13 Nervous Tissue

Objectives
In this chapter we will study

- methods for diagnosing nervous system disorders;
- two demyelinating diseases—Guillain-Barré syndrome and multiple sclerosis;
- the characteristics and treatment of brain tumors, especially gliomas; and
- a brief overview of stroke, or cerebrovascular accident.

Diagnosing Nervous System Disorders

The nervous system facilitates communication among the trillions of body cells through rapid electrical conduction of signals. When this system is disrupted, many other body systems are affected as well. The diagnosis of neurological disorders is especially challenging, not only because the nervous system itself is so complex, but also because the signs and symptoms of neurological disorders can be difficult to distinguish from those of other organ systems.

A neurological assessment is normally incorporated into a standard physical examination. Functions that the examining physician routinely tests include the following:

- **special senses**—vision, hearing, smell, taste, and balance;
- **general senses**—touch, temperature sensation, vibration, and pain;
- **motor function**—eye movements, tongue movements, voice, swallowing, facial expressions, muscle strength, symmetry of musculature, signs of muscular atrophy, body position, gait, and coordination;
- **deep tendon reflexes**—muscular responses elicited by striking a tendon with a reflex hammer in such sites as the knee, elbow, wrist, ankle, and heel, or by using the handle of the hammer to scratch the skin in such sites as the abdomen and sole; and
- **level of consciousness**—states of responsiveness, or lack thereof, such as alertness, lethargy, or stupor. There are specific definitions and tests for these and other states.

When nervous system disorders are suspected, a more complete neurological examination is conducted. As with any other disease, the patient history provides the first clues. For example, the patient’s social and travel history may indicate possible exposure to toxins or infectious agents that could affect the nervous system, while the family history may suggest inherited neurological disorders. Some of the most common neurological symptoms reported by patients are dizziness, insomnia, fatigue, back pain, headache, muscle weakness, and **paresthesia**—abnormal sensations such as pricking, burning, or tingling. Once a neurological disorder is suspected, the clinician must determine the site of the abnormality, such as the brain, the spinal cord, a nerve, or a muscle.

A complete neurological examination evaluates mental status, cranial nerve function, sensory function, reflex function, autonomic function, and the cerebral vasculature. In addition to the basic imaging techniques described in chapter 2, some specialized imaging methods for the nervous system include:

- **cerebral angiography**, in which the cerebral blood vessels are examined by injecting an opaque dye into the circulatory system and taking an X ray of the head;
- **myelography**, in which dye is injected into the nervous system itself to render the spinal cord and nerve roots visible on X rays; and
- **echoencephalography**, ultrasound examination of the nervous system.

In addition to imaging techniques, brain function can be measured using either an **electroencephalogram**, which is a recording of the spontaneous electrical potentials of the brain, or **evoked potentials**, which are electrical responses of...
the brain to specific external stimuli. In a lumbar puncture (spinal tap), a sample of cerebrospinal fluid (CSF) is aspirated and examined for color, composition, and the presence of blood cells or microorganisms. The normal appearance and constituents of the CSF can be found in the Appendix of Normal Values at the end of this manual.

**Demyelinating Diseases**

The myelin sheath found around many nerve fibers is important to their conduction speed and the precision of conduction pathways. Disorders of the sheath can thus disrupt nerve conduction and cause a variety of sensory, motor, and cognitive dysfunctions. Two examples of this are Guillain-Barré syndrome and multiple sclerosis.

**Guillain-Barré Syndrome**

The most common demyelinating disorder is Guillain-Barré (gee-YAN buh-RAY) syndrome (GBS), also known as acute idiopathic polyneuropathy and by several other names. GBS is a pathology of the peripheral nerves that affects people of both sexes and all ages. It typically follows recovery from a viral infection, but in rare cases it may be triggered by lymphoma, surgery, or a vaccination against influenza or some other viral disease. GBS is thought to be an autoimmune disease in which autoantibodies attack the peripheral nerves, the myelin degenerates, and the nerve fibers themselves sometimes follow. When it affects motor nerves, GBS results in muscle weakness and atrophy, although motor function can recover if the cell bodies of the neurons survive and the nerves regenerate.

GBS is characterized by acute-onset muscle weakness that typically progresses from the lower to the upper limbs. The first sign is a relatively symmetrical weakness in both legs, often accompanied by paresthesia. Muscle tone declines, and deep tendon reflexes are lost. As GBS progresses, the upper limbs are affected, and then the muscles of the face and neck. GBS also affects the autonomic nervous system, which controls much of our visceral function. This results in an elevated heart rate, unstable blood pressure, and shortness of breath. In severe cases, death sometimes results from respiratory paralysis and autonomic dysfunctions.

GBS is diagnosed from the patient history, examination of the CSF, electromyography, and nerve conduction tests. The CSF of a GBS patient contains abnormally high protein concentrations (500 mg/dL), but no abnormal cells. Nerve conduction speed is decreased.

The treatment of GBS depends upon the severity of the condition. Less severe cases can be treated with plasmapheresis to remove the autoantibodies from the blood (see chapter 12 of this manual). This shortens the course of the disease and reduces the risk of permanent paralysis or death. Heat is used to relieve the pain of GBS and thus make it possible for the patient to undergo other physical therapy. A physical therapist initiates passive range-of-motion exercises early in the treatment and encourages active exercise as the patient regains mobility. In severe cases, the patient is usually hospitalized to monitor vital functions and provide respiratory support if needed. These patients are susceptible to pressure ulcers and fluid imbalances. Caregivers must passively exercise the patient’s joints to prevent ankylosis (see chapter 10 of this manual). About 30% of adults who recover from GBS continue to show some muscular weakness even 3 years later. The residual effects of GBS may require occupational or physical therapy or orthotic appliances to provide the patient with some degree of independence.

**Multiple Sclerosis**

Multiple sclerosis (MS) usually strikes between the ages of 20 and 40 years and affects women twice as often as men. Like GBS, it apparently results from an autoimmune attack, often triggered by a viral infection. MS, however, strikes the oligodendrocytes—myelin-producing cells of the CNS—and does not affect the nerves of the PNS. The white matter of the CNS exhibits widespread plaques of scar tissue, often surrounded by regions of edema. As demyelination and scarring spread, nerve conduction becomes progressively impaired, and the signs and symptoms worsen.

The exact cause of MS is unknown, but it involves both hereditary and environmental risk factors. It is about nine times more likely to occur in two monozygotic twins (genetically identical twins who develop from the same fertilized egg) as in two dizygotic twins (nonidentical twins who develop from separate fertilized eggs). Whites are more susceptible to MS than other groups of people, and about 15% of people with MS have relatives with the same disease. MS is five times more common in people who live their first 15 years in temperate climates than in
people of the tropics; moving after the age of 15 does not affect the risk level. Thus, it appears that MS results from a combination of heredity and an environmental factor, possibly a virus, encountered in childhood. Conditions such as trauma, infection, and fatigue often seem to set off the initial attack of MS in people who have these risk factors. The fatigue following pregnancy is sometimes linked to the onset of MS. Conditions such as trauma, infection, and environmental factor, possibly a virus, encountered in childhood. Conditions such as trauma, infection, and fatigue often seem to set off the initial attack of MS in people who have these risk factors. The fatigue following pregnancy is sometimes linked to the onset of MS.

There are multiple types of MS: a mixed type characterized by rapid onset of visual defects; a spinal type characterized by weakness or numbness in the limbs and loss of bladder control; and a cerebellar type that involves a loss of coordination and a spastic gait. About half of MS patients show a mixture of these types after several years. Some cases of MS exhibit alternating remission (disappearance of signs) and relapses (reappearance of signs). Victims may exhibit several paroxysms (attacks) each day—episodes of paresthesia, ataxia (lack of coordinated movement), and dysarthria (speech disturbances) lasting from a few seconds to minutes.

Diagnosis of MS is based on the patient history and physical examination, with those findings confirmed by other tests. CSF immunoglobulin concentrations are found to be elevated in approximately 67% of MS patients. Imaging techniques such as MRI and CT scans are used to identify the location and severity of the plaques. MRI is the most sensitive diagnostic technique, often revealing plaques overlooked by CT. If these methods fail to indicate exact locations, evoked potential studies can be used to confirm the diagnosis.

Over the course of the disease, the patient experiences symptoms that require both supportive and rehabilitative therapies. These symptoms include weakness, pain, spasticity, depression, heat intolerance, tremor and ataxia, and bladder, bowel, and sexual dysfunction. Muscle training provides both physical and psychological benefits. The patient should be encouraged to maintain as normal and active a lifestyle as possible, but overwork and fatigue must be avoided. As the patient gets weaker, he or she becomes more bedridden, but this result can be delayed by physical therapy and prompt treatment of infections and urinary difficulties. In bedridden patients, preventing pressure ulcers and infections of the lungs and urinary tract is of utmost concern.

At present, there is no cure for MS. The average duration of the disease is about 30 years; many patients live a normal life span, while some die within a year of onset. Short-term corticosteroid therapy sometimes shortens acute attacks of MS and may reduce the risk of long-term neurological deficits. Subcutaneous injections of interferon reduce the frequency of relapses for some patients.

**Gliomas**

Brain tumors are classified as primary tumors if they arise from brain tissue itself and secondary (metastatic) tumors if they have invaded the brain by metastasis from a tumor elsewhere in the body (for example, metastatic lung or colon cancer that has invaded the brain). Primary brain tumors are further classified as extracerebral or intracerebral. Extracerebral tumors arise from structures outside the brain, such as the pituitary or pineal gland, cranial nerves, or meninges (membranes around the brain); intracerebral tumors arise from the brain tissue itself. Primary intracerebral tumors are also called gliomas because they usually arise from glial cells.

Some gliomas are encapsulated and noninvasive—that is, they are confined by a fibrous capsule and do not spread easily to adjacent neural tissue. They can nevertheless be life-threatening because they compress and displace other CNS tissue and cerebral blood vessels. Other gliomas are nonencapsulated and invasive; these tumors spread into adjacent tissue and destroy it.

Gliomas can arise from almost any type of CNS glial cell—for example, astrocytomas develop from astrocytes, oligodendrocytomas from oligodendrocytes, and ependymomas from ependymal cells. The signs and symptoms of a glioma depend on its location and type. Headaches may be an early symptom, sometimes accompanied by irritability and personality changes. As the tumors multiply and grow, they create increased intracranial pressure, often producing such signs as vomiting, seizures, vertigo, paresthesia, and motor and sensory deficits.

Treatment of a glioma depends on the type, location, and severity of the tumor. If at all possible, the tumor is surgically removed. Surgical excision is often coupled with either chemotherapy, radiation therapy, or both. If surgical removal is not feasible due to the tumor’s location, chemotherapy and radiation therapy are usually used. However, chemotherapy for brain tumors is often hindered by the blood-brain barrier, a system that makes it difficult to get drugs into the CNS tissue.
Stroke

More than 50% of hospital admissions for neurological problems are due to stroke, or cerebrovascular accident—a sudden loss of blood supply to the brain. Strokes occur either because a cerebral artery is obstructed (often by a fatty atherosclerotic deposit, a blood clot, or both) or because a weakened cerebral artery has hemorrhaged. These pathologies are usually secondary to hypertension (elevated blood pressure), atherosclerosis, or a combination of the two pathologies. Death (infarction) of brain tissue may or may not occur. The neurological effects of a stroke vary widely, depending on what region and how much brain tissue is damaged; blindness, speech defects, and paralysis are a few common consequences. Stroke is further discussed with other vascular diseases in chapter 20 of this manual.

Case Study 13  The Drummer with Tingling Fingers

Aaron, a 26-year-old musician, visits his physician complaining of tingling in the fingers of his right hand. The feeling is present when he plays his drums as well as at other times of the day and night. Sometimes the tingling is so bad that he has difficulty feeling anything with his right hand and ends up dropping things. He has also noted that his right hand and arm get tired more easily than his left hand. In addition, he has had problems seeing correctly for the past 3 weeks; even during the day or in bright rooms, his overall vision is “darker” than normal. At times he feels like something is crawling over the right side of his face. Finally, Aaron mentions that during the time he has been most worried about these symptoms, his legs have felt weak and he has been tripping over things.

Examination reveals weakness of the rectus muscles of Aaron’s right eye and mild weakness of his right facial muscles. Other muscles are of normal strength. Aaron exhibits normal reflexes, but his right-side reflexes are somewhat greater than those on his left side. The physician suggests that Aaron get more rest and have his eyes checked because he may need glasses. The physician also tells him to return if his condition does not improve.

Three months later, Aaron comes back. In addition to his previous symptoms, he has developed difficulty walking and speaking. Although he frequently feels the need to urinate, he is unable to fully empty his bladder. On this visit, the physical examination shows disturbances in Aaron’s gait—he has become ataxic, and his stance is wider than normal. His superficial reflexes are diminished, and his deep tendon reflexes are exaggerated. Based on these signs, the physician orders MRI scans and a spinal tap. The MRI results show areas of demyelination and plaques in the white matter of the brain. When the CSF is analyzed, elevated concentrations of leukocytes, protein, and antibodies are found, and myelin basic protein is present. These results lead to a diagnosis of multiple sclerosis.

Based on this case study and other information in this chapter, answer the following questions.

1. Why is multiple sclerosis not diagnosed initially?
2. How do Aaron’s physical signs and symptoms support the diagnosis of multiple sclerosis? How could you rule out Guillain-Barré syndrome?
3. What treatments would you expect the physician to prescribe?
4. If you were Aaron’s physical therapist and he asked your opinion of his prognosis, what would you tell him?
5. Why do plaques appear in the CNS of a patient with multiple sclerosis?
6. Suppose someone argued that the reason twins often share multiple sclerosis is not because it’s hereditary, but because of some abnormality in the mother’s pregnancy such as maternal exposure to a toxin or virus. What argument could you give against this hypothesis?
7. Autoantibodies are present in both Guillain-Barré syndrome and multiple sclerosis. Plasmapheresis is helpful in treating the former but not the latter. Explain this difference.

8. Are all gliomas malignant? Explain your answer.

9. Why are seizures a characteristic sign of gliomas?

10. Why are glial cells more likely than neurons to produce primary intracerebral tumors?

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**Selected Clinical Terms**

**ataxia** An inability to coordinate voluntary muscular activity of the limbs, trunk, or head; often suggests lesions of the cerebellum or spinal cord.

**dysarthria** A disturbance of speech, often resulting from brain lesions or from paralysis or spasticity of the muscles of speech.

**paresthesia** Abnormal sensations such as tingling, burning, or prickling, often in the absence of external stimulation.

**paroxysm** Any sudden onset or “attack” of a disease or intensification of symptoms; a sharp spasm or seizure.

**primary tumor** A tumor that originates from cells in the organ where it is found.

**relapse** A recurrence of the symptoms of a disease following a period of remission or improvement in the person’s condition.

**secondary tumor** A tumor that did not originate in the organ where it is found, but arrived there by metastasis from a primary tumor elsewhere; also called a metastatic tumor.

**vertigo** A sensation of spinning or whirling, or an illusion of objects moving around the person, often indicating disorders of the inner ear or brain; often used less precisely to denote a sensation of dizziness or lightheadedness.