# CHAPTER 1

# Neurologic History and Examination

In neurology, as in any branch of clinical medicine, a careful history and examination are critical in establishing the correct diagnosis. Many neurologic diseases do not have definitive physical findings (e.g., migraine, idiopathic epilepsy) or laboratory tests to aid in diagnosis; therefore good history-taking is critical. The student should follow a standard outline in performing the history and examination; in this way a routine will be established, and the examiner will always have a complete set of data from which to generate a diagnosis. A general outline is provided here; more specific details relating to history taking, examination, and the clinical significance of the findings are contained in Parts II and III.

## HISTORY

### Chief Complaint

The patient's chief complaint is a short statement of the problem for which neurologic evaluation is sought, and it is best recorded in the patient's own words.

### History of the Present Illness

The history of the present illness represents a spatial and temporal elaboration of the chief complaint. This is the most difficult and important aspect of the entire diagnostic process. It requires the physician to rearrange and organize the patient's symptoms into a logical historical sequence. The first step is to establish the time and character of onset (e.g., sudden, suggesting a vascular or epileptic event, or gradual, as is seen with mass or atrophic lesions). Next it is necessary to obtain a statement of the nature of the course: Is it progressive, remitting and exacerbating, or episodic such as a seizure disorder or headache? Then the actual symptoms must be detailed very carefully. The physician must not accept the patient's terminology unless it is perfectly clear; for instance, weakness or dizziness can have many meanings; therefore it is important for the physician to find out exactly what the patient means. Last, the patient is asked about any previous evaluation and treatment for the problem.

At this point the experienced examiner may have arrived at a tentative diagnosis and can expand the present illness description to include other relevant information to verify or reject that diagnosis; this skill comes with practice and with detailed knowledge of disease entities. However, the student will need to obtain a complete inventory of other neurologic symptoms, including a past history for medical illness or other conditions known to affect the nervous system.

When taking this type of detailed history, the examiner must use terms that will be understood by the patient; for example, asking an uneducated person if he has had a seizure may not elicit the proper response. A word such as blackout, passing-out, spell, or convulsion may be better. Redundancy is also helpful; using as many similar terms and descriptions as possible ensures that the patient comprehends the symptom being discussed. As in the history of the

present illness, each positive symptom in the review should be explored fully. Box 1-1 presents the neurologic review of the systems, and Box 1 -2 lists pertinent medical, social, and family history information.

**BOX 1-1 Neurologic Review of Systems**

1 Headache
2 Nausea or vomiting
3 Syncope
4 Seizure
5 Pain (back, neck, muscular, radiating)
6 Paresthesias, dysesthesias, or numbness
7. Motor difficulties
  a Weakness
  b Atrophy (wasting)
  c Ataxia
  d Clumsiness
  e Involuntary movements
  f Slowed motor movements (bradykinesia)
1.Visual disturbances
  a Diplopia
  b Blurring or visual loss (general or in one field of vision)
  c Scotoma (hole in the visual field)
9 Auditory/vestibular symptoms
  a Hearing loss (bilateral or unilateral)
  b Tinnitus (noise, usually a ringing in the ears)
  c Dizziness
10 Dysphagia (swallowing difficulty)
11 Speech and language symptoms
  a Dysarthria (an articulation disturbance)
  b Dysphonia (phonation difficulty usually caused by a vocal cord dysfunction)
  c Word-finding difficulty
  d Comprehension problems
12 Mental symptoms (a history should be obtained from relatives and close associates)
  a Memory difficulty
  b General intellectual deficits (trouble at work or with finances)
  c Disorientation in the environment (e.g., getting lost)
  d Episodes of confusion or abnormal behavior (e.g., wandering at night unclothed)
  e Inattention or difficulty concentrating
  f Lethargy
  g Insomnia or excessive daytime sleepiness
  h Anxiety
  i Depression
  j Hallucinations
  k Paranoid thoughts
  l Personality change
13 Autonomic dysfunction (bowel, bladder, sexual, postural hypotension)

**BOX 1-2 Pertinent Medical, Social, and Family History**

1 Hypertension
2 Heart disease (e.g., chest pain, heart failure)
3 Stroke or transient ischemic attack (TIA)
4 Diabetes
5 Endocrine disease (e.g., thyroid, adrenal)
6 Other neurologic disease
7 Medical disease
8 Cancer
9 Medications
10 Alcohol or drug use; smoking history
11 Head trauma
12 Handedness (patient and family)
13 Education and vocation
14 Toxic exposure
15 Birth, development, and scholastic history (most important in epilepsy or developmental disorders)
16 Family history of pertinent medical and neurologic disease

## NEUROLOGIC EXAMINATION

The neurologic examination is a systematic examination of the many functions of the nervous system. Because structure and function are closely related in the nervous system, the examination allows the examiner to determine both if there is dysfunction or damage of nervous tissue and also the location or structure involved. Focal, multifocal, and diffuse disease can be diagnosed. With the data from the history and examination, a logical differential diagnosis and evaluation plan can be proposed.

The following examination scheme is organized to minimize inconvenience to the patient. History and mental status examinations are carried out with the patient sitting in a chair or on the bedside; gait, strength, spine, skin, and coordination examinations are then carried out with the patient standing; the cranial nerves, carotid artery, reflexes, and sensory functions can be examined with the patient seated on the examining table or bed; and, finally, superficial reflexes, heel and shin testing, tests for meningeal irritability, and rectal examination are carried out with the patient lying down. In the following discussion, some areas are only briefly mentioned (e.g., involuntary movements, patterns of sensory loss) because these findings are discussed in the appropriate clinical chapters.

### Mental Status Examination

If the patient has any history or suspicion of behavior change, it is prudent to briefly screen mental functions. The first mental function to screen is level of consciousness (Box I-3).

**BOX 1-3 Level of Consciousness**

1 Alert (fully responsive, aware of the environment, and capable of responding appropriately to it)
2 Lethargic (sleepy but arousable and coherent)
3 Obtunded (very sleepy and incoherent on arousal)
4 Stuporous (requiring vigorous stimulation for arousal)
5 Comatose (unresponsive to environmental or internal stimuli such as pain)

***Behavioral Observations***

The patient should be observed for cleanliness, evidence of depression, anxiety, confusional behavior, frontal lobe personality change (see Neurobehavioral Diseases in Chapter 14), and unilateral neglect.

***Attention and Concentration***

Observation and digit span (normal 7) and serial subtraction (e.g., 100 minus 7) tests are used.

***Language***

The examiner should look for evidence of aphasia (e.g., errors in syntax, word choice, comprehension), specifically test naming (objects, colors, body parts), and repetition. In language testing simple items are presented first; then difficulty is increased. Dysarthria, which is an abnormality of articulation, must be separated from aphasia, which is a language disturbance.

***Memory***

The most important function is recent memory or new learning ability. The patient should be asked about personal identity, place, and date. The patient is given something specific to learn, such as a name, address, and flower or four -unrelated words such as brown, tulip, eyedropper, and honesty. The patient is asked to repeat the words and is then quickly asked about some recent personal information or current news items to prevent rehearsal of the items. In 5 minutes and again at the end of the examination, the examiner should ask for the information that the patient was requested to remember. A normal person should retain most of the name and address and three of the four words. Care is necessary in interpreting recent memory loss in patients with emotional problems; anxious patients are often too distracted, and depressed patients are too apathetic to perform well on learning tasks.

***Drawings***

The patient is asked to spontaneously draw or copy several simple drawings. Errors on this task are frequently indicative of organic brain damage, particularly dementia or parietal lobe damage. The samples and examples of errors shown in Figure 1-1 exemplify this task.

***Abstract Reasoning***

Proverb interpretation. Several examples should be used, such as "Don't cry over spilt milk," "Rome wasn't built in a day," and "People who live in glass houses shouldn't throw stones." The

patients with dementia, low IQ, or schizophrenia will give concrete interpretations such as, "Rome is a big place, you couldn't build it in a day or even a month."
Similarities. These are pairs of words that have some similarity or in some way belong to the same category (e.g., banana—apple [fruit], desk—bookcase [furniture], poem—novel [literature]). The demented or retarded person either does not see any similarity or gives a very concrete association, such as "a desk and a bookcase could both be in the same room or could be associated with studying."
Calculations (written). The patient is asked to perform several complex addition, subtraction, and multiplication problems; and the examiner can observe for preservation of rote tables, arithmetic processes (borrowing, carrying), and spatial alignment.

## Motor Examination

When examining a patient for motor skills, observe the following: gait, balance, involuntary movements, limb tone, strength, muscle bulk and consistency, and coordination.

### *Gait*

- The patient is asked to stand up from the chair. Difficulty doing this can denote proximal leg weakness, which can indicate muscle disease. This difficulty can also be caused by pain (back, hip, or knee) or by poor balance.
- The patient is asked to stand and walk in a normal fashion. The normal base is 12 to 18 inches between the inner surface of shoes or bare feet. The examiner should look for weakness, ataxia, wide-based stance, spasticity (stiffness of legs and the tendency to circumduct and scissor the legs), and arm posture (subtle flexion of one arm can indicate early hemiparesis). Patients with nerve disease (neuropathy, anterior horn cell disease) have distal weakness, with difficulty walking on heels and toes.
- The patient is asked to toe and heel walk. These maneuvers put additional demands on motor integration and balance mechanisms and bring out subtle abnormalities. Arm swing and natural hand posturing may be abnormal on the side opposite a damaged hemisphere. Toe-walking tests the strength of gastrocnemius and soleus muscles, which are primarily innervated by the S1 nerve root. Heel-walking tests the strength of foot dorsi-flexors (anterior tibial muscles), which are primarily innervated by L4 and L5.
- The patient is asked to tandem walk (heel to toe on a line). This task further challenges the balance mechanism. Any tendency by the patient to fall to the side or backward should be noted.

### *Balance*

The cerebellum, proprioceptive system, basal ganglia, and vestibular system, along with the pyramidal control of axial muscles, are the main systems responsible for maintaining proper balance. Balance is tested mainly during gait evaluation. Particular attention should be paid to performance on turns (often instability on turns is the first and only sign of imbalance). Elderly persons (usually 75 and older) have mild gait and balance problems as a concomitant of aging; therefore the examiner must adjust his or her expectations accordingly.

One useful classic clinical sign used in assessing balance is the Romberg sign. The patient stands with feet together and then closes the eyes. If the patient falls after closing the eyes, the test is considered positive. A positive Romberg sign usually indicates marked

proprioceptive loss, from either peripheral neuropathy or damage to the posterior columns of the spinal cord. Patients with cerebellar disease, significant unilateral weakness, or advanced parkinsonism may fall with their eyes open, and there is little or no difference with their eyes closed.

An additional test of balance or postural stability is performed by giving a gentle push backward to the patient who is standing with feet together. The normal person will resist the push adequately or catch himself or herself by putting one foot back. In some diseases, principally Parkinson's disease, the patient cannot make proper postural adjustments and will either fall backward or start to take small rapid steps backward (retropulsion).

***Involuntary Movements***

The examiner should expose the patient's arms, shoulders, and upper legs and have him or her stand quietly at rest. Notation is made of any adventitious movements: tremor, chorea, athetosis, myoclonus, dystonia, hemiballism, or fasciculation (see Chapter 20 for a full description of these abnormal movements).

***Limb Tone***

The examiner should passively flex and extend the patient's arms and wrists in a search for increased tone: spasticity (increased tone in antigravity muscles) with clasp knife phenomenon (sudden release of increased tone in spastic limb), rigidity (increased tone in both agonists and antagonists about a joint) with cogwheeling or ratcheting (intermittent rigidity with passive movements), and decreased tone (hypotonicity or flaccidity). The examiner should also supinate and pronate the patient's wrists, as increased limb tone is often first noticed with this maneuver. Contractures represent fixed joint deformity and can develop as a consequence of neurologic disorders, for example, frozen shoulder secondary to lack of shoulder movement in hemiplegia. Any asymmetries or change in tone of isolated muscle groups should be noted.

***Strength***

Evaluation of muscle strength is done systematically and is designed to elicit either generalized or specific weakness. Very few neurologic conditions produce true generalized muscle weakness, with the possible exception of potassium depletion or another metabolic problem. Most diseases are somewhat selective: unilateral in central nervous system upper motor neuron lesions; proximal limb and neck muscle in myopathy, dystrophy, or myositis; distal extremity in peripheral neuropathy and amyotrophic lateral sclerosis; and in a specific muscle group as is demonstrated in a nerve root lesion with disk disease or isolated peripheral nerve lesion from entrapment, trauma, or infarction (e.g., mononeuritis multiplex caused by diabetes, collagen vascular disease). The muscles can be tested by having the patient resist the force provided by the examiner. Adequate force is needed to assess subtle weakness. In patients with a history of bilateral weakness and easy fatigability, suggesting myasthenia, the patient should repetitively exercise one muscle group in an attempt to elicit true fatigability.

Lower leg muscles have been tested under gait evaluation; proximal leg muscles are best tested while observing the patient rise from a chair and with the patient seated or lying down. Walking up stairs, doing a deep knee bend, and rising from kneeling on one knee are excellent tests of proximal muscle strength. With the patient standing, the upper extremity muscles can be readily evaluated. The examination is begun by having the patient stand with feet together, arms extended to 90 degrees in front with palms up. The patient then closes his or her eyes, and the

examiner watches the patient's arms for 10 to 15 seconds. In mild hemiparesis the weak arm will pronate and drift downward (pronator drift). Table 1-1 is a simplified chart of muscle testing, with muscle groups, root levels, and peripheral nerves listed. The underlined root is the one principally responsible for the function.

***Muscle Bulk and Consistency***

The examiner should palpate muscles, particularly any weak muscle in a search for wasting, hypertrophy, or loss of the normal fleshy feeling of the muscle and for muscle tenderness. Muscle bellies should bulge outward. Muscles that are flat or bulge inward indicate wasting of muscles.

***Coordination***

The performance of a smooth, coordinated movement is a complicated motor task. Successful performance relies on an intact pyramidal system, cerebellum, and basal ganglia and their modulation through proprioceptive and sensory feedback from the lemniscal and vestibular systems. Damage or dysfunction of any portion of the system can produce a defect in coordination. Fortunately, distinctive abnormalities are produced by damage to each structure. During testing, the examiner must carefully compare performance of both sides, making due—but not undue—allowance for the preferred hand. The dominant hand is not necessarily the stronger but clearly is the best coordinated. Box 1-4 outlines a few small tests the patient can do during examination to test coordination.

BOX 1-4

1 Finger to nose. The examiner stands with an index finger at arm's length in front of the patient. The patient is asked to touch the examiner's finger with the index finger, then in rapid succession touch his or her nose and return to the examiner's finger. The examiner should look for past-pointing (missing the target consistently to one side), clumsy movement, slowness, tremor (note amplitude, e.g., coarse or fine), and weakness. After several excursions the examiner should move his or her finger and ask the patient to continue the task with a changing target.

2 Heel/shin (best done with the patient supine). The patient is asked to place the heel on the opposite knee and then run the heel down the shin. Coarse side-to-side tremor is typical of cerebellar disease.

3 Finger tapping. The patient rapidly opposes the index finger to thumb. Speed, clumsiness, maintenance of even rhythm, weakness, and breakdown (taps a few times then is unable to continue because the fingers appear to "stick together") are noted. This further challenges the patient's coordination and can dramatize subtle deficiencies.

4 Alternating hand movements (diadokokinesia). The patient is told to rapidly pronate and supinate one hand on the palm of the other. Again, the examiner must look closely for movement breakdown, dysrhythmia, clumsiness, and weakness.

5 Hand patting and foot tapping. Note should be made of the rhythm and evenness of the patting.

6. Circular motion. The patient is asked to make continuous circular motions with one hand on the back of the other. pain in vertebral body disease or root impairment (see Chapter 19).

## Spine

The spine is observed for scoliosis. In patients with back pain, the examiner should look for spasm and evaluate mobility. Percussion of spinous processes with a reflex hammer can produce localized or radiating pain in vertebral body disease pr root impairment (see Chapter 19).

## Skin

The patient's face is observed for butterfly rash, port-wine staining, or adenoma sebaceum; eyelids are examined for heliotrope rash, and elbows and knees are assessed for the erythematous rash of dermatomyositis; the trunk and extremities are checked for café au lait spots or neurofibroma. In addition, the lower spine is examined for a dimple or hair tuft that can indicate spina bifida.

### *Cranial Nerves*

Specific abnormalities in cranial nerve function are demonstrated in many neurologic and systemic medical illnesses. Because of their frequent involvement, all physicians should learn how to examine briefly, yet systematically, the cranial nerves. The examination of the various cranial nerves is outlined, showing the principal function and testing possibilities for these nerves.

#### *First (Olfactory) Nerve*

Principal function. Sense of smell (aromatic substances, not strongly irritating ones such as ammonia whose vapor stimulates pain fibers carried by trigeminal nerve). Patients with anosmia also complain of an inability to taste food unless it is highly salted or very sweet.

Testing. The patient closes his or her eyes, occludes one nostril, and then smells some aromatic substance such as cloves, coffee, tobacco, or mild perfume.

Unfortunately, such factors as atrophic or allergic rhinitis, heavy cigarette smoking, or nasal obstruction can interfere with olfaction; therefore the clinical interpretation of anosmia (impaired olfaction) must be made with caution. Olfaction can be abnormal bilaterally in trauma cases. In patients with subfrontal tumors it can be unilaterally or bilaterally abnormal.

#### *Second (Optic) Nerve*

*Principal function. Vision.*

*Testing*. Several aspects of the second cranial nerve can be assessed:

1 *Visual acuity*. Acuity should be tested in each eye individually and is most practically done at near point (14 cm) with a hand card. Normal vision is 20/15, not 20/20.

2 *Visual fields*. These are most easily tested with the patient facing the examiner; with one eye covered, the patient is asked to focus on the examiner's pupil. A cotton-tipped applicator or hat pin is brought into the periphery of the patient's field until the patient reports first seeing it. The object should be brought in from all quadrants (1:30, 4:30, 7:30, and 10:30 clock positions) to identify partial as well as full-field defects. An alternate method is to simultaneously flash varying numbers of fingers in two fields (e.g., the examiner briefly shows two fingers in the left and right inferior temporal fields) and to ask the patient how many total fingers were seen. If the patient can adequately fix on the examiner's pupil, it is possible to move the object through the entire field of vision and roughly map out the

patient's blind spot (the point at which the optic nerve enters the retina) and any scotoma that may be present.

3 *Funduscopy*. With the ophthalmoscope, the heads of the optic nerve, retina, macula, and retinal vessels can all be visualized. Papilledema, usually secondary to increased intracranial pressure, is the most important sign to search for on funduscopy. The earliest feature of papilledema is the loss of spontaneous pulsations in the veins entering the optic disc. As pressure increases, the veins engorge and become tortuous, disc margins blur, and the optic cup is lost. Finally, the disc elevates, margins are gone, and flame hemorrhages appear in the retina. Visual acuity is relatively spared despite the markedly abnormal appearance of the disc.

A second important disc abnormality to note is optic atrophy. Atrophy is characterized by a small, pale, sharply marginated disc with a decrease in the number of traversing capillaries. In the early stage, temporal pallor may be all that is seen.

4 *Pupillary light reflex.* The afferent limb of this reflex is the second nerve. In optic nerve disease or damage, the light reflex is sluggish or absent. If the light reflex is absent in one eye and the efferent limb via the third nerve is intact, a normal consensual reflex should be present when light is shone into the opposite eye. When the light is swung back to the eye with the damaged second nerve, however, a paradoxic dilation of the pupil occurs (Marcus Gunn phenomenon).

***Third (Oculomotor), Fourth (Trochlear), and Sixth (Abducens) Nerves***

*Principal functions*. Ocular rotation, lid elevation (third nerve), and pupillary constriction (third nerve).

*Testing.*

1 *Ocular rotation*. There are six extraocular muscles, and for many eye movements, groups of muscles work in concert to achieve the desired degree of ocular rotation. However, the examiner wishes to examine each muscle in isolation to determine which nerve or muscle is dysfunctional. Doing so requires a certain knowledge of the origin and insertion of the muscles and their innervation. The four rectus muscles (medial, superior, inferior innervated by the third nerve, and lateral rectus innervated by the sixth nerve) originate from their corresponding quadrants of the eye and insert in the posterior portion of the orbit at a 23-degree angle nasally from the midline of the globe. The oblique muscles (inferior oblique innervated by the third nerve and the superior oblique innervated by the fourth nerve) originate posteriorly on the globe and pull at a 51-degree angle nasally from the midline (Figures 1-2 and 1-3). To test ocular rotation, the examiner should note any muscle imbalance with the patient looking straight ahead. Next, ocular rotation of each eye separately is tested. First, abduction (pure lateral rectus—sixth nerve) is tested by having the patient follow the examiner's finger laterally. Then, with the- patient's "eyes in 20-degree to 25-degree lateral gaze, the patient is asked to look up (superior rectus—third), then down (inferior rectus—third), and then adduct the eye (medial rectus—third). Finally, with the eye adducted 50 to 55 degrees, the patient is asked to look up (inferior oblique—third) and then down (superior oblique—fourth).

2 *Lid retraction.* The levator of the upper eyelid is innervated by the third nerve, and a significant lid droop (ptosis) is often caused by a third-nerve paresis. Ptosis can also be seen in lesions of the sympathetic nerves that innervate the superior tarsal muscle.

3 *Pupils.* First, pupils are observed for regularity and symmetry. The most common cause of unequal pupils (anisocoria) is congenital and clinically insignificant. Next, light reflex, both direct and consensual, is checked by shining a bright light directly into the pupil. The response to light should be brisk; if it is not, a second-nerve (consensual reflex present in eye without light reflex) or third-nerve (consensual reflex absent in eye with absent light reflex) lesion should be suspected.
4 *Abnormal spontaneous eye movements.* While testing ocular rotation and observing pupils, the examiner can look for nystagmus or other abnormal spontaneous movements. Nystagmus is described in relation to the rapid phase and position of gaze (e.g., right beating nystagmus on right lateral gaze).
5 *Convergence*. The patient is asked to follow the examiner's finger to the tip of the patient's nose; both convergence and accommodation reflex (pupillary constriction) should be noted.

***Fifth (Trigeminal) Nerve***

*Principal function*. Control of the muscles of mastication and sensation of the face, anterior half of the scalp, meninges above the tentorium, and mucous membranes of mouth, nose, and sinuses.
*Testing*.

1 Muscles of mastication are evaluated by palpation of masseter and temporalis muscles in a relaxed state and with the teeth clenched. The examiner should look for atrophy and poor contraction and ask the patient to open his or her mouth to see if the jaw deviates (with unilateral weakness there is deviation toward the weak side). Finally, strength of lateral jaw motion is checked (weakness of the pterygoids is reflected in an inability to move the jaw to the side opposite the weak muscles).
2 The sensory portion of the fifth nerve has three divisions: ophthalmic (forehead and upper eyelid), maxillary (upper lip and cheek bone), and mandibular (chin and along the jaw line not including the angle). Sensory fibers from the ophthalmic division also supply the cornea.
3 The corneal reflex is tested. The fifth nerve is the afferent limb of this reflex, and the seventh (facial) nerve is the efferent limb. The reflex is tested by touching the cornea with a wisp of cotton in such a way that the patient does not see the stimulus before it touches the cornea. The reflex, integrated in the pons, consists of brisk bilateral eye closure. The bilateral nature of the reflex is important when assessing the integrity of corneal sensation in patients with facial paralysis on the side being tested. In such cases the contralateral blink attests to the adequacy of corneal sensation.

***Seventh (Facial) Nerve***

*Principal function*. Control of muscles of facial expression.
*Associated function.* Running with the seventh nerve are autonomic fibers that control tearing, the tone of the stapedius muscle, taste to the anterior two thirds of the tongue, and secretions of submaxillary and sublingual salivary glands. With peripheral seventh-nerve lesions, these functions can be disturbed.
*Testing.* Evaluation of facial muscles involves observing the face at rest and in action. The patient is asked to smile, close the eyes, then open the eyes widely and wrinkle the forehead. Any asymmetry should be noted (many patients have mild congenital facial asymmetry, which can suggest unilateral facial weakness). The patient is asked to slightly extend the neck and frown

deeply. This causes the seventh nerve-innervated platysma to contract. If the facial asymmetry is due to facial weakness, the platysma will be less prominent on the involved side. Subtle weakness can often be elicited by forcibly trying to open the eyes against effort. If facial weakness is found, the examiner should critically evaluate frontalis muscle strength. In central lesions such as a cortical stroke (supranuclear or upper motor neuron lesion), the forehead moves equally on both sides, whereas with lesions in the nucleus or in the peripheral nerve (intranuclear, lower motor neuron, or peripheral seventh nerve lesion), the frontalis is weak on the side of the lesion. However, partial or recovering peripheral lesions can show good forehead movement and simulate a supranuclear lesion.

***Eighth (Acoustic) Nerve***

*Principal functions.* Hearing and vestibular function.

*Testing.*

1. *Auditory*. The neurologist is most concerned with neural hearing loss, particularly unilateral. A screening examination can be done at the bedside by comparing the patient's hearing with the examiner's (assuming that it is normal). Each ear is tested separately. First, the examiner simply rubs his or her ringers together near the ear; then a tuning fork is used. If differences are found in hearing between patient's ears or between those of the patient and the examiner, bone conduction comparison (again, with patient's and examiner's hearing) is performed to assess sensorineural function. An actively vibrating tuning fork is placed on the bregma (Weber test); with normal hearing, the patient will report equal sound in both ears or on top of the head. Sound that is lateralized to one side indicates either a conductive loss on that side or a neural loss on the opposite side.

   The Rinne test (vibrating fork is placed on mastoid process, and, when the patient no longer hears the sound, the vibrating end of the fork is held to the ear) is used to compare bone conduction with air conduction in hearing. Normally air conduction is better, but in patients with a conduction hearing loss (e.g., otosclerosis), bone conduction will be better. If any abnormalities are found, a complete audiometric evaluation should be carried out.

1 *Vestibula*r. Vestibular testing is usually only performed if the patient complains of dizziness or unsteady gait. Evaluation of dizziness is discussed at length in Chapter 4.

***Ninth (Glossopharyngeal) Nerve***

*Principal function*. Supply of sensation to pharynx, tonsillar fossa, and taste to the posterior one third of the tongue.

*Testing*. Because of its close anatomic and functional relationship with the tenth nerve, these two nerves are often tested together.

1 The patient's pharynx or tonsil is touched with tongue blade or cotton-tipped applicator.
2 The examiner asks if the patient feels the touch and observes a gag response.
2 Both sides are tested, and any asymmetry of response is noted.

***Tenth (Vagus) Nerve***

*Principal functions.*

1 Motor to pharynx, palate, and larynx
2 Parasympathetics to thoracic and abdominal viscera
3 Visceral sensation

Only motor control of pharynx, palate, and larynx is of importance in the clinical neurologic examination.

*Testing.*

1 The patient's palate is observed for asymmetry or droop.
2 Palate movement is noted with the patient phonating to see if both sides elevate evenly. The uvula will deviate to the normal side.
3 Motor response to stimulation during gag reflex testing is observed.
4 Hoarseness or dysphonia is sought; this can be caused by vocal cord paralysis from a tenth-nerve lesion.
5 The patient is asked to produce a high squeaking sound; this requires very close vocal cord adduction and cord tension and can only be performed if both recurrent and superior laryngeal branches of the tenth nerve are functioning properly.
6 If there is any suggestion of weakness or inadequacy of the pharynx or palate control, it is advisable to watch the patient swallow some water to see if the swallowing mechanism is smooth and that no regurgitation is present.

***Eleventh (Spinal Accessory) Nerve***

*Principal functions*. Turn head (sternocleidomastoids) and assist in shrugging the shoulders (upper trapezius).

*Testing.*

1 Examiner should place his or her hands on the patient's shoulders and have the patient shrug the shoulders against pressure. The bulk and strength of the upper portion of the trapezius muscles are noted.
2 With the examiner's hand held on the side of the patient's chin, the patient is asked to rotate the head against that hand. Head turning to the right is accomplished by the left sternocleidomastoid and to the left by the right sternocleidomastoid.

***Twelfth (Hypoglossal) Nerve***

*Principal function*. Innervation of intrinsic muscles of the tongue.

*Testing*.

1 With the patient's tongue relaxed in the mouth, atrophy or fasciculations are sought.
2 The patient is asked to protrude the tongue and move it from side to side. The tongue will deviate toward the weak side. The seventh nerve innervates some muscles of the mouth, and some tongue deviation can accompany facial muscle weakness.
3 If weakness is suspected, the patient is asked to press the tongue as hard as possible against the buccal mucosa while the examiner presses against the cheek. In this fashion it is possible to compare relative strength of the two sides of the tongue. This tests intrinsic tongue muscle strength without interference from facial muscles.

## Carotid Arteries

Cerebral vascular disease is a major medical illness, and a high percentage of that disease is found in the extracranial portions of the carotid arteries. Because of this and because surgery of the carotid vessels may control the symptoms of vascular disease, a routine neurologic examination should include an examination of the carotid arteries in all patients.

Initially the examiner gently palpates (one at a time) the common carotids in the neck and compares the strength of the pulse. Then external carotid vessels in the face (temporal, facial, nasal, and infraorbital) are also palpated. In marked internal carotid stenosis or occlusion, the external carotid vessels will often demonstrate exaggerated pulses. Finally, the examiner should auscultate the carotid artery along its course from the angle of the jaw to the base of the neck; in patients with substantial narrowing, a high-pitched bruit can often be heard. The carotid bruit must be differentiated from a referred murmur from the heart or venous hum by auscultating at many points along the course of the vessel.

## Reflex Examination

Three principal types of reflexes should be tested.

### *Muscle Stretch Reflexes*

Muscle stretch reflexes, often called deep tendon reflexes, are tested when the examiner rapidly stretches a muscle, usually by striking the tendon with a reflex hammer, and observes the character and intensity of the resultant muscle contraction. The reflex arc is segmental within the spinal cord but is highly influenced by descending inhibitory pathways, particularly the corticospinal tracts. Damage to the upper motor neurons (i.e., cortical motor neurons) or their axons in the brain stem and spinal cord will cause a release of inhibitory influence and thus produce hyperactivity of the muscle stretch reflex. Damage to the lower motor neurons (i.e., the anterior horn cells in the spinal cord) or their axons to the muscle will abolish the activity of the reflex. Because of this effect on reflexes by focal damage in the nervous system, the muscle stretch reflexes are very useful in localization.

A great deal of variation in the activity of reflexes exists in normal people; therefore there is no specific clinical significance to the fact that a patient has hypoactive (0 or 1+) or brisk (3+) reflexes, including brief bursts of repetitive contractions (wnsustained clonus). The important observations to make in reference to the reflexes are listed here:

- Are they pathologically hyperactive (sustained clonus [4+] present)?
- Is there an asymmetry between the reflexes on the two sides of the body?
- Is there a specific rostral-caudal disparity (e.g., reflexes hyperactive in the legs and less so in the arms, suggesting spinal cord disease) or is there loss of ankle reflexes (often knee reflexes as well) as seen in peripheral neuropathy?
- Is there a loss of a specific reflex such as the ankle jerk on one side, indicating an S1 nerve-root lesion or a sciatic nerve lesion?

In testing the reflex, the examiner should start with a gentle tap and then increase the force with each tap. In this way, both a threshold for the reflex and the degree of response can be evaluated. Variation in the intensity of response can occur; therefore it is wise therefore, to elicit the reflex several times to appreciate fully its level of activity. If the reflex cannot be obtained, reinforcement is used by having the patient maximally contract other muscles (such as a Jendrassik maneuver in which the patient is asked to flex the arms and tightly interlock the fingers, and then try to pull the two hands apart) while the reflex is being elicited. Reflexes should always be tested in pairs (e.g., right and left biceps, right and left knees) so that ready comparisons can be made.

*Jaw jerk (masseter reflex).* The jaw jerk is tested by having the patient partially open the mouth. The examiner presses down lightly on the patient's chin with the index finger and gently strikes

the finger with a reflex hammer. This stretches the muscles of mastication. The reflex is integrated through the mandibular branch of the trigeminal nerve in the pons. The major importance of this reflex is to decide if a patient with pathologic hyperreflexia in the limbs has a lesion in the upper spinal cord or bilateral lesions in the brain. If the jaw reflex is hyperactive, it favors a brain lesion; but if it is normal, it suggests an upper cord lesion.

*Biceps*. The patient's arm is bent 60 to 90 degrees. With the patient's arm at rest, the examiner places an index finger on the tendon at its insertion point and strikes the finger to elicit the stretch. The reflex, flexion of the arm, is integrated through the fifth and sixth cervical roots, principally the sixth.

*Brachioradialis*. With the patient's arm in the same position as with the biceps reflex, the examiner strikes the radius above the wrist and notes arm flexion and finger flexion. The fifth and sixth cervical roots provide innervation via the radial nerve.

Triceps. With the patient's arm flexed, the examiner directly strikes the triceps tendon at its insertion point above the elbow. The response is extension of the arm. The reflex is integrated through the sixth, seventh, and eighth (principally the seventh) cervical roots via the radial nerve.

*Finger flexion.* The patient rests the fingertips (palms down) on the examiner's fingers. The examiner should strike his or her own fingers and observe the patient's fingers and thumb for flexion. This flexion can also be elicited by holding the patient's middle finger, with wrist dorsiflexed, and flicking the distal phalanx (Hoffmann reflex). This, in effect, stretches the flexor muscles of the fingers. The reflex is integrated through the eighth cervical segment and is considered hyperactive (although not necessarily pathologic) when there is thumb flexion. The Hoffmann reflex is not the upper extremity equivalent of the Babinski sign.

Patellar (knee jerk). The patient is seated with legs dangling freely. The examiner strikes the patellar tendon directly and notes leg extension as the quadriceps muscle contracts. This reflex can be reinforced by having the patient clasp the hands together and then try to pull them apart. The reflex is integrated by second,third, and fourth lumbar segments via the femoral nerve. If the patient cannot sit, a pillow can be placed under the knees with the patient supine so that the legs are slightly bent.

*Achilles (ankle jerk).* The examiner should passively dorsiflex the patient's foot slightly and then strike the tendon. The response of plantar flexion is due to contraction of gastrocnemius and soleus muscles and is integrated through the first and second (primarily the first) sacral segments via the tibial branch of the sciatic nerve. This reflex can be reinforced by having the patient push the foot lightly down against the examiner's hand. When any stretch reflex, but particularly the Achilles reflex, is pathologically hyperactive (4+), clonus can be elicited. Clonus is an oscillation of contraction between the agonist and antagonist muscles of a joint. For example, in ankle clonus, if the examiner stretches the gastrocnemius muscle by quickly dorsiflexing the foot, that muscle rapidly and forcibly contracts, thus plantar flexing the foot. In doing so, the dorsiflexors of the foot (the anterior tibial muscles) are quickly stretched, and they contract, dorsiflexing the foot again. Because of the hypersensibility of the stretch reflex in these muscles, sustained oscillating contractions (i.e., clonus) are established.

### *Superficial Reflexes*

Superficial reflexes are elicited by lightly stroking the skin and observing contraction of the underlying muscle (innervated by the same spinal segment). The reflex will be absent if there is an upper motor neuron lesion above the level of the segment tested.

*Abdominal.* The abdominal skin is stroked with a broken applicator stick (or similar sharp object); a swift stroke is used, starting in either the upper (T8-9) or lower (T10-12) outer quadrant and going toward the umbilicus. The reflex quickly fatigues and can be absent in obese persons, the elderly, or women who have had children or patients after abdominal surgery. Deep abdominal reflexes are elicited by pressing down on the muscles and striking the hand with the reflex hammer; these reflexes can be hyperactive when the superficial abdominal skin reflexes are absent.
*Cremasteric.* The inner aspect of the thigh is stroked and observed for retraction of the testis. Innervation is through the first and second lumbar segments via the ilioinguinal and genitofemoral nerves.

***Pathologic or Release Reflexes***
Pathologic reflexes are normally found in infants but disappear in the first or second year. With cortical damage in the child or adult, the reflexes return and are useful in diagnosing and localizing central nervous system damage.
*Babinski sign or extensor toe sign.* The sole of the foot is stroked with a relatively sharp object. This is a nociceptive (pain) reflex; therefore a sharp object is used to stimulate the reflex. The examiner strokes up the lateral side of the foot and then across the ball of the foot to the base of the great toe. A normal response is toe flexion. A pathologic response is extension of the great toe and flaring of the other toes. A positive Babinski sign is always abnormal in patients over age 3 and is the cardinal sign of pyramidal tract disorder.
*Thumb adduction (Wartenberg hand sign).* The patient and examiner flex distal phalanges, hook their fingers together, and pull against each other's fingertips. Normally the thumb should fix in an abducted position, but in pyramidal tract disease the thumb will adduct across the palm in a simian grasp.
*Snout or rooting reflex.* The examiner presses or taps on the upper lip. Normally there is no response. An abnormal response consists of pursing and protruding the lips. In marked examples merely touching the cheek or corner of the mouth will elicit the response (rooting).
*Grasp reflex.* The examiner should rub his or her fingers against the patient's relaxed palm or in the web between the thumb and first finger. An abnormal response consists of the patient's uncontrolled forced grasping of the examiner's finger despite instructions to the contrary. This reflex is usually the last of the so-called frontal release signs to show up; therefore its presence usually indicates significant pathology.
*Palmomental reflex.* Stroking the thenar entrance with a sharp object will elicit in many patients a twitch of the mentalis muscle of the chin. Unfortunately, this reflex is so commonly seen in the normal population, especially over age 65, that it is usually of little clinical use unless it is asymmetric.
*Glabellar reflex.* The examiner repeatedly taps the glabellar area lightly with a reflex hammer. The normal patient will blink the eyes several times and then accommodate to the stimulus and stop blinking. Patients with Parkinson's disease or demented persons with diffuse cerebral atrophy tend not to accommodate and will continue blinking as long as the examiner taps.

## Sensation

Accurate evaluation of the sensory system requires full patient cooperation and careful instruction by the examiner. The examiner should carefully explain what is going to be done and

what the patient should report. The examiner must also have a distinct plan when starting the sensory examination. If the patient has arm pain and the goal of the sensory examination is to determine if the patient has impingement on a nerve root by an extruded cervical disk, the examiner must systematically evaluate the dermatomes in that arm and compare sensation, both in the corresponding dermatomes on the opposite side and with the contiguous dermatomes in the same arm. Testing should be as brief as possible because exhaustive attempts to map out patterns of loss frquently tire and confuse the patient and leave the examiner with an unclear picture.

The sensory examination, like the reflex examination, can provide very useful localizing information:

- Unilateral sensory loss in contralateral central lesions
- Distal loss in extremities in peripheral neuropathies
- Specific dermatomal loss in root lesions
- Specific peripheral patterns in individual peripheral nerve lesions
- Specific level of lesion with spinal cord lesions
- Crossed (ipsilateral face and contralateral body) caused by brain stem lesions

Although many modalities can be tested, there are three main aspects to the sensory system as tested clinically: pinprick sensation, which is pure spinothalamic sensation (temperature is usually not tested routinely because the temperature system parallels pinprick

BOX 1-5

1 *Pin*. The pin is stuck lightly one or two times in each area tested. First the examiner asks if the patient feels the sensation and whether it is sharp. Then the patient is asked to compare the initial stick with a second set of sticks in the opposite side or in a contiguous area. If normal (unaffected) areas are worth 100 cents, the patient is asked to state how much the opposite-side homologous areas are worth. The pin is applied once on each side to avoid a temporal summation effect. If the response is abnormal, the examiner should reverse the order in which the stimulus is applied for confirmation because sometimes in normals the second stimulus is perceived as sharper. Figure 1-4 is a guide to localization of root lesions, and Table 1-2 indicates the most consistent location with least overlap to test for each root or peripheral nerve. There is considerable variation in the distribution of peripheral nerves; thus these are to be used as guides only.

2 *Touch*. Touch can be tested with a cotton swab or light fingertip touch.

3 *Proprioception*, Position is most easily tested using the great toe and distal phalanx of the thumb or other finger. The digit is grasped on the sides and moved through a very short excursion either up or down. Even the slightest movement of a finger should be detected. If the toe or finger is pulled up or pushed down in exaggerated fashion, subtle defects will be missed.

4 *Vibration*. The 128-cps tuning fork is probably the best to use for testing vibration sense. The test is done over bony prominences. This sensation is normally more acute proximally and tends to diminish distally in the elderly.

5 *Stereognosis*. Several small familiar objects are placed in the patient's hand, one at a time. The patient is asked to manipulate the object in the hand, and then identify it. Right side should be compared with left side.

6 *Graphesthesia*. The examiner writes numbers on the patient's palm and asks the patient to identify them.

sensation); position and vibration senses, which are almost pure lemniscal sensations (posterior columns); and stereognosis, graphesthesia, and touch localization, which are integrative sensations and are primarily cortical. These cortical sensations are often difficult to assess if primary sensations are impaired. Touch sensation is a complex sensation that is partially lemniscal and partially spinothalamic but can be very useful in localization.

Testing. It is always best to test patients with their eyes closed. The types of sensation tests given are listed in Box 1-5.

## Meningeal Irritation

If there is any suggestion of an intracranial hemorrhage or meningeal infection, the patient's nuchal mobility should be tested. The patient lies supine and completely relaxed. The examiner passively flexes the neck. Any pain or resistance should raise suspicion that the meninges are irritated. When flexing the neck the examiner should observe the patient's legs; in meningitis the patient (particularly a child) will flex his or her thighs (Brudzinski sign). Another sign of meningeal irritation is the Kernig sign. In this sign the patient's thigh is flexed on his or her chest, and then the leg is extended; this stretches the meninges, and, if they are inflamed, the patient will report pain and flex his or her neck.

## Autonomic Evaluation

In any patient with bowel or bladder symptoms, a rectal examination should be performed. Tone, degree of voluntary contraction of the sphincter, as well as perianal sensation should be noted.

In patients with syncope, particularly with rapid change in position, blood pressure and pulse should be taken in supine, sitting, and standing positions. Note is made of appearance of symptoms and change in pressure. In dysautonomia, the pressure drops dramatically, yet there is no compensatory tachycardia.

## Summary of Examination

At first this examination seems lengthy; with experience the student will learn to perform the many steps rapidly and modify the examination to suit each patient. The complete examination can be performed in 15 to 20 minutes, depending on the patient.

## Neurologic Localization

Based on the pattern of the abnormal signs elicited by the examination, the physician must consider if a lesion is localized. The examination findings should indicate if the lesion is unilateral, bilateral, cerebral, spinal, peripheral, or muscular. The clinical sections of this book will discuss the various findings relevant to the different conditions. Box 1-6 is a brief summary of patterns of findings.

## Mechanism of Neurologic Disorders

If the onset of symptoms is sudden, vascular or electric disorders (seizures with abnormal conical discharges) should be considered. Vascular disorders are characterized by loss of function

(hemiplegia, hemianesthesia, visual field loss). Seizures are characterized by neuronal hyperactivity (e.g., myoclonic jerks, paresthesias, flashing lights) or impairment of consciousness caused by disturbed reticular formation function. In most patients with vascular disorders, there is rapid stabilization with gradual neurologic improvement. The patient with seizures usually recovers rapidly; however, there can be postictal paralysis (Todd's paralysis).

If the onset of symptoms is less acute, atrophic or mass lesions are suggested. In atrophic disorders there is slow progression over months to years, usually with no plateaus of stabilization. In mass lesions the tempo of progression is more rapid than with atrophic lesions. There is continued worsening, or new symptoms develop. Mass lesions in the brain usually also cause signs of increased intracranial pressure.

## SUMMARY

The neurologic history and examination are highly specialized yet not complicated when a systematicapproach is used. The examination itself usually takes only 15 to 20 minutes, unless full mental status testing is carried out.

Data from the history and examination will usually localize the disease within the nervous system and can often allow the examiner to make a specific clinical diagnosis.

BOX 1-6 Common Patterns of Abnormal Neurologic Signs

**Cerebral Hemisphere Lesion (e.g., cerebrovaseular accident or tumor)**
Contralateral weakness, incoordination, sensory loss, increased tone in body and face. Possible visual field loss but no diplopia. Reflexes increased in affected side with positive Babinski and Hoffmann signs. Can have mental status changes, e.g., aphasia, with left hemisphere lesions.

**Spinal Cord (e.g., spondylosis with myelopalhy)**
Cranial nerves normal. Weakness and increased tone and reflexes below the lesion. Babinskis are present, bowel and bladder function can be impaired.

**Radiculopathy Secondary to Ruptured Disk**
Weakness, decreased sensation, and decreased reflex in the distribution of the nerve root affected.

**Mononeuropathy (e.g., carpal tunnel syndrome—median nerve entrapment in the wrist)**
Weakness, sensory loss in distribution of that nerve. Reflex will be down if the nerve supplies a muscle involved in one of the major reflex arcs.

**Peripheral Neuropathy (e.g., diabetic),**
Decreased sensation and decreased reflexes in distal legs. Weakness in distal muscles will occur as the disease progresses.

**Myopathy or Myositis**
Weakness of proximal muscles of arms and legs without reflex and sensory changes.

## Suggested Readings

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# Tables and Figures

TABLE 1-1 Muscle Testing

| Action | Muscle(s) | Root(s) | Peripheral Nerve |
|---|---|---|---|
| **Upper Extremities** | | | |
| 1.Abduct (initial) and external rotation of arm | Supraspinalus, Infraspinatus | C5,C6 | Supracapular |
| 2 Abduct arm (hold at 90 degrees against resistance) | Deltoid | C5 | Axillary |
| 3 Flex arm (hand supine) | Biceps | C5,C6 | Musculocutaneous |
| 4 Flex arm (hand midway between supine and prone) | Brachioradialis | C5,C6 | Radial |
| 5 Extend arm | Triceps | C7 | Radial |
| 6 Extension of wrist | | | |
| a Hand abducted (toward thumb) | Extensor carpi radialis longus | C5,C6 | Radial |
| b Hand adducted (toward fifth finger) | Extensor carpi ulnaris | C7,C8 | Posterior interosseous |
| 7 Flexion of wrist | Flexor carpi radialis | C6,C7 | Median |
| 8 Flexion of fingers | Flexor digitorum superficialis (proximal)<br>Flexor digitorum profundus (distal) | C7,C8,T1 | Median |
| | a First and second digits | C7,C8 | Anterior interosseous |
| | b Third and fourth digits | C7,C8 | Ulnar |
| 9 Palmar abduction of thumb | Abductor pollicis brevis | C8,T1* | Median |
| 10 Opposing thumb to base of fifth finger | Opponens pollicis | C8,T1 | Median |
| 11 Spreading and adducting fingers | Interossei | C8,T1 | Ulnar |
| **Lower Extremities** | | | |
| 1 Flexion of hip | Iliopsoas | L1,L2,L3 | Direct branches from root |
| 2 Extension of hip | Gluteus maximus | L5,S1 | Inferior gluteal |
| 3 Adduction of thigh | Adductors | L2,L3,L4 | Obturator |
| 4 Extension of leg (lower) | Quadriceps femoris | L2,L3,L4 | Femoral |
| 5 Flexion of knee | Hamstrings | L5,S1,S2 | Sciatic |
| 6 Plantar flexion of foot | Gastrocnemius and Soleus | S1,S2 | Tibial |
| 7 Dorsiflexion of foot | Anterior tibialis | L4,L5 | Deep peroneal |
| 8 Inversion of foot | Posterior tibialis | L4,L5 | Tibial |
| 9 Extension of toes | Extensor digitorum longus and extensor hallucis longus | L5,S1 | Deep peroneal |
| 10 Eversion of foot | Peroneal longus and brevis | L5,S1 | Sciatic |

*The underlined root is principally responsible for the function.

TABLE 1-2 Sensory Localization

| Location | Root | Peripheral Nerve |
|---|---|---|
| 1 Over deltoid muscle | C5* | Axillary* |
| 2 Volar surface distal thumb | C6* | Median |
| 3 Volar surface index finger | C6* | Median* |
| 4 Volar surface middle finger (side toward thumb) | C7* | Median |
| 5 Dorsal surface hand over base of thumb and index finger | C7* | Radial* |
| 6 Volar surface of little finger | C8* | Ulnar* |
| 7 Inner surface of forearm | T1 | T1 root |
| 8 Inner surface of upper arm | T2 | T2 root |
| 9 Lateral thigh | L2 | Lateral femoral cutaneous* |
| 10 Anterior thigh above knee | L3,L4 | Femoral* |
| 11 Medial leg (mid-calf level) | L4 | Saphenous |
| 12 Dorsal web between great toe | L5* | Deep peroneal and second toe * |
| 13 Lateral foot | S1* | Sural |
| 14 Lateral foot and posterolateral leg | S1,S2 | Sciatic |
| 15 Anterolateral leg | L5 | Common peroneal |

* Indicates that the location tested is almost exclusively innervated by the nerve or root starred

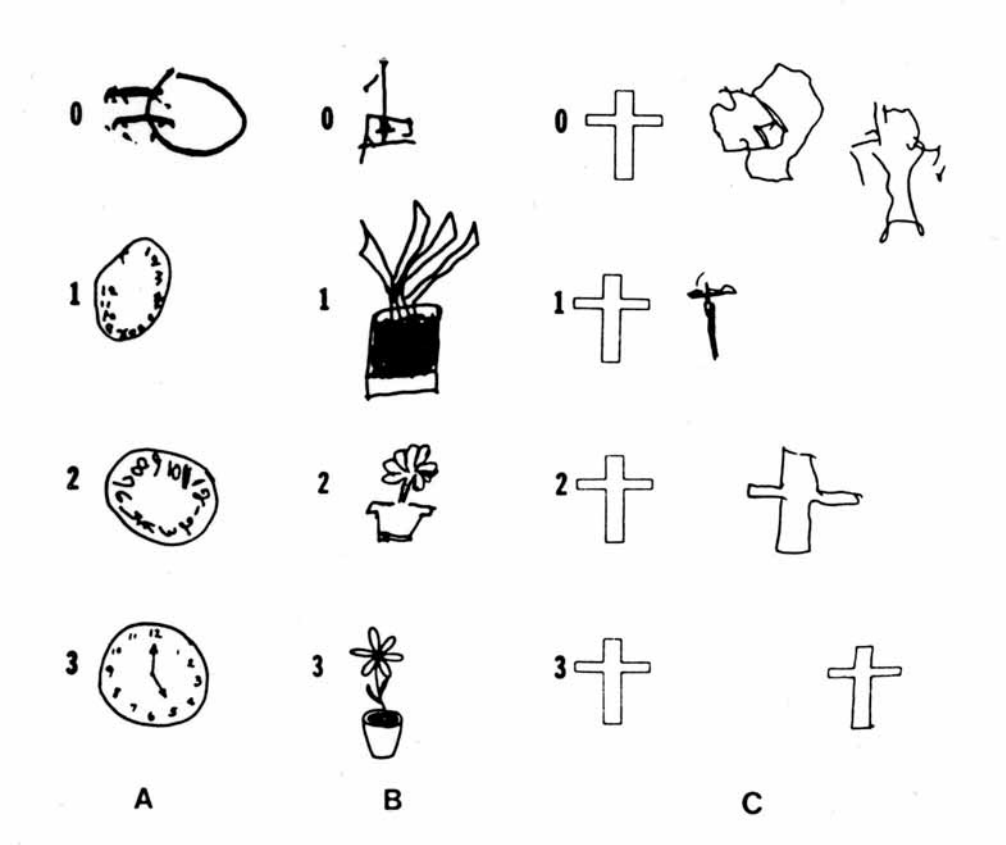


FIGURE 1-1. Illustrations of drawing ability. A and B are drawn on command, and C is a copy of the examiner's example. The bottom drawing in each example (3) is normal. The next (2) is good, yet mildly abnormal; this type of performance can be seen in persons with lower intelligence. The top two drawings (0 and 1) are abnormal and highly correlated with organic brain disease. From Strub RL, Black FW: The mental status examination in neurology, Philadelphia, 1977, FA Davis. Copyright 1977 by F.A. Davis Company. Reprinted by permission.

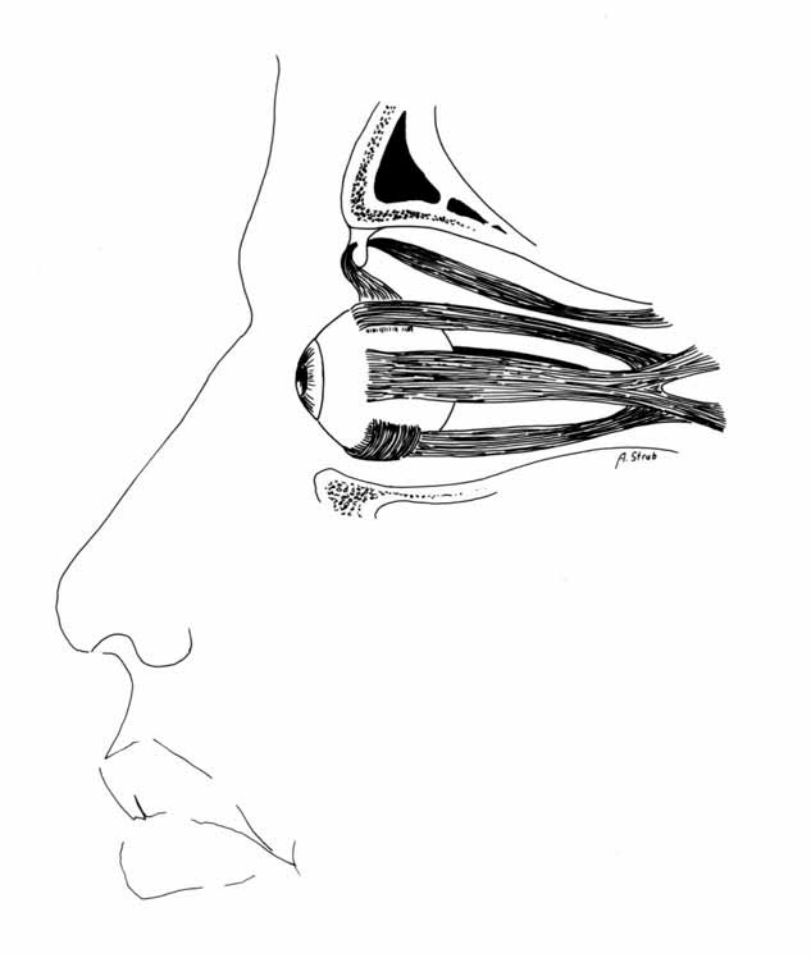


FIGURE 1-2. Attachments of the extraocular muscles. From Cogan DC: Neurology of the ocular muscles, Springfield, III, 1948, Charles C Thomas. Copyright 1948 by Charles C Thomas. Adapted by permission.

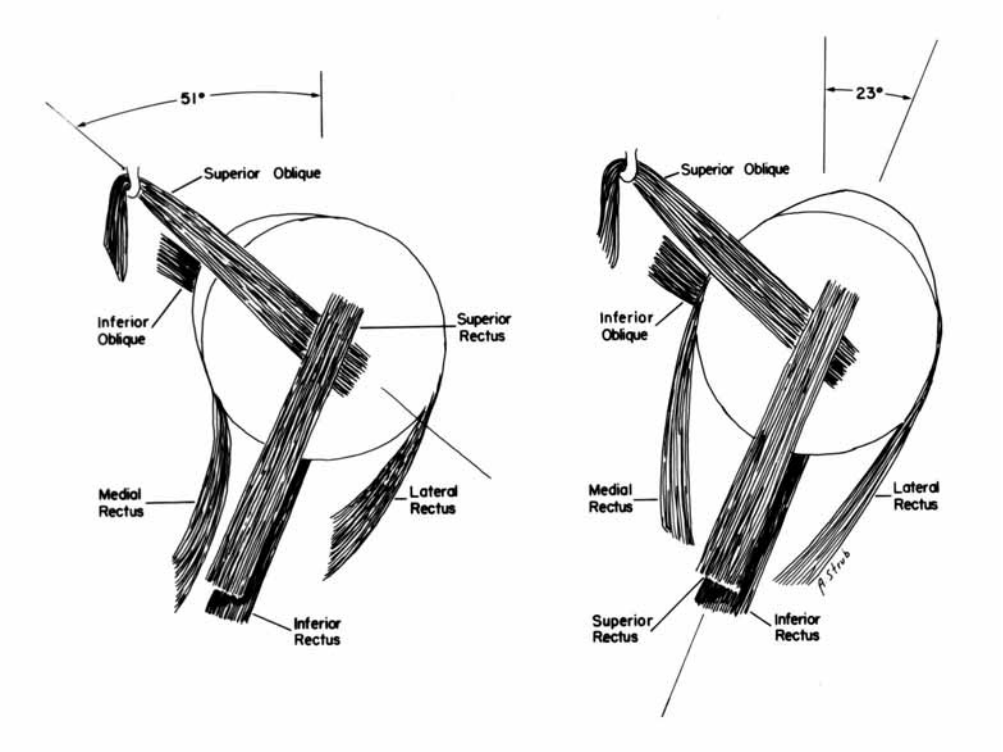


FIGURE 1-3. Illustration on right—Right eye. A 23-degree lateral rotation in the horizontal plane, the superior rectus acts as a pure elevator and the inferior rectus as a pure depressor. Illustration on left—Right eye. At 51 degrees medial rotation in the horizontal plane, the action of the superior oblique is pure depression and that of the inferior oblique is pure elevation. From Cogan DC: Neurology of the ocular muscles, Springfield, III, 1948, Charles C Thomas. Copyright 1948 by Charles C Thomas. Adapted by permission.

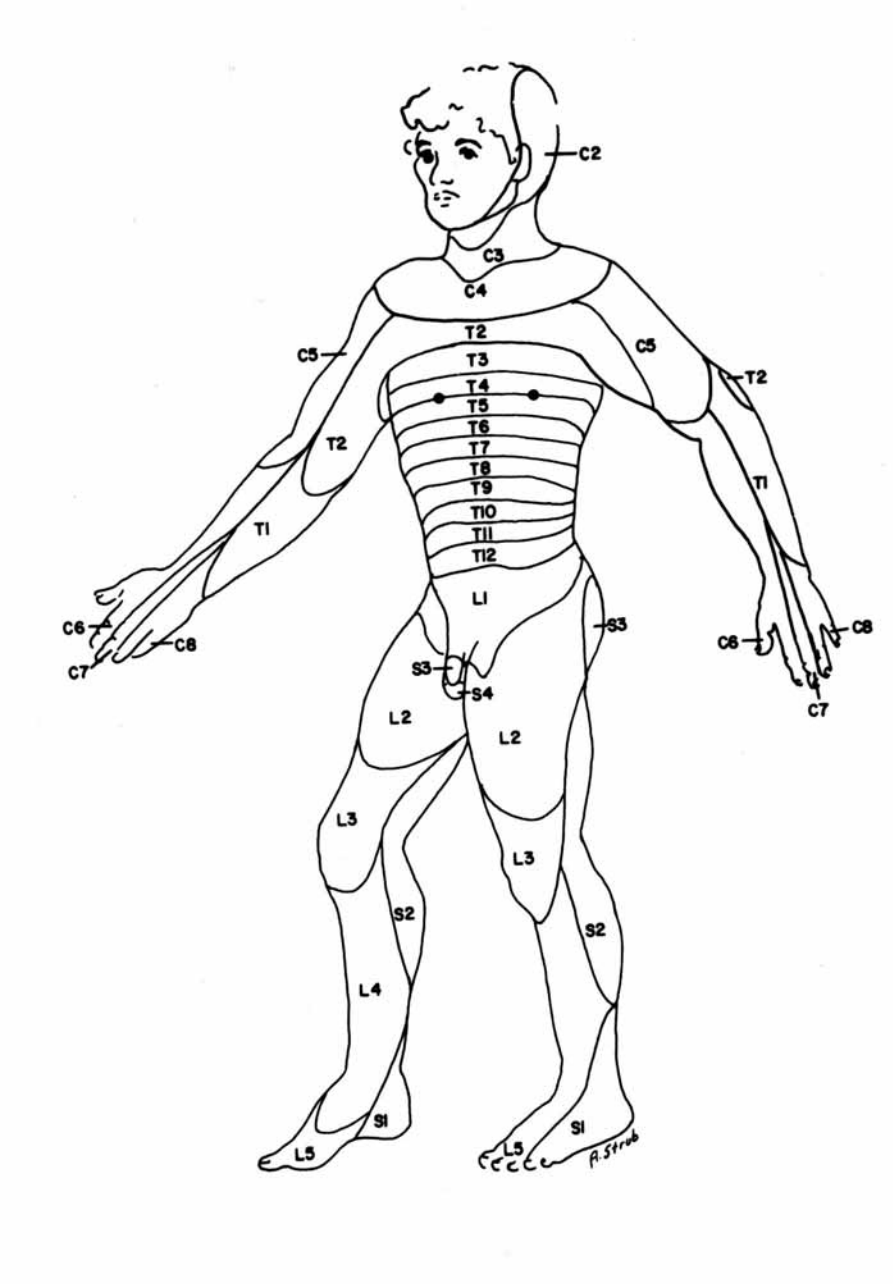


FIGURE 1-4. Sensory distribution.