon RP, Aminoff MJ, Greenberg DA, eds. Clinical Neurology, 10th ed. New York: McGraw Hill; 2017.*)

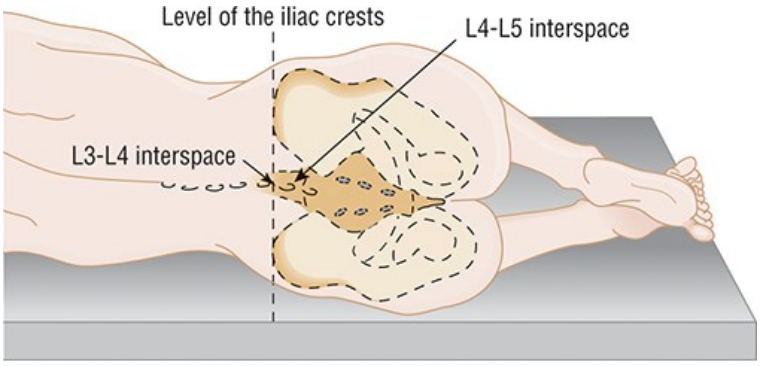


TABLE e72-3

Commonly Obtained Cerebrospinal Fluid Measurements

Laboratory Value	Normal Value	Common Abnormalities	Abnormalities May Suggest
Color	Clear	• Xanthochromia • Turbidity	• Subarachnoid hemorrhage • Meningitis, encephalitis
Opening pressure	Less than 20 cm H_2O (2.0 kPa) (adults) Less than 28 cm H_2O ((2.7 kPa) (children)	Increased pressure	Hydrocephalus, cerebral edema
Protein	0.15-0.50 g/L	Increased protein	Trauma, infection, cerebral hemorrhage, subarachnoid hemorrhage, tumor
Glucose	30-60 mg/dL 1.7-3.3 mmol/L	Decreased glucose	Bacterial meningitis
White blood cells	Less than or equal to 5 cells/mm^3 (5×10^6/L)	Greater than 5 cells/mm^3 (5×10^6/L)	Meningitis, encephalitis
Red blood cells	0 cells/mm^3 (0×10^6/L)	Greater than 0 cells/mm^3 (0×10^6/L)	Subarachnoid hemorrhage, cerebral hemorrhage, traumatic lumbar puncture
Bacteria	0	Positive	Meningitis, encephalitis

Data from References 9 and 10.

ASSESSING NEUROLOGIC DYSFUNCTION

In addition to the history, neurologic examination, and laboratory examinations, certain imaging techniques and procedures may be essential in the diagnosis of neurologic disorders. Electroencephalography (EEG) records the electrical activity of the brain through electrodes placed on the scalp. The record is interpreted by observing the basic rhythms and waveforms, the symmetry of the recording, and abnormal electrical discharges.[9] It also may be used to assess the response to photic stimulation or hyperventilation. While used primarily in the diagnosis of seizures, EEG may be helpful in the evaluation of patients with altered mental status. In some cases, long duration (more than 24 hours) EEGs are obtained, but most are approximately 30 minutes in length.[9]

Evoked potentials can be used to measure the responses to electrical signals sent along various sensory pathways (visual, auditory, and somatosensory)[9] to examine conduction along those pathways. It may be helpful for localizing a lesion within sensory pathways and may be useful in evaluating conditions such as spinal cord lesions, hearing problems, and multiple sclerosis.

Electromyography (EMG) and nerve conduction velocities (NCVs) are used to assess the function of the peripheral nerves, neuromuscular junction, and muscles.[9] Measuring NCVs involves stimulating the nerve and recording the speed and amplitude of conduction of the impulse. It can be used to detect the presence of localized peripheral nerve injuries (eg, carpal tunnel syndrome) or diffuse neuropathies[9] and to look for neuromuscular junction disorders such as myasthenia gravis. Muscle dysfunction as a result of primary muscle disease or secondary to nerve injury can be assessed with EMG.[9] A needle is placed in the muscle to measure the resting and contractual electrical activity of the muscles to help diagnose peripheral neuropathies,

amyotrophic lateral sclerosis, radiculopathies, and muscle diseases.[9]

DIAGNOSING NEUROLOGIC ANATOMIC ABNORMALITIES

Modern radiological imaging provides the clinician with several modalities to examine anatomical lesions of the nervous system itself and its vasculature. Computed tomography (CT) uses x-rays to produce images of thin "slices" of the brain.[9] It is currently available in most communities and is used to evaluate patients with intracranial disease. Because CT scans can be done relatively rapidly, they are used to evaluate patients in urgent circumstances (eg, acute ischemic stroke or hemorrhage) as well as less urgent assessment to identify tumors, hydrocephalus, atrophy, and other intracranial pathologies.[9] Intravenous contrast agents can provide imaging of vessel structure; they may also be used to identify areas of breakdown of the blood–brain barrier as the result of abscesses, other inflammatory conditions, aneurysms, tumors, or stroke.[9]

Magnetic resonance imaging (MRI) uses the magnetic properties of the hydrogen atom to produce computer-processed scans that provide improved anatomic detail compared with CT scans.[9] Advantages of MRI include better differentiating between white and gray matter and delineating lesions close to bone (brainstem and cerebellum) and has no radiation risk; however, it is not as readily available as CT, takes longer to perform, and is more expensive.[9] Patients who have metal implants or who have claustrophobia may be unable to undergo MRI. It has a proven advantage over CT in evaluating lesions in the posterior fossa and in detecting lesions in the white matter, such as plaques in multiple sclerosis.[9] MRI is also useful in the diagnosis of tumors and very early ischemic stroke (eg, diffusion-weighted imaging).

The cerebral circulatory system can be imaged or evaluated in a number of ways, depending on the type and location of the abnormality suspected. Imaging techniques can be used to identify local arterial stenosis, aneurysms, and vascular malformations.[9] Atherosclerosis of the extracranial arteries, a frequent cause of stroke, can be evaluated using ultrasonography (referred to as duplex sonography, carotid Doppler, or color-flow Doppler), magnetic resonance angiography (MRA), or computed tomographic angiography (CTA).[9] The intracranial arterial circulation can be evaluated using transcranial Doppler, MRA, CTA, or conventional dye angiography.[9] Each technique has its own advantages and disadvantages. Conventional dye angiography provides the best imaging of the smaller arteries of the cerebral circulation but is more invasive than the other measures.[9]

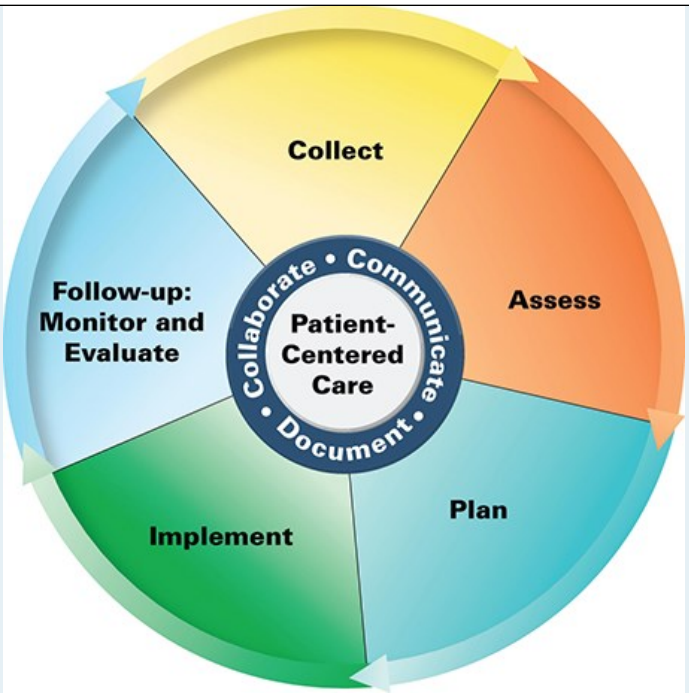
Imaging of the spinal canal and its contents can be accomplished by conventional dye myelography, CT myelography, CT, or MRI. Myelography refers to injecting a contrast agent via LP into the CSF, which is then imaged by x-ray (conventional dye myelography) or CT scan.[9] Myelography outlines the spinal cord and provides indirect information about the spinal cord, nerve roots, and surrounding structures. Direct imaging of the soft tissue of the spinal cord can be obtained via CT or MRI, although MRI provides higher quality images for structures around bones than CT because the bony structures cause the x-ray beams to scatter and produce artifacts on the images.[9] Compressive lesions and fractures can be identified by any of these methods; soft tissue lesions such as tumors, radiculopathies, and vascular malformations are better seen by MRI.[9]

SPECIAL PROCEDURES USED IN THE DIAGNOSIS OF NEUROLOGIC DISORDERS

Other imaging techniques, such as positron emission tomography (PET), single-photon emission computed tomography (SPECT), and functional MRI (fMRI), are considered tests of brain function. These tests are being studied extensively in epilepsy as well as in cerebrovascular disorders, cerebral tumors, movement disorders, and dementia.[9] Using a positron-emitting isotope, PET scans can image regional metabolic changes in the brain.[9] Measuring radiotracer uptake by tissues, SPECT scans assess cerebral blood flow. Although the resolution of SPECT is not as good as PET, it has use in localizing epileptic foci.[9] Functional MRI visualizes blood flow to focal areas of the brain by measurement differences in oxygenated blood concentrations to determine areas of greater activity.[9] Unlike PET scans, injection of radioactive isotopes is not necessary with fMRI. It is used for epilepsy and cognitive research.

PATIENT CARE PROCESS

Patient Care Process for Neurological Evaluation



Collect

- Patient characteristics (eg, age, sex, pregnancy status)
- Patient medical history (personal, family, birth, and developmental) (see section "Signs and Symptoms of Neurologic Disorders"; Table e72-1)
- Social history (eg, tobacco/ethanol use)
- Current and previous medications including nonprescription medications, herbal products, and dietary supplements (see section "Signs and Symptoms of Neurologic Disorders")
- Objective data
    - Neurologic examination (ie, higher cortical function, cranial nerves, motor function, reflexes, cerebellar function, sensory function, and gait) (see section "The Neurologic Examination"; Table e72-2)
    - Blood pressure (BP), heart rate (HR), height, weight
    - Laboratory examinations as appropriate for the differential diagnosis and possibly including examination of the CSF (see section "Laboratory Findings for Neurologic Disorders and Their Interpretation"; Table e72-3; Fig. e72-1)
    - Imaging studies as appropriate (eg, CT of head) (see section "Diagnosing Neurologic Anatomic Abnormalities")
    - Electrophysiology studies as appropriate (eg, NCVs, EMG, and EEG) (see section "Assessing Neurologic Dysfunction")

Assess

- Results of history and neurological examination
- Ability/willingness to obtain diagnostic testing (eg, insurance coverage, travel, undergoing invasive testing)
- Relative contraindications for lumbar puncture (see section "Laboratory Findings for Neurologic Disorders and Their Interpretation")
    - Relative contraindications for MRI (see section "Diagnosing Neurologic Anatomic Abnormalities")

- Emotional status (eg, presence of anxiety, depression)

Plan*

- Order appropriate diagnostic testing
- With established diagnosis, develop therapeutic plan (see disease-specific chapters)
- Monitoring parameters including efficacy and safety of any therapies; frequency and timing of follow-up
- Patient education regarding testing and diagnosis
- Referrals to other neurology specialists when appropriate (eg, memory disorders, stroke)

Implement

- Provide patient education regarding all elements of evaluation and treatment plan
- Use motivational interviewing and coaching strategies to maximize adherence to any therapies
- Schedule follow-up

Follow-up: Monitor and Evaluate

- Resolution of neurologic symptoms
- Presence of adverse effects of therapy
- Patient adherence to treatment plan using multiple sources of information
- Reevaluate as needed

****Collaborate with patients, caregivers, and other healthcare professionals.***

CONCLUSION

Through collation and interpretation of the patient's history, the neurologic examination, and other diagnostic tests, the clinician can fully understand the patient's diagnosis and assessment. This comprehension allows the clinician to devise and monitor a pharmacotherapeutic plan that will be of most benefit to the patient with neurological disorders.

ABBREVIATIONS

ALS	amyotrophic lateral sclerosis
CSF	cerebrospinal fluid
CT	computed tomography
CTA	computed tomographic angiography
EEG	electroencephalography
EMG	electromyography
LP	lumbar puncture
MRA	magnetic resonance angiography
MRI	magnetic resonance imaging
NCVs	nerve conduction velocities
PET	positron emission tomography
SPECT	single-photon emission computed tomography

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SELF-ASSESSMENT QUESTIONS

1. When evaluating a spinal cord lesion near a bone, the best imaging choice would be which of the following?
   A. Computed tomography (CT)
   B. Computed tomography angiography (CTA)
   C. Magnetic resonance imaging (MRI)
   D. Single-photon emission computed tomography (SPECT)
2. Lumbar puncture is most useful in the diagnosis of which of the following?
   A. Epilepsy
   B. Ischemic stroke
   C. Meningitis
   D. Parkinson's disease
3. Which of the following is a component of the neurologic examination?
   A. Abdominal rebound
   B. Gait
   C. Heart sounds
   D. Skin turgor
4. You are presented with the following cerebrospinal fluid (CSF) results: red blood cells = 400/mm^3 (400 × 10^6/L), white blood cells = 0/mm^3 (0 × 10^6/L), protein = 200 mg/dL (2.0 g/L), and xanthochromia. Which of the following is the best interpretation?
   A. Meningitis
   B. Multiple sclerosis
   C. Normal
   D. Subarachnoid hemorrhage
5. A patient presents with bilateral leg weakness, difficulty urinating, and numbness from the waist down. Which of the following is the best imaging technique to localize the lesion?
   A. Functional MRI of the spine
   B. MRI of the head

C. MRI of the spine

D. SPECT scan of the head

6. Elements of the pediatric neurologic history may include which of the following:

A. Electroencephalography (EEG)

B. Evaluation of developmental milestones

C. Evaluation of respiratory signs

D. Measurement of waist girth

7. When obtaining a history on an adult patient with recent numbness and tingling in her left arm, which of the following should be asked?

A. What exacerbates the symptoms?

B. Do you have shortness of breath that causes the symptom to occur?

C. Were there any anomalies when you were born?

D. When was your last menstrual period?

8. For which of the following patients could a lumbar puncture (LP) be performed?

A. A patient with a coagulopathy

B. A patient with symptoms of meningitis

C. A patient with a space-occupying lesion with mass effect

D. A patient with papilledema

9. A patient presents with headache and fever. CSF is obtained with the following results: red blood cells = 0/mm^3 (0 × 10^6/L), white blood cells = 215/mm^3 (215 × 10^6/L), protein = 200 mg/dL (2.0 g/L), and glucose 15 mg/dL (0.8 mmol/L). Which of the following is the best interpretation?

A. Meningitis

B. Multiple sclerosis

C. Normal

D. Subarachnoid hemorrhage

10. Which of the following neurologic examination techniques is most useful to diagnose a patient with myasthenia gravis?

A. Reflexes

B. Gait

C. Cerebellar function

D. Cranial nerve examination

11. A patient presents with decreased strength, reflex changes, and cranial nerve findings. Which of the following diagnoses should be considered?

A. Meningitis

B. Parkinson's disease

C. Amyotrophic lateral sclerosis

D. Peripheral neuropathy

12. You are asked to evaluate the pharmacotherapy of a patient with Parkinson disease. Which of the following neurologic examination techniques is best to assess the effects of the therapy?

A. Cranial nerve evaluation

B. Sensation testing

C. Motor function evaluation

D. Reflex testing

13. You are participating in a study of a new agent for cerebellar degeneration. Which of the following tests should be performed at study visits?

A. Memory tests

B. Reflex testing

C. Visual acuity testing

D. Finger-to-nose testing

14. You watch a neurologist perform the following tests: tandem walking, walking on tiptoe, Romberg testing. Which of the following is the neurologist likely assessing?

A. Mental status

B. Reflexes

C. Cranial nerves

D. Gait

15. A patient presents with a suspected small vessel vasculitic stroke. Which of the following tests provides the best images of the small vessels?

A. Conventional dye angiography

B. Computed tomography

C. Magnetic resonance angiography

D. Transcranial Doppler ultrasonography

SELF-ASSESSMENT QUESTION-ANSWERS

1. **C.** MRI is better than CT for examining lesions near bone because the x-rays used in CT are scattered by the bony structures and produce artifact on the image. MRA is for examining the circulatory system. SPECT is a test of brain function. See section "Diagnosing Neurologic Anatomic Abnormalities" for a full discussion.

2. **C.** Lumbar puncture samples the CSF and is useful for diagnosing an infection such as meningitis in this space. See section "Laboratory Findings for Neurological Disorders and Their Interpretation" and Table e72-3 for more discussion of lumbar puncture findings.

3. **B.** The neurologic examination consists of the following domains: higher cortical function (mental status), cranial nerves, motor function, reflexes, cerebellar function, sensory function, and gait. See section "The Neurologic Examination" for a discussion of the examination and Table e72-2 for common findings.

4. **D.** A comparison of these CSF results to Table e72-3 demonstrates values consistent with subarachnoid hemorrhage. Red blood cells are elevated, protein is elevated, and the sample is xanthochromic.

5. **C.** MRI is the best imaging technique for exploring soft tissue lesions such as in the spinal cord. The details of the examination (ie, bilateral leg weakness, difficulty urinating, and numbness from the waist down) pinpoint a lesion in the spinal cord rather than the head. See section "Diagnosing Neurologic Anatomic Abnormalities" for a full discussion.

6. **B.** Developmental milestones are an important component of the pediatric neurologic history (see section "Signs and Symptoms of Neurologic Disorders"). The other items are not components of the history.

7. **A.** Questions to evaluate symptoms should include ameliorating and exacerbating factors. See section "Signs and Symptoms of Neurologic Disorders" and Table e72-1 for additional items to ask.

8. **B.** Space-occupying lesions in the brain, papilledema, and coagulopathies are contraindications or relative contraindications to lumbar puncture. See section "Laboratory Findings for Neurological Disorders and Their Interpretation" for more information.

9. **A.** A comparison of these CSF results to Table e72-3 demonstrates values consistent with bacterial meningitis. White blood cells are elevated, protein is elevated, and glucose is decreased.

10. **D.** As seen in Table e72-2, cranial nerve examination is often abnormal in patients with myasthenia gravis.

11. **C.** Upper and lower motor neuron dysfunction seen in ALS often leads to cranial nerve dysfunction, reflex changes, and muscle weakness as seen in Table e72-2.

12. **C.** Therapy for Parkinson's disease should improve motor function parameters such as tremor, bradykinesia, rigidity, and postural instability as seen in Table e72-2.

13. **D.** Cerebellar testing typically involves such tests as finger-to-nose, heel-to-shin, and rapid alternating movements as seen in Table e72-2.

14. **D.** Elements of the gait examination include walking (tandem, on heels, on toes), standing (Romberg test—closing eyes tests proprioception) as seen in Table e72-2 and may also include running and climbing.

15. **A.** Only conventional dye angiography images the small vessels adequately. See section "Diagnosing Neurologic Anatomic Abnormalities" for the advantages and disadvantages of this technique.