FOCUS ON
ADULT HEALTH
Medical-Surgical Nursing

SECOND EDITION

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Preface

I have researched the experience of becoming a nurse and have discovered what you already know—that learning nursing is more difficult than you anticipated. I have also taught educators of nursing and can tell you that they too discover that teaching basic nursing is more difficult than anticipated. Thus, the idea for this book was to meet the needs of both students and teachers. I began this journey with a thoughtful analysis of what core content, values, and skills should form the foundation of medical-surgical nursing, and that is how this book was built. No, this book will not provide all answers to questions related to internal medical and surgical care; rather it focuses on what is essential. That said, it is not a cursory viewpoint but one that will give depth and breadth to essential content. You, the reader, will be the judge of our success.

Additionally, I wanted expert clinicians to write this book. Nurses who continue to live in the real world of clinical practice and have strong opinions about essential nursing knowing have informed this book with their wisdom.

I also know that often seeing the weight and thickness of medical-surgical texts scares you to the point that you never crack the binding. Thus, we have aimed to distill the essential and place the rest online. As an example, although we rigorously researched current references, we have placed them online for you, if needed, rather than add to the pages in this text. I am hoping for cracked binding, dog-eared pages, multicolored highlights, and notes in the margins of this book. They will stand as evidence of our success.

FEATURES

We have designed some special features to help engage you, the reader, and assist you in your understanding of the content and the nurse's role in caring for patients.

Guidelines for Nursing Care provide steps and rationales for important procedures.

Focused Assessment boxes summarize important assessment criteria and significant findings related to a particular disorder.

Risk Factors provide a bulleted list of risk factors for a particular disorder, drawing attention to factors that can impair health.

Patient Education summarizes patient teaching, home care, and discharge planning.

Health Promotion reviews important points the nurse should discuss with the patient to prevent common health problems from developing.

Gerontologic Considerations highlight information that pertains specifically to the care of older adults who comprise the fastest-growing segment of our population.

Laboratory and Diagnostic Tests tables list common lab tests for particular disorders along with normal values, critical values, and nursing implications.

Nursing Research: Bridging the Gap to Evidence-Based Practice demonstrates the nursing implications of important research.

Focus on Pathophysiology highlights and describes important pathophysiologic processes.

Nutrition Alert highlights nutritional considerations for particular disorders.

NURSING ALERTS offer brief tips or highlight red-flag warnings for clinical practice.

DRUG ALERTS highlight key nursing considerations and drug safety information.

Pathophysiology Alerts highlight key pathophysiology concerns.

Unfolding Patient Stories feature patients from Wolters Kluwer's *vSim for Nursing.*

PEDAGOGICAL FEATURES

The following features will help you focus your attention on important content and relate it to the challenges of nursing and patient care.

Unit Case Study Each unit opens with a short case study and related questions to help prepare you for the content to be presented and to engage your critical thinking skills. Answers to the unit case studies appear at the end of the book so that you can instantly check your knowledge of the subject.

Learning Objectives appear at the beginning of each chapter to help guide and focus you on the important content in the chapter.

Critical Thinking Exercises appear at the end of each chapter and use situation-based questions to aid you in applying the knowledge you have gained.

NCLEX-Style Review Questions test your comprehension and application of the content. Answers to these review questions are available on the Instructor's Resource DVD-ROM and the Instructor's Resources on the Point.

References and Selected Readings can be found on the Point in addition to a large array of resources that will aid your comprehension and expand your knowledge of the subject matter.

Glossary appears at the end of the book to assist you in understanding key terminology.

COMPREHENSIVE LEARNING PACKAGE

A carefully designed ancillary package is available to students who purchase the book and to faculty who adopt the book to further facilitate teaching and learning. A wide variety of multimedia tools are readily available and are just a click away on the Web site that accompanies the text. Visit http://thepoint.lww.com/Honan2e.

Resources for Students

Find the following resources on

- E-book
- NCLEX-Style Student Review Questions
- Animations
- Video clips
- Audio glossary
- Journal articles
- Learning objectives
- Breath sounds
- Internet resources
- References from the book
- Plan of Nursing Care for selected chapters
- And more!

Resources for Instructors

Instructor resources are available online at http://thepoint.lww.com/Honan2e.

In addition to all of the student assets, instructor resources include the following items:

- Test Generator Questions
- PowerPoint Presentations
- Image Bank
- Pre-lecture Quizzes
- Guided Lecture Notes
- Topics for Discussion and Suggested Answers
- Assignments and Suggested Answers
- Case Studies and Suggested Answers
- Syllabus
- E-book
- Answers to NCLEX-Style Chapter Review Questions from the book
- QSEN Competency KSAs Mapped to *Focus on Adult Health: Medical-Surgical Nursing*

Linda Honan, RN, PhD, CNS-BC, ANEF, FAAN

Acknowledgments

I must acknowledge and thank the following people who helped clear cobwebs in my understanding. They include Walter Zawalich, my GEPN soul mate who always came through with answers to my pathophysiology questions; Lisa B. Meland, my pharmacology guru who answered questions from standard dosages to interactions, and everything in between; and, finally, my anatomy sages William Stewart and Shanta Kapadia for all their support. To all the nursing staff on 6-4 at Yale New Haven Hospital and all the GEPNs who have honed my skills as a nurse and educator for over a quarter of a century. I am in your debt. To Helen Kogut and Stephanie Kelly who edited this edition with care. Finally, my thanks to all the clinician colleagues who wrote chapters about their day-to-day practice so that this book is grounded in the real world of clinical.

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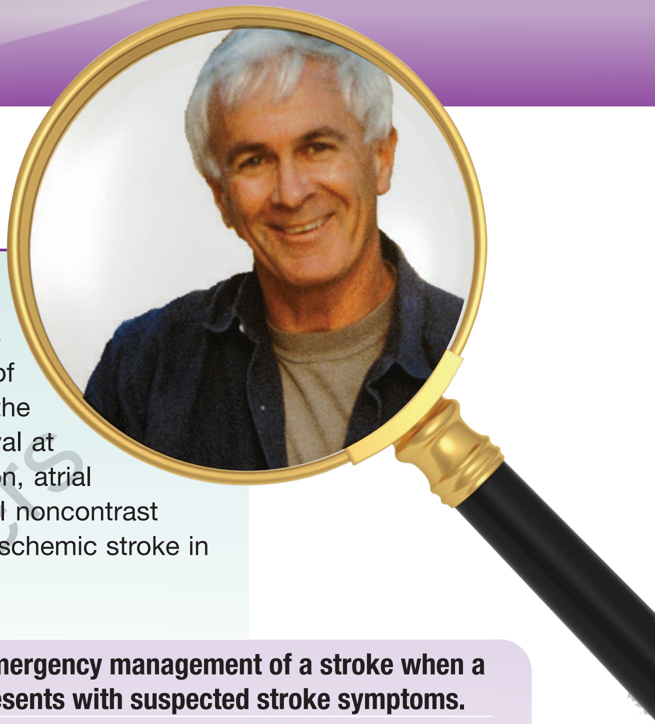
Problems Related to Neurologic Function



A 65-year-old patient presents to the emergency department by ambulance. The paramedics state that the patient's roommate witnessed the patient's sudden onset of confusion, weakness of the right arm and leg, and difficulty speaking (inability to get the right words out). The symptoms occurred 2 hours prior to arrival at the hospital. The patient has a history of smoking, hypertension, atrial fibrillation, and prior transient ischemic attacks (TIAs). An initial noncontrast head CT was negative for intracerebral hemorrhage. An acute ischemic stroke in the left hemisphere is suspected.

- **Discuss emergency management of a stroke when a patient presents with suspected stroke symptoms.**
- **What sub-type of ischemic stroke is the patient most likely experiencing?**
- **Discuss nursing considerations for the patient receiving tPA.**
- **Describe three of the eight standardized performance measures that are considered for a patient with an ischemic stroke.**

CHAPTER 42

Nursing Assessment: Neurologic Function

Learning Objectives

After reading this chapter, you will be able to:

1. Describe the structures and functions of the central and peripheral nervous systems.
2. Differentiate between pathologic changes that affect motor control and those that affect sensory pathways.
3. Compare the functioning of the sympathetic and parasympathetic nervous systems.
4. Describe changes in neurologic function associated with aging and their impact on neurologic assessment findings.
5. Describe the significance of physical assessment to the diagnosis of neurologic dysfunction.
6. Describe diagnostic tests used for assessment of suspected neurologic disorders and the related nursing implications.

Nurses in many practice settings encounter patients with altered neurologic function. Disorders of the nervous system can occur at any time during the lifespan and can vary from mild, self-limiting symptoms to devastating, life-threatening disorders. Nurses must be skilled in the assessment of the neurologic system, whether the assessment is generalized or focused on specific areas of function. In either case, assessment requires knowledge of the anatomy and physiology of the nervous system and an understanding of the array of tests and procedures used to diagnose neurologic disorders. Knowledge about the nursing implications and interventions related to assessment and diagnostic testing is also essential.

ANATOMIC AND PHYSIOLOGIC OVERVIEW

The function of the nervous system is control of all motor, sensory, autonomic, cognitive, and behavioral activities. The nervous system consists of two major divisions: the central nervous system (CNS), including the brain and spinal cord; and the peripheral nervous system (PNS), which includes cranial and spinal nerves that lie outside the brain and spinal cord. The PNS can be further divided into the somatic, or voluntary nervous system, and the autonomic, or involuntary nervous system.

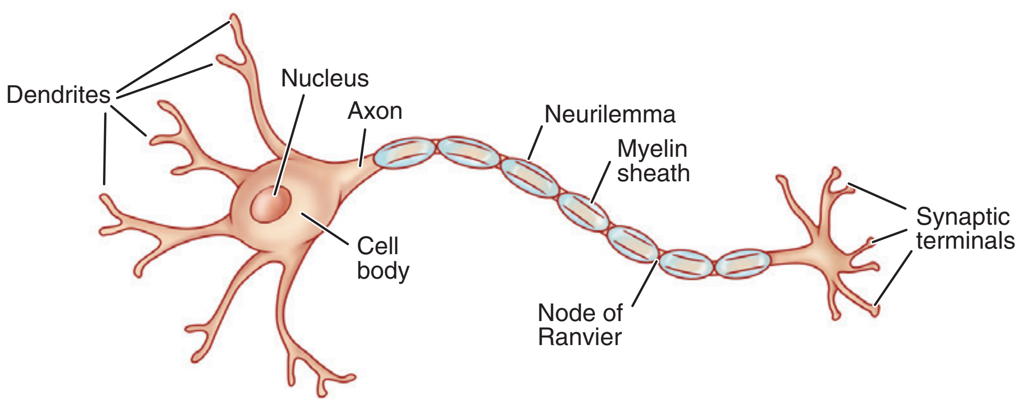


FIGURE 42-1 **Neuron.**

TABLE **42-1 Major Neurotransmitters**

Neurotransmitter	Source	Action	Example of Dysfunction
Acetylcholine (major transmitter of the parasympathetic nervous system)	Many areas of the brain; autonomic nervous system	Usually excitatory; parasympathetic effects sometimes inhibitory (stimulation of heart by vagal nerve)	↓ Leads to yasthenia gravis
Serotonin	Brainstem, hypothalamus, dorsal horn of the spinal cord	Inhibitory, helps control mood and sleep, inhibits pain pathways	↓ Leads to depression
Dopamine	Substantia nigra and basal ganglia	Usually inhibits, affects behavior (attention, emotions) and fine movement	↓ Leads to Parkinson disease
Norepinephrine (major transmitter of the sympathetic nervous system)	Brainstem, hypothalamus, postganglionic neurons of the sympathetic nervous system	Usually excitatory; affects mood and overall activity	Seen rarely
Gamma-aminobutyric acid (GABA)	Spinal cord, cerebellum, basal ganglia, some cortical areas	Inhibitory	↓ Leads to seizures
Enkephalin, endorphin	Nerve terminals in the spine, brainstem, thalamus and hypothalamus, pituitary gland	Excitatory; pleasurable sensation, inhibits pain transmission	Poor pain control

Anatomy of the Nervous System

Cells and Neurotransmitters of the Nervous System

Cells of the brain link the motor and sensory pathways, monitor the body's processes, respond to the internal and external environment, maintain homeostasis, and direct all psychological, biologic, and physical activity through complex chemical and electrical messages. The basic functional unit of the brain is the neuron (Fig. 42-1). It is composed of a cell body, a dendrite, and an axon. The **dendrite** is a branch-type structure with synapses (a gap between two neurons, in which impulses jump from one neuron to another) for receiving electrochemical messages. The **axon** is a long projection that carries impulses away from the cell body. Nerve cell bodies occurring in clusters are called *ganglia* or *nuclei.* A cluster of cell bodies with the same function is called a *center* (e.g., the respiratory center).

Neurotransmitters communicate messages from one neuron to another or from a neuron to a specific target tissue and are responsible for all types of brain activity. Each neurotransmitter has an affinity for specific receptors in the postsynaptic bulb. When released, neurotransmitters cross the synaptic cleft and bind to receptors in the postsynaptic cell membrane. The action of a neurotransmitter is to potentiate, terminate, or modulate a specific action, and it can either excite or inhibit the activity of the target cell. Usually, multiple neurotransmitters are at work in the neural synapse. Imbalances or deficiencies of a particular neurotransmitter may cause neurologic dysfunction. Major neurotransmitters are described in Table 42-1.

The Central Nervous System

The Brain

The brain is divided into three major areas: the cerebrum, the brainstem, and the cerebellum. The cerebrum is composed of two hemispheres, the thalamus, the hypothalamus, and the basal ganglia. In addition, connections for the olfactory (cranial nerve I) and optic (cranial nerve II) nerves are found in the cerebrum. The brainstem includes the midbrain, pons, medulla, and connections for cranial nerves III through XII. The cerebellum is located under the cerebrum and behind the brainstem (Fig. 42-2).

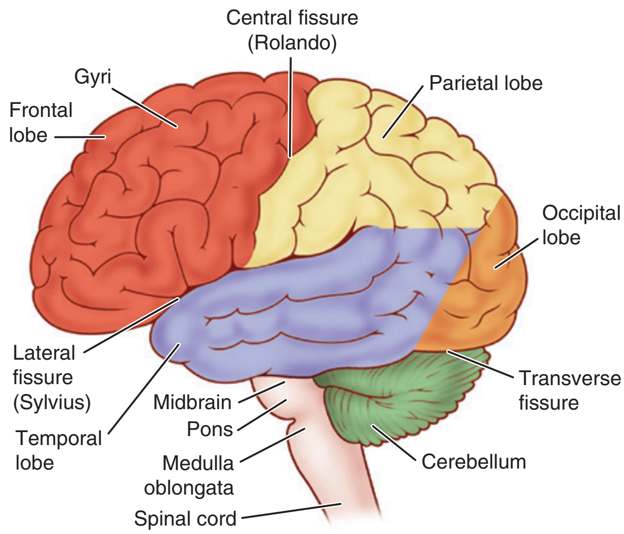


FIGURE 42-2 **View of the external surface of the brain showing lobes, cerebellum, and brainstem.**

Cerebrum. The cerebrum consists of two hemispheres that are incompletely separated by the great longitudinal fissure. This sulcus (a depression or groove) separates the cerebrum into the right and left hemispheres. The two hemispheres are joined at the lower portion of the fissure by the corpus callosum. The outside surface of the hemispheres has many folded layers or convolutions called *gyri,* which increase the surface area of the brain. The external or outer portion of the cerebrum (the cerebral cortex) is made up of gray matter, approximately 2 to 5 mm in depth. White matter makes up the innermost layer and is composed of nerve fibers and neuroglia (support tissue) that form tracts or pathways connecting various parts of the brain. The cerebral hemispheres are divided into pairs of frontal, parietal, temporal, and occipital lobes. The four lobes are as follows (see Fig. 42-2):

- Frontal: The frontal lobe is the largest lobe in the front of the skull. The major functions are concentration, abstract thought, information storage or memory, and motor function. The motor strip, which lies in the frontal lobe, anterior to the central sulcus, is responsible for muscle movement. Refer to Figure 42-3 for specific locations of control of motor movement. It also contains Broca's area (left frontal lobe region in most people), critical for motor control of speech. The frontal lobe is responsible in large part for a person's affect, judgment, personality, emotions, attitudes, and inhibitions, and contributes to the formation of thought processes.
- Parietal: The parietal lobe is the primary sensory cortex, which is located posterior to the motor strip, and is organized topographically similar to the motor strip. This lobe analyzes sensory information such as pressure, vibration, pain, and temperature, and relays the interpretation of this information to the thalamus from the sensory cortex. It is also essential to a person's awareness of the body in space, as well as orientation in space and spatial relations. For example, stereognosis, or the ability to perceive an object using the sense of touch, is processed in this area.
- Temporal: The temporal lobes contain the auditory receptive areas located around the temple regions. The interpretive area of the temporal lobe provides integration of visual and auditory areas and plays the most dominant role of any area of the cortex in thinking. Located in the posterior region of the temporal lobe is the area responsible for receptive speech referred to as *Wernicke's area.* For most people, whether right- or left-handed, Wernicke's area is located in the left lobe. Long-term memory recall is also associated with this lobe.
- Occipital: The occipital lobe located in the posterior portion of the cerebral hemispheres is known as the primary visual cortex. The occipital lobe also assists in some visual reflexes, and allows for some involuntary eye movements.

The corpus callosum (Fig. 42-4) is a thick collection of nerve fibers that connects the two hemispheres of the brain and transmits the information from one side of the brain to the other. Right-handed people and some left-handed people have cerebral dominance on the left side of the brain for verbal, linguistic, arithmetical, calculating, and analytic functions. The nondominant hemisphere is responsible for geometric, spatial, visual, pattern, and musical functions.

The basal ganglia are masses of nuclei located deep in the white matter of the cerebral hemispheres and are responsible for control of fine motor movements. The thalamus lies on either side of the third ventricle and acts primarily as a relay station for all sensations except smell. All memory also passes through this section of the brain.

The hypothalamus (see Fig. 42-4) is anterior and inferior to the thalamus and lies next to the third ventricle. It includes the optic chiasm (where the two optic tracts cross)

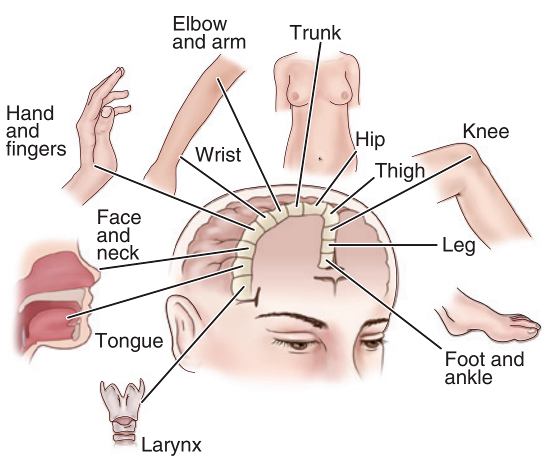


FIGURE 42-3 **Diagrammatic representation of the cerebrum showing locations for control of motor movement of various parts of the body.**

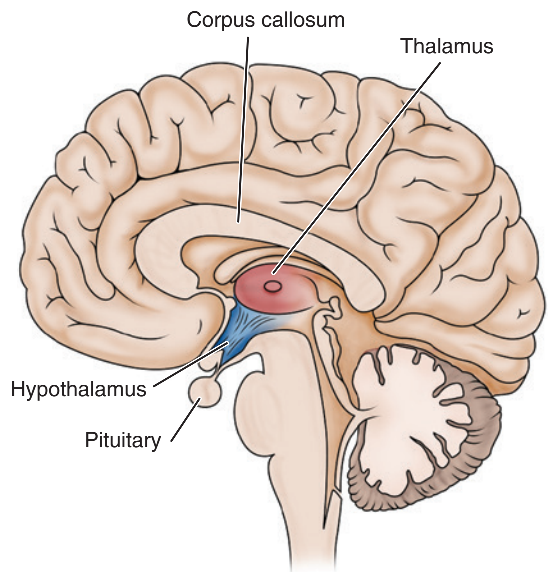


FIGURE 42-4 **Medial view of the brain. The brain is divided into the right and left hemisphere, and the two halves are connected by the corpus callosum. This bundle of nerve tissue contains over 200 million axons (nerve fibers that carry electrical impulses from neurons' cell bodies) by rough estimate. This neural tissue facilitates communication between the two sides of the brain (Healthline, 2015).**

and the mammillary bodies (involved in olfactory reflexes and emotional response to odors). The infundibulum of the hypothalamus connects to the posterior pituitary gland. The hypothalamus, important in the endocrine system, regulates the pituitary secretion of hormones influencing metabolism, reproduction, stress response, and urine production. It works with the pituitary to maintain fluid balance (refer to Chapter 28 for further details). In addition, the hypothalamus, the site of the hunger center, is involved in appetite control. It contains centers that regulate the sleep–wake cycle, blood pressure, aggressive and sexual behavior, and emotional responses (i.e., blushing, rage, depression, panic, and fear). The hypothalamus also controls and regulates the autonomic nervous system and maintains temperature regulation by promoting vasoconstriction or vasodilatation.

The pituitary gland is located in the sella turcica at the base of the brain. The pituitary is a common site of brain tumors in adults, which are frequently detected by signs and symptoms traced to the pituitary, such as hormonal imbalance or visual disturbances due to pressure on the optic chiasm (see Chapter 30).

Nerve fibers from the cortex converge in each hemisphere and exit in a tight bundle of nerve fibers known as the *internal capsule.* After entering the pons and medulla, each bundle crosses to the corresponding bundle from the opposite side. Although the various cells in the cerebral cortex are quite similar in appearance, their functions vary widely, depending on location.

Brainstem. The brainstem is responsible for automatic functions such as heart rate, breathing, and swallowing. It consists of the **midbrain, pons**, and **medulla oblongata** and contains motor and sensory pathways (see Fig. 42-2). The midbrain connects the pons and cerebellum with the cerebral hemispheres and serves as the center for auditory and visual reflexes. Cranial nerves III and IV originate in the midbrain. The pons is situated in front of the cerebellum, between the midbrain and the medulla, and acts as a bridge between the cerebrum, the cerebellum, and the medulla. Cranial nerves V through VIII originate in the pons and connect the brain to the pons. Portions of the pons also control the heart rate, respiration, and blood pressure.

The medulla oblongata contains motor fibers from the brain to the spinal cord and sensory fibers from the spinal cord to the brain. Most of these fibers cross, or *decussate*, at this level. Cranial nerves IX through XII originate in the medulla and connect the brain to the medulla. The medulla and pons are essential for respiratory function.

Cerebellum. The cerebellum is separated from the cerebral hemispheres by a fold of dura mater, the *tentorium cerebelli.* The cerebellum is largely responsible for coordination of all movement. It also controls fine movement, balance, **position (postural) sense** or proprioception (awareness of where each part of the body is), and integration of sensory input.

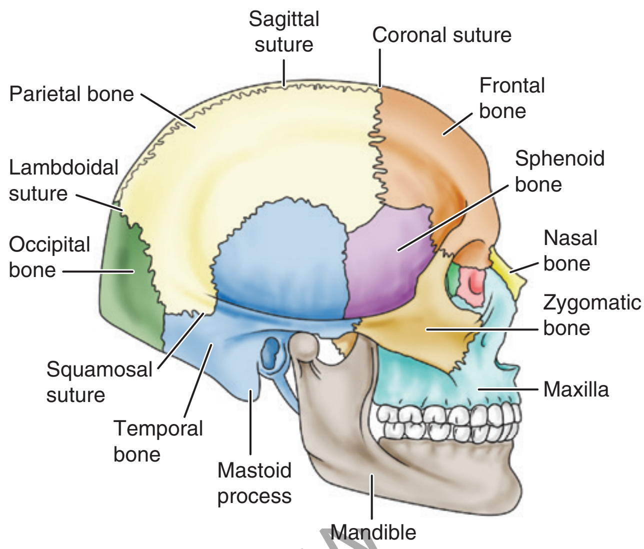


FIGURE 42-5 Bones and sutures of the skull.

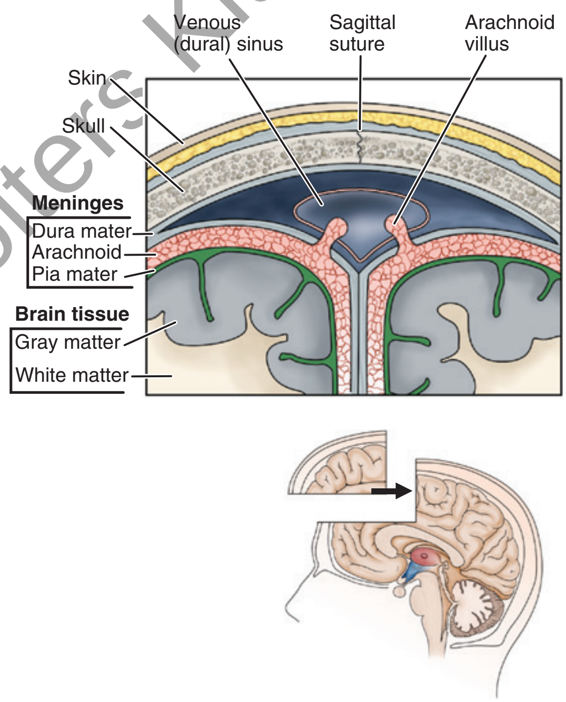


FIGURE 42-6 Meninges and related structures.

Structures Protecting the Brain

Skull. The brain is contained in a rigid skull, protecting it from injury. The major bones of the skull are the frontal, temporal, parietal, and occipital bones (Fig. 42-5). These bones join at suture lines.

Meninges. The meninges (fibrous connective tissues) cover the brain and spinal cord, and provide protection, support, and nourishment. The three layers of the meninges are the **dura, arachnoid, and pia mater** (Fig. 42-6). An easy way to remember the layers is to note that the meninges **"PAD"** the brain (*p*ia, *a*rachnoid, and *d*ura).

The **dura mater**, the outermost layer, covers the brain and the spinal cord. The dura mater is tough, thick, inelastic, fibrous, and gray. There are four extensions of the dura: the **falx cerebri**, which separates the two hemispheres in a longitudinal plane; the **tentorium**, which is an infolding of the dura that forms a tough, membranous shelf between the cerebrum and cerebellum; the **falx cerebelli**, which lies between the two lateral lobes of the cerebellum; and the **diaphragm sellae**, which provides a "roof" for the sella turcica. The tentorium supports the hemispheres and separates them from the lower part of the brain. When excess pressure occurs in the cranial cavity, brain tissue may be compressed against the tentorium or displaced downward, a process called ***herniation***.

The epidural space, a *potential space* that has the capacity to expand slightly, lies outside the outermost layer of the dura. In the spinal canal, the dura forms a tubular sheath around the spinal cord. This narrow space between the dura mater and the periosteum (lining of the bones) is where local anesthetic can be injected for pain relief.

The **arachnoid**, the middle membrane, is an extremely thin, delicate membrane resembling a spider web (hence the name arachnoid). It appears white because it has no blood supply. This membrane has unique finger-like projections, **arachnoid villi**, which absorb cerebrospinal fluid (CSF). In the normal adult, approximately 500 mL of CSF is produced each day; all but 125 to 150 mL is absorbed by the villi (Hickey, 2019). When blood enters the system (from trauma or hemorrhagic stroke), the villi become obstructed, and hydrocephalus (increased size of ventricles) may result. The subarachnoid space is between the arachnoid and pia layers and contains CSF.

The pia mater, the innermost membrane, is a thin, transparent layer that hugs the brain closely and extends into every fold of the brain's surface. It is highly vascular.

Cerebrospinal Fluid

CSF, a clear and colorless fluid, is produced in the lateral ventricles by the choroid plexus and is circulated around the brain and spinal cord through the ventricular system. There are four ventricles. The two lateral ventricles, normally containing 25 mL of CSF each, open into the third ventricle at the interventricular foramen or the foramen of Monro. The third and fourth ventricles connect via the aqueduct of Sylvius. The fourth ventricle supplies CSF to the subarachnoid space and down the spinal cord on the dorsal surface. CSF is returned to the brain and then circulated, where it is absorbed by the arachnoid villi.

The composition of CSF is similar to other extracellular fluids (such as blood plasma), but the concentrations of the various constituents differ. The laboratory report of CSF analysis usually contains information on color, specific gravity, protein count, white blood cell (WBC) count, glucose, and other electrolyte levels. Normal CSF contains a minimal number of WBCs and no red blood cells (RBCs). The intracranial pressure (ICP) within the skull results from a combination of brain tissue, blood flow, and CSF. Normal CSF pressure is approximately 5 to 15 mm Hg (Hickey, 2019), while pressures greater than 20 mm Hg indicate increased ICP.

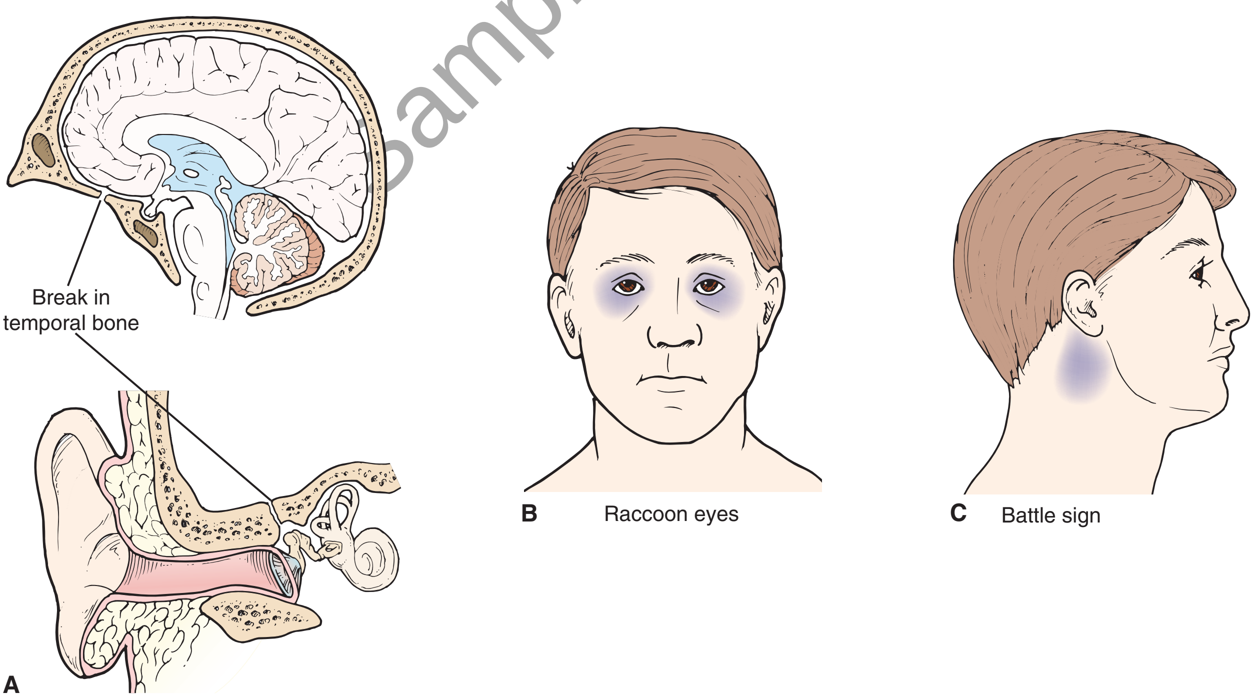


FIGURE 42-7 **A. Basilar skull fracture in the temporal bone can cause cerebrospinal fluid (CSF) to leak from the nose or ear. B. Periorbital ecchymosis, called raccoon's eyes. C. Battle sign over the mastoid process. (From Rosdahl, C. B., & Kowalski, M. (2021). Textbook of basic nursing (12th ed.; Fig 78-7). Philadelphia, PA: Wolters Kluwer.)**

Nursing Alert

In the event of a skull fracture, the nurse should be alert for signs of CSF leakage. Suspect rhinorrhea (leakage of CSF via nares) with fractures involving the cribriform plates of the anterior cranial fossa, while otorrhea (leakage of CSF via ear) is suspected with fractures involving the basilar skull. Depending on the site of the fracture, the patient may present with ***raccoon eyes*** *(bruising around the eyes) or* ***Battle sign*** *(ecchymosis of the mastoid process of the temporal bone). Leakage of CSF places the patient at risk for meningitis. If a CSF leak is suspected, the nurse is aware that nothing is allowed into the patient's nose or ears (suction or nasogastric catheters, dressings, tissues, etc.). Example, an orogastric tube (mouth to stomach) would be used rather than a nasogastric tube (nose to stomach). See Figure 42-7.*

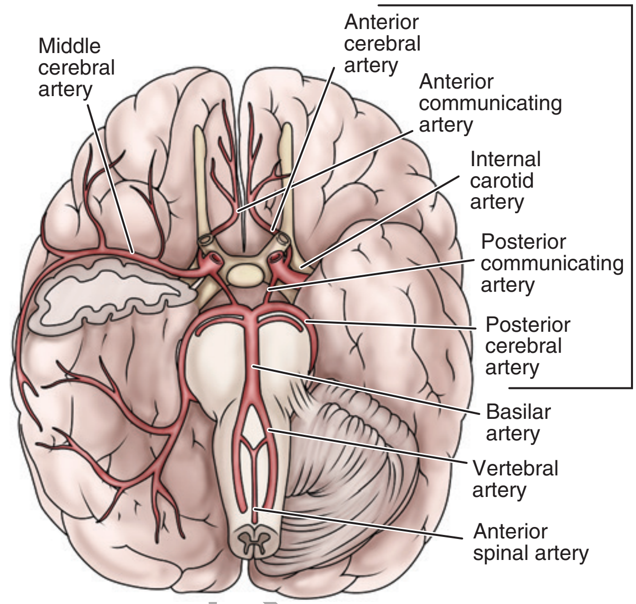


FIGURE 42-9 **Arterial blood supply of the brain, including the circle of Willis, as viewed from the ventral surface.**

Cerebral Circulation

The cerebral circulation receives approximately 15% of the cardiac output, or 750 mL per minute. The brain does not store nutrients, has a high metabolic demand, and requires high blood flow. The brain's blood pathway is unique because it flows against gravity; its arteries fill from below, and the veins drain from above. The brain has poor collateral blood flow, which results in irreversible tissue damage when blood flow is occluded for even short time periods.

Arteries. Two internal carotid arteries and two vertebral arteries and their extensive system of branches provide blood supply to the brain (Fig. 42-8). The internal carotids arise from the bifurcation of the common carotid and supply much of the anterior circulation. The vertebral arteries branch from the subclavian arteries, flow back and upward on either side of the cervical vertebrae, and enter the cranium through the foramen magnum. The vertebral arteries join to become the basilar artery at the brainstem; then the basilar artery divides to form the two branches of the posterior cerebral arteries. The vertebrobasilar arteries supply most of the posterior circulation of the brain.

The circle of Willis is formed from the branches of the anterior circulation and posterior circulation connected by one anterior communicating artery and two posterior communicating arteries (Fig. 42-9). The arteries of the circle of Willis can provide collateral circulation if one or more of the four vessels supplying it becomes occluded.

The arterial bifurcations (branches) along the circle of Willis are frequent sites of aneurysm formation. Aneurysms may be congenital or result from changes in the vessel wall

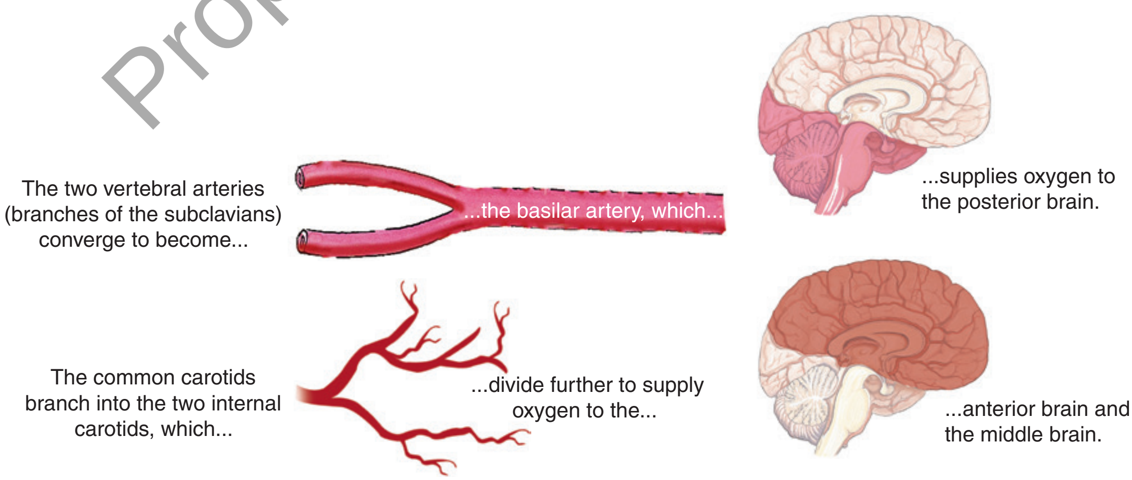


FIGURE 42-8 **Arterial circulation to the brain. (From Lippincott. (2014). *Anatomy and physiology made incredibly visual!* (2nd ed., p. 62). Philadelphia, PA: Lippincott Williams & Wilkins.)**

associated with atherosclerotic disease. If an artery with an aneurysm bursts, depending on its size and location, catastrophic effects can be seen. Additionally, if a blood vessel becomes constricted by vasospasm, it may lead to diminished blood flow, causing potential damage to neurons distal to the constriction, leading to cell death. If not aggressively treated, this may result in an ischemic stroke. The effects of the constriction depend on which vessels are involved and the areas these vessels supply.

Veins. Venous drainage for the brain does not follow the arterial circulation, as in other body structures. The veins reach the brain's surface, join larger veins, then cross the subarachnoid space and empty into the **dural sinuses**, which are the vascular channels lying within the dura mater (see Fig. 42-6). The network of sinuses empties into the internal jugular vein, returning blood to the heart. Cerebral veins and sinuses are unique because, unlike other veins, they do not have valves to prevent blood from flowing backward and depend on both gravity and blood pressure.

Blood–Brain Barrier

The CNS and its neurons are inaccessible to many substances that circulate in the blood plasma (e.g., dyes, medications, and antibiotics) because of the blood–brain barrier. This barrier is formed by the tight junction of the endothelial cells in the brain's capillaries. All substances entering the CSF must filter through the capillary endothelial cells and astrocytes (Hickey, 2019). The blood–brain barrier has a protective function but can be altered by trauma, cerebral edema, and cerebral hypoxemia; this has implications in the treatment and selection of medication for CNS disorders.

Spinal Cord

The spinal cord and medulla form a continuous structure extending from the cerebral hemispheres and serving as the connection between the brain and the periphery. Approximately 45 cm (18 in) long and about the thickness of a finger, it extends from the foramen magnum at the base of the skull to the lower border of the first lumbar vertebra, where it tapers to a fibrous band called the *conus medullaris*. Continuing below the second lumbar space are the nerve roots that extend beyond the conus, which are called the *cauda equina* because they resemble a horse's tail. Similar to the brain, the spinal cord consists of gray and white matter. Gray matter in the brain is external and white matter is internal; in the spinal cord, gray matter is in the center and is surrounded on all sides by white matter (Fig. 42-10). The spinal cord is an H-shaped structure with nerve cell bodies (gray matter) surrounded by ascending and descending tracts (white matter). The spinal cord is encased by the meninges as in the brain including the pia mater, arachnoid, and dura mater.

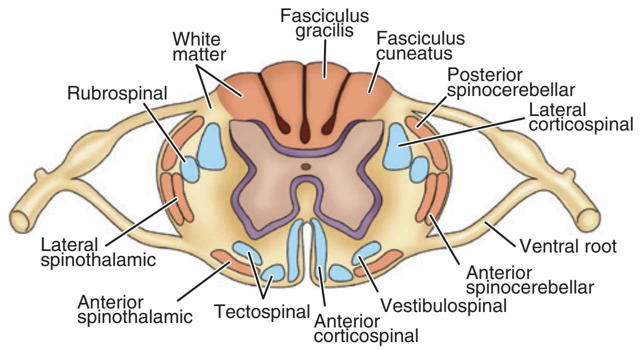


FIGURE 42-10 Cross-sectional diagram of the spinal cord showing major spinal tracts.

Nursing Alert

The nurse understands that the spinal cord extends to L1; therefore, if a lumbar puncture (spinal tap) is to be performed, the site for insertion of the needle will be below L1. Typically, the needle is placed in the interspace between L3 and L4 or between L4 and L5, which is a safe distance from the distal spinal cord. The bony landmark for the L4 spinous process is located at the intersection of the line between the top of the iliac crests and the midline of the lumbar spine.

Sensory and Motor Pathways: The Spinal Tracts. The white matter of the cord is composed of **myelinated** and **unmyelinated** nerve fibers. The fast-conducting **myelinated fibers** form bundles that also contain **glial cells**. Fiber bundles with a common function are called ***tracts***.

There are six **ascending** tracts (see Fig. 42-10). Two conduct sensation, principally the perception of touch, pressure, vibration, position, and passive motion from the same side of the body. Before reaching the cerebral cortex, these fibers cross to the opposite side in the medulla. The two spinocerebellar tracts conduct sensory impulses from muscle spindles, providing necessary input for coordinated muscle contraction. They ascend essentially uncrossed and terminate in the cerebellum. The last two spinothalamic tracts are responsible for conduction of pain, temperature, proprioception, fine touch, and vibratory sense from the upper body to the brain. They ascend, cross to the opposite side of the brain, and terminate in the thalamus.

There are eight **descending** tracts. The two corticospinal tracts conduct motor impulses to the anterior horn cells from the opposite side of the brain and control voluntary muscle activity. The three vestibulospinal tracts descend uncrossed and are involved in some autonomic functions (sweating, pupil dilation, and circulation) and involuntary muscle control. The corticobulbar tract conducts impulses responsible for voluntary head and facial muscle movement and crosses at

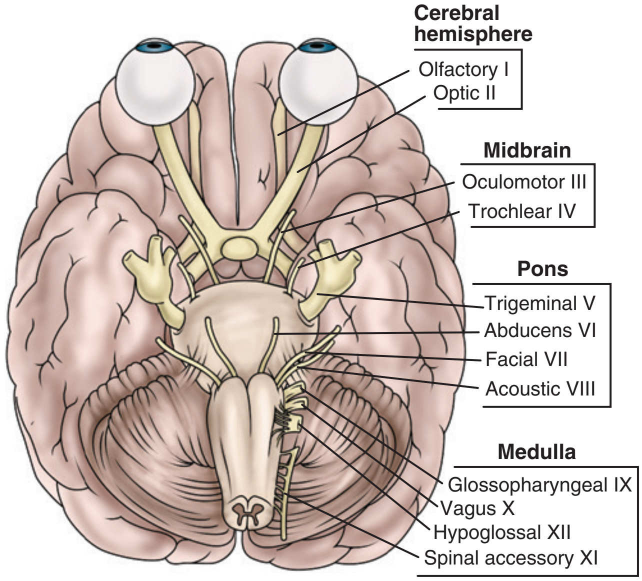


FIGURE 42-11 Diagram of the base of the brain showing entrance or exit of the cranial nerves. The right column shows the anatomic location of the connection of each cranial nerve to the central nervous system.

the level of the brainstem. The rubrospinal and reticulospinal tracts conduct impulses involved with involuntary muscle movement.

Vertebral Column. The bones of the vertebral column surround and protect the spinal cord and normally consist of seven **cervical**, 12 **thoracic**, and five **lumbar** vertebrae, as well as the **sacrum** (a fused mass of five vertebrae), and terminate in the **coccyx**. Nerve roots exit from the vertebral column through the intervertebral foramina (openings). The vertebrae are separated by disks, except for the first and second cervical, the sacral, and the coccygeal vertebrae. The vertebral body, arch, pedicles, and laminae all encase and protect the spinal cord.

The Peripheral Nervous System

The PNS includes the **cranial nerves**, the **spinal nerves**, and the **autonomic nervous system**.

Cranial Nerves

Twelve pairs of cranial nerves emerge from the lower surface of the brain and pass through the foramina in the skull (Fig. 42-11). Three are entirely sensory (I, II, VIII), five are motor (III, IV, VI, XI, and XII), and four are mixed (V, VII, IX, and X), because they have both sensory and motor functions. Most cranial nerves innervate the head, neck, and special sense structures. Table 42-2 lists the names and primary functions of the cranial nerves.

Nursing Alert

Anisocoria is the term for unequal pupils. A difference of 1 mm or less between pupils occurs in approximately 20% of the population. This is termed physiological anisocoria. However, if the nurse discovers a new pupil asymmetry, this finding must be reported immediately and the patient must be reassessed for other neurological changes as any change in pupillary reaction can indicate neurologic deterioration (Ryan, 2019).

TABLE **42-2 Cranial Nerves**

Cranial Nerve (CN)	Type	Assessment	Dysfunction
I (Olfactory)	Sensory	With eyes closed, the patient should be asked to identify two familiar odors (e.g., coffee, tobacco). Each nostril is tested separately. Avoid using strong odors, such as ammonia, as the trigeminal nerve may be stimulated. Testing of this CN is usually deferred.	Inability to identify odor, termed anosmia
II (Optic)	Sensory	Assess visual acuity using a portable eye chart or, if not available, grossly assess vision by having the patient read a card or newspaper from big print to small. Assess visual fields by testing peripheral vision: stand directly in front of the patient. Ask the patient to close one eye and focus on your nose as you assess the patient's ability to see your fingers that are positioned in four visual fields (upper right and left and lower right and left). In combination with CN III, assess the pupils (the light emitted into the pupil begins the process by which constriction is seen; constriction is the function of CN III).	Decreased visual acuity Decreased visual fields

(*continued*)

TABLE **42-2 Cranial Nerves *(continued)***

Cranial Nerve (CN)	Type	Assessment	Dysfunction
III (Oculomotor)	Motor	CN III controls most extraocular eye movement (EOM), eyelid elevation, and pupillary constriction. To assess EOM, ask the patient to follow your finger through the six cardinal positions (use the letter H as a guide to assess the ability of the eye to move to the left superior, left lateral, left inferior, right superior, right lateral, and right inferior). CN III is responsible for all movements except lateral movement (CN VI) and movement of the eye downward and inward (CN IV). While the patient is looking in the six positions, have him or her hold the position briefly while you assess for nystagmus (rotary oscillation of the eye). Test for pupillary reflexes (constriction of the pupil to light), and inspect the eyelids for ptosis (drooping of the eyelid).	Inability to move the eyes in the visual field described Ptosis of affected eye Nonreactive or dilated pupil
IV (Trochlear)	Motor	This is assessed with EOM as described above. CN IV moves the eye down and in (as if looking toward the nose).	Inability to look down and in
V (Trigeminal)	Mixed	Assess facial sensation, corneal reflex (sensory aspect), and chewing or mastication. Have the patient close the eyes. Touch cotton to the patient's forehead, cheeks, and jaw. Test sensitivity to superficial pain in these same three areas by using the sharp and dull ends of a broken tongue blade. Alternate between the sharp point and the dull end. Patient reports "sharp" or "dull" with each movement. If responses are incorrect, test for temperature sensation. Test tubes of cold and hot water are used alternately. To assess chewing, ask the patient to clench the jaw while you palpate the temporal and masseter muscles. Corneal reflex may be assessed by having the patient look up and away while you brush the cornea with a wisp of cotton; both eyes should blink (Note: use of contact lens decreases this response). Similar to the pupillary reaction (CN II and III), corneal reflexes are a combination CN V and VII.	Absence of corneal reflex Diminished sensation to forehead, maxillary and mandibular region Weakness of muscles responsible for chewing
VI (Abducens)	Motor	Abducens moves the eye laterally (side to side or horizontally) and is assessed with EOMs.	Inability to look laterally, double vision
VII (Facial)	Mixed	Assess for symmetry of facial movement. Ask the patient to smile, raise the eyebrows, keep eyes and lips closed while you try to open them, and puff out the cheeks. Taste is also a function of this CN, although testing is often deferred. The motor response of closing the eye in response to stimuli is assessed with corneal reflex (combination of CN V and VII).	Facial paralysis Facial asymmetry, droop of mouth Absent nasolabial fold Decreased ability to taste
VIII (Acoustic)	Sensory	Assess hearing by rubbing your fingers, placing a ticking watch, or whispering near each ear. Equilibrium can be assessed with the Romberg test and is usually deferred.	Decreased hearing in affected ear
IX (Glossopharyngeal)	Mixed	This CN's function is primarily innervation of the pharynx and tongue, pharyngeal muscles, and swallowing. Ask the patient to open the mouth and say "Ah." Note symmetrical elevation of the upper palate and uvula in the midline position. Assessing for the gag reflex tests this nerve and CN X, as they travel together. To test gag reflex, use a cotton swab or tongue blade to touch the patient's posterior pharynx; note gag response.	Dysphagia Absence of gag reflex
X (Vagus)	Mixed	This CN is assessed by swallowing and gag reflex as noted above. In addition, the quality of the patient's voice is noted.	Hoarse or nasal quality to voice Slurred speech
XI (Spinal accessory)	Motor	Have the patient shrug the shoulders and turn their head from side to side; assess the sternocleidomastoid and trapezius muscles for symmetry.	Inability to shrug shoulders
XII (Hypoglossal)	Motor	Inspect the patient's tongue for atrophy at rest. To assess movement of the tongue, have the patient stick out the tongue and move it internally from cheek to cheek.	Tongue weakness

Spinal Nerves

The spinal cord is composed of 31 **pairs of spinal nerves**: eight cervical, 12 thoracic, five lumbar, five sacral, and one coccygeal. Each spinal nerve has a **ventral** and **dorsal** root (Fig. 42-12).

The dorsal roots are sensory and transmit sensory impulses from specific areas of the body known as ***dermatomes*** (Fig. 42-13) to the dorsal ganglia. The sensory fiber may be **somatic**, carrying information about pain, temperature, touch, and position sense (proprioception) from the tendons, joints, and body surfaces; or **visceral**, carrying information from the internal organs.

The ventral roots are motor and transmit impulses from the spinal cord to the body, and these fibers are also either somatic or visceral. The visceral fibers include autonomic fibers that control the cardiac muscles and glandular secretions.

Autonomic Nervous System

The **autonomic nervous system** regulates activities of internal organs, such as the heart, lungs, blood vessels, digestive

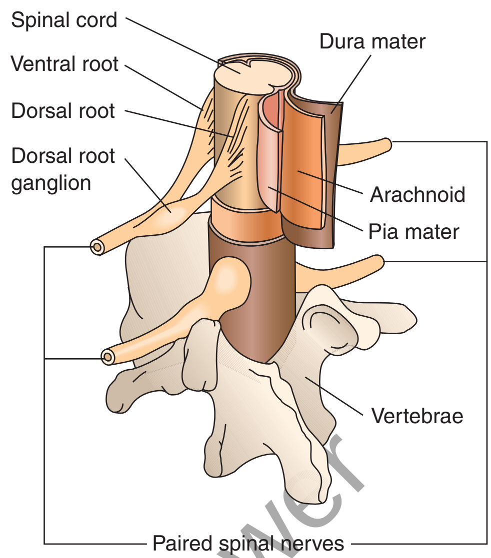


FIGURE 42-12 **Spinal cord and meninges. (From Norris, T. L., & Lalchandani, R. (2018). *Porth's pathophysiology* (10th ed.; Figure 13.13). Lippincott Williams & Wilkins.)**

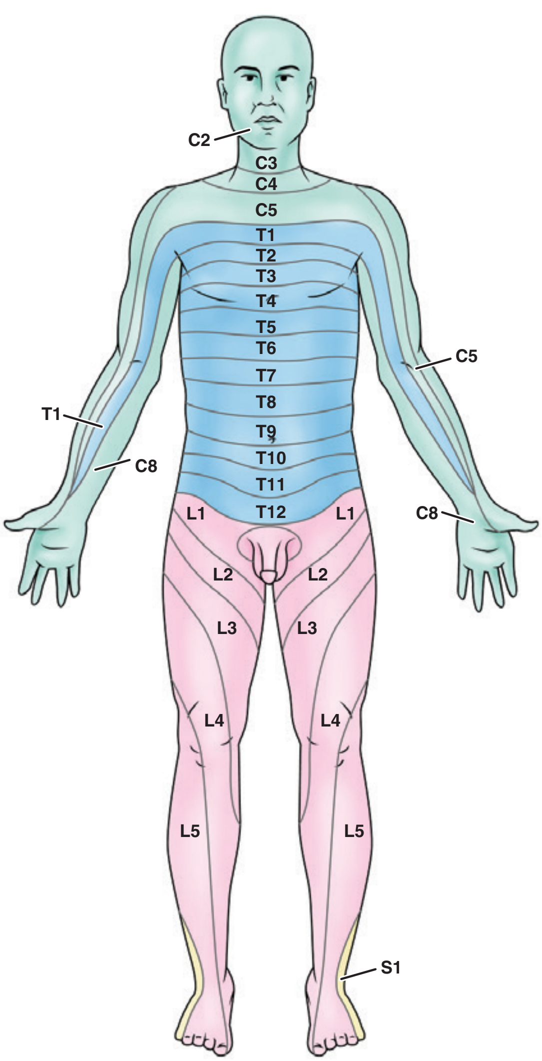


FIGURE 42-13 **Dermatome distribution.**

organs, and glands. Maintenance and restoration of internal homeostasis is largely the responsibility of the autonomic nervous system. There are two major divisions: the **sympathetic nervous system**, with predominantly excitatory responses, most notably the "fight-or-flight" response, and the **parasympathetic nervous system**, which controls mostly visceral functions, known as "rest-and-digest."

The autonomic nervous system is regulated by centers in the spinal cord, brainstem, and hypothalamus. Its regulatory effects are exerted not on individual cells but on large expanses of tissue and on entire organs. The responses elicited do not occur instantaneously but after a lag period. These responses are sustained far longer than other neurogenic responses to ensure maximal functional efficiency on the part of receptor organs, such as blood vessels. The autonomic nervous system transmits its impulses by way of nerve pathways, enhanced by chemical mediators.

Sympathetic stimuli are mediated by norepinephrine, and parasympathetic impulses are mediated by acetylcholine. Both divisions produce stimulatory and inhibitory effects. Table 42-3 compares sympathetic and parasympathetic effects on different systems of the body.

TABLE 42-3 Autonomic Effects of the Nervous System

Structure or Activity	Parasympathetic Effects	Sympathetic Effects
Pupil of the Eye	Constricted	Dilated
Circulatory System		
Rate and force of heartbeat	Decreased	Increased
Blood Vessels		
In heart muscle	Constricted	Dilated
In skeletal muscle	[a]	Dilated
In abdominal viscera and the skin	[a]	Constricted
Blood pressure	Decreased	Increased
Respiratory System		
Bronchioles	Constricted	Dilated
Rate of breathing	Decreased	Increased
Digestive System		
Peristaltic movements of digestive tube	Increased	Decreased
Muscular sphincters of digestive tube	Relaxed	Contracted
Secretion of salivary glands	Thin, watery saliva	Thick, viscid saliva
Secretions of stomach, intestine, and pancreas	Increased	[a]
Conversion of liver glycogen to glucose	[a]	Increased
Genitourinary System		
Urinary bladder Muscle walls	Contracted	Relaxed
Sphincters	Relaxed	Contracted
Muscles of the uterus	Relaxed; variable	Contracted under some conditions; varies with menstrual cycle and pregnancy

Structure or Activity	Parasympathetic Effects	Sympathetic Effects
Blood vessels of external genitalia	Dilated	[a]
Integumentary System		
Secretion of sweat	[a]	Increased
Pilomotor muscles	[a]	Contracted (gooseflesh)
Adrenal Medulla	[a]	Secretion of epinephrine and norepinephrine

[a]No direct effect.
From Hickey, J. (2019). *Clinical practice of neurological and neurosurgical nursing* (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Motor and Sensory Functions of the Nervous System

Motor System Function

The motor cortex, a vertical band within each cerebral hemisphere, controls the voluntary movements of the body. The exact locations within the brain at which the voluntary movements of the muscles of the face, thumb, hand, arm, trunk, and leg originate are known (see Fig. 42-3). Stimulation of these cells results in muscle contraction. En route to the pons, the motor fibers converge into a tight bundle known as the ***internal capsule***. A comparatively small injury to the capsule results in paralysis in more muscles than does a much larger injury to the cortex itself.

Within the medulla, the motor axons from the cortex form the **corticospinal** or **pyramidal tracts**. Here, most of the fibers cross (or decussate) to the opposite side. The remaining fibers enter the spinal cord on the same side as the direct pyramidal tract. All of the motor fibers of the spinal nerves represent extensions of the anterior horn cells, with each of these fibers communicating with only one particular muscle fiber. The motor system is complex, and motor function depends on the integrity of the corticospinal tracts, the extrapyramidal system, and cerebellar function.

Upper and Lower Motor Neurons

The voluntary motor system consists of two groups of neurons: **upper motor neurons** and **lower motor neurons**. Upper motor neurons originate in the cerebral cortex, the cerebellum, and the brainstem, where they cross over and descend throughout the corticospinal tract. Their fibers make up the descending motor pathways, are located entirely within the CNS, and modulate the activity of the lower motor neurons. Lower motor neurons are located either in the anterior horn of the spinal cord gray matter or within cranial nerve nuclei in the brainstem. Axons of lower motor neurons in both sites extend through peripheral nerves and terminate in skeletal muscle at the myoneural junction. Lower motor neurons are located in both the CNS and the PNS. The clinical features of lesions of upper and lower motor neurons are discussed in Table 42-4.

Coordination of Movement

The smoothness, accuracy, and strength that characterize muscular movements are attributable to the influence of the cerebellum and the basal ganglia.

The cerebellum (see Fig. 42-2) is responsible for the coordination, balance, and timing of all muscular movements. Through the action of the cerebellum, the contractions of opposing muscle groups are adjusted in relation to each other to maximal mechanical advantage.

The basal ganglia play an important role in planning and coordinating motor movements and posture. Complex neural connections link the basal ganglia with the cerebral cortex. The major effect of these structures is to inhibit unwanted muscular activity; disorders of the basal ganglia result in exaggerated, uncontrolled movements.

Impaired cerebellar function, which may occur as a result of an intracranial injury, cerebrovascular event, or some type of an expanding mass, results in loss of muscle tone, weakness, and fatigue. Cerebellar signs such as ataxia, which is an inability to coordinate voluntary muscular movements and incoordination, as well as CSF obstruction and compression of the brainstem may be seen. Signs of increased ICP, including vomiting, headache, and changes in vital signs and level of consciousness (LOC), are especially common when CSF flow is obstructed.

TABLE 42-4 Comparison of Lesions of the Upper Motor Neurons and Lower Motor Neurons

Upper Motor Neuron Lesions	Lower Motor Neuron Lesions
Loss of voluntary control	Loss of voluntary control
Increased muscle tone	Decreased muscle tone
Muscle spasticity	Flaccid muscle paralysis
No muscle atrophy	Muscle atrophy
Hyperactive and abnormal	Absent or decreased reflexes

Destruction or dysfunction of the basal ganglia leads not to paralysis but to muscle rigidity, with disturbances of posture and movement. The patient tends to have involuntary movements. These may take the form of coarse tremors, most often in the upper extremities, particularly in the distal portions; athetosis (movement of a slow, squirming, writhing, twisting type); or chorea (spasmodic, purposeless, irregular, uncoordinated motions of the trunk and the extremities, and facial grimacing). Disorders due to lesions of the basal ganglia include Parkinson disease, Huntington disease, and spasmodic torticollis (a painful condition where neck muscles contract involuntarily, causing the head to twist or turn to one side).

Sensory System Function

Integrating Sensory Impulses

The thalamus, a major receiving and transmitting center for the afferent sensory nerves, is a large structure connected to the midbrain (see Fig. 42-4). The thalamus integrates all sensory impulses except olfaction. It plays a role in the conscious awareness of pain and the recognition of variation in temperature and touch. The thalamus is responsible for the sense of movement and position and the ability to recognize the size, shape, and quality of objects.

Receiving Sensory Impulses

Afferent impulses travel from their points of origin to their destinations in the cerebral cortex via the ascending pathways directly, or they may cross at the level of the spinal cord or in the medulla, depending on the type of sensation that is registered. Sensory information may be integrated at the level of the spinal cord or may be relayed to the brain. Knowledge of these pathways is important for neurologic assessment and for understanding symptoms and their relationship to various lesions.

Sensory Losses

Destruction of a sensory nerve results in total loss of sensation in its area of distribution. **Transection** of the spinal cord yields complete anesthesia (a lack of feeling or sensation) below the level of injury. Selective destruction or degeneration of the posterior columns of the spinal cord is responsible for a loss of position and vibratory sense in segments distal to the lesion, without loss of touch, pain, or temperature perception. A lesion, such as a cyst, in the center of the spinal cord causes dissociation of sensation—loss of pain at the level of the lesion. This occurs because the fibers carrying pain and temperature cross within the cord immediately on entering; thus, any lesion that divides the cord longitudinally divides these fibers. Damage to the anterior spinal would result in loss of motor function, as well as pain and temperature with preservation of vibration, position, and touch.

Lesions affecting the posterior spinal nerve roots may cause impairment of tactile sensation, including intermittent severe pain that is referred to the area of distribution. Tingling of the fingers and the toes can be a prominent symptom of spinal cord disease, presumably due to degenerative changes in the sensory fibers that extend to the thalamus (i.e., belonging to the spinothalamic tract).

> BOX 1-1 **Gerontologic Considerations**
>
> During the normal aging process, the nervous system undergoes many changes, and it is extremely vulnerable to general systemic illness. Changes throughout the nervous system that occur with age vary in degree. Nerve fibers that connect directly to muscles show little decline in function with age, as do simple neurologic functions that involve a number of connections in the spinal cord. Disease in the elderly often makes it difficult to distinguish normal from abnormal changes. It is important for clinicians not to attribute abnormality or dysfunction to aging without appropriate investigation. Pain in the absence of disease, for example, is not a normal part of aging and should be assessed, diagnosed, and treated. Table 42-5 summarizes structural changes.

Structural Changes

A number of alterations occur with increasing age. Brain weight decreases, as does the number of synapses. A loss of neurons occurs in select regions of the brain. Cerebral blood flow and metabolism are reduced. Temperature regulation

TABLE **42-5** **GERONTOLOGICAL CONSIDERATIONS / Age-Related Changes in the Neurologic System**

Structural changes	Sensory changes
Brain weight decreases	Atrophy of taste buds
Loss of neurons in the brain	Degeneration of olfactory bulb
Reduced cerebral blood flow	Degeneration of nerve cells in vestibular system of inner ear, cerebellum, and proprioceptive pathways
Decreased myelin, resulting in decreased nerve conduction in some nerves	Decreased neural transmission leading to difficulty in discriminating important sounds from background noise; hearing loss becomes more common
Decrease in muscle bulk	Stage IV sleep is decreased; sleep apnea becomes more common
Slowing in deep tendon reflexes	Presence of cataracts
Overall slowing of the autonomic and sympathetic nervous system	Dulling of tactile sensation
Temperature regulation becomes less efficient	
Reduced pupillary response	

becomes less efficient. In the PNS, myelin is lost, resulting in a decrease in conduction velocity in some nerves. There is an overall reduction in muscle bulk and the electrical activity within muscles. Taste buds atrophy, and nerve cell fibers in the olfactory bulb degenerate. Nerve cells in the vestibular system of the inner ear, cerebellum, and proprioceptive pathways also degenerate. Deep tendon reflexes can be decreased or, in some cases, absent. Hypothalamic function is modified such that stage IV sleep is reduced. There is an overall slowing of autonomic nervous system responses. Pupillary responses are reduced or may not appear at all in the presence of cataracts.

Motor Alterations

Changes in motor function often result in a flexed posture, shuffling gait, and rigidity of movement. These changes create difficulties for the older person in maintaining or recovering balance. Strength and agility are diminished, and reaction time and movement time are decreased. Repetitive movements and mild tremors may be noted during an examination and may be of concern to the person. Observation of gait may reveal a wide-based gait with balance difficulties.

Sensory Alterations

Sensory isolation due to visual and hearing loss can cause confusion, anxiety, disorientation, misinterpretation of the environment, and feelings of inadequacy. Sensory alterations may require modification of the home environment, such as large-print reading materials or sound enhancement for the telephone, as well as extra orientation to new surroundings. Simple explanations of routines, the location of the bathroom, and how to operate the call bell or light are just a few examples of information the elderly patient may need when hospitalized.

Temperature Regulation and Pain Perception

Other manifestations of neurologic changes are related to temperature regulation and pain. The elderly patient may feel cold more readily than heat and may require extra covering when in bed; a room temperature somewhat higher than usual may be desirable. Reaction to painful stimuli may be decreased with age. Because pain is an important warning signal, caution must be used when hot or cold packs are used. The older patient may be burned or suffer frostbite before being aware of any discomfort. Reports of pain, such as abdominal discomfort or chest pain, may be more serious than the patient's perception might indicate and thus require careful evaluation. Two pain syndromes that are common in the neurologic system in older adults are diabetic neuropathies and postherpetic neuropathies (refer to Chapters 29 and 51 for further information).

Taste and Smell Alterations

The acuity of the taste buds decreases with age; along with an altered olfactory sense, this may cause a decreased appetite and subsequent weight loss. Extra seasoning often increases food intake as long as it does not cause gastric irritation. A decreased sense of smell due to atrophy of olfactory organs may present a safety hazard because elderly people living alone may be unable to detect household gas leaks or fires. Smoke and carbon monoxide detectors, important for all, are critical for the elderly.

Tactile and Visual Alterations

Another neurologic alteration in the elderly patient is the dulling of tactile sensation. There may be difficulty in identifying objects by touch, and because fewer tactile cues are received from the bottom of the feet, the person may become confused about body position and location.

These factors, combined with sensitivity to glare, decreased peripheral vision, and a constricted visual field, may result in disorientation, especially at night when there is little or no light in the room. Because the elderly person takes longer to recover visual sensitivity when moving from a light to dark area, night-lights and a safe and familiar arrangement of furniture are essential.

Mental Status

Mental status is evaluated when obtaining the history. Areas of judgment, intelligence, memory, affect, mood, orientation, speech, and grooming are assessed. Family members who bring the patient to the attention of the health care provider may have noticed changes in the patient's mental status. Drug toxicity should always be suspected as a causative factor when the patient has a change in mental status. **Delirium** (mental confusion, usually with delusions and hallucinations) is seen in elderly patients who have underlying CNS damage or are experiencing an acute condition, such as infection, adverse medication reaction, or dehydration. Many elderly patients admitted to the hospital have delirium, and the cause is often reversible and treatable (e.g., drug toxicity, vitamin B deficiency, thyroid disease). Depression may produce impairment of attention and memory. In elderly patients, delirium, which is an acute change in mental status attributable to a treatable medical problem, must be differentiated from dementia, which is a chronic and irreversible deterioration of cognitive status.

Nursing Implications

Nursing care for patients with age-related changes to the nervous system and for patients with long-term neurologic disability who are aging should include the previously described modifications. In addition, the consequences of any neurologic deficit and its impact on overall function, such as activities of daily living, use of assistive devices, and individual coping, should be assessed and considered in planning patient care.

Patient teaching is also affected because the nurse must understand the altered responses and the changing needs of the elderly patient before beginning to teach. When caring for the elderly patient, the nurse adapts activities, such as preoperative teaching, diet therapy, and instruction about new medications, their timing, and doses, to the patient's needs and capabilities. The nurse considers the presence of decline in fine motor movement and failing vision. When using visual materials for teaching or menu selection, adequate lighting without glare, contrasting colors, and large print are used to offset visual difficulties caused by rigidity and opacity of the lens in the eye and slower pupillary reaction.

Even with hearing loss, the elderly patient often hears adequately if the speaker uses a low-pitched, clear voice; shouting only makes it harder for the patient to understand the speaker. Providing auditory and visual cues aids understanding; if the patient has a significant hearing or visual loss, assistive devices, a signer, or a translator may be needed.

Teaching at an unrushed pace and using reinforcement enhances learning and retention. Material should be short, concise, and concrete. Vocabulary is matched to the patient's ability, and terms are clearly defined. The elderly patient requires adequate time to receive and respond to stimuli, learn, and react. These measures allow comprehension, memory, and formation of association and concepts.

ASSESSMENT

Health History

The history-taking portion of the neurologic assessment is critical and, in many cases of neurologic disease, leads to an accurate diagnosis. The initial interview provides an excellent opportunity to systematically explore the patient's current condition and related events while simultaneously observing overall appearance, mental status, posture, movement, and affect. Depending on the patient's condition, the nurse may need to rely on yes-or-no answers to questions, a review of the medical record, or input from the family or a combination of these.

Common Concerns

An important aspect of the neurologic assessment is the history of the present illness. Neurologic disease may be acute or progressive, characterized by symptom-free periods as well as fluctuations in symptoms. Therefore, the nurse asks about the onset, character, severity, location, duration, and frequency of symptoms and signs; associated complaints; precipitating, aggravating, and relieving factors; progression, remission, and exacerbation; and the presence or absence of similar symptoms among family members.

The clinical manifestations of neurologic disease are as varied as the disease processes themselves. Symptoms may be subtle or intense, fluctuating or permanent, inconvenient or devastating. An introduction to some of the most common symptoms associated with neurologic disease is given in this chapter. Detailed discussions regarding how specific symptoms relate to a particular disorder are covered in later chapters in this unit.

Pain

Pain is considered an unpleasant sensory perception and emotional experience associated with actual or potential tissue damage or described in terms of such damage. Therefore, pain is viewed as multidimensional and entirely subjective. Pain can be acute or chronic. In general, acute pain lasts for a relatively short period of time and remits as the pathology resolves. In neurologic disease, this type of pain is often associated with spinal disk disease, trigeminal neuralgia, or other neuropathic pathology (e.g., postherpetic neuralgia or painful neuropathies). In contrast, chronic or persistent pain extends for long periods of time and may represent a low level of pathology. This type of pain can occur with many degenerative and chronic neurologic conditions (e.g., cerebral palsy).

Headache and Migraine

Headache, or cephalalgia, is one of the most common of all human physical complaints. Headache is a symptom rather than a disease entity; it may indicate organic disease (neurologic or other disease), a stress response, vasodilation (migraine), skeletal muscle tension (tension headache), or a combination of factors. A **primary headache** is one for which no organic cause can be identified. These types of headache include migraine, tension-type, and cluster headaches. **Migraine headache** is characterized by periodic and recurrent attacks of severe headaches lasting from 4 to 72 hours in adults. The cause of migraine has not been clearly demonstrated, but it is primarily a vascular disturbance that occurs more commonly in women and has a strong familial tendency (Pescador-Ruschel & De Jesus 2021). The typical time of onset is at puberty, and the highest prevalence in adults occurs between 25 and 55 years of age. Migraine headaches may occur with or without an aura (a sensation that precedes the headache); however, most patients do not exhibit auras. Migraine with aura affects 5% of the adult population, and 90% of auras are visual.

A **secondary headache** is a symptom associated with an organic cause, such as a brain tumor or an aneurysm. Although most headaches do not indicate serious disease, persistent headaches require further investigation. Serious disorders related to headache include brain tumors, subarachnoid hemorrhage, stroke, severe hypertension, meningitis, and head injuries.

Temporal arteritis is a cause of headache in the older population, reaching its greatest incidence in those older than 70 years of age. Inflammation of the cranial arteries is characterized by a severe headache localized in the region of the temporal arteries. The inflammation may be generalized (in which case temporal arteritis is part of a vascular disease) or focal (in which case only the cranial arteries are involved) and may be associated with visual loss.

Seizures

Seizures are the result of abnormal paroxysmal discharges in the cerebral cortex, which then manifest as an alteration in sensation, behavior, movement, perception, or consciousness. The alteration may be short, such as a blank stare that lasts only a second, or of longer duration, such as a tonic-clonic seizure that can last several minutes. The type of seizure activity is a direct result of the area of the brain affected. Seizures can occur as isolated events, such as when induced by a high fever, alcohol or drug withdrawal, or hypoglycemia. A seizure may also be the first obvious sign of a brain lesion.

Dizziness and Vertigo

Dizziness is an abnormal sensation of imbalance or movement. It is fairly common in the elderly and one of the most common complaints encountered by health professionals. Dizziness can occur as a result of a variety of medical conditions that include viral syndromes, hypotension, cardiac arrhythmia, hypoglycemia, and middle ear infections, to name a few. One difficulty confronting health care providers when assessing dizziness is the vague and varied terms patients use to describe the sensation.

About 50% of all patients with dizziness have **vertigo**, which is defined as an illusion of movement, usually rotation. Vertigo is usually a manifestation of vestibular dysfunction. It can be so severe as to result in spatial disorientation, light-headedness, loss of equilibrium (staggering), and nausea and vomiting.

Visual Disturbances

Visual defects that cause people to seek health care can range from the decreased visual acuity associated with aging to sudden blindness caused by acute glaucoma. Normal vision depends on functioning visual pathways through the retina and optic chiasm and the radiations into the visual cortex in the occipital lobes. Lesions of the eye itself (e.g., cataract), lesions along the pathway (e.g., tumor), or lesions in the visual cortex (from stroke) interfere with normal visual acuity. Abnormalities of eye movement can also compromise vision by causing **diplopia** or double vision.

Weakness

Weakness, specifically muscle weakness, is a common manifestation of neurologic disease. Weakness frequently coexists with other symptoms of disease and can affect a variety of muscles, causing a wide range of disabilities. Weakness can be sudden and permanent, as in stroke; or progressive, as in many neuromuscular diseases, such as amyotrophic lateral sclerosis (ALS). Any muscle group can be affected.

Abnormal Sensation

Numbness, abnormal sensation, or loss of sensation is a neurologic manifestation of both central and peripheral nerve disease. Altered sensation can affect small or large areas of the body. It is frequently associated with weakness or pain and is potentially disabling. Both numbness and weakness can significantly affect balance and coordination.

History

A review of the medical history, including a system-by-system evaluation, is part of the health history. The nurse should be aware of any history of trauma or falls that may have involved the head or spinal cord.

Family History

The nurse may also use the interview to inquire about any family history of genetic diseases, such as Huntington disease, dystonia, and epilepsy.

Social History

The nurse questions the patient regarding the use of alcohol, medications (including over-the-counter medications and supplements), and illicit drugs, and assesses for signs and symptoms of withdrawal. Additionally, the nurse is aware that certain agents, such as sedatives, analgesics, or neuromuscular blocking agents, may interfere with an accurate neurologic assessment.

The nurse assesses the impact that any neurologic impairment has on the patient's lifestyle. Issues to consider include the limitations imposed on the patient by any deficit and the patient's role in society, including family and community roles. The plan of care that the nurse develops needs to address and support adaptation to the neurologic deficit and continued function to the extent possible within the patient's support system.

There is an increasing awareness that the social and structural determinants of health should be considered when assessing patients. When considering a patient's risk for disease, the nurse needs to consider social variables such as educational level, annual household income, insurance status, zip code, and social support as well as structural variables such as public health and transportation infrastructure, food delivery systems, and cultural norms, among others (Maalouf, Fearon, Lipa, Chow- Johnson, Tayeh & Lipa, 2021; Murray, 2021).

Lifting the Lens Up Alert

The nurse is aware that as the number of social determinants of health affecting a patient increases, so too does that person's incidence of stroke. For example, in those 75 or younger, stroke risk was more than 2.5 times higher for people with three or more social determinants of health than in those with no social determinants of health (Reshetnyak et al., 2020).

Physical Assessment

The neurologic examination is a systematic process that includes a variety of clinical tests, observations, and assessments designed to evaluate the neurologic status of a complex system. Although the neurologic examination is often limited to a simple screening, the examiner must be able to conduct a thorough neurologic assessment when the patient's history or other physical findings warrant it. An example of a simple screening tool for patients with head injury is the Glasgow Coma Scale (GCS; refer to Box 44-6 in Chapter 44). A GCS score is based on three patient responses: eye opening, motor response, and verbal response. The patient receives a score for their best response in each of these areas, and the three scores are added together. The total score will range from 3 to 15; the higher the number, the better. A score of 8 or lower usually indicates coma.

The brain and spinal cord cannot be examined as directly as other systems of the body. Thus, much of the neurologic examination is an indirect evaluation that assesses the function of the specific body part or parts controlled or innervated by the nervous system. A neurologic assessment is divided into five components: cerebral function, cranial nerves, motor system, sensory system, and reflexes. As in other parts of the physical assessment, the neurologic examination follows a logical sequence and progresses from higher levels of cortical function, such as abstract thinking, to lower levels of function, such as the determination of the integrity of peripheral nerves.

Assessing Cerebral Function

Cerebral abnormalities may cause disturbances in mental status, intellectual functioning, and thought content, and in patterns of emotional behavior. There may also be alterations in perception and motor and language abilities, as well as lifestyle.

Interpretation and documentation of neurologic abnormalities, particularly mental status abnormalities, should be specific and nonjudgmental. Lengthy descriptions and the use of terms such as ***inappropriate*** or ***demented*** are avoided. Terms such as these often mean different things to different people and, therefore, are not useful when describing behavior. The examiner records and reports specific observations regarding level of consciousness (LOC), orientation, emotional state, or thought content, all of which permit comparison by others over time. Analysis and the conclusions that may be drawn from these findings usually depend on the examiner's knowledge of neuroanatomy, neurophysiology, and neuropathology.

Level of Consciousness

The first cue to a change in the neurologic function of a patient may be a change in the LOC, which is evaluated clinically as the patient's ability to respond appropriately to stimuli. It involves both wakefulness and cognition. The nurse compares current findings to previous patient baseline and notifies providers when any deterioration is noted. Rather than use terms like *stuporous* or *obtunded,* it is beneficial to describe the behavior in detail rather than use a broad term.

Nursing Alert

The major source of energy for the brain is glucose. Neurons of the brain are incapable of creating or storing glucose. Therefore, the brain is dependent on blood flow for brain glucose. When blood glucose drops because of insulin administration, patients exhibit signs of decreased mentation, progressing to unconsciousness. If a patient has a history of diabetes or is receiving insulin treatment for other causes, the nurse should perform a glucose fingerstick to assess blood glucose level when a change in the LOC is noted.

Mental Status

An assessment of mental status begins by observing the patient's appearance and behavior, noting dress, grooming, and personal hygiene. Posture, gestures, movements, facial expressions, speech, and motor activity often provide important information about the patient.

Assessing orientation to time, place, and person assists in evaluating mental status. Does the patient know what day it is, what year it is, and where they are? Is the patient aware of who the examiner is and of their purpose for being in the room?

Assessment of mental status also includes both long- and short-term memory, and the ability to concentrate and attend to tasks asked of them as well. A more detailed mental status assessment may also include assessment of an individual's ability to calculate as well as perform abstract reasoning, such as "What would you do if you spotted a fire in your kitchen?"

Perception

The examiner may now consider more specific areas of higher cortical function. **Agnosia** is the inability to interpret or recognize objects seen through the special senses. The patient may see a pencil but not know what it is called or what to do with it. The patient may even be able to describe it but not interpret its function. The patient may experience auditory or tactile agnosia as well as visual agnosia. Each of the dysfunctions implicates a different part of the cortex (Table 42-6).

Screening for visual and tactile agnosia provides insight into the patient's cortical interpretation ability. The patient is shown a familiar object and asked to identify it by name. Placing a familiar object (e.g., key, coin) in the patient's hand and having him or her identify it with both eyes closed is an easy way to assess tactile interpretation.

TABLE 42-6 **Types of Agnosia and Corresponding Sites of Lesions**

Type of Agnosia	Affected Cerebral Area
Visual	Occipital lobe
Auditory	Temporal lobe (lateral and superior portions)
Tactile	Parietal lobe
Body parts and relationships	Parietal lobe (posteroinferior regions)

TABLE 42-7 Types of Aphasia and Region of Brain Involved

Type of Aphasia	Brain Area Involved
Auditory-receptive	Temporal lobe
Visual-receptive	Parietal-occipital area
Expressive speaking	Inferior posterior frontal areas
Expressive writing	Posterior frontal area

Motor Ability

Nurses assess cortical motor integration by asking the patient to perform a skilled act (comb hair, brush teeth). Successful performance requires the ability to understand the activity desired and normal motor strength. Failure signals cerebral dysfunction.

Language Ability

The person with normal neurologic function can understand and communicate in spoken and written language. Does the patient answer questions appropriately? Can they read a sentence from a newspaper and explain its meaning? Can the patient write their name or copy a simple figure that the examiner has drawn? A deficiency in language function is called *aphasia.* Different types of aphasia result from injury to different parts of the brain (Table 42-7).

Unfolding Patient Stories: M.H • Part 2

Recall from Chapter 41 the patient who came to the hospital after falling on icy stairs and sustaining a left midshaft tibula-fibula fracture requiring surgery. The patient also hit their head and was unresponsive for a short time after the fall. Describe the neurologic assessment performed by the nurse. Why should the nurse to report this information promptly to the health care team?

Care for this patient in a realistic virtual environment: ***vSim** for Nursing* (thepoint.lww.com/vSimMedicalSurgical). Practice documenting this patient's care in DocuCare (thepoint.lww.com/DocuCareEHR).

Assessing the Cranial Nerves

Refer back to Table 42-2 on page xxx for assessment of the cranial nerves. Opposite sides of the face and neck are compared throughout the examination. The assessment of multiple cranial nerves may be combined, such as eye movement (CN III, IV, VI) and **dysphagia**, difficulty swallowing (CN IX, X, XII).

Examining the Motor System

A thorough examination of the motor system includes an assessment of muscle size, tone, and strength as well as coordination and balance. The muscles are inspected, and palpated if necessary, for their size and symmetry. Any evidence of atrophy or involuntary movements (tremors, tics) is noted. Muscle **tone** (the tension present in a muscle at rest) is evaluated by palpating various muscle groups at rest and during passive movement. Resistance to these movements is assessed and documented. Abnormalities in tone include **spasticity** (increased muscle tone), **rigidity** (resistance to passive stretch), and flaccidity.

Strength

Assessing the patient's ability to flex or extend the extremities against resistance tests muscle strength. The function of an individual muscle or group of muscles is evaluated by placing the muscle at a disadvantage. The evaluation of muscle strength compares the sides of the body to each other.

Clinicians use a five-point scale to rate muscle strength:

- 5 indicates full power of contraction against gravity and resistance or normal muscle strength;
- 4 indicates fair but not full strength against gravity and a moderate amount of resistance or slight weakness;
- 3 indicates just sufficient strength to overcome the force of gravity or moderate weakness;
- 2 indicates the ability to move but not to overcome the force of gravity or severe weakness;
- 1 indicates minimal contractile power (weak muscle contraction can be palpated but no movement is noted) or very severe weakness; and
- 0 indicates no movement.

Distal and proximal strength in both upper and lower extremities is recorded.

Nursing Alert

There are occasional situations in which weakness of the upper extremities may be so subtle that the nurse is unsure if weakness is present. In these situations, the pronator drift can help assess for weakness. The patient holds her arms out in front of herself with palms facing the ceiling. The patient is asked to hold the position and close her eyes for approximately 20 seconds. If pronation (turning inward of the palm or the arm) or a downward drift of an arm is noted, the limb is weak. A positive pronator drift is associated with upper motor neurons in the brain and spinal cord that control voluntary movement.

Balance and Coordination

Cerebellar influence on the motor system is reflected in balance control and coordination. Coordination in the upper and lower extremities is tested by having the patient perform rapid, alternating movements and point-to-point testing. Speed, symmetry, and degree of difficulty are noted.

Point-to-point testing for coordination of the upper extremities is accomplished by having the patient touch the examiner's extended finger and then their own nose. This is repeated with each arm several times. Coordination in the lower extremities is tested by having the patient run the heel down the anterior surface of the tibia of the other leg. Each leg is tested in turn. **Ataxia** is defined as an inability

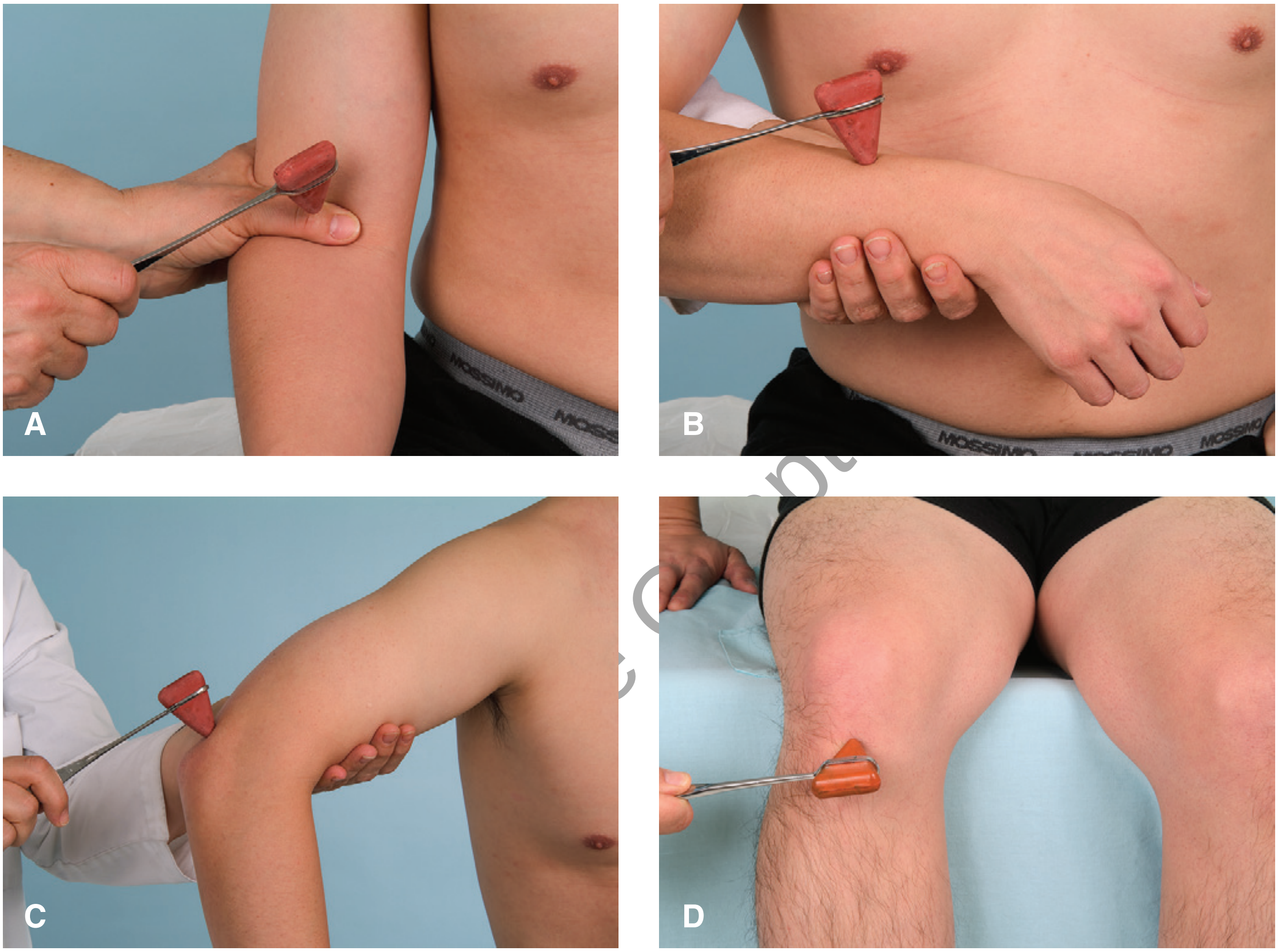


FIGURE 42-14 **Deep tendon reflexes: (A) biceps, (B) brachioradialis, (C) triceps, (D) patellar, and (E) ankles. (From Rhoads, J. (2006). *Advanced health assessment and diagnostic reasoning*. Lippincott Williams & Wilkins; Fig 16.14.)**

to coordinate voluntary muscle action, particularly of the muscle groups used in activities such as walking or reaching for objects. The presence of ataxia or tremors (rhythmic, involuntary movements) during these movements suggests cerebellar disease.

The **Romberg test** is a screening test for balance. The patient stands with feet together and arms at the side, first with eyes open and then with both eyes closed for 20 to 30 seconds. The examiner stands close to reassure the patient of support if they begin to fall. Slight swaying is normal, but a loss of balance is abnormal and is considered a positive Romberg test.

Examining the Reflexes

The motor reflexes are involuntary contractions of muscles or muscle groups in response to abrupt stretching near the site of the muscle's insertion. Common reflexes that may be tested include the deep tendon reflexes (biceps, brachioradialis, triceps, patellar, and ankle reflexes; Fig. 42-14) and superficial or cutaneous reflexes (abdominal reflexes and plantar or Babinski reflex).

Deep Tendon Reflexes

The tendon is struck directly with a reflex hammer, or indirectly by striking the examiner's digit with the hammer, which is placed firmly against the patient's tendon. Testing these reflexes enables the examiner to assess involuntary reflex arcs that depend on the presence of afferent stretch receptors, spinal synapses, efferent motor fibers, and a variety of modifying influences from higher levels.

Grading. The absence of reflexes is significant, although ankle jerks (Achilles reflex) may be normally absent in older people. Deep tendon reflex responses are often graded on a scale of 0 to 4+. Box 42-1 depicts how to document reflexes using this scale. As stated previously, scale ratings are highly subjective. Findings can be recorded as a fraction, indicating the scale range (e.g., 2/4). Some examiners prefer to use the terms *present*, *absent*, and *diminished* when describing reflexes.

Clonus. When reflexes are very hyperactive, a phenomenon called *clonus* may be elicited. If the foot is abruptly dorsiflexed, it may continue to "beat" two or three times before it settles into a position of rest. Occasionally, with CNS disease, this activity persists, and the foot does not come to rest while the tendon is being stretched but continues the repetitive activity. The unsustained clonus associated with normal but hyperactive reflexes is not considered pathologic. Sustained clonus always indicates the presence of CNS disease and requires further evaluation.

Superficial Reflexes

The major superficial reflexes include corneal, gag or swallowing, upper/lower abdominal, cremasteric (men only), plantar, and perianal. These reflexes are graded differently than the motor reflexes and are noted to be present (+) or absent (–). Of these, only the corneal, gag, and plantar reflexes are commonly tested.

The corneal reflex is tested carefully using a clean wisp of cotton and lightly touching the outer corner of each eye on the sclera. The reflex is present if the action elicits a blink. Conditions such as a stroke or coma might result in loss of this reflex, either unilaterally or bilaterally. Loss of this reflex indicates the need for eye protection and possible lubrication to prevent corneal damage.

The gag reflex is elicited by gently touching the back of the pharynx with a cotton-tipped applicator; first on one side of the uvula and then the other. Positive response is an equal elevation of the uvula and "gag" with stimulation. Absent response on one or both sides can be seen following a stroke and requires careful evaluation and treatment of the resultant swallowing dysfunction to prevent aspiration of food and fluids.

The plantar reflex, also known as the **Babinski reflex**, is elicited by stroking the lateral side of the foot with a tongue blade or the handle of a reflex hammer. In a person with an intact CNS, if the lateral aspect of the sole of the foot is stroked, the toes contract and draw together. However, in a person who has CNS disease of the motor system, the toes fan out. This is normal in newborns but in adults, the presence of Babinski indicates brain dysfunction (see Fig 2-15).

BOX 42-1

Documenting Reflexes

Deep tendon reflexes are graded on a scale of 0 to 4:

0	No response
1+	Diminished (hypoactive)
2+	Normal
3+	Increased (may be interpreted as normal)
4+	Hyperactive (hyperreflexia)

The deep tendon responses and plantar reflexes are commonly recorded on stick figures. The arrow points downward if the plantar response is normal and upward if the response is abnormal.

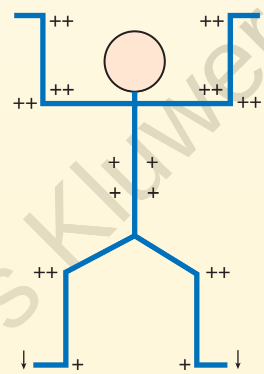


FIGURE 42-15 **The clinician uses an instrument to stroke the sole of the patient's foot, beginning at the heel and curving upward, causing toe flexion (negative Babinski sign) (A and B). Toes that fan outward (positive Babinski sign) may indicate injury to the brain or spinal nerves. (From Bickley, L. S., & Szilagyi, P. (2003).** ***Bates' guide to physical examination and history taking*** **(8th ed.; Unfig 16-67, 68, and 69). Lippincott Williams & Wilkins.)**

Sensory Examination

The sensory system is even more complex than the motor system because sensory modalities are carried in different tracts located in different portions of the spinal cord. The sensory examination is largely subjective and requires the cooperation of the patient. The examiner should be familiar with dermatomes that represent the distribution of the peripheral nerves that arise from the spinal cord (see Fig. 42-13). Exceptions to this include major destructive lesions of the brain; loss of sensation, which may affect an entire side of the body; and the neuropathies associated with alcoholism, which occur in a glove-and-stocking distribution (i.e., over the entire hand or foot, in areas traditionally covered by a glove or sock).

Assessment of the sensory system involves tests for tactile sensation, superficial pain, vibration, and position sense (proprioception). During the sensory assessment, the patient's eyes are closed. Simple directions and reassurance that the examiner will not hurt or startle the patient encourage cooperation. Comparisons between the left- and right-side findings are documented depending on which modality is found to have a deficit.

Diagnostic Evaluation

Computed Tomography Scanning

Computed tomography (CT) scanning makes use of a narrow x-ray beam to scan the body part in successive layers. The images provide cross-sectional views of the brain, with distinguishing differences in tissue densities of the skull, cortex, subcortical structures, and ventricles. The image is displayed on a monitor and is photographed and stored digitally.

Lesions in the brain are seen as variations in tissue density differing from the surrounding normal brain tissue. Abnormalities of tissue indicate possible tumor masses, brain infarction, displacement of the ventricles, and cortical atrophy. An emergency CT scan is performed in the patient with suspected brain bleed (e.g., subarachnoid hemorrhage) since blood within the basal cisterns is generally evident within the first 24 hours, whereas conventional magnetic resonance imaging (MRI) generally is less sensitive than CT scans for detecting blood (Ferri, 2019).

Procedure

CT scanning is usually performed first without contrast material and then with IV contrast enhancement. The patient lies on an adjustable table with the head held in a fixed position while the scanning system rotates around the head or spine and produces cross-sectional images. The patient must lie perfectly still without talking or moving because motion distorts the image.

CT scanning is noninvasive and painless and has a high degree of sensitivity for detecting lesions. With advances in CT scanning, the number of disorders and injuries that can be diagnosed is increasing.

Nursing Interventions

Essential nursing interventions include preparation for the procedure and patient monitoring. Preparation includes teaching the patient about the need to lie quietly throughout the procedure. A review of relaxation techniques may be helpful for patients with claustrophobia. Sedation can be used if agitation, restlessness, or confusion will interfere with a successful study. Ongoing patient monitoring during sedation is necessary.

If an intravenous (IV) contrast agent is used, the patient must be assessed before the CT scan for a contrast agent allergy. The contrast is iodine based; however, since early to mid-2000s a less allergenic, nonionic/low osmolar agent has been used. Previously, it was believed that a shellfish allergy was a risk factor for an allergic reaction to iodine-based dye; however, the shellfish allergen is not a component of intravenous contrast (Ruff, Banayan, & Overdeck, 2021; Wuff, Schmitz, Choi, & Kapusnik-Uner, 2021).

An IV line for injection of the contrast agent is required prior to the study. Patients who receive an IV or inhalation contrast agent are monitored during and after the procedure for allergic reactions, kidney function, and other side effects, including flushing, nausea, and vomiting. Preprocedure hydration, along with the lowest possible dose of contrast for the study, is recommended, since contrast-induced nephropathy (CIN) is a cause of acute kidney injury (AKI). The incidence of CIN-AKI ranges from 6% to 27%, and thus the nurse should monitor urinary output and serum creatinine post procedure (Efe et al, 2021). Risk factors for CIN-AKI include preexisting impaired renal function, diabetes, left ventricular dysfunction, and anemia.

Positron Emission Tomography

Positron emission tomography (PET) is a computer-based nuclear imaging technique that produces images of actual organ functioning.

Procedure

The patient either inhales a radioactive gas or is injected with a radioactive substance that emits positively charged particles. When these positrons combine with negatively charged electrons (normally found in the body's cells), the resultant gamma rays can be detected by a scanning device that produces a series of two-dimensional views at various levels of the brain. This information is integrated by a computer and gives a composite picture of the brain at work.

PET permits the measurement of blood flow, tissue composition, and brain metabolism and thus indirectly evaluates brain function. The brain is one of the most metabolically active organs, consuming 80% of the glucose the body uses. PET measures this activity in specific areas of the brain and can detect changes in glucose use.

In addition, PET is useful in showing metabolic changes in the brain (Alzheimer disease), locating lesions (brain tumor, epileptogenic lesions), identifying blood flow and oxygen metabolism in patients with strokes, evaluating new therapies for brain tumors, and revealing biochemical abnormalities associated with mental illness. The isotopes used have a very short half-life and are expensive to produce, requiring specialized equipment for production.

Nursing Interventions

Key nursing interventions include patient preparation, which involves explaining the test and teaching the patient about inhalation techniques and the sensations (e.g., dizziness, light-headedness, and headache) that may occur. The IV injection of the radioactive substance produces similar side effects. Relaxation exercises may reduce anxiety during the test.

Single-Photon Emission Computed Tomography

Procedure

Single-photon emission computed tomography (SPECT) is a three-dimensional imaging technique that uses radionuclides and instruments to detect single photons. It is a perfusion study that captures a moment of cerebral blood flow at the time of injection of a radionuclide. Gamma photons are emitted from a radiopharmaceutical agent administered to the patient and are detected by a rotating gamma camera or cameras; the image is sent to a minicomputer. This approach allows areas behind overlying structures or background to be viewed, greatly increasing the contrast between normal and abnormal tissue. It is relatively inexpensive, and the duration is similar to that of a CT scan.

SPECT is useful in detecting the extent and location of abnormally perfused areas of the brain, thus allowing detection, localization, and sizing of stroke (before it is visible by CT scan); localization of seizure foci in epilepsy; detection of tumor progression; and evaluation of perfusion before and after neurosurgical procedures. Pregnancy and breastfeeding are contraindications to SPECT.

Nursing Interventions

The nursing interventions for SPECT primarily include patient preparation and patient monitoring. Teaching about what to expect before the test can allay anxiety and ensure patient cooperation during the test. Premenopausal women are advised to practice effective contraception before and for several days after testing, and the woman who is breastfeeding is instructed to stop nursing for the time period recommended by the nuclear medicine department.

The nurse may need to accompany and monitor the patient during transport to the nuclear medicine department for the scan. Patients are monitored during and after the procedure for allergic reactions to the radiopharmaceutical agent.

Magnetic Resonance Imaging

Procedure

MRI uses a powerful magnetic field to obtain images of different areas of the body. This diagnostic test involves altering hydrogen ions in the body. Placing the patient into a powerful magnetic field causes the hydrogen nuclei (protons) within the body to align like small magnets in a magnetic field. In combination with radiofrequency pulses, the protons emit signals, which are converted to images. An MRI scan can be performed with or without a contrast agent and can identify a cerebral abnormality earlier and more clearly than other diagnostic tests. It can provide information about the chemical changes within cells, allowing the clinician to monitor a tumor's response to treatment. The use of MRA allows visualization of the cerebral vasculature without the administration of an arterial contrast agent, but the clarity of the images is enhanced when a contrast agent is used. MRI does not involve ionizing radiation and if contrast is required the agent is gadolinium-based. Noniodinated IV contrast agents and generally considered safe (Ferri, 2019). However, if contrast is used, kidney function must be assessed. At present, MRI is most valuable in the diagnosis of nonacute conditions because the test may take up to an hour to complete.

Nursing Interventions

Patient preparation should include teaching relaxation techniques and informing the patient that they will be able to talk to the staff by means of a microphone located inside the scanner. Many MRI suites provide headphones so that patients can listen to the music of their choice during the procedure.

Before the patient enters the room where the MRI is to be performed, all metal objects and credit cards (the magnetic field can erase them) are removed. This includes medication patches that have a metal backing; these can cause burns if not removed. No metal objects may be brought into the room where the MRI is located; this includes oxygen tanks, traditional ventilators, or even stethoscopes. The magnetic field generated by the unit is so strong that any metal-containing items will be strongly attracted and literally can be pulled away with such force that they fly like projectiles toward the magnet. There is a risk of severe injury and death; furthermore, damage to a very expensive piece of equipment may occur. A patient history is obtained to determine the presence of any metal objects (e.g., aneurysm clips, orthopedic hardware, pacemakers, artificial heart valves). These objects could malfunction, be dislodged, or heat up as they absorb energy. Cochlear implants will be inactivated by MRI; therefore, other imaging procedures are considered.

The patient lies on a flat platform that is moved into a tube housing the magnet, thus an MRI requires a cooperative patient. The scanning process is painless, but the patient hears loud thumping of the magnetic coils as the magnetic field is being pulsed. Because the MRI scanner is a narrow tube, patients may experience claustrophobia; sedation may be prescribed in these circumstances. Newer versions of MRI machines (open MRI) are less claustrophobic than the earlier devices and are available in some locations. However, the images produced on these machines are not optimal, and traditional devices are preferable for accurate diagnosis.

Nursing Alert

For patient safety, the nurse must make sure no patient care equipment (e.g., portable oxygen tanks) that contains metal or metal parts enters the room where the MRI is located. Oxygen tanks made of aluminum are MRI compatible. The patient must be assessed for the presence of medication patches with foil backing (such as nicotine) that may cause a burn. For a list of medical devices and compatibility with MRI, please refer to the website http://www.mrisafety.com/List.html.

Cerebral Angiography

Procedure

Cerebral angiography is an x-ray study of the cerebral circulation with a contrast agent injected into a selected artery. Cerebral angiography is a valuable tool to investigate vascular disease, aneurysms, and arteriovenous malformations and to define their anatomy. It is still considered the gold standard for diagnosing these conditions.

Most cerebral angiograms are performed by threading a catheter through the femoral artery in the groin and up to the desired vessel. After the groin is shaved and prepared, a local anesthetic is administered to prevent pain at the insertion site and to reduce arterial spasm. A catheter is introduced into the femoral artery, flushed with heparinized saline, and filled with contrast agent. Fluoroscopy is used to guide the catheter to the appropriate vessels. During injection of the contrast agent, images are made of the arterial and venous phases of circulation through the brain.

Nursing Interventions

The patient is NPO for 4 to 6 hours prior to the test. Before going to the x-ray department, the patient is instructed to void. The locations of the appropriate peripheral pulses are marked with a felt-tip pen. The patient is instructed to remain immobile during the angiogram process and is told to expect a brief feeling of warmth in the face, behind the eyes, or in the jaw, teeth, tongue, and lips, and a metallic taste when the contrast agent is injected.

Nursing care after cerebral angiography includes observation for signs and symptoms of altered cerebral blood flow. In some instances, patients may experience major or minor arterial blockage due to embolism, thrombosis, or hemorrhage, producing a neurologic deficit. Signs of such an occurrence include alterations in the level of responsiveness and consciousness, weakness on one side of the body, motor or sensory deficits, and speech disturbances. Therefore, it is necessary to observe the patient frequently for these signs and to report them immediately if they occur. In addition, the nurse monitors intake and output, looking for renal complications from the dye.

The most common complication post-procedure is a groin hematoma (Biller, Schneck, & Ruland, 2022); therefore, the injection site is observed for hematoma formation (a localized collection of blood), and an ice bag may be applied intermittently to the puncture site to relieve swelling and discomfort. Because a hematoma at the puncture site or embolization to a distant artery affects the peripheral pulses, these pulses are monitored frequently. The color and temperature of the involved extremity are assessed to detect possible embolism (the limb would be cool and pale if arterial perfusion is impaired)..

Nursing Alert

The nurse should be aware that patients undergoing vascular diagnostic studies (angiography or venography) who present with AKI or chronic kidney failure (refer to chapter 26) and are also prescribed metformin (an oral anti-hyperglycemic medication for patients with non-insulin-dependent diabetes mellitus), the metformin may be withheld due to the rare development of lactic acidosis. Lactic acidosis in this scenario has a 50% mortality rate (Shin, 2021). In general, the medication is withheld for the 48 hours after the vascular procedure and resumed only after renal function has been reassessed.

Myelography

Procedure

A myelogram is an x-ray of the spinal subarachnoid space taken after the injection of a contrast agent through a lumbar puncture. It outlines the spinal subarachnoid space and shows any distortion of the spinal cord or spinal dural sac caused by tumors, cysts, herniated vertebral disks, or other lesions. Water-based agents have replaced oil-based agents, and their use has reduced side effects and complications; these agents disperse upward through the CSF. Myelography is performed less frequently today because of the sensitivity of CT and MRI scanning. It is still used occasionally to provide information about the spinal cord and nerve roots and is useful if that patient cannot have an MRI (Rocos, 2020).

Nursing Interventions

Because many patients have misconceptions about myelography, the nurse clarifies the explanation given by the provider and answers questions. The patient is informed about what to expect during the procedure and should be aware that changes in position may be made during the procedure. The meal that normally would be eaten before the procedure is omitted. A sedative may be prescribed to help the patient cope with this rather lengthy test. Patient preparation for lumbar puncture is discussed later in this chapter.

After myelography, the patient lies in bed with the head of the bed elevated 30 to 45 degrees. The patient is advised to remain in bed in the recommended position for 3 hours or as prescribed by the provider. The patient is encouraged to drink liberal amounts of fluid for rehydration and replacement of CSF. The blood pressure, pulse, respiratory rate, and temperature are monitored, as well as the patient's ability to void. Untoward signs include headache, fever, stiff neck, **photophobia** (sensitivity to light), seizures, and signs of chemical or bacterial meningitis. Headaches occur in approximately 10% to 25% of patients (Ferri, 2019).

Noninvasive Carotid Flow Studies

Procedure

Noninvasive carotid flow studies use ultrasound imagery and Doppler measurements of arterial blood flow to evaluate carotid and deep orbital circulation. The graph produced indicates blood velocity. Increased blood velocity can indicate stenosis or partial obstruction. These tests are often obtained before arteriography, which carries a higher risk of stroke or death. Carotid Doppler, carotid ultrasonography, oculoplethysmography, and ophthalmodynamometry are four common noninvasive vascular techniques that permit evaluation of arterial blood flow and detection of arterial stenosis, occlusion, and plaques. These vascular studies allow noninvasive imaging of extracranial and intracranial circulation.

Nursing Interventions

When a carotid flow study is scheduled, the procedure is described to the patient. The patient is informed that this is a noninvasive test, that a hand-held transducer will be placed over the neck or orbits of the eyes, and that some type of water-soluble jelly is used on the transducer.

Electroencephalography (EEG)

Procedure

An electroencephalogram (EEG) represents a record of the electrical activity generated in the brain. It is obtained through electrodes applied on the scalp or through microelectrodes placed within the brain tissue. It provides a physiologic assessment of cerebral activity.

The EEG is a useful test for diagnosing and evaluating seizure disorders, coma, or organic brain syndrome. Tumors, brain abscesses, blood clots, and infection may cause abnormal patterns in electrical activity. The EEG is also used in making a determination of brain death.

For a baseline recording, the patient lies quietly with both eyes closed. The patient may be asked to hyperventilate for 3 to 4 minutes and then look at a bright, flashing light for photic stimulation. These activation procedures are performed to evoke abnormal electrical discharges, such as seizure potentials. A sleep EEG may be recorded after sedation because some abnormal brain waves are seen only when the patient is asleep.

Nursing Interventions

To increase the chances of recording seizure activity, it is sometimes recommended that the patient be deprived of sleep on the night before the EEG. Antiseizure agents, tranquilizers, stimulants, and depressants should be withheld 24 to 48 hours before an EEG because these medications can alter the EEG wave patterns or mask the abnormal wave patterns of seizure disorders (England & Plueger, 2019).

The patient is informed that the standard EEG takes 45 to 60 minutes (12 hours for a sleep EEG). The patient is assured that the procedure does not cause an electric shock and that the EEG is a diagnostic test, not a form of treatment. An EEG requires patient cooperation and ability to lie quietly during the test. Sedation is not advisable because it may lower the seizure threshold in patients with a seizure disorder and it alters brain wave activity in all patients. The nurse needs to check with the physician regarding the administration of antiseizure medication prior to testing.

Routine EEGs use a water-soluble lubricant for electrode contact, which at the conclusion of the study can be wiped off and removed by shampooing. Sleep EEGs involve the use of collodion glue for electrode contact, which requires acetone for removal.

Electromyography (EMG)

Procedure

An electromyogram (EMG) is obtained by inserting needle electrodes into the skeletal muscles to measure changes in the electrical potential of the muscles and the nerves leading to them. The electrical potentials are shown on an oscilloscope and amplified so that both the sound and appearance of the waves can be analyzed and compared simultaneously.

An EMG is useful in determining the presence of neuromuscular disorders and myopathies. It helps distinguish weakness due to neuropathy (functional or pathologic changes in the PNS) from weakness resulting from other causes.

Nursing Interventions

The procedure is explained, and the patient is warned to expect a sensation similar to that of an intramuscular injection as the needle is inserted into the muscle. The muscles examined may ache for a short time after the procedure.

Lumbar Puncture and Examination of Cerebrospinal Fluid

Procedure

A lumbar puncture (spinal tap) is an aseptic procedure carried out by inserting a needle into the lumbar subarachnoid space to withdraw CSF. The test may be performed to obtain CSF for examination, to measure and reduce CSF pressure, to assess for infection, and to determine the presence or absence of blood in the CSF. Antibiotics may be administered intrathecally (into the spinal canal) in certain cases of infection or contrast injected for diagnostic purposes.

The needle is usually inserted into the subarachnoid space between the third and fourth or fourth and fifth lumbar vertebrae. Because the spinal cord divides into a sheaf of nerves at the first lumbar vertebra, insertion of the needle below the level of the third lumbar vertebra prevents puncture of the spinal cord.

A successful lumbar puncture (LP) requires that the patient be relaxed; an anxious patient is tense, and this may increase the pressure reading. CSF pressure with the patient in a lateral recumbent position is normally 70 to 200 mm H_2O. This value is position dependent and will change with a horizontal or sitting position (Fischbach & Dunning, 2021). Pressures of more than 200 mm H_2O are considered abnormal.

An LP may be risky in the presence of an intracranial mass lesion because ICP is decreased by the removal of CSF, and the brain may herniate downward through the tentorium and the foramen magnum. To avoid this complication, a CT scan must be done prior to the procedure for patients with a suspected intracranial mass. Additionally, LPs are avoided in patients on antiplatelet therapy or anticoagulants. See Box 42-2 for nursing guidelines for assisting with a lumbar puncture.

Cerebrospinal Fluid Analysis

The CSF should be clear and colorless. Pink, blood-tinged, or grossly bloody CSF may indicate a subarachnoid hemorrhage. Cloudiness of CSF may be due to increased WBCs or increased protein from microorganisms; whereas xanthochromia (yellow, orange, or brown color) of CNS is usually due to RBC breakdown (Hickey, 2019). Sometimes, with a difficult lumbar puncture, the CSF initially is bloody because of local trauma but then becomes clearer. Usually, specimens are obtained for cell count, culture, and glucose and protein testing. The specimens should be sent to the laboratory immediately because changes will take place and alter the result if the specimens are allowed to stand.

Post–Lumbar Puncture Headache

A post–lumbar puncture headache, ranging from mild to severe, may occur a few hours to several days after the procedure. This is the most common complication, occurring in 15% to 30% of patients. It is a throbbing bifrontal or occipital headache, dull and deep in character. It is particularly severe on sitting or standing but lessens or disappears when the patient lies down.

The headache is caused by CSF leakage at the puncture site. The fluid continues to escape into the tissues by way of the needle track from the spinal canal. It is then absorbed promptly by the lymphatic system. As a result of this leak, the supply of CSF in the cranium is depleted to a point at which it is insufficient to maintain proper mechanical stabilization

BOX 42-2

ASSISTING WITH A LUMBAR PUNCTURE

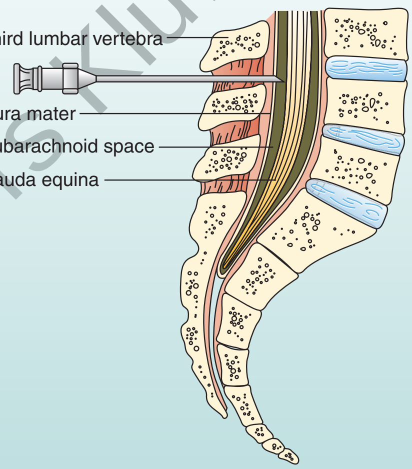
A needle is inserted into the subarachnoid space through the third and fourth or fourth and fifth lumbar interface to withdraw spinal fluid.

PREPROCEDURE

1. Determine whether written consent for the procedure has been obtained.
2. Explain the procedure to the patient and describe sensations that are likely during the procedure (i.e., a sensation of cold as the site is cleansed with solution, a needle prick when local anesthetic is injected).
3. Determine whether the patient has any questions or misconceptions about the procedure; reassure the patient that the needle will not enter the spinal cord or cause paralysis.
4. Instruct the patient to void before the procedure.

PROCEDURE

1. The patient is positioned on one side (knee to chest position) at the edge of the bed or examining table with back toward the provider; the legs are flexed as much as possible to increase the space between the spinous processes of the vertebrae, for easier entry into the subarachnoid space.
2. A small pillow may be placed under the patient's head to maintain the spine in a horizontal position; a pillow may be placed between the legs to prevent the upper leg from rolling forward.
3. The nurse assists the patient to maintain the position to avoid sudden movement, which can produce a traumatic (bloody) tap.
4. The patient is encouraged to relax and is instructed to breathe normally because hyperventilation may lower an elevated pressure.
5. The nurse describes the procedure step by step to the patient as it proceeds.
6. Using an aseptic technique, the provider cleanses the puncture site with an antiseptic solution and drapes the site.
7. The provider injects local anesthetic to numb the puncture site and then inserts a spinal needle into the subarachnoid space through the third and fourth or fourth and fifth lumbar interspace.
8. A specimen of CSF is removed and usually collected in three test tubes, labeled in order of collection. A pressure reading may be obtained. The needle is withdrawn.



9. The provider applies a small dressing to the puncture site.
10. The tubes of CSF are sent to the laboratory immediately.

POSTPROCEDURE

Typically patients are instructed to rest in bed for a few hours after a lumbar tap, and fluids are encouraged; however, research reveals no definite differences in the effects of bed rest or hydration of patients. Therefore, the nurse should refer to institutional procedures for postprocedure care.

1. Monitor the patient for complications of lumbar puncture; notify the provider if complications occur:
   a. Common complications: Post–lumbar puncture headache, voiding difficulties, slight elevation of temperature, backache or spasms, stiffness of neck. Typical management of postprocedure headache includes maintaining a supine posture, hydration, and analgesia and/or antiemetics prn; however, the nurse follows institutional procedures until best practices are delineated.
   b. Rare complications: Herniation of intracranial contents, spinal epidural abscess, spinal epidural hematoma, meningitis

of the brain. This leakage of CSF allows settling of the brain when the patient assumes an upright position, producing tension and stretching the venous sinuses and pain-sensitive structures. Both traction and pain are lessened and the leakage is reduced when the patient lies down for 4 to 8 hours (Fischbach & Dunning, 2019).

Post–lumbar puncture headache may be avoided if a small-gauge needle is used. The postpuncture headache is

Clinical Judgment Alert

A patient, K.J. is on your orthopedic unit after a motorcycle collision (without helmet) resulting in multiple injuries including three rib fractures (left 9, 10, and 11), right femur fracture and a concussion. CT scan on admission was negative for cranial fractures or bleed. Today is hospital day 3 and post op day two after an open reduction and internal fixation (ORIF) repair of the right femur fracture. You have cared for KJ for the past two days and notice today that the patient is complaining of a headache and some neck pain. You assess vital signs at 8 am which are: T 98.2 F, P 88 and regular, 24 RR with pulse oximetry of 94% on room air. B/P is 138/82. Physical examination reveals S1S2 without murmur, gallop or rub, lungs are decreased breath sounds to mid on the left, crackles of left lower lobe, trach is deviating slightly to the left, abdomen is soft, nondistended, nontender, Bowel sounds (BS)+ in all 4 Q, + flatus, no bowel movement. Tolerating regular diet well, no nausea or vomiting. Pedal and posterior tibial pulses are 3+ bil, there is some LLE peripheral edema, non-pitting, capillary refill is 2 seconds all extremities. Skin and warm and dry with multiple abrasions noted on lower extremities and left temporal area. Pupils equal and reacting to light (PEARL) 3 mm bil. Pt has 5/5 strength in both upper extremities and left lower extremity (unable to assess full strength of right lower extremity [RLE]). Pt is oriented to person, place, time, and situation. Although the neuro status is unchanged, there is a slowness in KJ's responses today as compared for yesterday. Morning laboratory data taken at 6am are as follows: Na of 140 mEq/L, K+ of 3.7 mEq/L, Cl of 98 mEq/L, CO2 25 mEq/L; glucose of 95 mg/dL. Complete blood count (CBC) is pending.

Step One: Recognize cues where relevant and important information is identified from different sources, such as medical history or vital signs.

Answer: Multiple injuries including three rib fractures (left 9, 10, and 11), right femur fracture and concussion. Negative CT scan, open reduction and internal fixation (ORIF) repair of the right femur fracture. Complaints of a headache and neck pain, sluggish verbal responses, normal pupils and full strength of ¾ extremities. Respiratory rate of 24 with pulse oximetry of 94% on room air. B/P is 138/82. Decreased breath sounds to mid on the left, crackles of left lower lobe, trach deviated to left, LLE peripheral edema, multiple abrasions noted on lower extremities and left temporal area. Complete blood count (CBC) is pending. Normal electrolytes and glucose.

Step Two: Analyze cues, which is organizing and linking the recognized cues to the patient's clinical presentation.

Answer: *You link left rib fractures 9-11 with potential complication of splenic injury and are awaiting the CBC, however there is no evidence of hypovolemia as there is no tachycardia or hypotension, capillary refill is normal and skin is warm and dry.*

You also link the left rib fractures with decreased left sided breath sounds, crackles, tachypnea, tracheal deviation and decreased oxygen saturation on room air with potential atelectasis.

You link the headache, neck pain, and sluggish verbal responses with the concussion, abrasion of left temporal area and although the CT scan was negative on admission, you are concerned about potential rising intracranial pressure (ICP), and seizures. There are no complaints of nausea or vomiting.

Step Three: Forms and Prioritize hypotheses, where hypotheses are evaluated and ranked according to priority. This can include urgency, likelihood, risk, difficulty and/or time. In this phase you cluster your findings, to arrive at a list of problems (actual and or potential problems) you believe the patient is experiencing and determine the importance or urgency. What do you think is of greatest concern?

Answer: *You rank the highest priority is concern for rising ICP, headache, neck pain, known head trauma (concussion) and the potential for seizures. Your next concern is the potential atelectasis of the left lung related to multiple fractures, increased respiratory rate, tracheal deviation, and decreasing O2 sat. And although the patient has no symptoms of hypovolemia, you are aware of the risk of splenic lacerations and are awaiting the CBC to assess trending with yesterday's labs.*

Step Four: Generate solutions, which is identifying expected outcomes and using hypotheses to define a set of interventions for the expected outcomes.

Answer: Since your priority is the patient's neurological status, you will ensure oxygen is in the room and suction. You will notify the providers of the new complaint of headache, and neck pain, sluggish sensorium and your concern about potential for ICP and seizures. You will also inform them of the lung sound changes, tachypnea, tracheal deviation, and decreasing oxygen saturation and the CBC is still pending (you are assessing for leukocytosis or elevated WBC) and

the need for low flow oxygen. You will also note trending of the H/H related to left 9, 10, 111 rib fractures and continue to monitor vital signs.

Step Five: Take action, where the solutions that address the highest priorities are implemented.

***Answer:** You continue to monitor neuro signs and prepare in case of seizures which will involve pushing aside furniture that may injure the patient during a seizure, loosening constrictive clothing, padding and raising the side rails. If the patient wears glasses you may remove them if seizures are anticipated. You notified the provider and a repeat CT scan is ordered stat. The patient is placed on nasal cannula at 2 Liters and a repeat chest film is ordered. You will place the patient on their side in case of seizures to prevent aspiration and protect the airway.*

Step Six: Evaluate outcomes, which is comparing observed outcomes against expected outcomes.

***Answer:** The CT scan reveals a small traumatic intracerebral hemorrhage, and the patient is transferred to the neuro step down area. The CBC came back within normal limits and the chest X-ray did reveal atelectasis of the left lower lobe. As soon as the patient stabilizes you will teach the patient about the use of incentive spirometry. The patient remained seizure free but you are prepared for this potential complication and ensured all needed equipment was at the bedside. You alerted the team to your concerns, and you learned that sometimes complications occur after the first 24 hours and you always need to be alert to subtle changes. You did great!*

usually managed by bed rest, analgesic agents, and hydration. The nurse should follow hospital standards while best practices are being developed. Occasionally, if the headache persists, an epidural blood patch may be used. Blood is withdrawn from the antecubital vein and injected into the epidural space, usually at the site of the previous spinal puncture. The rationale is that the blood acts as a gelatinous plug to seal the hole in the dura, preventing further loss of CSF. The success rate of a single epidural blood patch is estimated between 70% and 98% (Garza, Robertson, Smith, & Whealy, 2022)

Other Complications of Lumbar Puncture

Herniation of the intracranial contents, spinal epidural abscess, spinal epidural hematoma, and meningitis are rare but serious complications of lumbar puncture. Other complications include temporary voiding problems, slight elevation of temperature, backache or spasms, and stiffness of the neck.

CHAPTER REVIEW

NCLEX-Style Review Questions

1. A patient is undergoing a cerebral angiography to rule out an aneurysm. When preparing the patient for the procedure, what would the nurse include in the instructions? Select all that apply.

a. Expect a metallic taste when the contrast agent is injected.
b. You will need a full bladder prior to the procedure.
c. General sedation will be given prior to procedure.
d. Assess and document peripheral pulses pre-procedure
e. Evaluate if the patient is on metformin pre-procedure.

Answer: A, D, E. A cerebral angiography involves the injection of contrast into an **artery**. The patient is NPO for 4 to 6 hours pre-procedure. It is imperative that peripheral pulses (radial or pedal and posterior tibial) are assessed pre-procedure so that a baseline record of the patient's perfusion is established. Anticipatory guidance involves informing the patient about the sights, sounds, smells, tastes, and temperature of the environment where the angiography takes place. The contrast when injected results in a brief feeling of warmth in the face, behind the eyes, or in the jaw, teeth, tongue, and lips, and a metallic taste when the contrast agent is injected. The contrast is an iodinated material that has been associated with contrast induced acute kidney injury (CI-AKI). If a patient is at risk for CI-AKI and has been taking metformin, notify the provider and assess if it should be discontinued for 48 hours after the procedure.

2. The nurse is assisting with a lumbar puncture. What is the most common complication for which the nurse should monitor the patient following the procedure (column 1) and what intervention is indicated (column 2)? Select one from each column.

Column 1	**Column 2**
a. Post–lumbar puncture headache	a. Assess for back pain.
b. Herniation of intracranial contents	b. Assess for dilated pupils.
c. Spinal epidural abscess	c. Place the patient on bedrest.
d. Meningitis	d. Assess for stiff neck.

Answers Column 1-A, Column 2 C, Headache is the most common complication, occurring in 15% to 30% of patients. It is a throbbing bifrontal or occipital headache, dull and deep in character. It is particularly severe on sitting or standing but lessens or disappears when the patient lies down. Hydration is also useful. Brain herniation is associated with pupillary changes, decreased level of consciousness (LOC), vomiting, headache, and Cushing's triad (hypertension, bradycardia, and bradypnea). Spinal epidural abscess symptoms may include back pain, fever, unusual sensations throughout the body, and headache, whereas meningitis presents with nuchal rigidity (stiff neck), fever, sensitivity to light (photophobia), and headache. These disorders will be covered in subsequent chapters.

3. A patient is scheduled for an EEG tomorrow. Which information should the nurse provide to the patient prior to the procedure? (Select all that apply.)

a. Antiseizure medications will be withheld prior to procedure.
b. Sedation will be given during the procedure.
c. There is a slight chance of electric shock.
d. Maintain a sleep-deprived state the night before the procedure.
e. The procedure will be completed in 20 to 30 minutes
f. Patient cooperation is required as is the ability to lie quietly during the test

Answers: A, D F Patient cooperation is required for an EEG as they will be asked to lie quietly initially. The patient may then be asked to hyperventilate for 3 to 4 minutes, then look at a bright, flashing light for photic stimulation. The procedure takes 45 to 60 minutes to complete. The patient may be deprived of sleep on the night before the EEG. Antiseizure agents, tranquilizers, stimulants, and depressants should be withheld 24 to 48 hours before an EEG because these medications can alter the EEG wave patterns or mask the abnormal wave patterns of seizure disorders.

4. A patient was an unrestrained driver involved in a motor vehicle collision. Upon arrival, multiple facial lacerations are noted and serosanguinous drainage is noted from both nares bilaterally. The nurse anticipates that the serosanguinous drainage may indicate ______ (select from column 1) and two actions that will be taken are __ (select two from column 2).

Column 1	**Column 2**
a. Rhinorrhea	a. Nasal packing will be placed in each nares.
b. Otorrhea	b. If required, an orogastric tube should be inserted.
c. Battle's sign	c. Monitor for signs and symptoms of meningitis.
d. Raccoon sign	d. Nasotracheal suctioning is permitted.

Column 1- A, column 2 B & C. Rhinorrhea is the leakage of cerebral spinal fluid (CSF), suggesting a fracture involving the cribriform plates of the anterior cranial fossa. The nurse understands that CSF is usually clear but in the presence of multiple facial lacerations and fractures, the drainage may be bloody or serosanguinous (contains both blood and serum). The nurse recognizes that the patient is at risk for meningitis and that nothing is allowed into the patient's nose or ears (suction or nasogastric catheters, dressings, tissues, etc.). If needed, an orogastric tube (mouth to stomach) would be used rather than a nasogastric tube (nose to stomach). Subsequent chapters will detail how to test drainage for CSF.

5. The nurse is testing the extraocular movements (EOM) of a patient. Which cranial nerves are assessed when evaluating EOMs? (Select all that apply.) a. Abducensb. Oculomotor c. Optic d. Trochlear

Answers A, B and D. Assessing EOMs evaluates cranial nerve (CN) 3 (oculomotor), CN 4 (trochlear) and CN 6 (abducens), which are responsible for eye movement.

Try these additional resources, available at **http://thepoint.lww.com/Honan3e**, to enhance your learning and understanding of this chapter:

- NCLEX-Style Student Review Questions
- Journal Articles

REFERENCES AND SELECTED READINGS

References and selected readings associated with this chapter can be found on the website that accompanies the book. Visit **http://thepoint.lww.com/Honan3e** to access the references and other additional resources associated with this chapter.

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