Objectives

In this chapter we will study

- the diagnostic value of testing somatic reflexes;
- the neurological basis of low back pain; and
- the epidemiology, pathogenesis, treatment, and prevention of rabies.

Reflex Testing

The peripheral nervous system (PNS) is composed of cranial nerves, spinal nerves, the distal branches of these nerves, and ganglia. Any disorder of nerve function is called a neuropathy. The spinal cord and spinal nerves are tested by assessing various somatic reflexes. Testing a reflex helps a clinician evaluate not only the individual components of a reflex arc (receptors, neurons, and muscles) but also the overall state of the nervous system. Abnormalities of reflex function, coupled with other information gathered during the physical examination, provide valuable clues to diagnosis.

One advantage of reflex testing is that it is easy to do; it requires only simple tools and good powers of observation. Although just a few reflexes are routinely tested, many others can be tested if necessary. Reflexes are usually graded on a scale of 0 to 4+:

- **0** Areflexia, absence of response
- **1+** Hyporeflexia, a somewhat diminished response
- **2+** An average or normal response
- **3+** Hyperreflexia, a stronger than normal response, possibly indicating disease
- **4+** Intense hyperreflexia with sustained clonus, indicating disease

Areflexia or hyporeflexia typically indicates a segmental lesion of the spinal cord segment or nerve root that innervates the muscle. Hyperreflexia typically indicates a suprasegmental lesion of higher levels of the CNS that normally inhibit the reflex.

The following discussion describes a few of the deep and superficial reflexes most commonly tested in adults and some of the reflexes tested in infants.

Deep Reflexes

The testing of deep reflexes usually involves striking the skin with a reflex hammer to stretch specific tendons and stimulate the tendon organs and muscle spindles. Clinicians commonly test the biceps, knee, and ankle reflexes and may test for clonus.

**Biceps Reflex**  The patient lies supine with the elbow flexed about 30°. The clinician presses on the cubital fossa to stretch the biceps tendon and strikes his or her own fingers with the reflex hammer. In a normal response, the biceps should contract slightly, but not enough to flex the elbow. If there is a lesion of the musculocutaneous nerve or segment C6 of the spinal cord, the biceps does not contract but the finger flexors may contract slightly. If there is a suprasegmental lesion, the biceps may contract more forcefully than normal and the brachioradialis or finger flexors may contract.

**Knee Reflex**  The patient either sits or lies supine with the knee flexed 90°. The examiner strikes the patellar ligament with the reflex hammer. Normal responses range from a slight twitch of the quadriceps femoris muscle to extension of the knee, lifting the leg. The absence of a response indicates a disease of lumbar nerve roots L3 and L4 or the femoral nerve.

**Ankle Reflex**  There are several ways to test this reflex. One is to have the patient kneel on the examining table with the foot extending beyond the end of the table. The examiner presses slightly against the foot to dorsiflex it, thus stretching the gastrocnemius muscle, and then strikes the calcaneal tendon with the reflex hammer. The gastrocnemius should contract and plantar flex the foot. Other positions and methods can be tried if this one fails, but if no response is obtained by any method, a disease of the first sacral nerve root or the tibial nerve is indicated.
Clonus  Clonus was described in the preceding chapter in connection with epilepsy (clonic seizures), but it can also be elicited in normal persons by the proper test. The patient should lie supine with the hip and knee flexed at 30° to 45° angles. The examiner then produces a sudden and sustained contraction of the gastrocnemius and soleus muscles by passively dorsiflexing the foot. In normal people, the calf muscles contract, relax, and contract again for about two or three beats. This occurs because the contraction of one muscle stimulates the stretch receptors in the antagonistic muscle. When the antagonist contracts, it stimulates the stretch receptors in the original muscle and triggers a reflex contraction. In people with suprasegmental lesions, the clonus continues for as long as the examiner dorsiflexes the patient’s foot.

Superficial Reflexes

Superficial reflexes are tested by stimulating the skin. Following are three examples of these tests:

Abdominal Reflex  The patient must be supine and relaxed. The examiner strokes the skin of the abdomen with a pointed object such as a pencil or the handle of a reflex hammer, moving from the lateral margins of the abdomen toward the midsagittal plane along a given dermatome. Normally, the underlying muscle contracts and pulls the umbilicus toward the stimulus. An absence of response in a given dermatome may indicate lesions to spinal nerves or roots T7 to T11. The response is often absent, however, in elderly patients and people with lax abdominal muscles.

Cremasteric Reflex  In males, stroking the inner, upper aspect of the thigh with a pin or pencil point causes the ipsilateral testicle (but not the scrotum) to rise, owing to contraction of the cremaster muscle. Lesions in spinal cord segments or nerve roots L1 to L2 or in the corticospinal tracts abolish this reflex.

Plantar Reflex  To test this reflex, the patient must be supine with the lower limbs extended. The examiner strokes the sole of the foot firmly with the handle point of the reflex hammer, progressing from the heel toward the toes. Normal subjects show a flexor plantar response in which they quickly flex the hip and knee, dorsiflex the ankle, and adduct and plantar flex (curl) the toes. An abnormal extensor plantar (Babinski) response is a reliable, early warning sign of corticospinal tract disease; the patient extends and dorsiflexes the great toe and abducts (fans) the other toes. The extensor plantar response also sometimes occurs in persons unconscious from drug or alcohol intoxication.

Reflexes of Infants

Because the nervous system is not completely developed at birth, neurological examination of infants differs somewhat from the techniques used for adults. Normally, a neonatal examination is performed between 36 and 60 hours after birth. In addition to reflexes, the infant’s motor pattern and body posture are observed. A normal infant has flexed limbs, and its head may be turned to one side. The lower limbs may be moving or kicking, and the infant is expected to become more active and to begin crying during the examination. On the other hand, certain responses are considered abnormal. For instance, an infant extending its limbs may have suffered intracranial hemorrhage. Asymmetric behavior of the upper limbs suggests brachial plexus palsy. Lack of increased activity during the examination suggests anoxia or intracerebral hemorrhage.

Infants are tested for the same reflexes as adults as well as some additional ones described here.

The trunk incurvation (Galant) reflex is tested by stroking the back from the shoulder to the buttocks or vice versa, about 1 cm from the midline. This stimulus should elicit contraction of the ipsilateral back muscles, causing the infant’s shoulders and pelvis to curve toward the stimulus while the trunk curves away. This response normally disappears at 2 months of age. Its earlier absence may indicate a transverse spinal cord lesion.

The grasp reflex is evaluated by determining the infant’s ability to forcefully grasp the examiner’s hand when the ulnar palmar surface is stimulated. This reflex normally disappears at 3 to 4 months of age. Persistence of the reflex beyond 4 months may indicate cerebral dysfunction.

The rooting reflex is a response to tactile stimulation of the lips. When the corner of the baby’s mouth is stroked, the baby opens its mouth and turns its head toward that side. When the midline of the upper lip is stroked, the baby extends its head, and when the midline of the lower lip is stroked, the jaw drops. This reflex disappears at 3 to 4 months of age, although sleeping infants exhibit it at slightly older
ages. Absence of this reflex before 3 to 4 months indicates severe CNS disease.

The startle (Moro) reflex is a response to a sudden stimulus such as a jolt, a loud noise, or being dropped a short distance (supporting the baby in a supine position and suddenly lowering it about 2 feet). The normal response is for the infant to extend and abduct all four limbs and extend and fan the digits, then flex and adduct the limbs. Neurologic disease is suspected if this reflex persists beyond 4 months and is almost certain if it persists beyond 6 months. An asymmetric response may indicate hemiparesis, brachial plexus injury, or fracture of the clavicle or humerus. The absence of a startle reflex may indicate kernicterus—damage to the basal nuclei or other areas of the CNS by accumulated bilirubin, a hemoglobin breakdown product seen in hemolytic disease of the newborn and some other conditions.

Diseases Affecting the PNS

Low Back Pain

Pain along the course of a nerve is called neuralgia. Because of the phenomenon of referred pain, the origin of pain can be difficult to identify—that is, pain may seem to come from the muscles or skin of a region when it actually originates in the abdominal or pelvic viscera. Sometimes pain originates in the ligaments of the spine, which are often damaged and which have abundant pain receptors.

Abnormal pressure on the peripheral nerves of the lumbar to sacral regions can cause low back pain. As noted in chapter 9 of this manual, low back pain may be idiopathic or may result from various vertebral disorders that create pressure on the spinal nerves. Two common causes are degenerative disc disease and herniated (ruptured or slipped) disc. For example, the pressure on the spinal nerves from a herniated disc causes pain that radiates along the sciatic nerve into the gluteal region and as far as the ankle. Even the strain of coughing or sneezing can trigger the pain. Pressure on a spinal nerve can also cause muscular weakness of the foot, paresthesia, and reduced sensations of touch, temperature, and pain.

The cause of low back pain, if it can be identified at all, may be determined through CT or MRI scans, specialized X-ray techniques, electromyography, and nerve conduction tests. Treatment typically involves bed rest, heat or ice, analgesics and anti-inflammatory drugs, and sometimes traction. Spinal surgery is of limited value in treating low back pain, but may be indicated if other treatments fail, if there is evidence of severe nerve compression, or if there is a loss of deep tendon reflexes or bladder or bowel control.

Rabies (Hydrophobia)

Rabies is an acute viral encephalitis that is usually transmitted by the saliva of infected mammals. It can affect any species of mammal. Worldwide, dogs are the most common source of human rabies because they interact so extensively with wildlife and humans; cats present a similar danger. Canine and feline rabies are now quite rare in the United States because of vaccination of pets—yet cats have twice the incidence of rabies that dogs do because people are less conscientious about keeping their cats vaccinated. Most human cases in the United States result from the bites of bats and other wild mammals. Many people who are bitten by bats are unaware of it, because most bats have tiny teeth and produce barely perceptible scratches on the skin. Raccoons, skunks, and foxes are common carriers of rabies but are rarely the source of human rabies infections. Although raccoons are the most common carriers of rabies in the United States, no one has ever gotten rabies from a raccoon bite, perhaps because people bitten by raccoons are well aware of it and are more likely to cleanse the wound and seek medical attention. Horses, cattle, and other livestock become infected from the bites of foxes and skunks. They can transmit the virus to humans when their owners examine the animals’ mouths. Infected horses and cattle also sometimes pursue and bite humans. Rabbits and small rodents such as mice, chipmunks, and squirrels seldom transmit rabies to humans. In a few cases, humans have contracted rabies by inhaling the dust in bat-infested caves. A few people have died after receiving corneal transplants from donors with rabies.

Rabid animals exhibit either dumb rabies or furious rabies. In dumb (paralytic) rabies, animals show signs of paralysis, especially of the pharyngeal and masseter muscles. They salivate profusely and cannot swallow. Dogs with dumb rabies often wander about with the jaw open. In furious rabies, the “mad dog” form of the disease, animals are agitated, viciously aggressive, and show no fear of humans or their other natural enemies. (The word rabies is from the Latin rabio, “to rage.”) Rabies should be suspected in wild mammals that seem unafraid of approaching humans and in normally nocturnal
mammals (such as skunks, raccoons, bats, and foxes) that become uncharacteristically active during the day.

**Pathogenesis** Following a bite by a rabid animal, the saliva-borne virus replicates in the skeletal muscle at the site of the bite, then invades the nerves that supply either the muscle spindles or extrafusal fibers of the muscle. The virus travels about 3 mm/hr up the peripheral nerve fibers until it reaches the CNS. There, it multiplies in the gray matter and then travels down the autonomic nerve fibers to such sites as the adrenal medulla, kidneys, lungs, liver, heart, skin, and salivary glands. Infection of the salivary glands facilitates transmission to a new host.

The first stage of the infection is an **incubation period** in which the virus travels and replicates in the body but produces no noticeable symptoms. This can last from 10 days to more than a year in humans; it is usually 30 to 50 days long and on the short end of this range in people with bites on the face or trunk, people with multiple bites, and children. This is followed by a **prodromal phase** about 1 to 4 days long in which a person experiences vague, nonspecific signs and symptoms such as malaise, fever, fatigue, headache, nausea, and sore throat. The prodromal symptom most indicative of rabies is **paresthesia** (see chapter 13 of this manual), abnormal sensations that may result from the infection of dorsal root ganglia by the virus. Paresthesia is experienced by 50% to 80% of patients.

The third stage is **encephalitis**. As it sets in, the victim experiences confusion and deranged thoughts and may exhibit agitation, combativeness, muscle spasms, seizures, paralysis, and extreme sensitivity to stimuli such as light and sound. This phase is soon followed by brainstem and cranial nerve involvement characterized by double vision, visual hallucinations, facial palsy, excessive salivation, and difficulty swallowing. In about 50% of cases, attempts to swallow produce intensely painful muscle spasms of the pharynx and larynx. Infected humans and animals thus develop an aversion to water even though they are intensely thirsty. The alternative name of rabies, **hydrophobia**, refers to this seeming “fear of water.” Not long after this stage, the patient lapses into a coma and dies of respiratory arrest.

By the time the first symptoms are felt, the virus has already invaded the CNS, and death is essentially 100% certain. Therefore, early diagnosis is of no help to the patient. However, the sooner a diagnosis of rabies is confirmed, the sooner preventive treatment may be initiated for others who have come in contact with the patient.

**Diagnosis** Rabies is typically diagnosed from the patient history (having suffered an animal bite) combined with the rapid neurological degeneration of the patient’s condition. The signs and symptoms of rabies are ambiguous, however, and it is difficult to distinguish rabies from several other neurological diseases that are much more common and probable. A fluorescent antibody test for the rabies antigen confirms the diagnosis of rabies but comes too late to save the patient.

Because of the seriousness of rabies, when an apparently healthy dog or cat bites a person, the animal should be observed for a period of 10 days. If the animal shows no signs of rabies, treatment is not initiated. If the animal does exhibit signs of rabies, it is killed and its head is sent to a diagnostic laboratory. The brain tissue is histologically examined for diagnostic **Negri bodies**, small spherical masses of rabies antigen and viruses. The absence of Negri bodies does not necessarily mean an absence of rabies, however. If none are found, the brain tissue is further examined with the fluorescent antibody test.

**Treatment** An animal bite should be allowed to bleed freely and then promptly scrubbed with soap and flushed with water. Benzalkonium chloride, a germicide present in medicinal soaps, deactivates the rabies virus. Antibiotics and tetanus immune globulin should be given. The wound should not be cauterized or sutured.

If the animal that inflicted the bite is confirmed to have rabies, or if it escaped but is suspected to have had rabies, the patient is treated immediately with **rabies immune globulin (RIG)** and an antirabies **human diploid cell vaccine (HDVC)**. RIG is given as soon as possible after the exposure, and only once. It provides **passive immunity** to the rabies virus that serves until the patient builds up his or her own **active immunity** in response to the HDVC. The first dose of HDVC is given with the RIG on “day 0,” followed by additional HDVC doses at 3, 7, 14, and 28 days (and sometimes 21 and 90 days).

**Prevention** People at high risk of contact with the rabies virus—animal handlers, laboratory personnel, veterinarians, and cave explorers—should be vaccinated with HDVC, get periodic evaluations of their antirabies antibody levels, and receive booster doses when their antibody levels fall below a critical
value. The risk of exposure to rabies is greatly reduced by vaccinating dogs and cats, controlling stray animals, and strictly avoiding contact with wild mammals. It is important to bear in mind that wild animals can be infected and can transmit the virus even in their prodromal period, when they show no obvious signs of disease.

---

Case Study 15 Getting Close to Nature—Too Close

Michael invites his college roommate, Steven, to spend spring break with him at his family’s hunting cabin in the hills of Pennsylvania. The cabin is not well kept; it is drafty and has a broken window. One night, Steven is awakened by something crawling on his right shoulder. It feels furry as he brushes it onto the floor. He guesses that it was a mouse, but doesn’t get up to inspect it. In the morning, however, Michael finds a bat clinging to one of the log walls. It makes strange noises and flies about the room, but it appears unable to fly very well and repeatedly lands on the floor. Michael forces the bat out the cabin door with a broom. It flies several feet away into the woods and lands on the ground.

Back at college a month later, Steven wakes up one morning with a headache and low back pain. He attends a morning class, but as the day progresses, his neck and shoulder begin to ache, his arm hurts and feels weak, and he begins to get a sore throat. He doesn’t feel like eating, so instead of going to lunch, he goes back to the dormitory, takes two Tylenol, and lies down for a nap. When Michael comes in, he wakes up and tries to speak, but his voice is very hoarse. Michael notes that Steven seems a little confused and disoriented, and takes him to the campus infirmary.

At the infirmary, Steven is found to have a slightly elevated temperature, and his sore throat feels worse. He is given more Tylenol, an antibiotic, and an anesthetic throat spray and told to check back if his condition changes. The next day, Steven has a high fever (104°F) and chills, combined with nausea and vomiting. The pain in his neck and shoulder is intense, and his speech is slurred. Michael notes that Steven seems a little confused and disoriented, and takes him to the campus infirmary.

At the infirmary, Steven is found to have a slightly elevated temperature, and his sore throat feels worse. He is given more Tylenol, an antibiotic, and an anesthetic throat spray and told to check back if his condition changes. The next day, Steven has a high fever (104°F) and chills, combined with nausea and vomiting. The pain in his neck and shoulder is intense, and his speech is slurred. Now increasingly concerned for his friend, Michael drives Steven to the emergency room of the county hospital.

At the hospital, a laryngeal examination shows paralysis of the vocal cords on the left side. Steven is now hypersalivating and cannot swallow his saliva without intense pain. He is admitted to the hospital for observation. A few hours later, he begins to exhibit clonus of the right arm, progressing to generalized clonus of the trunk and other limbs. He is given anticonvulsive medication and undergoes several tests. The results of an electroencephalogram reveal no evidence of epileptiform seizure, and the results of CT and MRI scans appear normal.

Over the following day, Steven requires continual oropharyngeal suction to remove excess saliva and is placed on I.V. fluid to prevent dehydration. The doctors suspect tetanus because Steven has had a work-study job in the biology department greenhouse. They give him tetanus immune globulin and continue antibiotic treatment. They also consider herpes simplex encephalitis and spongiform encephalopathy to be possibilities. Steven now begins to have double vision and to see odd flashes of colored light and other hallucinations.

Samples of blood serum, saliva, CSF, and a nuchal skin biopsy are sent to the Centers for Disease Control for diagnostic examination. While doctors await the results, Steven goes into respiratory arrest and is put on a mechanical ventilator. The results of the serum and CSF analyses come back negative, but Steven’s saliva and skin biopsy test positive for rabies. Eight days after the onset of the symptoms, Steven can no longer breathe on his own, his pupils are unreactive, and he shows no corneal reflex. At 12 days, he shows no cranial nerve reflexes at all, and lapses into a coma. On day 14, Steven’s parents consent to withdraw respiratory support, and Steven dies.

Upon autopsy, no brain tumors are found, and there is no gross evidence of cerebral necrosis or hemorrhage. Samples of brain tissue are sent to the CDC, where histological examination shows microscopic necrosis and the presence of Negri bodies, especially in the cerebellum and hippocampus. A fluorescent antibody test confirms the presence of rabies antigen. An RNA sequence analysis shows that Steven was infected with a variety of the rabies virus associated with two species of bats, the silver-haired bat and the eastern pipistrelle, both known to be common carriers of rabies.
Because of the rabies diagnosis, the hospital begins post-exposure prophylaxis (PEP) of the people who were or may have been exposed to Steven’s saliva, including Steven’s roommate, his parents and sister, his girlfriend, and 42 nurses, doctors, orderlies, and other staff of the campus infirmary and the county hospital. All 47 people receive an initial dose of rabies immune globulin (RIG) and five doses of rabies vaccine (HDVC) over the next 28 days.

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

1. How could this tragedy have been prevented? What should Steven have done, and when?

2. Name the stage of the disease that Steven is in on the day he first goes to the campus infirmary. Could his death have been prevented if the disease had been correctly diagnosed on that day? Explain.

3. From what you know of the pathogenesis of rabies, explain why the disease progresses less rapidly in a person bitten on the leg than in a person bitten on the neck or shoulder.

4. Why are so many different tissue and fluid samples from Steven sent to the CDC? From what part of the body is the skin biopsy taken? (Use a common term, as if you were explaining this to someone with no background in human anatomy.)

5. What does Steven’s work-study job have to do with the doctors’ tentative diagnosis of tetanus?

6. Steven’s parents request that his organs and tissues be used for transplant to other patients. Do you think the hospital would honor his parents’ wish? Why or why not?

7. What sign do rabies and grand mal epilepsy have in common? In what sign do they differ?

8. What is the adaptive significance (survival value) of the rooting reflex?

9. How does paresthesia differ from reduced sensitivity to touch, temperature, or pain?

10. Low back pain could result from any of the following except
    a. rabies.
    b. driving earth-moving machinery for a living.
    c. competitive weight-lifting.
    d. hyporeflexia.
    e. osteoporosis.

---

**Selected Clinical Terms**

- **active immunity** Immunity that results from one’s own production of antibodies or immune cells against a pathogen.

- **clonus** The pulsating, repetitive contraction and relaxation of a muscle or muscle group. A few pulsations are normal when clonus is properly tested, but persistent clonus can indicate certain seizure disorders such as epilepsy and other neuropathies such as rabies.

- **incubation period** A period in the course of an infectious disease between the time the pathogen enters the body and the appearance of the first signs or symptoms of disease; also called latent period.

- **Negri body** A microscopic round mass of rabies virus and rabies antigen found in the cytoplasm of neurons (especially in the cerebellum and hippocampus) of infected people and animals; serves as a histopathological confirmation of rabies.

- **neuralgia** Nerve pain; especially sharp stabbing or throbbing pain along the course of a nerve.

- **neuropathy** Any disorder of nerve function—for example, sciatica, rabies, or shingles.

- **passive immunity** Immunity conferred by antibodies or immune cells acquired from another donor, usually through injection (vaccination).

- **prodromal phase** A period in the course of a disease when the first symptoms are felt and a person has a premonition of oncoming illness.

- **segmental lesion** An injury to a segment of the spinal cord through which passes a particular reflex arc that is being tested; tends to produce hyporeflexia or areflexia.

- **suprasegmental lesion** An injury to a level of the CNS higher than the segment of the spinal cord involved in a particular reflex arc that is being tested; tends to produce hyperreflexia because of a loss of normal inhibitory influence.