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# 60 Assessment of Neurologic Function

## LEARNING OUTCOMES

*On completion of this chapter, the learner 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 and contrast the functioning of the sympathetic and parasympathetic nervous systems.
4. Explain the significance of physical assessment to the diagnosis of neurologic dysfunction.
5. Discuss diagnostic tests used for assessment of suspected neurologic disorders and the related nursing implications.

## NURSING CONCEPTS

Assessment  
Intracranial Regulation  
Mobility  
Mood and Affect  
Patient Education  
Sensory Perception

## GLOSSARY

**agnosia:** loss of ability to recognize objects through a particular sensory system; may be visual, auditory, or tactile

**ataxia:** inability to coordinate muscle movements, resulting in difficulty in walking, talking, and performing self-care activities

**autonomic nervous system:** division of the nervous system that regulates the involuntary body functions

**axon:** portion of the neuron that conducts impulses away from the cell body

**Babinski reflex (sign):** a reflex action of the toes; in adults is indicative of abnormalities in the motor control pathways leading from the cerebral cortex

**clonus:** abnormal movement marked by alternating contraction and relaxation of a muscle occurring in rapid succession

**delirium:** an acute, confused state that begins with disorientation and if not recognized and treated early can progress to changes in level of consciousness, irreversible brain damage, and sometimes death

**dendrite:** portion of the neuron that conducts impulses toward the cell body

**flaccidity:** displaying lack of muscle tone; limp, floppy

**parasympathetic nervous system:** division of the autonomic nervous system active primarily during nonstressful conditions, controlling mostly visceral functions

**position (postural) sense:** awareness of position of parts of the body without looking at them (*synonym:* proprioception)

**reflex:** an automatic response to stimuli

**rigidity:** increase in muscle tone at rest characterized by increased resistance to passive stretch

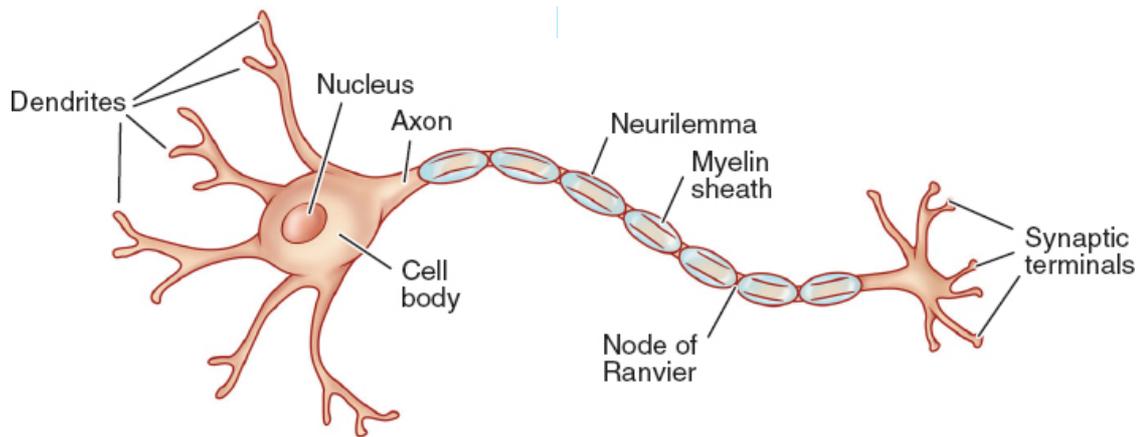
**Romberg test:** test for cerebellar dysfunction that can be done with the patient seated or standing; inability to maintain position for 20 seconds is a positive test

**spasticity:** sustained increase in tension of a muscle when it is passively lengthened or stretched

**sympathetic nervous system:** division of the autonomic nervous system with predominantly excitatory responses (*synonym:* the “fight-or-flight” system)

**vertigo:** illusion of movement in which the individual or the surroundings are sensed as moving

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 general assessment of neurologic function and be able to focus on specific areas as needed. 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.



**Figure 60-1 • Neuron.**

## Anatomic and Physiologic Overview

The nervous system consists of **two major parts**: the central nervous system (CNS), including the brain and spinal cord, and the peripheral nervous system, which includes the cranial nerves, spinal nerves, and autonomic nervous system. The function of the nervous system is to control motor, sensory, autonomic, cognitive, and behavioral activities. The brain itself contains more than 100 billion cells that 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 (Klein & Stewart-Amidei, 2017).

## Cells of the Nervous System

The basic functional unit of the brain is the neuron (see Fig. 60-1). It is composed of dendrites, a cell body, and an axon. The **dendrites** are branch-type structures for receiving electrochemical messages. The **axon** is a long projection that carries electrical impulses away from the cell body. Some axons

have a myelinated sheath that increases speed of conduction. 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). Neurons are supported, protected, and nourished by glial cells, which are 50 times greater in number than neurons (Hickey & Strayer, 2020).

## Neurotransmitters

Neurotransmitters communicate messages from one neuron to another or from a neuron to a target cell, such as muscle or endocrine cells. Neurotransmitters are manufactured and stored in synaptic vesicles. As an electrical action potential moves along the axon and reaches the nerve terminal, neurotransmitters are released into the synapse. The neurotransmitter is transported across the synapse, binding to receptors on the postsynaptic cell membrane. A neurotransmitter can either excite or inhibit activity of the target cell. Usually, multiple neurotransmitters are at work in the neural synapse. The source and action of major neurotransmitters are described in [Table 60-1](#). Once released, enzymes either destroy the neurotransmitter or reabsorb it into the neuron for future use.

Many neurologic disorders are due, at least in part, to an imbalance in neurotransmitters. For example, Parkinson's disease develops from decreased availability of dopamine, whereas acetylcholine binding to muscle cells is impaired in myasthenia gravis (Norris, 2019). All brain functions are modulated through neurotransmitter receptor site activity, including memory and other cognitive processes (Hickey & Strayer, 2020).

**TABLE 60-1** Major Neurotransmitters

Neurotransmitter	Source	Action
Acetylcholine (major transmitter of the parasympathetic nervous system)	Neurons in many areas of the brain; autonomic nervous system	Usually excitatory; parasympathetic effects sometimes inhibitory (stimulation of heart by vagal nerve)
Serotonin	Brain stem, hypothalamus, dorsal horn of the spinal cord	Inhibitory; helps control mood and sleep, inhibits pain pathways
Dopamine	Neurons on the substantia nigra and basal ganglia	Usually inhibitory; affects behavior (attention, emotions) and fine movement
Norepinephrine (major transmitter of the sympathetic nervous system)	Brain stem, hypothalamus, postganglionic neurons of the sympathetic nervous system	Usually excitatory; affects mood and overall activity
Gamma-aminobutyric acid	Nerve terminals of the spinal cord, cerebellum, basal ganglia, some cortical areas	Inhibitory
Enkephalin, endorphin	Nerve terminals in the spine, brain stem, thalamus and hypothalamus, pituitary gland	Excitatory; pleasurable sensation, inhibits pain transmission

Adapted from Norris, T. L. (2019). *Porth's pathophysiology: Concepts of altered health state* (10th ed.). Philadelphia, PA: Wolters Kluwer.

Ongoing research is evaluating diagnostic tests that can detect abnormal levels of neurotransmitters in the brain. Positron emission tomography (PET), for example, can detect dopamine, serotonin, and acetylcholine. Single-photon emission computed tomography (SPECT), similar to PET, can detect changes in some neurotransmitters, such as dopamine in Parkinson's disease (Fischbach & Fischbach, 2018). Both PET and SPECT are discussed in more detail later in this chapter.

## The Central Nervous System

The CNS consists of the brain and the spinal cord.

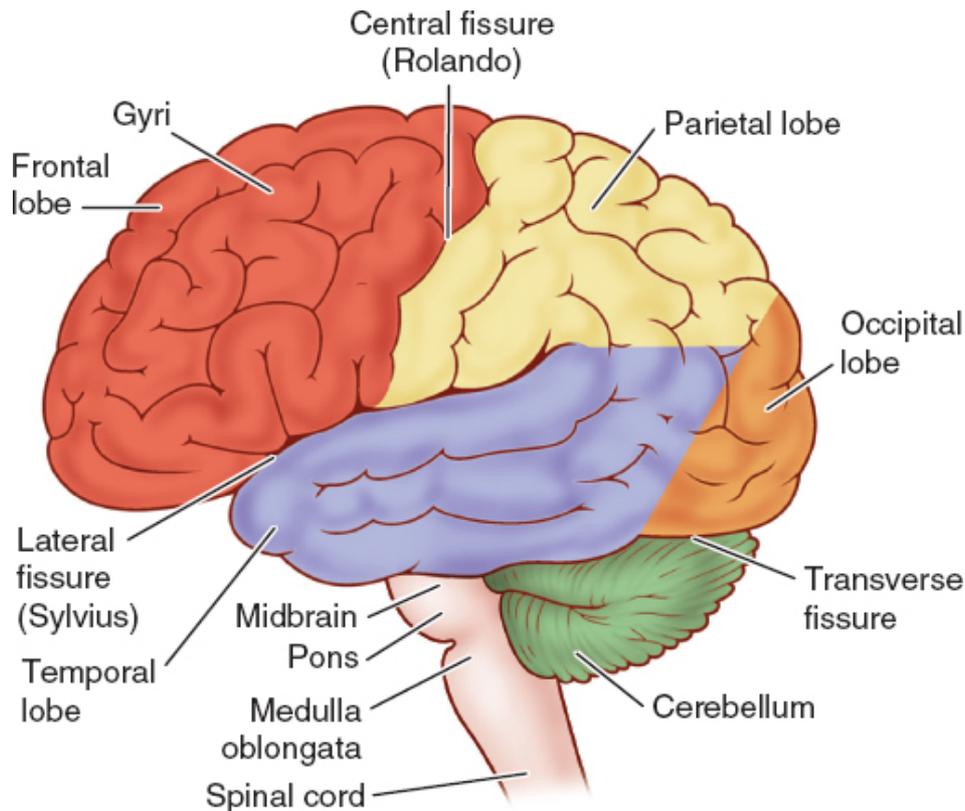
### The Brain

The brain accounts for approximately 2% of the total-body weight; in an average young adult, the brain weighs approximately 1400 g, whereas in an average older adult, the brain weighs approximately 1200 g (Hickey & Strayer,

2020). The brain is divided into three major areas: the cerebrum, the brain stem, and the cerebellum. The cerebrum is composed of two hemispheres, the thalamus, the hypothalamus, and the basal ganglia. The brain stem includes the midbrain, pons, and medulla. The cerebellum is located under the cerebrum and behind the brain stem (see [Fig. 60-2](#)).

## Cerebrum

The outside surface of the hemispheres has a wrinkled appearance that is the result of many folded layers or convolutions called *gyri*, which increase the surface area of the brain, accounting for the high level of activity carried out by such a small-appearing organ. Between each gyrus is a sulcus or fissure that serves as an anatomic division. In between the cerebral hemispheres is the great longitudinal fissure that 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 external or outer portion of the hemispheres (the cerebral cortex) is made up of gray matter approximately 2 to 5 mm in depth; it contains billions of neuron cell bodies, giving it a gray appearance. White matter makes up the innermost layer and is composed of myelinated nerve fibers and neuroglia cells that form tracts or pathways connecting various parts of the brain with one another. These pathways also connect the cortex with lower portions of the brain and spinal cord. The cerebral hemispheres are divided into pairs of lobes as follows (see [Fig. 60-2](#)):

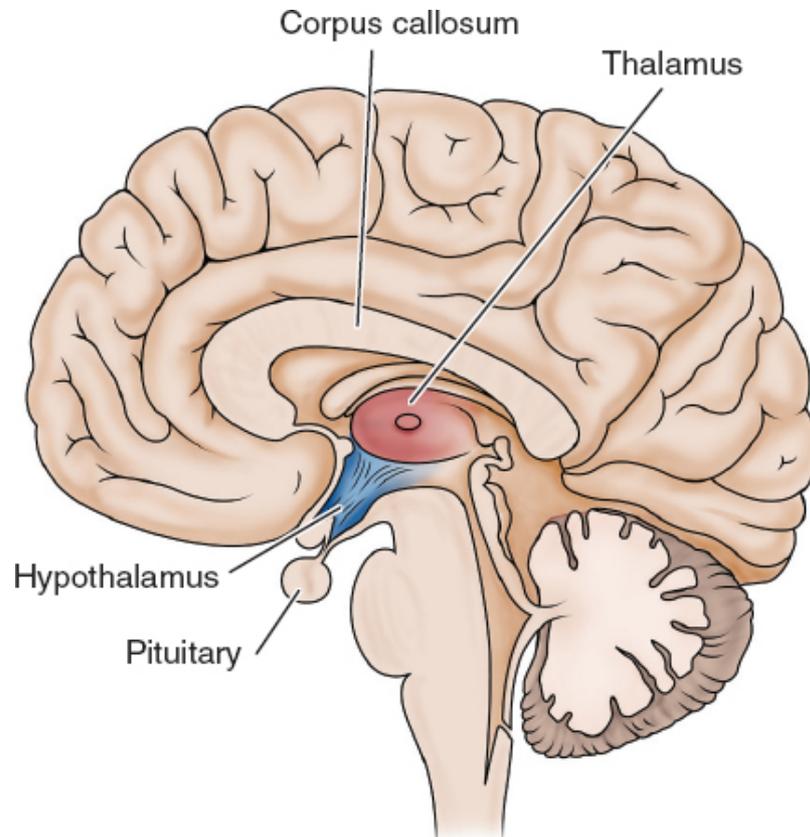


**Figure 60-2** • View of the external surface of the brain showing lobes, cerebellum, and brain stem.

- **Frontal**—the largest lobe, located in the front of the brain. The major functions of this lobe are concentration, abstract thought, information storage or memory, and motor function. It contains Broca area, which is in the left hemisphere and is critical for motor control of speech. The frontal lobe is also responsible in large part for a person's affect, judgment, personality, and inhibitions (Hickey & Strayer, 2020).
- **Parietal**—a predominantly sensory lobe posterior to the frontal lobe. This lobe analyzes sensory information and relays the interpretation of this information to other cortical areas and is essential to a person's awareness of body position in space, size and shape discrimination, and right–left orientation (Hickey & Strayer, 2020).
- **Temporal**—located inferior to the frontal and parietal lobes, this lobe contains the auditory receptive areas and plays a role in memory of sound and understanding of language and music.
- **Occipital**—located posterior to the parietal lobe, this lobe is responsible for visual interpretation and memory.

**The corpus callosum** (see Fig. 60-3), a thick collection of nerve fibers that connects the two hemispheres of the brain, is responsible for the transmission of information from one side of the brain to the other. Information transferred includes sensation, memory, and learned discrimination. Right-handed people

and some left-handed people have cerebral dominance on the left side of the brain for verbal, linguistic, arithmetic, calculation, and analytic functions. The nondominant hemisphere is responsible for geometric, spatial, visual, pattern, and musical functions. Nuclei for cranial nerves I and II are also located in the cerebrum.



**Figure 60-3 •** Medial view of the brain.

The thalami lie on either side of the third ventricle and act primarily as a relay station for all sensation except smell. All memory, sensation, and pain impulses pass through this section of the brain. The hypothalamus (see [Fig. 60-3](#)) is located anterior and inferior to the thalamus, and beneath and lateral to the third ventricle. The infundibulum of the hypothalamus connects it to the posterior pituitary gland. The hypothalamus plays an important role in the endocrine system because it regulates the pituitary secretion of hormones that influence metabolism, reproduction, stress response, and urine production. It works with the pituitary to maintain fluid balance through hormonal release and maintains temperature regulation by promoting vasoconstriction or vasodilatation. In addition, the hypothalamus is the site of the hunger center and is involved in appetite control. It contains centers that regulate the sleep-wake cycle, blood pressure, aggressive and sexual behavior, and emotional responses (e.g., blushing, rage, depression, panic, fear). The hypothalamus also controls and regulates the autonomic nervous system. The optic chiasm (the

point at which the two optic tracts cross) and the mammillary bodies (involved in olfactory reflexes and emotional response to odors) are also found in this area.

The basal ganglia are masses of nuclei located deep in the cerebral hemispheres that are responsible for control of fine motor movements, including those of the hands and lower extremities.

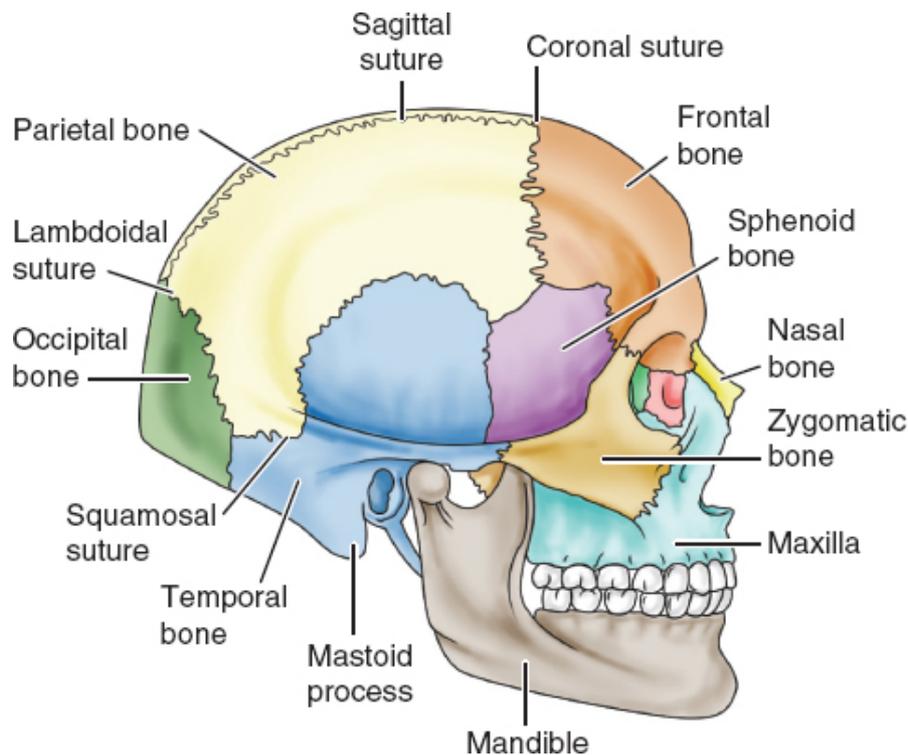
## Brain Stem

The brain stem consists of the midbrain, pons, and medulla oblongata (see Fig. 60-2). The midbrain connects the pons and the cerebellum with the cerebral hemispheres; it contains sensory and motor pathways 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 is a bridge between the two halves of the cerebellum, and between the medulla and the midbrain. Cranial nerves V through VIII originate in the pons. The pons also contains motor and sensory pathways. Portions of the pons help regulate respiration.

Motor fibers from the brain to the spinal cord and sensory fibers from the spinal cord to the brain are in the medulla. Most of these fibers cross, or decussate, at this level. Cranial nerves IX through XII originate in the medulla. Reflex centers for respiration, blood pressure, heart rate, coughing, vomiting, swallowing, and sneezing are also located in the medulla. The reticular formation, responsible for arousal and the sleep–wake cycle, begins in the medulla and connects with numerous higher structures.

## Cerebellum

The cerebellum is posterior to the midbrain and pons, and below the occipital lobe (see Fig. 60-2). The cerebellum integrates sensory information to provide smooth coordinated movement. It controls fine movement, balance, and **position (postural) sense** or proprioception (awareness of position of extremities without looking at them).



**Figure 60-4 •** Bones and sutures of the skull.

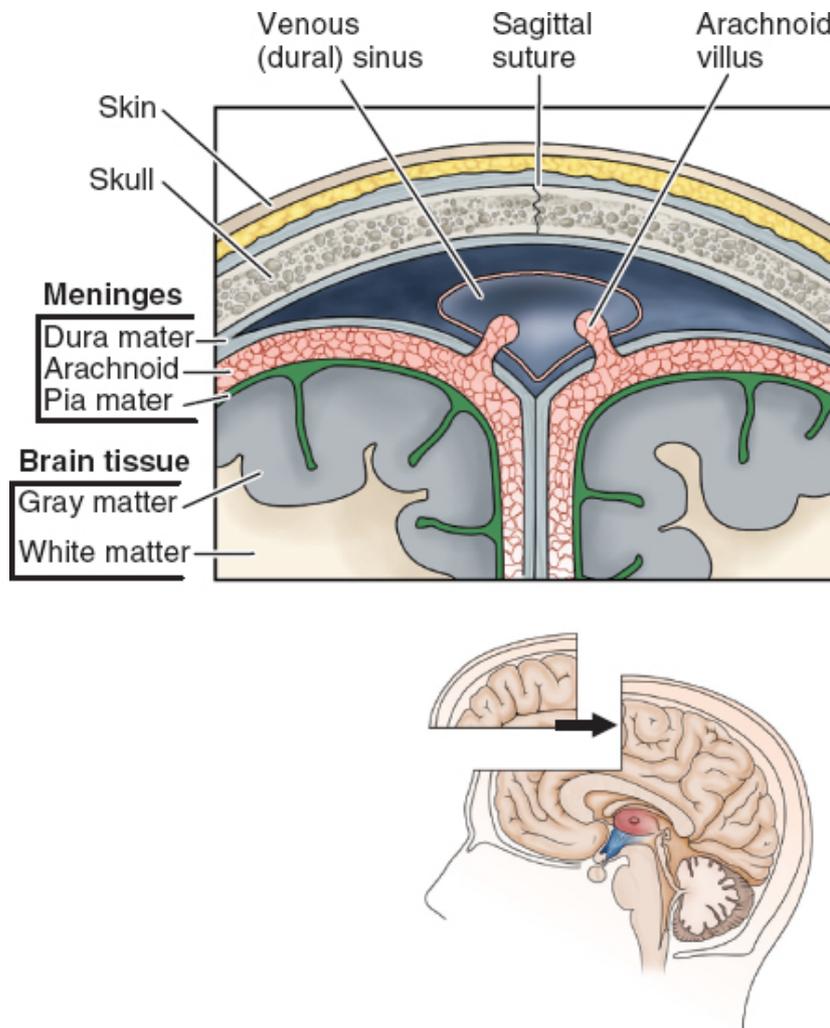
### Structures Protecting the Brain

The brain is contained in the rigid skull, which protects it from injury. The major bones of the skull are the frontal, temporal, parietal, occipital, and sphenoid bones. These bones join at the suture lines (see Fig. 60-4) and form the base of the skull. Indentations in the skull base are known as fossae. The anterior fossa contains the frontal lobe, the middle fossa contains the temporal lobe, and the posterior fossa contains the cerebellum and brain stem.

The meninges (fibrous connective tissues that cover the brain and spinal cord) provide protection, support, and nourishment. The layers of the meninges are the dura mater, arachnoid, and pia mater (see Fig. 60-5):

- *Dura mater*—the outermost layer; covers the brain and the spinal cord. It is tough, thick, inelastic, fibrous, and gray. There are three major extensions of the dura: the falx cerebri, which folds between the two hemispheres; the tentorium, which folds between the occipital lobe and cerebellum to form a tough, membranous shelf; and the falx cerebelli, which is located between the right and left side of the cerebellum. When excess pressure occurs in the cranial cavity, brain tissue may be compressed against these dural folds or displaced around them, a process called *herniation*. A potential space exists between the dura and the skull, and between the periosteum and the dura in the vertebral column, known as the epidural space. Another potential space, the subdural space, also

exists below the dura. Blood or an abscess can accumulate in these potential spaces.



**Figure 60-5 •** Meninges and related structures.

- *Arachnoid*—the middle membrane; an extremely thin, delicate membrane that closely resembles a spider web (hence the name *arachnoid*). The arachnoid membrane has cerebrospinal fluid (CSF) in the space below it, known as the subarachnoid space. This membrane has arachnoid villi, which are unique finger-like projections that absorb CSF into the venous system. When blood or bacteria enter the subarachnoid space, the villi become obstructed and *communicating* hydrocephalus (increased size of ventricles) may result.
- *Pia mater*—the innermost, thin, transparent layer that hugs the brain closely and extends into every fold of the brain's surface.

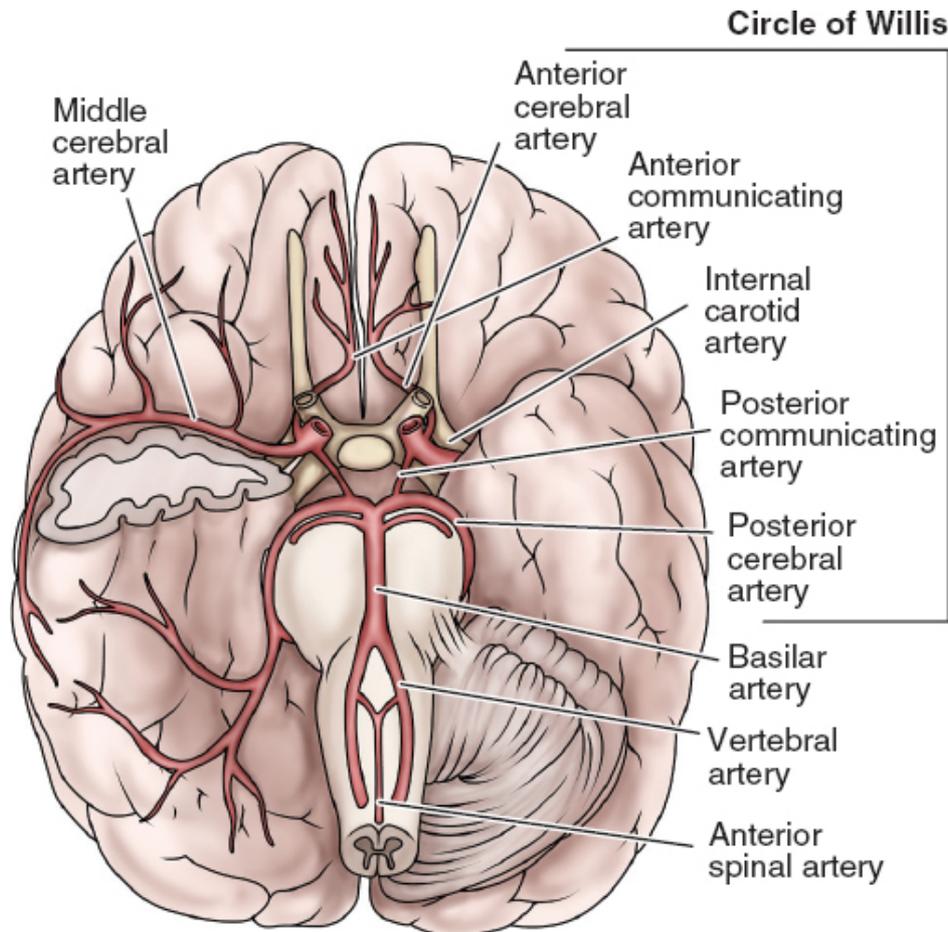
## Cerebrospinal Fluid

CSF is a clear and colorless fluid that is produced in the choroid plexus of the ventricles and circulates around the surface of the brain and the spinal cord. There are four ventricles: the right and left lateral and the third and fourth ventricles. The two lateral ventricles open into the third ventricle at the interventricular foramen (also known as the foramen of Monro). The third and fourth ventricles connect via the aqueduct of Sylvius. The fourth ventricle drains CSF into the subarachnoid space on the surface of the brain and spinal cord, where it is absorbed by the arachnoid villi. Blockage of the flow of CSF anywhere in the ventricular system produces *obstructive* hydrocephalus.

CSF is important in immune and metabolic functions in the brain. It is produced at a rate of about 500 mL/day; the ventricles and subarachnoid space contain approximately 125 to 150 mL of fluid (Hickey & Strayer, 2020). The composition of CSF is similar to other extracellular fluids (such as blood plasma), but the concentrations of the various constituents differ. A laboratory analysis of CSF indicates color (clear), specific gravity (normal 1.007), protein count, cell count, glucose, and other electrolyte levels (see Table A-5 in Appendix A on **thePoint**). Normal CSF contains a minimal number of white blood cells and no red blood cells. The CSF may also be tested for immunoglobulins or the presence of bacteria. A CSF sample may be obtained through a lumbar puncture or intraventricular catheter (Hickey & Strayer, 2020).

## Cerebral Circulation

The brain does not store nutrients and requires a constant supply of oxygen. These needs are met through cerebral circulation; the brain receives approximately 15% of the cardiac output, or 750 mL per minute of blood flow. Brain circulation is unique in several aspects. First, arterial and venous vessels are not parallel as in other organs in the body; this is due in part to the role the venous system plays in CSF absorption. Second, the brain has collateral circulation through the circle of Willis (see later discussion), allowing blood flow to be redirected on demand. Third, blood vessels in the brain have two rather than three layers, which may make them more prone to rupture when weakened or under pressure.



**Figure 60-6** • Arterial blood supply of the brain, including the circle of Willis, as viewed from the ventral surface.

## Arteries

Arterial blood supply to the anterior brain originates from the common carotid artery, which is the first bifurcation of the aorta. The internal carotid arteries arise at the bifurcation of the common carotid. Branches of the internal carotid arteries (the anterior and middle cerebral arteries) and their connections (the anterior and posterior communicating arteries) form the circle of Willis (see [Fig. 60-6](#)).

The vertebral arteries branch from the subclavian arteries to supply most of the posterior circulation of the brain. At the level of the brain stem, the vertebral arteries join to form the basilar artery. The basilar artery divides to form the two branches of the posterior cerebral arteries. Functionally, the posterior and anterior portions of the circulation usually remain separate. However, the circle of Willis can provide collateral circulation through communicating arteries if one of the vessels supplying it becomes occluded or is ligated.

The bifurcations along the circle of Willis are frequent sites of aneurysm formation. Aneurysms are outpouchings of the blood vessel due to vessel wall

weakness. Aneurysms can rupture and cause a hemorrhagic stroke. See [Chapter 62](#) for a more detailed discussion of aneurysms.

## 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, and then cross the subarachnoid space and empty into the dural sinuses, which are the vascular channels embedded in the dura (see [Fig. 60-5](#)). The network of the sinuses carries venous outflow from the brain and empties into the internal jugular veins, returning the blood to the heart. Cerebral veins are unique, because unlike other veins in the body, they do not have valves to prevent blood from flowing backward and depend on both gravity and blood pressure for flow.

## Blood–Brain Barrier

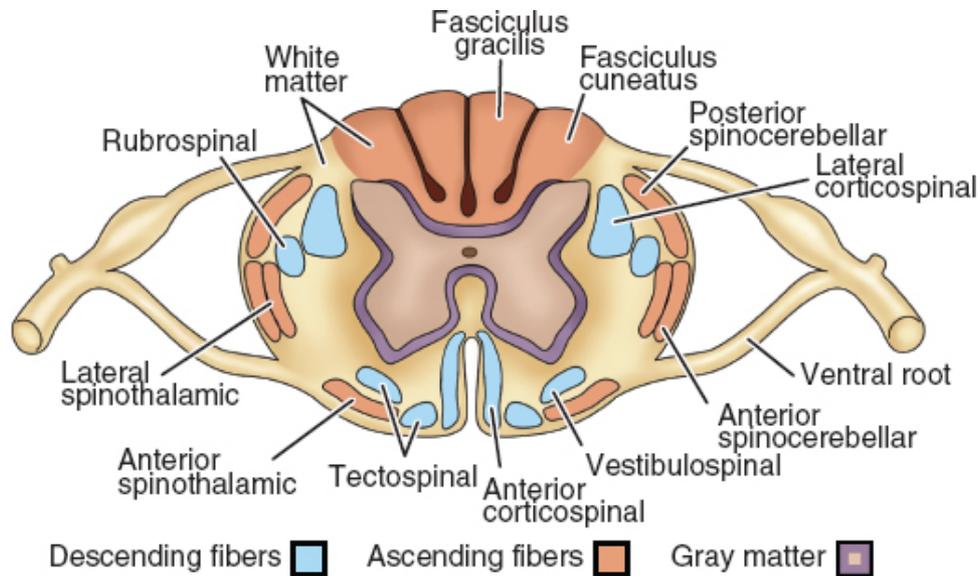
The CNS is inaccessible to many substances that circulate in the blood plasma (e.g., dyes, medications, antibiotic agents) because of the blood–brain barrier. This barrier is formed by the endothelial cells of the brain's capillaries, which form continuous tight junctions, creating a barrier to macromolecules and many compounds. All substances entering the CSF must filter through the capillary endothelial cells and astrocytes. The blood–brain barrier has a protective function but can be altered by trauma, cerebral edema, and cerebral hypoxemia; this has implications for treatment and selection of medications for CNS disorders (Hickey & Strayer, 2020).

## The Spinal Cord

The spinal cord is continuous with the medulla, extending from the cerebral hemispheres and serving as the connection between the brain and the periphery. Approximately 45 cm (18 inches) 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. Meninges surround the spinal cord.

In a cross-sectional view, the spinal cord has an H-shaped central core of nerve cell bodies (gray matter) surrounded by ascending and descending tracts (white matter) (see [Fig. 60-7](#)). The lower portion of the H is broader than the upper portion and corresponds to the anterior horns. The anterior horns contain cells with fibers that form the anterior (motor) root and are essential for the voluntary and reflex activity of the muscles they innervate. The thinner posterior (upper horns) portion contains cells with fibers that enter over the

posterior (sensory) root and thus serve as a relay station in the sensory/reflex pathway.



**Figure 60-7** • Cross-sectional diagram of the spinal cord showing major spinal tracts.

The thoracic region of the spinal cord has a projection from each side at the crossbar of the H-shaped structure of gray matter called the *lateral horn*. It contains the cells that give rise to the autonomic fibers of the sympathetic division. The fibers leave the spinal cord through the anterior roots in the thoracic and upper lumbar segments.

### The Spinal Tracts

The white matter of the spinal cord is composed of myelinated and unmyelinated nerve fibers. The fast-conducting myelinated fibers form bundles; fiber bundles with a common function are called *tracts*.

There are six ascending tracts (see [Fig. 60-7](#)). Two tracts, known as the fasciculus cuneatus and gracilis or the posterior columns, conduct sensations of deep 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 anterior and posterior spinocerebellar tracts conduct sensory impulses from muscle spindles, providing necessary input for coordinated muscle contraction. They ascend uncrossed and terminate in the cerebellum. The anterior and lateral spinothalamic tracts are responsible for conduction of pain, temperature, proprioception, fine touch, and vibratory sense from the upper body to the brain. They cross to the opposite side of the cord and then ascend to the brain, terminating in the thalamus (Klein & Stewart-Amidei, 2017).

There are eight descending tracts (see [Fig. 60-7](#)). The anterior and lateral corticospinal tracts conduct motor impulses to the anterior horn cells from the opposite side of the brain, cross in the medulla, 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 the level of the brain stem. 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 7 cervical, 12 thoracic, and 5 lumbar vertebrae, as well as the sacrum (a fused mass of 5 vertebrae) and terminate in the coccyx. Nerve roots exit from the vertebral column through the intervertebral foramina (openings). The vertebrae are separated by discs, except for the first and second cervical, the sacral, and the coccygeal vertebrae. Each vertebra has a ventral solid body and a dorsal segment or arch, which is posterior to the body. The arch is composed of two pedicles and two laminae supporting seven processes. The vertebral body, arch, pedicles, and laminae all encase and protect the spinal cord.

## The Peripheral Nervous System

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

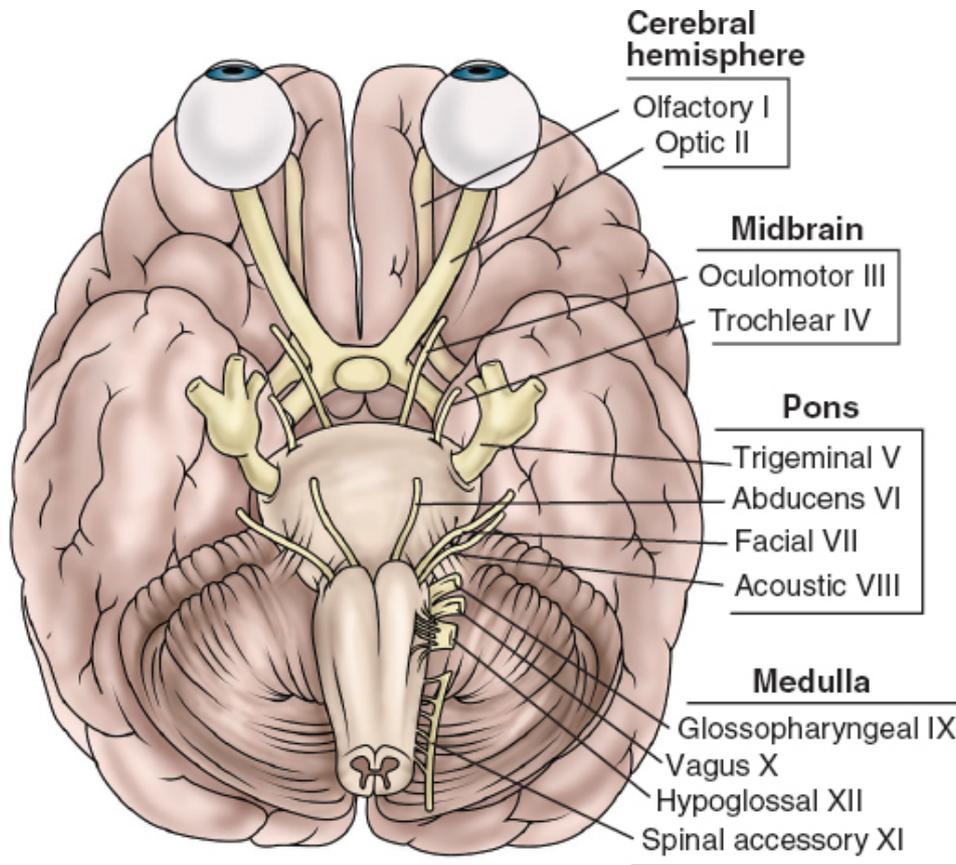
### Cranial Nerves

Twelve pairs of cranial nerves emerge from the lower surface of the brain and pass through openings in the base of the skull. Three cranial nerves are entirely sensory (I, II, VIII), five are motor (III, IV, VI, XI, and XII), and four are mixed sensory and motor (V, VII, IX, and X). The cranial nerves are numbered in the order in which they arise from the brain (see [Fig. 60-8](#)). The cranial nerves innervate the head, neck, and special sense structures. [Table 60-2](#) provides a summary of the cranial nerves.

### Spinal Nerves

The spinal cord is composed of 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal. Each spinal nerve has a ventral root and a dorsal root. The dorsal roots are sensory and transmit sensory impulses from specific areas of the body known as dermatomes (see [Fig. 60-9](#)) to the dorsal horn 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.



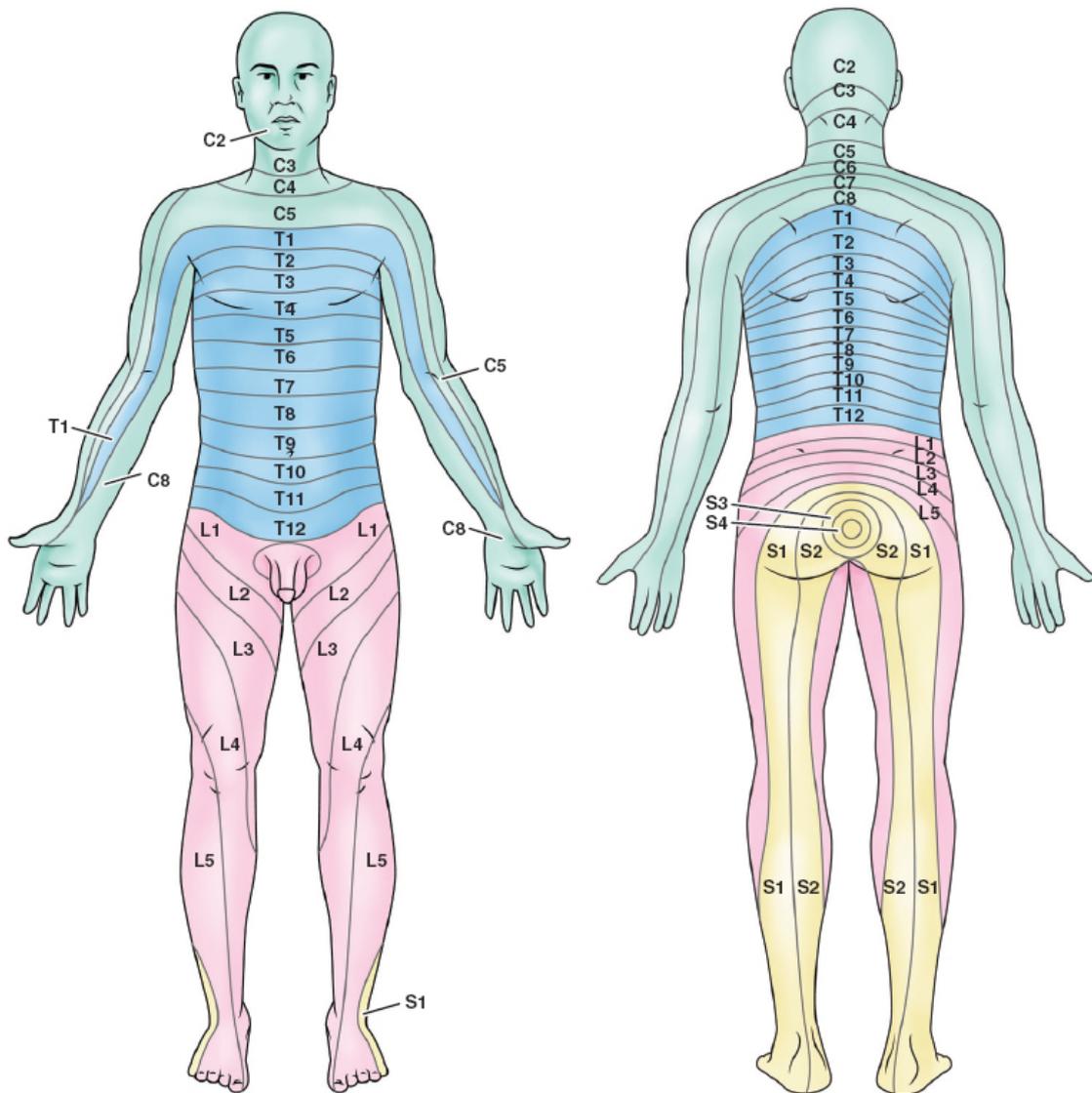
**Figure 60-8 •** Diagram of the base of the brain showing location of the cranial nerves.

**TABLE 60-2** Summary of Cranial Nerves

Nerve (Number)	Type	Functions	Methods for Examining Nerve
Olfactory (I)	Sensory	Sense of smell	Test each nostril for smell reception with various agents and interpretation
Optic (II)	Sensory	Sense of vision	Test vision for acuity and visual fields
Oculomotor (III)	Motor	Pupil constriction	
	Raise eyelids	Test pupillary reaction to light and ability to open and close eyelids	
Trochlear (IV)	Motor/proprioceptor	Downward, inward eye movement	Test for downward and inward movement of the eye
Trigeminal (V)	Motor	Jaw movements—chewing and mastication	Ask patient to open and clench jaws while you palpate the jaw muscles
	Sensory	Sensation on the face and neck	Test face and neck for pain sensations, light touch, and temperature
Abducens (VI)	Motor	Lateral movement of the eyes	Test ocular movement in all directions
Facial (VII)	Motor	Muscles of the face	Ask the patient to raise eyebrows, smile, show teeth, and puff out cheeks
	Sensory	Sense of taste on the anterior two thirds of the tongue	Test for the taste sensation with various agents
Acoustic (VIII)	Sensory	Sense of hearing	Test hearing ability
Glossopharyngeal (IX)	Motor	Pharyngeal movement and swallowing	Ask the patient to say “ah,” and have patient yawn to observe upward movement of the soft palate; elicit gag

			response; note ability to swallow
	Sensory	Sense of taste on the posterior one third of the tongue	Test for taste with various agents
Vagus (X)	Motor/sensory	Swallowing and speaking	Ask the patient to swallow and speak; note hoarseness
Accessory (XI)	Motor/sensory	Movement of shoulder muscles	Ask the patient to shrug shoulders against your resistance
Hypoglossal (XII)	Motor	Movement of the tongue; strength of the tongue	Ask the patient to protrude tongue; ask patient to push tongue against cheek

Reprinted with permission from Taylor, C., Lynn, P., & Bartlett, J. L. (2019). *Fundamentals of nursing: The art and science of person-centered care* (9th ed., Table 26-6). Philadelphia, PA: Wolters Kluwer.



**Figure 60-9 • Dermatome distribution.**

The ventral roots are motor and transmit impulses from the spinal cord to the body; 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 the activities of internal organs such as the heart, lungs, blood vessels, digestive organs, and glands (see Fig. 60-10). 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 (i.e., the “fight-or-flight” response), and the parasympathetic nervous system, which controls mostly visceral functions.

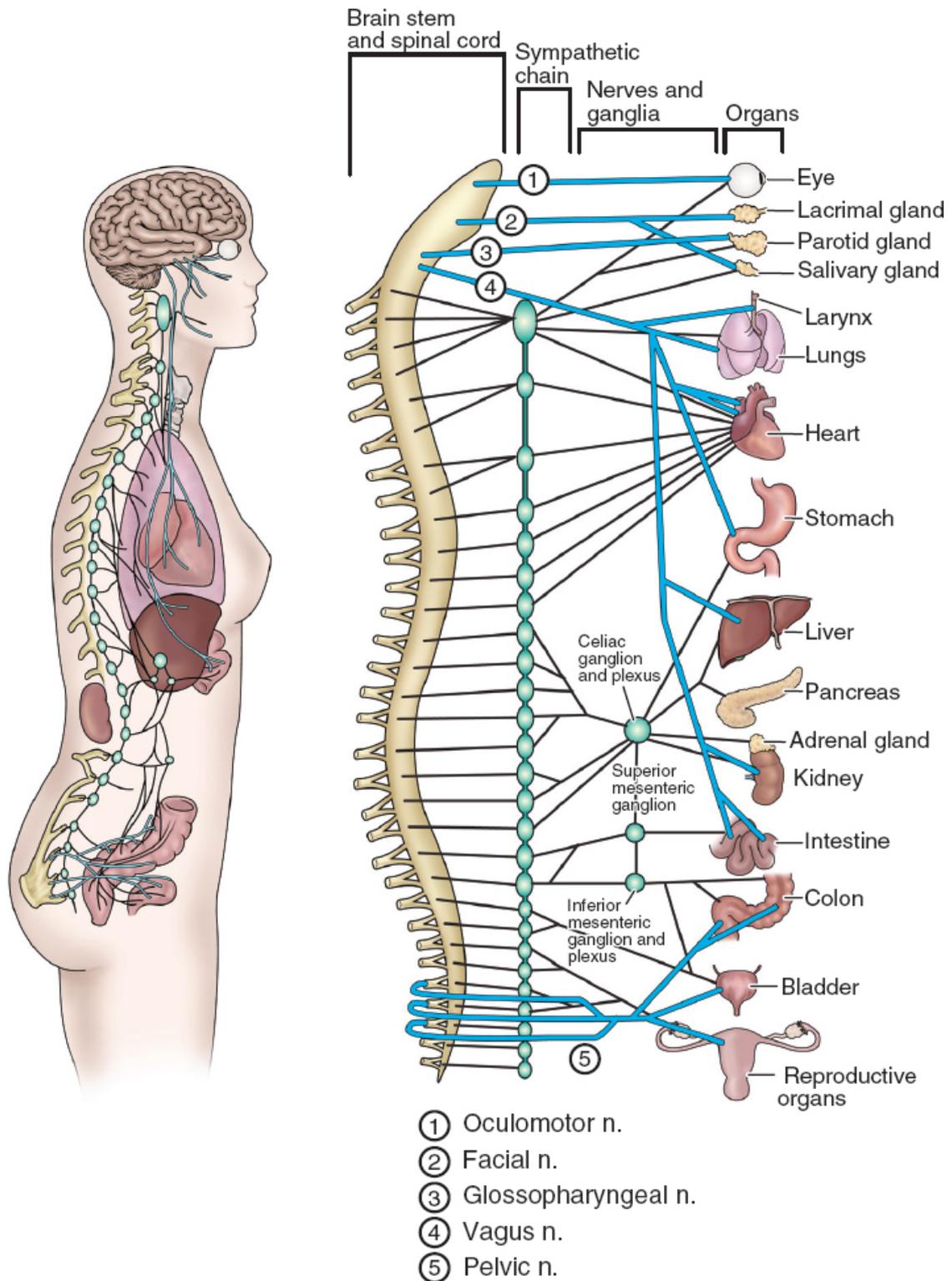
The autonomic nervous system innervates most body organs. Although usually considered part of the peripheral nervous system, this system is regulated by centers in the spinal cord, brain stem, and hypothalamus.

The hypothalamus is the major subcortical center for the regulation of autonomic activities, serving an inhibitory–excitatory role. The hypothalamus has connections that link the autonomic system with the thalamus, the cortex, the olfactory apparatus, and the pituitary gland. Located here are the mechanisms for the control of visceral and somatic reactions that were originally important for defense or attack and are associated with emotional states (e.g., fear, anger, anxiety); for the control of metabolic processes, including fat, carbohydrate, and water metabolism; for the regulation of body temperature, arterial pressure, and all muscular and glandular activities of the gastrointestinal tract; for control of genital functions; and for the sleep cycle.

The autonomic nervous system is separated into the anatomically and functionally distinct sympathetic and parasympathetic divisions. Most of the tissues and the organs under autonomic control are innervated by both systems. For example, the parasympathetic division causes contraction (stimulation) of the urinary bladder muscles and a decrease (inhibition) in heart rate, whereas the sympathetic division produces relaxation (inhibition) of the urinary bladder and an increase (stimulation) in the rate and force of the heartbeat. [Table 60-3](#) compares the sympathetic and the parasympathetic effects on the different systems of the body.

### Sympathetic Nervous System

The sympathetic division of the autonomic nervous system is best known for its role in the body's fight-or-flight response. Under stress from either physical or emotional causes, sympathetic impulses increase greatly. As a result, the bronchioles dilate for easier gas exchange; the heart's contractions are stronger and faster; the arteries to the heart and voluntary muscles dilate, carrying more blood to these organs; peripheral blood vessels constrict, making the skin feel cool but shunting blood to essential organs; the pupils dilate; the liver releases glucose for quick energy; peristalsis slows; hair stands on end; and perspiration increases. **The main sympathetic neurotransmitter is norepinephrine (noradrenaline).** A sympathetic discharge releases epinephrine (adrenalin)—hence, the term *adrenergic* is often used to refer to this division.



**Figure 60-10 •** Anatomy of the autonomic nervous system.

Sympathetic neurons are located primarily in the thoracic and lumbar segments of the spinal cord, and their axons, or the preganglionic fibers, emerge by way of anterior nerve roots from the eighth cervical or first thoracic segment to the second or third lumbar segment. A short distance from the cord,

these fibers diverge to join a chain, composed of 22 linked ganglia, that extends the entire length of the spinal column, adjacent to the vertebral bodies on both sides. Some form multiple synapses with nerve cells within the chain. Others traverse the chain without making connections or losing continuity to join large “prevertebral” ganglia in the thorax, the abdomen, or the pelvis or one of the “terminal” ganglia in the vicinity of an organ, such as the bladder or the rectum at the end of the colon (see [Fig. 60-10](#)). Postganglionic nerve fibers originating in the sympathetic chain rejoin the spinal nerves that supply the extremities and are distributed to blood vessels, sweat glands, and smooth muscle tissue in the skin. Postganglionic fibers from the prevertebral plexuses (e.g., the cardiac, pulmonary, splanchnic, pelvic plexuses) supply structures in the head and neck, thorax, abdomen, and pelvis, respectively, having been joined in these plexuses by fibers from the parasympathetic division.

**TABLE 60-3**



Effects of the Autonomic Nervous System

Structure or Activity	Parasympathetic Effects	Sympathetic Effects
<b>Pupil of the Eye</b>	Constricted	Dilated
<b>Circulatory System</b>		
Rate and force of heartbeat	Decreased	Increased
Blood vessels		
In heart muscle	Constricted	Dilated
In skeletal muscle	<i>a</i>	Dilated
In abdominal viscera and the skin	<i>a</i>	Constricted
Blood pressure	Decreased	Increased
<b>Respiratory System</b>		
Bronchioles	Constricted	Dilated
Rate of breathing	Decreased	Increased
<b>Gastrointestinal System</b>		
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	<i>a</i>
Conversion of liver glycogen to glucose	<i>a</i>	Increased
<b>Genitourinary System</b>		
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
Blood vessels of external genitalia	Dilated	<i>a</i>
<b>Integumentary System</b>		
Secretion of sweat	<i>a</i>	Increased
Pilomotor muscles	<i>a</i>	Contracted (goose flesh)
<b>Adrenal Medulla</b>	<i>a</i>	Secretion of epinephrine and norepinephrine

<sup>a</sup>No direct effect.

Adapted from Hickey, J. V., & Strayer, A. L. (2020). *The clinical practice of neurological and neurosurgical nursing* (8th ed.). Philadelphia, PA: Wolters Kluwer.

The adrenal glands, kidneys, liver, spleen, stomach, and duodenum are under the control of the giant celiac plexus, commonly known as the solar plexus. This receives its sympathetic nerve components by way of the three splanchnic nerves, composed of preganglionic fibers from nine segments of the spinal cord (T4 to L1), and is joined by the vagus nerve, representing the parasympathetic division. From the celiac plexus, fibers of both divisions travel along the course of blood vessels to their target organs.

Certain syndromes are distinctive to the sympathetic nervous system. For example, sympathetic storm is a syndrome associated with changes in level of consciousness, altered vital signs, diaphoresis, and agitation that may result from hypothalamic stimulation of the sympathetic nervous system following traumatic brain injury (Fischbach & Fischbach, 2018).

## Parasympathetic Nervous System

The **parasympathetic nervous system** functions as the dominant controller for most visceral functions; the primary neurotransmitter is acetylcholine. During quiet, nonstressful conditions, impulses from parasympathetic fibers (cholinergic) predominate. The fibers of the parasympathetic system are located in two sections: one in the brain stem and the other from spinal segments below L2. Because of the location of these fibers, the parasympathetic system is referred to as the craniosacral division, as distinct from the thoracolumbar (sympathetic) division of the autonomic nervous system.

The parasympathetic nerves arise from the midbrain and the medulla oblongata. Fibers from cells in the midbrain travel with the third oculomotor nerve to the ciliary ganglia, where postganglionic fibers of this division are joined by those of the sympathetic system, creating controlled opposition, with a delicate balance always maintained between the two systems.

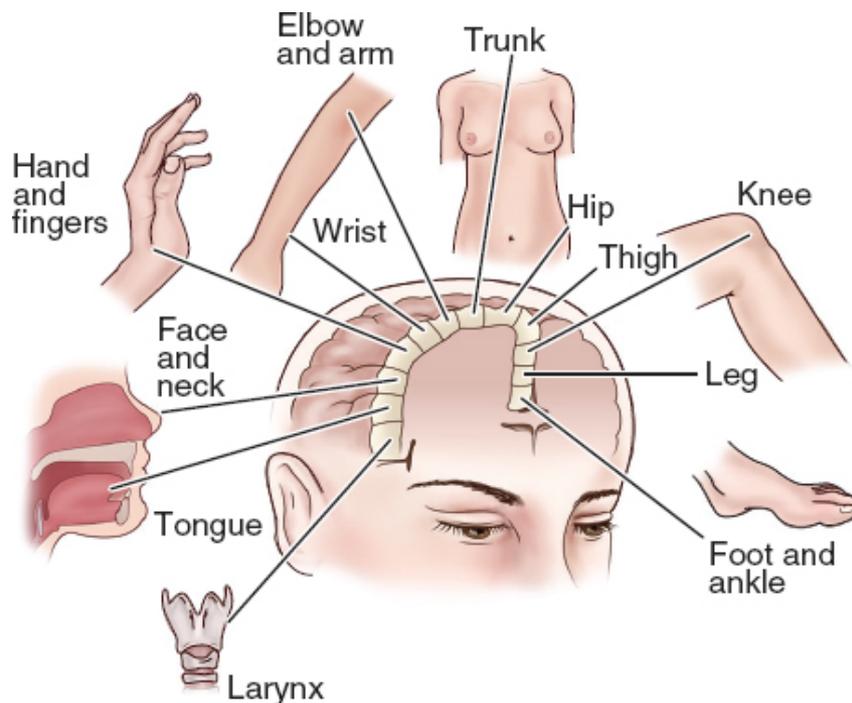
## Motor and Sensory Pathways of the Nervous System



Motor pathways within the CNS are responsible for voluntary, involuntary, and coordination of movement. Sensory pathways receive, integrate, and transmit a wide variety of sensations within the CNS.

### Motor Pathways

The corticospinal tract begins in the motor cortex, a vertical band within each frontal lobe, and controls 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. 60-11). To initiate movement, these particular cells must send the stimulus along their fibers. Stimulation of these cells with an electric current also 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 internal capsule results in a more severe paralysis than does a larger injury to the cortex itself.



**Figure 60-11** • Diagrammatic representation of the cerebrum showing locations for control of motor movement of various parts of the body.

At the medulla, the corticospinal tracts cross to the opposite side, continuing to the anterior horn of the spinal cord, in proximity to a motor nerve cell. Until this point, neurons are known as upper motor neurons. As they connect to motor fibers of the spinal nerves, they become lower motor neurons. The lower motor neurons receive the impulse in the posterior part of the cord and run to the myoneural junction located in the peripheral muscle.

Involuntary motor activity is also possible and is mediated through reflex arcs. Synaptic connections between anterior horn cells and sensory fibers that have entered adjacent or neighboring segments of the spinal cord serve as protective mechanisms. These connections are seen during deep tendon reflex testing.

## 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 brain stem. 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 brain stem. Axons of lower motor neurons in both sites extend through peripheral nerves and terminate in skeletal muscle. Lower motor neurons are located in both the CNS and the peripheral nervous system.

The motor pathways from the brain to the spinal cord, as well as from the cerebrum to the brain stem, are formed by upper motor neurons. They begin in the cortex of one side of the brain, descend through the internal capsule, cross to the opposite side in the brain stem, descend through the corticospinal tract, and synapse with the lower motor neurons in the cord. The lower motor neurons receive the impulse in the posterior part of the cord and run to the myoneural junction located in the peripheral muscle. The clinical features of lesions of upper and lower motor neurons are discussed in the following sections and in [Table 60-4](#).

**TABLE 60-4** Comparison of Upper Motor Neuron and Lower Motor Neuron Lesions

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 reflexes	Absent or decreased reflexes

Adapted from Hickey, J. V., & Strayer, A. L. (2020). *The clinical practice of neurological and neurosurgical nursing* (8th ed.). Philadelphia, PA: Wolters Kluwer.

### Upper Motor Neuron Lesions

Upper motor neuron lesions can involve the motor cortex, the internal capsule, the spinal cord gray matter, and other structures of the brain through which the corticospinal tract descends. If the upper motor neurons are damaged or destroyed, as frequently occur with stroke or spinal cord injury, paralysis (loss of voluntary movement) results. However, because the inhibitory influences of intact upper motor neurons are impaired, **reflex** (involuntary) movements are uninhibited, and hence hyperactive deep tendon reflexes, diminished or absent superficial reflexes, and pathologic reflexes such as a Babinski response occur. Severe leg spasms can occur as the result of an upper motor neuron lesion; the spasms result from the preserved reflex arc, which lacks inhibition along the

spinal cord below the level of injury. There is little or no muscle atrophy, and muscles remain permanently tense, exhibiting spastic paralysis.

Paralysis associated with upper motor neuron lesions can affect a whole extremity, both extremities, or an entire half of the body. *Hemiplegia* (paralysis of an arm and leg on the same side of the body) can be the result of an upper motor neuron lesion. If hemorrhage, an embolus, or a thrombus destroys the fibers from the motor area in the internal capsule, the arm and the leg of the opposite side become stiff, weak, or paralyzed, and the reflexes are hyperactive. If both legs are paralyzed, the condition is called *paraplegia*. If all four extremities are paralyzed, the condition is called *tetraplegia* (quadriplegia). See [Chapter 63](#) for additional discussion of these disorders.

### Lower Motor Neuron Lesions

A patient is considered to have lower motor neuron damage if a motor nerve is damaged between the spinal cord and muscle. The result of lower motor neuron damage is muscle paralysis. Reflexes are lost, and the muscle becomes flaccid (limp) and atrophied from disuse. If the patient has injured the spinal trunk and it can heal, the use of muscles connected to that section of the spinal cord may be regained. However, if the anterior horn motor cells are destroyed, the nerves cannot regenerate, and the muscles are never useful again.

Flaccid paralysis and atrophy of the affected muscles are the principal signs of lower motor neuron disease. Lower motor neuron lesions can be the result of trauma, infection (poliomyelitis), toxins, vascular disorders, congenital malformations, degenerative processes, and neoplasms. Compression of nerve roots by herniated intervertebral discs is a common cause of lower motor neuron dysfunction.

### Coordination of Movement

The motor system is complex, and motor function depends not only on the integrity of the corticospinal tracts but also on other pathways from the basal ganglia and cerebellum that control and coordinate voluntary motor function. The smoothness, accuracy, and strength that characterize the muscular movements of a normal person are attributable to the influence of the cerebellum and the basal ganglia.

Through the action of the cerebellum, the contractions of opposing muscle groups are adjusted in relation to each other to maximal mechanical advantage; muscle contractions can be sustained evenly at the desired tension and without significant fluctuation, and reciprocal movements can be reproduced at high and constant speed, in stereotyped fashion and with relatively little effort.

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.

Impaired cerebellar function, which may occur as a result of an intracranial injury or some type of an expanding mass (e.g., a hemorrhage, an abscess, or a tumor), results in loss of muscle tone, weakness, and fatigue. Depending on the area of the brain affected, the patient has different motor symptoms or responses. The patient may demonstrate abnormal flexion, abnormal extension, or flaccid posturing. **Flaccidity** (lack of muscle tone) preceded by abnormal posturing in a patient with cerebral injury indicates severe neurologic impairment, which may herald brain death (Klein & Stewart-Amidei, 2017; Posner, Saper, Schiff, et al., 2019). See [Chapter 61](#), Figure 61-1 for further explanation of posturing.

Destruction or dysfunction of the basal ganglia leads not to paralysis but to muscle rigidity, disturbances of posture, and difficulty initiating or changing 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, which is movement of a slow, squirming, writhing, twisting type; or chorea, marked by spasmodic, purposeless, irregular, uncoordinated motions of the trunk and the extremities, and facial grimacing. Disorders affecting basal ganglia activity include Parkinson's and Huntington diseases (see [Chapter 65](#)).

## Sensory System Function

### 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 carried. Knowledge of these pathways is important for neurologic assessment and for understanding symptoms and their relationship to various lesions.

Sensory impulses convey sensations of heat, cold, and pain; position; and vibration. The axons enter the spinal cord by way of the posterior root, specifically in the posterior gray columns of the spinal cord, where they connect with the cells of secondary neurons. Pain and temperature fibers (located in the spinothalamic tract) cross immediately to the opposite side of the cord and course upward to the thalamus. Fibers carrying sensations of touch, light pressure, and localization do not connect immediately with the second neuron but ascend the cord for a variable distance before entering the gray matter and completing this connection. The axon of the secondary neuron traverses the cord, crosses in the medulla, and proceeds upward to the thalamus.

Position and vibratory sensations are produced by stimuli arising from muscles, joints, and bones. These stimuli are conveyed, uncrossed, all the way to the brain stem by the axon of the primary neuron. In the medulla, synaptic

connections are made with cells of the secondary neurons, whose axons cross to the opposite side and then proceed to the thalamus.

### **Integrating Sensory Impulses**

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 as well as the ability to recognize the size, shape, and quality of objects. Sensory information is relayed from the thalamus to the parietal lobe for interpretation.

### **Sensory Losses**

Destruction of a sensory nerve results in total loss of sensation in its area of distribution (see Fig. 60-9). Lesions affecting the posterior spinal nerve roots may impair tactile sensation, causing intermittent severe pain that is referred to their areas of distribution. Destruction of the spinal cord yields complete anesthesia 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 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. Other sensory fibers ascend the cord for variable distances, some even to the medulla, before crossing, thereby bypassing the lesion and avoiding destruction. Lesions in the thalamus or parietal lobe result in impaired touch, pain, temperature, and proprioceptive sensations.

## **Assessment of the Nervous System**

An assessment of the nervous system involves conducting a health history and physical assessment.

### **Health History**

An important aspect of the neurologic assessment is the history of the present illness. 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, input from witnesses or the family, or a combination of these.

Neurologic disorders may be stable or progressive, characterized by symptom-free periods as well as fluctuations in symptoms. The health history therefore includes details 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.

## Common Symptoms

The symptoms of neurologic disorders are as varied as the disease processes. Symptoms may be subtle or intense, fluctuating or permanent, inconvenient or devastating. This chapter discusses the most common signs and symptoms associated with neurologic disease; the relationship of specific signs and symptoms to a disorder is presented 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. Pain is therefore considered 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, acute pain may be associated with brain hemorrhage, spinal disc disease (Jarvis, 2020), or trigeminal neuralgia. In contrast, chronic or persistent pain extends for long periods of time and may represent a broader pathology. This type of pain can occur with many degenerative and chronic neurologic conditions (e.g., multiple sclerosis). See [Chapter 9](#) for a more detailed discussion of pain.

### Seizures

Seizures are the result of abnormal electrical 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 in a blank stare that lasts only a second, or of longer duration, such as a tonic–clonic grand mal seizure that can last several minutes. The seizure activity reflects 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 (Hickey & Strayer, 2020).

### Dizziness and Vertigo

Dizziness is an abnormal sensation of imbalance or movement. It is common in the older adult and a common complaint encountered by health

professionals (Jarvis, 2020). Dizziness can have a variety of causes, including viral syndromes, hot weather, roller-coaster rides, and middle ear infections, to name a few. One difficulty confronting health care providers when assessing dizziness is the vague and varied terms that patients use to describe the sensation.

About 50% of all patients with dizziness have **vertigo**, or the illusion of movement in which the individual or the surroundings are sensed as moving, usually as rotation (Jarvis, 2020). Vertigo is usually a manifestation of vestibular dysfunction. It can be so severe as to result in spatial disorientation, lightheadedness, 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 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 (e.g., stroke) interfere with normal visual acuity. Abnormalities of eye movement (as in the nystagmus associated with multiple sclerosis) can also compromise vision by causing diplopia or double vision. See [Chapter 58](#) for a more detailed discussion of disorders that affect vision.

### Muscle Weakness

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

### Abnormal Sensation

Abnormal sensation is a neurologic manifestation of both central and peripheral nervous system disease. Altered sensation can affect small or large areas of the body. It is frequently associated with weakness or pain and is potentially disabling. Lack of sensation places a person at risk for falls and injury.

### Past Health, Family, and Social History

The nurse may inquire about any family history of genetic diseases (see [Chart 60-1](#)). 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.

Questions regarding the use of alcohol, medications, and illicit drugs are also relevant. The history-taking portion of the neurologic assessment is critical and, in many cases of neurologic disease, leads to an accurate diagnosis.

## 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. Many neurologic rating scales exist (Herndon, 2006), and some of the more common ones are discussed in this chapter.

The brain and spinal cord cannot be examined as directly as other systems of the body. Therefore, much of the neurologic examination is an indirect evaluation that assesses the function of the specific body part or parts controlled by the nervous system. A neurologic assessment is divided into five components: consciousness and cognition, cranial nerves, motor system, sensory system, and reflexes. One or more components may become the priority assessment, depending on the patient's condition. For example, motor, sensory, and reflex assessments are the priority in patients with spinal injury, whereas in a patient who is comatose, the cranial nerves and level of consciousness become the priority.

### Assessing Consciousness and Cognition

Cerebral abnormalities may cause disturbances in mental status, intellectual functioning, thought content, and emotional status. There may also be alterations in language abilities as well as lifestyle. The examiner must also be aware of the patient's overall level of consciousness and any changes over time (Posner et al., 2019).

The examiner records and reports specific observations regarding mental status, intellectual function, thought content, and emotional status, all of which permit comparison by others over time. Alterations should be described in specific and nonjudgmental terms. The use of terms such as “inappropriate” or “demented” is avoided, because they often mean different things to different people and are therefore not useful when describing behavior. Analysis and the conclusions that may be drawn from these findings usually depend on the examiner's knowledge of neuroanatomy, neurophysiology, and neuropathology.

Chart 60-1



## GENETICS IN NURSING PRACTICE

## Neurologic Disorders

Several neurologic disorders are associated with genetic abnormalities. Neurologic impairment is noted with many other genetic illnesses. Some examples include:

Autosomal Dominant:

- Cerebral arteriopathy
- Familial Alzheimer's disease
- Huntington disease
- Myotonic dystrophies
- Neurofibromatosis
- Von Hippel–Lindau syndrome

Autosomal Recessive:

- Canavan disease
- Familial dysautonomia
- Friedreich ataxia

X Linked:

- Duchenne muscular dystrophy
- Fragile X syndrome

Inheritance pattern is not distinct; however, there is a genetic predisposition for the disease:

- Amyotrophic lateral sclerosis (ALS)
- Epilepsy
- Neural tube defects (e.g., spina bifida, anencephaly)
- Parkinson's disease
- Tourette syndrome

Other genetic disorders that also impact the neurologic system:

- Bipolar disease
- Down syndrome
- Phenylketonuria (PKU)
- Schizophrenia
- Tay–Sachs disease
- Tuberous sclerosis complex

## Nursing Assessments

Refer to [Chapter 4, Chart 4-2](#): Genetics in Nursing Practice: Genetic Aspects of Health Assessment

[Family History Assessment Specific to Neurologic Disorders](#)

- Assess for other similarly affected relatives with neurologic impairment.
- Inquire about age of onset (e.g., present at birth—spina bifida; developed in childhood—Duchenne muscular dystrophy; developed in adulthood—Huntington disease, Alzheimer’s disease, ALS).
- Inquire about the presence of related conditions such as intellectual disability or learning disabilities (neurofibromatosis type 1).

### Patient Assessment

- Assess for the presence of other physical features suggestive of an underlying genetic condition, such as skin lesions seen in neurofibromatosis (*café-au-lait* spots).
- Assess attention span, and the presence of hyperactivity or withdrawn behavior.
- Assess for other congenital abnormalities (e.g., cardiac, ocular).
- Inspect for presence of freckles in the axillary or inguinal areas.
- Assess for presence of uncoordinated movement of extremities, muscle twitching, or history of seizures.
- Assess for poor or hyperactive muscle tone.
- Assess for episodes of forgetfulness or uncharacteristic changes in behavior or mood.
- Inspect for disproportionate facial features (fragile X or Down syndrome).
- Observe for presence of “tics” or uncontrolled body movement.
- Ask about history of seizures or head trauma.

### Genetics Resources

Epilepsy Foundation, [www.epilepsy.com/learn/diagnosis/genetic-testing](http://www.epilepsy.com/learn/diagnosis/genetic-testing)

Huntington’s Disease Society of America, [hdsa.org](http://hdsa.org)

Muscular Dystrophy Association, [www.mda.org](http://www.mda.org)

See [Chapter 6](#), [Chart 6-7](#) for components of genetic counseling.

### 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, and facial expressions often provide important information about the patient. Does the patient appear to be aware of and interact with the surroundings?

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 the name of the president of the United States? Is the patient aware of where they are? Is the patient aware of who the examiner is and of their purpose for being in the room? Assessment of immediate and remote memory is also important. Is the capacity for immediate memory intact?

## Intellectual Function

A person with an average intelligence quotient (IQ) can repeat seven digits without faltering and can recite five digits backward. The examiner might ask the patient to count backward from 100 or to subtract 7 from 100, then 7 from that, and so forth (referred to as serial 7s). The capacity to interpret well-known proverbs tests abstract reasoning, which is a higher intellectual function—for example, does the patient know what is meant by “a stitch in time saves nine”? The intellectual function of patients with damage to the frontal cortex appears intact until one or more tests of intellectual capacity are performed. Questions designed to assess this capacity might include the ability to recognize similarities—for example, how are a mouse and dog or pen and pencil alike? Can the patient make judgments about situations—for example, if the patient arrives home without a house key, what alternatives are there?

## Thought Content

During the interview, it is important to assess the patient’s thought content. Are the patient’s thoughts spontaneous, natural, clear, relevant, and coherent? Does the patient have any fixed ideas, illusions, or preoccupations? What are their insights into these thoughts? Preoccupation with death or morbid events, hallucinations, and paranoid ideation are examples of unusual thoughts or perceptions that require further evaluation.

## Emotional Status

An assessment of consciousness and cognition also includes the patient’s emotional status. Is the patient’s affect (external manifestation of mood) natural and even, or irritable and angry, anxious, apathetic or flat, or euphoric? Does their mood fluctuate normally, or does the patient unpredictably swing from joy to sadness during the interview? Is affect appropriate to words and thought content? Are verbal communications consistent with nonverbal cues?

## 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 (see [Table 60-5](#)). See [Chapter 62](#) for a detailed discussion of aphasia.

## Impact on Lifestyle

The nurse assesses the impact of any impairment on the patient’s lifestyle. Issues to consider include the limitations imposed on the patient by any

cognitive 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.

### Level of Consciousness

Consciousness is the patient’s wakefulness and ability to respond to the environment. Level of consciousness is the most sensitive indicator of neurologic function. To assess level of consciousness, the examiner observes for alertness and ability to follow commands.

If the patient is not alert or able to follow commands, the examiner observes for eye opening; verbal response and motor response to stimuli, if any; and the type of stimuli needed to obtain a response. Noxious stimuli should be used first, then painful stimuli if no response is observed. In the patient with decreased level of consciousness, motor and cranial nerve functions become the priority assessments, because abnormalities can indicate the area of involvement in the absence of responsiveness. See [Chapter 61](#) for further discussion of changes in level of consciousness.

**TABLE 60-5** Types of Aphasia and Region of Brain Involved

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

Adapted from Norris, T. L. (2019). *Porth’s pathophysiology: Concepts of altered health state* (10th ed.). Philadelphia, PA: Wolters Kluwer.

## Unfolding Patient Stories: Marilyn Hughes • Part 2



Recall from [Chapter 37](#) Marilyn Hughes, who came to the hospital after falling on icy stairs. She sustained a left midshaft tibia–fibula fracture, which requires surgery. Her husband informs the nurse that she also hit her head and did not respond to him for a short time after the fall. Describe the neurologic assessment performed by the nurse. Why should the nurse report this information promptly to the health care team?

Care for Marilyn and other patients in a realistic virtual environment: [vSim\(thepoint.lww.com/vSimMedicalSurgical\)](https://www.thepoint.lww.com/vSimMedicalSurgical). Practice documenting these patients’ care in DocuCare ([thepoint.lww.com/DocuCareEHR](https://www.thepoint.lww.com/DocuCareEHR)).

## Examining the Cranial Nerves

Cranial nerves are assessed when level of consciousness is decreased, with brain stem pathology, or in the presence of peripheral nervous system disease (Weber & Kelley, 2018). Right and left cranial nerve functions are compared throughout the examination.

See [Table 60-2](#) for methods of examining the cranial nerves.

## Examining the Motor System

### Motor Ability

A thorough examination of the motor system includes an assessment of muscle size and tone as well as strength, coordination, and balance. The patient is instructed to walk across the room, if possible, while the examiner observes posture and gait. 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.

### Muscle 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 quadriceps, for example, is a powerful muscle responsible for straightening the leg. Once the leg is straightened, it is exceedingly difficult for the examiner to flex the knee. If the knee is flexed and the patient is asked to straighten the leg against resistance, weakness can be elicited. The evaluation of muscle strength compares the sides of the body to each other. For example, the right upper extremity is compared to the left upper extremity. Subtle differences in strength may be evaluated by testing for drift. For example, both arms are out in front of the patient with palms up; drift is seen as pronation of the palm, indicating a subtle weakness that may not have been detected on the resistance examination.

Clinicians use a 5-point scale to rate muscle strength. A 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 (Jarvis, 2020).

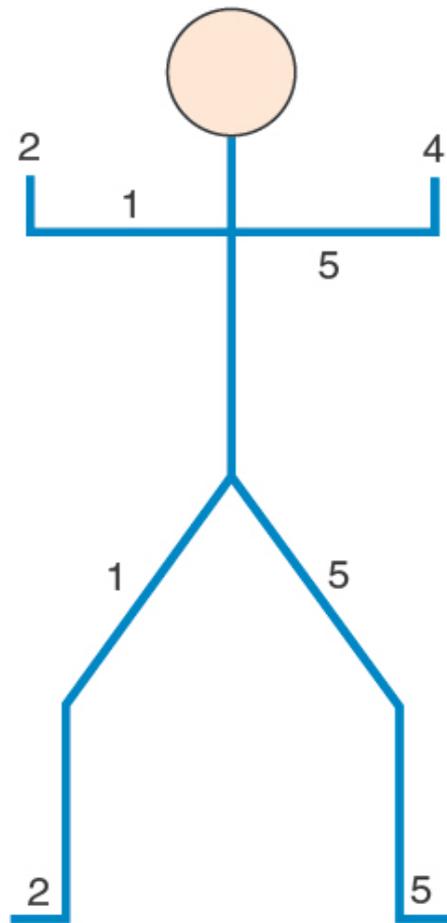
 **Concept Mastery Alert**

When recording muscle strength, a stick figure is used as a precise form to document findings. The five-point scale is used to rate and record distal and proximal strength in both upper and lower extremities. Figure 60-12 provides further details.

Assessment of muscle strength may be as detailed as necessary. One may quickly test the strength of the proximal muscles of the upper and lower extremities, always assessing both sides by comparing one side to the other. The strength of the finer muscles that control the function of the hand (hand grasp) and the foot (dorsiflexion and plantar flexion) can then be assessed.

### **Balance and Coordination**

Cerebellar and basal ganglia influence on the motor system is reflected in balance control and coordination. Coordination in the hands and upper extremities is tested by having the patient perform rapid, alternating movements and point-to-point testing. First, the patient is instructed to pat their thigh as fast as possible with each hand separately. Then, the patient is instructed to alternately pronate and supinate the hand as rapidly as possible. Last, the patient is asked to touch each of the fingers with the thumb in a consecutive motion. Speed, symmetry, and degree of difficulty are noted. Point-to-point testing is accomplished by having the patient touch the examiner's extended finger and then their own nose. This is repeated several times.



**Figure 60-12** • A stick figure may be used to record muscle strength.

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 an incoordination of voluntary muscle action, particularly of the muscle groups used in activities such as walking or reaching for objects. **Tremors** (rhythmic, involuntary movements) noted at rest or during movement suggest a problem in the anatomic areas responsible for balance and coordination.

**The Romberg test** is a screening test for balance that can be done with the patient seated or standing. The patient can be seated or stand with feet together and arms at the side, first with eyes open and then with both eyes closed for 20 seconds (Weber & Kelley, 2018). The examiner stands close to support the standing patient if they begin to fall. Slight swaying is normal, but a loss of balance is abnormal and is considered a positive Romberg test. Additional cerebellar tests for balance in the patient who is ambulatory include hopping in place, alternating knee bends, and heel-to-toe walking (both forward and backward).

## Examining the Sensory System

The sensory system is even more complex than the motor system, because sensory modalities are more widespread throughout the central and peripheral nervous systems. 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. 60-9) (Jarvis, 2020).

Assessment of the sensory system involves tests for tactile sensation, superficial pain, temperature, 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 the cooperation of the patient.

Tactile sensation is assessed by lightly touching a cotton wisp or fingertip to corresponding areas on each side of the body. The sensitivity of proximal parts of the extremities is compared with that of distal parts, and the right and left sides are compared.

Pain and temperature sensations are transmitted together in the lateral part of the spinal cord, so it is unnecessary to test for temperature sense in most circumstances. Determining the patient's sensitivity to a sharp object can assess superficial pain perception. However, pain sensation is usually reserved for patients who do not respond to or cannot discriminate touch stimulation. The patient is asked to differentiate between the sharp and dull ends of a broken wooden cotton swab or tongue blade; using a safety pin is inadvisable because it breaks the integrity of the skin. Both the sharp and dull sides of the object are applied with equal intensity at all times, and the two sides are compared. In the patient with an altered level of consciousness alternative methods of assessing pain may need to be used (Poulsen, Brix, Andersen, et al., 2016).

Vibration and proprioception are transmitted together in the posterior part of the spinal cord. Vibration may be evaluated through the use of a low-frequency (128 or 256 Hz) tuning fork. The handle of the vibrating fork is placed against a bony prominence, and the patient is asked if a sensation is felt; the patient is then instructed to signal the examiner when the sensation ceases. Common locations used to test for vibratory sense include the distal joint of the great toe and the proximal thumb joint. If the patient does not perceive the vibrations at the distal bony prominences, the examiner progresses upward with the tuning fork until the patient perceives the vibrations. As with all measurements of sensation, a side-to-side comparison is made.

Position sense or proprioception may be determined by asking the patient to close both eyes and indicate, as the great toe or index finger is alternately moved up and down, in which direction movement has taken place. Vibration and position sense are often lost together, frequently in circumstances in which all other sensation remains intact.

Integration of sensation in the brain is evaluated by testing two-point discrimination. When the patient is touched with two sharp objects simultaneously, are they perceived as two or as one? If touched simultaneously on opposite sides of the body, the patient should normally report being touched in two places. If only one site is reported, the one not being recognized is said to demonstrate extinction. Another test of higher cortical sensory ability is tactile identification. The patient is instructed to close both eyes and identify an object (e.g., key, coin) that is placed in one hand by the examiner; inability to identify an object by touch is known as **tactile agnosia or astereognosis**. **Agnosia** is the general loss of ability to recognize objects through a particular sensory system. The patient can also be shown a familiar object and asked to identify it by name; inability to identify a visualized object is known as **visual agnosia**. Each of these dysfunctions implicates a different part of the brain (see [Table 60-6](#)).

Decreased or absent sensations occur with problems anywhere along the sensory pathway. Sensory deficits resulting from peripheral neuropathy or spinal cord injury follow anatomic dermatomes. Destructive lesions of the brain may affect sensation on an entire side of the body. Stroke affecting a portion of the sensory cortex will produce altered sensory discrimination.

**TABLE 60-6** 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)

Adapted from Norris, T. L. (2019). *Porth's pathophysiology: Concepts of altered health state* (10th ed.). Philadelphia, PA: Wolters Kluwer.

## Examining the Reflexes

Reflexes are involuntary contractions of muscles or muscle groups in response to a stimulus. Reflexes are classified as deep tendon, superficial, or pathologic. Testing reflexes enables the examiner to assess involuntary reflex arcs that depend on the presence of afferent stretch receptors, spinal or brain stem synapses, efferent motor fibers, and a variety of modifying influences from higher levels.

### Deep Tendon Reflexes

A reflex hammer is used to elicit a deep tendon reflex. The handle of the hammer is held loosely between the thumb and index finger, allowing a full swinging motion. The wrist motion is similar to that used during percussion. The extremity is positioned so that the tendon is slightly stretched. This

requires a sound knowledge of the location of muscles and their tendon attachments. The tendon is then struck briskly (see Fig. 60-13), and the response is compared with that on the opposite side of the body. A wide variation in reflex response may be considered normal; however, it is more important that the reflexes be symmetrically equivalent. When the comparison is made, both sides should be equivalently relaxed, and each tendon struck with equal force.

Valid findings depend on several factors: proper use of the reflex hammer, proper positioning of the extremity, and a patient who is relaxed (Jarvis, 2020). If the reflexes are symmetrically diminished or absent, the examiner may use isometric contraction of other muscle groups to increase reflex activity. For example, if lower extremity reflexes are diminished or absent, the patient is instructed to lock the fingers together and pull in opposite directions. Having the patient clench the jaw or press the heels against the floor or examining table may similarly elicit more reliable biceps, triceps, and brachioradialis reflexes.

The absence of reflexes is significant, although ankle jerks (Achilles reflex) may be normally absent in older adults. Deep tendon reflex responses are often graded on a scale of 0 to 4+, with 2+ considered normal (see Chart 60-2) but 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. As with muscle strength recording, a stick figure may be used to record numerical findings.

### Biceps Reflex

The biceps reflex is elicited by striking the biceps tendon over a slightly flexed elbow (see Fig. 60-13A). The examiner supports the forearm at the elbow with one arm while placing the thumb against the tendon and striking the thumb with the reflex hammer. The normal response is flexion at the elbow and contraction of the biceps.

### Triceps Reflex

To elicit a triceps reflex, the patient's arm is flexed at the elbow and hanging freely at the side. The examiner supports the patient's arm and identifies the triceps tendon by palpating 2.5 to 5 cm (1 to 2 inches) above the elbow. A direct blow on the tendon (see Fig. 60-13B) normally produces contraction of the triceps muscle and extension of the elbow.



**Figure 60-13 •** Techniques for eliciting major reflexes. **A.** Eliciting the biceps reflex. **B.** Eliciting the triceps reflex. **C.** Eliciting the patellar reflex. **D.** Eliciting the Achilles reflex. Parts **A–D** reprinted with permission from Weber, J., & Kelley, J. (2018). *Health assessment in nursing* (6th ed., Figs. 25-31, 25-32, 25-33A, 25-34A). Philadelphia, PA: Lippincott Williams & Wilkins.

### Brachioradialis Reflex

With the patient's forearm resting on the lap or across the abdomen, the brachioradialis reflex is assessed. A gentle strike of the hammer 2.5 to 5 cm (1 to 2 inches) above the wrist results in flexion and supination of the forearm (Jarvis, 2020).

### Patellar Reflex

The patellar reflex is elicited by striking the patellar tendon just below the patella. The patient may be in a sitting or a lying position. If the patient is supine, the examiner supports the legs to facilitate relaxation of the muscles (see Fig. 60-13C). Contractions of the quadriceps and knee extension are normal responses.

### Achilles Reflex

To elicit an Achilles reflex, the foot is dorsiflexed at the ankle and the hammer strikes the stretched Achilles tendon (see Fig. 60-13D). This reflex normally produces plantar flexion. If the examiner cannot elicit the ankle reflex and suspects that the patient cannot relax, the patient is instructed to kneel on a chair or similar elevated, flat surface. This position places the ankles in dorsiflexion and reduces any muscle tension in the gastrocnemius. The Achilles tendons are struck in turn, and plantar flexion is usually demonstrated (Jarvis, 2020).

### Clonus

When reflexes are hyperactive, a movement 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 system disease, this activity persists, and the foot does not come to rest while the tendon is being stretched but persists in 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.

## Chart 60-2

## Documenting Reflexes

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

0 No response

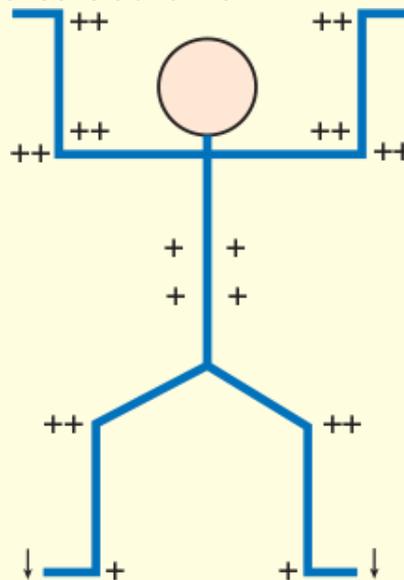
1+ Diminished (hypoactive)

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.



## Superficial Reflexes

The major superficial reflexes include corneal, palpebral, gag, upper/lower abdominal, cremasteric (men only), 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. A stroke or brain injury 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.

## Pathologic Reflexes

Pathologic reflexes are seen in the presence of neurologic disease; they often represent emergence of earlier reflexes that disappeared with maturity of the nervous system. A pathologic reflex indicative of CNS disease affecting the corticospinal tract is the **Babinski reflex (sign)**. 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 and draw back (Jarvis, 2020). **This is normal in newborns but represents a serious abnormality in adults.** Other pathologic reflexes include the **suck** (sucking motions in response to touching the lips), **snout** (lip pursing in response to touching the lips), **palmar** (grasp in response to stroking the palm), and **palmomentary** (contraction of the facial muscle in response to stimulation of the thenar eminence near the thumb) reflexes in adults. These reflexes often signify progressive nervous system degeneration (Klein & Stewart-Amidei, 2017).

## Gerontologic Considerations

During the normal aging process, the nervous system undergoes many changes and is more vulnerable to illness. Age-related changes in the nervous system vary in degree and must be distinguished from those due to disease. It is important for clinicians not to attribute abnormality or dysfunction to aging without appropriate investigation. For example, although diminished strength and agility are a normal part of aging, localized weakness can only be attributed to disease.

### Structural and Physiologic Changes

As the brain ages, neurons are lost, leading to a decrease in the number of synapses and neurotransmitters. This results in slowed nerve conduction and response time. Brain weight decreases, and the ventricle size increases to maintain cranial volume leading to a decreased brain volume. These changes in brain volume accelerate even in healthy people between the ages of 60 and 70 years (Battaglini, Gentile, Luchetti, et al., 2019). Cerebral blood flow and metabolism are reduced, leading to slower mental functions. Temperature regulation becomes less efficient. In the peripheral nervous system, myelin is lost, resulting in a decrease in conduction velocity in some nerves. Visual and auditory nerves degenerate, leading to loss of visual acuity and hearing. Taste buds atrophy, and nerve cell fibers in the olfactory bulb degenerate (Jarvis, 2020). Nerve cells in the vestibular system of the inner ear, cerebellum, and proprioceptive pathways also degenerate, leading to balance difficulties. 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**

Reduced nerve input into muscle contributes to an overall reduction in muscle bulk, with atrophy most easily noted in the hands. Changes in motor function often result in decreased strength and agility, with increased reaction time. Gait is often slowed and wide based. These changes can create difficulties in maintaining balance, predisposing the older person to falls.

### **Sensory Alterations**

Tactile sensation is dulled in the older adult due to a decrease in the number of sensory receptors. There may be difficulty in identifying objects by touch, because fewer tactile cues are received from the bottom of the feet and the person may become confused about body position and location.

Sensitivity to glare, decreased peripheral vision, and a constricted visual field occur due to degeneration of visual pathways, resulting in disorientation, especially at night when there is little or no light in the room. Because the older adult takes longer to recover visual sensitivity when moving from a light to dark area, nightlights and a safe and familiar arrangement of furniture are essential.

Loss of hearing can contribute to confusion, anxiety, disorientation, misinterpretation of the environment, feelings of inadequacy, and social isolation. A decreased sense of taste and smell may contribute to weight loss and disinterest in food. A decreased sense of smell may present a safety hazard, because older adults living alone may be unable to detect household gas leaks or fires. Smoke and carbon monoxide detectors—important in every residence—are critical for the older adult.

### **Temperature Regulation and Pain Perception**

The older adult 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. Complaints 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. In older adults, two common pain syndromes that affect the neurologic system are diabetic and postherpetic neuropathies. These frequently occur due to the high rate of these comorbid conditions in older adults. See [Chapter 46](#) for a discussion of diabetic neuropathy.

## Mental Status

Although mental processing time decreases with age, memory, language, and judgment capacities remain intact. Change in mental status should never be assumed to be a normal part of aging. **Delirium** is an acute confused state that begins with disorientation and if not recognized and treated early can progress to changes in level of consciousness, irreversible brain damage, and sometimes death. Older age is a risk, but delirium is also seen in patients who have underlying CNS damage or are experiencing an acute condition such as infection, adverse medication reaction, or dehydration. Drug toxicity and depression may produce impairment of attention and memory and should be evaluated as a possible cause of mental status change. Assessment with validated screening tool leads to improved detection of delirium (Smulter, LingeHall, Gustafson, et al., 2019). The Confusion Assessment Method (CAM) is a commonly used screening tool (Inouye, van Dyck, Alessi, et al., 1990) (see [Chapter 8, Chart 8-7](#)). Delirium must be differentiated from dementia, which is a chronic and irreversible deterioration of cognitive status. See [Chapter 61, Table 61-4](#) for further discussion of delirium and dementia.

## 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 modifications described previously. In addition, the consequences of any neurologic deficit and its impact on overall function such as activities of daily living, the use of assistive devices, and individual coping should be assessed and considered in planning patient care. Fall risk must be evaluated and fall prevention measures instituted for the patient who is hospitalized as well as in the home.

The nurse must understand the altered responses and the changing needs of the older adult patient before providing education. Visual and hearing deficits require adaptations in activities such as preoperative education, diet therapy, and education about new medications. When using visual materials for education 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. Procedures and preparations needed for diagnostic tests are explained, taking into account the possibility of impaired hearing and slowed responses in the older adult. Even with hearing loss, the older adult 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, an interpreter, or a translator may be needed.

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

## Diagnostic Evaluation

A wide range of diagnostic studies may be performed in patients with altered neurologic function. The nurse should educate the patient about the purpose, what to expect, and any possible side effects related to these examinations prior to testing. Women who are premenopausal are advised to practice effective contraception before and for several days after any diagnostic procedure using contrast, and the woman who is breast-feeding is instructed to stop for the time period recommended by the nuclear medicine department (Pagana & Pagana, 2018). The nurse should note trends in results, because they provide information about disease progression as well as the patient's response to therapy.

## Computed Tomography Scanning

Computed tomography (CT) scanning uses a narrow x-ray beam to scan body parts in successive layers. The images provide cross-sectional views of the brain, distinguishing differences in tissue densities of the skull, cortex, subcortical structures, and ventricles. An intravenous (IV) contrast agent may be used to highlight differences further. The brightness of each slice of the brain in the final image is proportional to the degree to which it absorbs x-rays. The image is displayed on an oscilloscope or television monitor and is photographed and stored digitally (Fischbach & Fischbach, 2018). CT scanning is usually performed first without contrast material and then with IV contrast, if needed. The patient lies on an adjustable table with the head in a headrest while the scanning system rotates around the head and produces cross-sectional images. **The patient must lie with the head held perfectly still without talking or moving the face, because head motion distorts the image.** CT scanning is quick and painless and uses a small amount of radiation to produce images; it has a high degree of sensitivity for detecting lesions.

Brain lesions have a different tissue density from the surrounding normal brain tissue. Abnormalities detected on brain CT include tumor or other masses, infarction, hemorrhage, displacement of the ventricles, and cortical atrophy (Fischbach & Fischbach, 2018). CT angiography allows visualization of blood vessels; in some situations, this eliminates the need for formal

angiography. Whole-body CT scanners allow cross-sections of the spinal cord to be visualized. The injection of a water-soluble iodinated contrast agent into the subarachnoid space through lumbar puncture improves the visualization of the spinal and intracranial contents on these images. The CT scan, along with magnetic resonance imaging (MRI), has largely replaced myelography as a diagnostic procedure for the diagnosis of herniated lumbar discs.

### Nursing Interventions

Essential nursing interventions include preparation for the procedure and patient monitoring. Preparation includes educating 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 interferes with a successful study. Ongoing patient monitoring during sedation is necessary. If a contrast agent is used, the patient must be assessed before the CT scan for an iodine/shellfish allergy, because the contrast agent used may be iodine based. Kidney function must also be evaluated because the contrast material is cleared through the kidneys. A suitable IV line for contrast injection and a period of fasting (usually 4 hours) are required prior to the study. Patients who receive an IV contrast agent are monitored during and after the procedure for allergic reactions and changes in kidney function (Fischbach & Fischbach, 2018). Fluid intake is also encouraged after IV contrast to facilitate contrast clearance through the kidney.

### Magnetic Resonance Imaging

MRI uses a powerful magnetic field to obtain images of different areas of the body. The 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 (Fischbach & Fischbach, 2018). It can provide information about the chemical changes within cells, allowing the clinician to monitor a tumor's response to treatment. It is particularly useful in the diagnosis of brain tumor, stroke, and multiple sclerosis and does not involve ionizing radiation. An MRI scan may take an hour or longer to complete, so its use in emergency situations is limited.

Several MRI applications allow imaging of brain blood flow and metabolism via special imaging techniques added to the MRI. Such techniques include diffusion-weighted imaging (DWI), perfusion-weighted imaging (PWI), magnetic resonance spectroscopy, and fluid attenuation inversion recovery (FLAIR) (Fischbach & Fischbach, 2018). Magnetic resonance angiography (MRA) allows separate visualization of the cerebral vasculature

without the administration of an arterial contrast agent. Both MRI and CT images are used as tools to plan and direct surgical intervention.

## Nursing Interventions

Patient preparation includes providing education and obtaining an adequate history. Ferromagnetic substances in the body may become dislodged by the magnet, so history of working with metal fragments must be reviewed. Patients with any type of cardiac implantable electronic device need to be screened to see if it is safe for the patient to undergo any type of MRI (Indik, Gimbel, Abe, et al., 2017). The patient is assessed for implants containing metal (e.g., aneurysm clips, orthopedic hardware, artificial heart valves, intrauterine devices). 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. A complete list of metal compatibility may be found on MRI manufacturer Web sites.

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) must be removed. This includes medication patches that have a metal backing and metallic lead wires; these can cause burns if not removed (Fischbach & Fischbach, 2018). No metal objects may be brought into the room where the MRI is located; this includes oxygen tanks, IV poles, 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. Further, damage to expensive equipment may occur.



### Quality and Safety Nursing Alert

*For patient safety, the nurse prevents any patient care equipment containing metal or metal parts (e.g., portable oxygen tanks, wheelchairs) from entering the room where the MRI is located. The nurse also assesses for and removes any medication patches with foil backing (such as nicotine patches) that may cause a burn while an MRI scan is being performed.*

For the MRI, the patient lies with the head in a frame on a flat platform that is moved into a tube housing the magnet (see Fig. 60-14). The tube is narrow; people with a wide girth may not fit into the scanner. Patients who are unable to lie flat will not be able to tolerate an MRI. The scanning process is painless, but the patient hears loud thumping of the magnetic coils as the magnetic field is being pulsed. Patients may experience claustrophobia while inside the

narrow tube; sedation may be prescribed in these circumstances. “Open” MRI machines are less claustrophobic than the other devices and are available in many locations. However, the images produced on these machines are sometimes not so detailed, and traditional devices are preferred for accurate diagnosis. The patient may be educated about the use of relaxation techniques while in the scanner. The patient is informed that it will be possible to talk to the staff during the scan through a microphone inside the scanner (Fischbach & Fischbach, 2018).



**Figure 60-14 •** Technician explains what to expect during a magnetic resonance imaging procedure.

## Positron Emission Tomography

PET is a computer-based nuclear imaging technique that produces images of actual organ functioning. 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 (Hickey & Strayer, 2020). PET measures this activity in specific areas of the brain and can detect changes in glucose use.

PET is useful in showing metabolic changes in the brain (Alzheimer's disease), locating lesions (brain tumor, epileptogenic lesions), identifying blood flow and oxygen metabolism in patients with strokes, distinguishing tumor from areas of necrosis, 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. Improvement in the scanning procedure and production of isotopes, as well as the advent of reimbursement by third-party payers, has increased the clinical applications of PET studies.

### Nursing Interventions

Key nursing interventions include patient preparation, which involves explaining the test and educating the patient about inhalation techniques and the sensations (e.g., dizziness, lightheadedness, 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

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 given 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 (Fischbach & Fischbach, 2018); and evaluation of perfusion before and after neurosurgical procedures.

### Nursing Interventions

The nursing interventions for SPECT primarily include patient preparation and patient monitoring. Providing education about what to expect before the test can allay anxiety and ensure patient cooperation during the test. **Pregnancy and breast-feeding are contraindications to SPECT.**

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.

## Cerebral Angiography

Cerebral angiography is an x-ray study of the cerebral circulation with a contrast agent injected into a selected artery. A valuable tool in investigating vascular disease or anomalies, it is used to determine vessel patency, identify presence of collateral circulation, and provide detail on vascular anomalies that can be used in planning interventions. With the advent of additional imaging techniques, formal cerebral angiography is less frequently performed.

Cerebral angiograms are performed by threading a catheter through the femoral artery in the groin or the radial artery of the wrist and up to the desired vessel. Alternatively, direct puncture of the carotid artery may be performed. X-ray images are obtained as the contrast agent flows through the vessels; the carotid and vertebral arterial systems are visualized, as well as venous drainage. Arterial access may also be used for interventional procedures, such as placing coils in an aneurysm or arteriovenous malformation.

## Nursing Interventions

Prior to the angiography, the patient's blood urea nitrogen and creatinine should be checked to ensure the kidneys will be able to excrete the contrast agent. The patient should be well hydrated, and clear liquids are usually permitted up to the time of the test. The patient is instructed to void immediately before the test, and 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.

When the femoral artery is selected for access, the hair in the groin is clipped and prepared and a local anesthetic agent is given to minimize 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. When the radial artery is selected for access, the wrist will be prepared and accessed using medications to relax and dilate the vessel to allow the catheter to pass (Mason, Shah, Tamis-Holland, et al., 2018). Fluoroscopy is used to guide the catheter to the appropriate vessels. Neurologic assessment is conducted during and immediately following cerebral angiography to observe for embolism or arterial dissection that may occur during the test. Signs of these complications include new onset of alterations in the level of consciousness, weakness on one side of the body, motor or sensory deficits, and speech disturbances.

Nursing care after cerebral angiography includes observation of the injection site for bleeding or hematoma formation (a localized collection of blood). Because a hematoma at the puncture site or embolization to a distal artery affects peripheral pulses, the peripheral pulses that were marked prior to the test are monitored frequently. The color and temperature of the involved extremity are assessed to detect possible embolism (Fischbach & Fischbach, 2018; Mason et al., 2018). Fluids are encouraged to facilitate clearance of the contrast through the kidney. The nurse also monitors for an allergic reaction to the contrast agent, as well as hypotension if vasodilatory medications were used to facilitate a radial approach (Mason et al., 2018).

## Myelography

A myelogram is an x-ray of the spinal subarachnoid space taken after the injection of a contrast agent into the spinal subarachnoid space through a lumbar puncture. The water-based contrast agent disperses upward through the CSF to outline the spinal subarachnoid space and shows any distortion of the spinal cord or spinal dural sac caused by tumors, cysts, herniated vertebral discs, or other lesions. Myelography is often followed by CT scanning (Fischbach & Fischbach, 2018).

## Nursing Interventions

The patient is educated about what to expect during the procedure and made aware that changes in position may be made during the procedure. 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 4 to 24 hours after testing. Drinking liberal amounts of fluid for rehydration and replacement of CSF may decrease the incidence of post-lumbar puncture headache. The blood pressure, pulse, respiratory rate, and temperature are monitored, as well as the patient's ability to void. Complications that may occur include nausea, vomiting, headache, fever, stiff neck, seizures, paralysis of one side of the body, and changes in level of consciousness (Fischbach & Fischbach, 2018).

## Noninvasive Carotid Flow Studies

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 more invasive tests such as arteriography or are used as screening tools. 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 extra- and intracranial circulation (Fischbach & Fischbach, 2018).

## Transcranial Doppler

Transcranial Doppler uses the same noninvasive techniques as carotid flow studies but records the blood flow velocities of the intracranial vessels. Arterial flow velocities can be measured through thin areas of the temporal and occipital bones of the skull. A handheld Doppler probe emits a pulsed beam; the signal is reflected by the moving red blood cells within the blood vessels. Transcranial Doppler is a noninvasive technique that is helpful in assessing vasospasm (a complication following subarachnoid hemorrhage), altered cerebral blood flow found in occlusive vascular disease, other cerebral pathologies, and brain death.

## Nursing Interventions

When a carotid flow study or transcranial Doppler is scheduled, the procedure is described to the patient. The patient is informed that this is a noninvasive test, that a handheld transducer will be placed over the neck and the orbits of the eyes, and that a water-soluble gel or lubricant is used on the transducer (Fischbach & Fischbach, 2018). Either of these two low-risk tests can be performed at the patient's bedside.

## Electroencephalography

An electroencephalogram (EEG) represents a record of the electrical activity generated in the brain (Hickey & Strayer, 2020). It is obtained through electrodes applied on the scalp or through microelectrodes placed within the brain tissue. It provides an assessment of cerebral electrical activity. It is useful 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.

Electrodes are applied to the scalp to record the electrical activity in various regions of the brain. The amplified activity of the neurons between any two of these electrodes is recorded on continuously moving paper; this record is called the *encephalogram*.

For a baseline recording, the patient lies quietly with both eyes closed. The patient may be asked to hyperventilate for 3 to 4 minutes or to 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. If the epileptogenic area is inaccessible to conventional scalp electrodes, nasopharyngeal electrodes may be used.

Chart 60-3



**NURSING RESEARCH PROFILE**

## Electroencephalographic Patterns During Nursing Interventions in Neurointensive Care

Elf, K., Carlsson, T., Santeliz Rivas, L., et al. (2019). Electroencephalographic patterns during common nursing interventions in neurointensive care: A descriptive pilot study. *Journal of Neuroscience Nursing*, 51(1), 10–15.

### Purpose

The purpose of this study was to identify changes on electroencephalography (EEG) during standard neurointensive nursing care.

### Design

The study was a descriptive pilot study using a convenience sample of patients admitted to the neurointensive care unit with impaired consciousness due to a neurosurgical condition. The sample included 12 participants, with a mean age of 65 years with diagnoses of subarachnoid hemorrhage, intracerebral hemorrhage, acute subdural hematoma, meningitis, ischemic infarction, or traumatic brain injury. All participants were mechanically ventilated, with continuous sedations and intracranial monitoring. The study design included the monitoring of simultaneous continuous EEG and video recording. The nursing interventions monitored included airway suctioning, repositioning, and when professionally touched for assessment of hygienic interventions.

### Findings

Four participants had seizure activity during four nursing interventions (0.4% of nursing interventions); one participant had stimulus-induced rhythmic discharges during an intervention. All 12 participants showed muscle artifacts during 353 nursing interventions (36.3%), which may be a sign of stress. Muscle artifacts happened during all types of nursing interventions but occurred most often when more than one intervention was performed.

### Nursing Implications

Patients with neuroscience disorders in intensive care undergo many stressors, and the results of this study indicate that nursing interventions may cause stress in patients. Oral care, repositioning, suctioning, and hygienic care may cause stress. Nurses should be mindful of the comfort of the patient with a neuroscience disorder when delivering care at the bedside and consider shorter and fewer interventions in patients who are sensitive.

Depth recording of EEG is performed by introducing electrodes stereotactically (radiologically placed using instrumentation) into a target area of the brain, as indicated by the patient's seizure pattern and scalp EEG. It is used to identify patients who may benefit from surgical excision of epileptogenic foci. Special transsphenoidal, mandibular, and nasopharyngeal

electrodes can be used, and video recording combined with EEG monitoring and telemetry is used in hospital settings to capture epileptiform abnormalities and their sequelae. Some epilepsy centers provide long-term ambulatory EEG monitoring with portable recording devices. Some evidence suggests that continuous EEG may be a useful tool for nurses planning interventions in patients who are critically ill (Elf, Carlsson, Santeliz Rivas, et al., 2019). See the Nursing Research Profile in [Chart 60-3](#).

## Nursing Interventions

To increase the chances of recording seizure activity, it is sometimes recommended that the patient be deprived of sleep the night before the EEG. Anticonvulsant 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 (Pagana & Pagana, 2018). Coffee, tea, chocolate, and cola drinks are omitted from the meal before the test because of their stimulating effect. However, the meal itself is not omitted, because an altered blood glucose level can cause changes in brain wave patterns.

The patient is informed that the standard EEG takes 45 to 60 minutes; a sleep EEG requires 12 hours. 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 the patient 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 the prescription regarding the administration of anticonvulsant medication prior to testing.

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

## Electromyography

An electromyogram (EMG) is obtained by inserting needle electrodes into the skeletal muscles to measure changes in the electrical potential of the muscles (Pagana & Pagana, 2018). 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 peripheral nervous system) 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.

## Nerve Conduction Studies

Nerve conduction studies are performed by stimulating a peripheral nerve at several points along its course and recording the muscle action potential or the sensory action potential that results. Surface or needle electrodes are placed on the skin over the nerve to stimulate the nerve fibers. This test is useful in the study of peripheral neuropathies and is often included as part of the EMG.

## Evoked Potential Studies

Evoked potential studies involve application of an external stimulus to specific peripheral sensory receptors with subsequent measurement of the electrical potential generated. Electrical changes are detected with the aid of computerized devices that extract the signal, display it on an oscilloscope, and store the data on magnetic tape or disc. In neurologic diagnosis, they reflect nerve conduction times in the peripheral nervous system. In clinical practice, the visual, auditory, and somatosensory systems are most often tested.

In visual evoked responses, the patient looks at a visual stimulus (flashing lights, a checkerboard pattern on a screen). The average of several hundred stimuli is recorded by EEG leads placed over the occipital lobe. The transit time from the retina to the occipital area is measured using computer-averaging methods.

Brainstem auditory evoked responses (BAERs) are measured by applying an auditory stimulus (repetitive auditory click) and measuring the transit time via the brain stem into the cortex. Specific lesions in the auditory pathway modify or delay the response. BAERs may be used in the diagnosis of brain stem abnormalities and in determination of brain death.

In somatosensory evoked responses (SERs), the peripheral nerves are stimulated (electrical stimulation through skin electrodes) and the transit time along the spinal cord to the cortex is measured and recorded from scalp electrodes. SERs are used to detect deficits in spinal cord or peripheral nerve conduction and to monitor spinal cord function during surgical procedures. It is also useful in the diagnosis of demyelinating diseases, such as multiple sclerosis and polyneuropathies, where nerve conduction is slowed.

## Nursing Interventions

The nurse explains the procedure and reassures the patient and encourages him or her to relax. The patient is advised to remain perfectly still throughout the recording to prevent artifacts (signals not generated by the brain) that interfere with the recording and interpretation of the test.

## Lumbar Puncture and Examination of Cerebrospinal Fluid

A lumbar puncture (spinal tap) is carried out by inserting a needle into the lumbar subarachnoid space to withdraw CSF (Schreiber, 2019). The test may be performed to obtain CSF for examination, to measure and reduce CSF pressure, to determine the presence or absence of blood in the CSF, and to administer medications intrathecally (into the spinal canal).

The needle is inserted into the subarachnoid space in the widest intervertebral spaces; between the second and third, the third and fourth, or fourth and fifth lumbar vertebrae (Schreiber, 2019). Because the spinal cord ends at the first lumbar vertebra, insertion of the needle below the level of the second lumbar vertebra prevents puncture of the spinal cord.

A lumbar puncture may be risky in the presence of an intracranial mass lesion because intraspinal pressure is decreased by removal of CSF, and the brain may herniate downward through the foramen magnum. A successful lumbar puncture requires that the patient be relaxed; a patient who is anxious is tense, and this may artificially alter the pressure reading. The nurse may be asked to assist with a lumbar puncture.



For the procedural guidelines for assisting with a lumbar

puncture, go to [the-point.lww.com/Brunner15e](https://the-point.lww.com/Brunner15e).

## Cerebrospinal Fluid Analysis

The CSF should be clear and colorless. Pink, blood-tinged, or grossly bloody CSF may indicate a subarachnoid hemorrhage. The CSF may be bloody initially because of local trauma but becomes clearer as more fluid is drained (Hickey & Strayer, 2020; Schreiber, 2019). Specimens are obtained for cell count, culture, glucose, protein, and other tests as indicated. The specimens should be sent to the inhibitor laboratory immediately because changes will take place and alter the result if the specimens are allowed to stand. See Table A-5 in Appendix A on **thePoint** for the normal values of CSF.

## 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. It is a throbbing bifrontal or occipital headache that is 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 (Schreiber, 2019). The fluid continues to escape into the tissues by way of the needle track from the spinal canal. As a result of a leak, the supply of CSF in the cranium is depleted to a point at which it is insufficient to maintain proper mechanical stabilization of the brain. When the patient assumes an upright position, tension and stretching of the venous sinuses and pain-sensitive structures occur.

Post–lumbar puncture headache may be avoided if a small-gauge needle (22 gauge) is used (Hickey & Strayer, 2020). A post–lumbar puncture headache is usually managed with analgesic agents, encouraging hydration, ingestion of caffeine, and lying supine (Schreiber, 2019).

### 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.

## Promoting Home, Community-Based, and Transitional Care



### Educating Patients About Self-Care

Many diagnostic tests are carried out in short-procedure units or outpatient testing settings or units. As a result, family members often provide the postprocedure care. Therefore, the patient and family must receive adequate education about precautions to take after the procedure, complications to watch for, and steps to take if complications occur. Because many patients undergoing neurologic diagnostic studies are older adults or have neurologic deficits, provisions must be made to ensure that transportation, postprocedure care, and appropriate monitoring are available.

### Continuing and Transitional Care

Contacting the patient and family after diagnostic testing enables the nurse to determine whether they have any questions about the procedure or whether the patient had any untoward results. Education is reinforced and the patient and family are reminded to make and keep follow-up appointments. Patients,