THE NEUROLOGICAL EXAMINATION

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I) Introduction

The care of the patients in all specialties has been enhanced by the use of an increasingly sophisticated array of biomarkers, genetic tests, and imaging modalities.

Yet even in the setting of these critical advancements, the physical examination remains of utmost importance in Neurology.

We glean valuable information from listening to the manner in which concerns are expressed, observing how patients walk into the clinic or lie in a hospital bed, and performing maneuvers designed to interrogate the functional integrity of nervous system components.

Ultimately, the examination is a tool we use to pinpoint the nature and origin of abnormalities .

The resultant picture can narrow the list of possible diagnoses and guide further investigation.

II) PRINCIPLES

1. **It is useful to conduct a complete examination at least once for every Neurology patient.**

The Neurological examination may be unique in its length, but it is worthwhile to complete a thorough assessment at least once with each Neurology patient for several reasons:

First , that examination provides a baseline assessment of neurologic status- which can be particularly valuable in the hospital, where examination can evolve in important and sometimes unforeseen ways.

Second, a full examination may uncover unexpected abnormalities.One might be tempted to skip a full mental status examination for a patient who can exchange pleasantries normally-only to be surprised when the patients identifies the year as 1962.

Because neurologic problems can present with discrete deficits, formal testing in each domain is sensible.

Third, abnormalities on basic tests can point out the need for more in-depth , specialized evaluations.

For example, the emergence of diplopia on testing extraocular muscles might prompt a search for fatigable eyelid weakness that can raise concern for myasthenia gravis.

In this way, the neurologic examination becomes tailored for each individual patient.

Fourth, the examination allows one to directly confirm or refute hypotheses about contributory problems suggested by the history.

Foot drop is more likely to result from a lumbo-sacral radiculopathy if accompanied by back pain; a positive straight leg raise test can help corroborate this explanation.

Finally, the examination can show a pattern of abnormalities that provides a clue as to where in the nervous system the problem lies.

2. **The goal is to localize the problem**

The nervous system is extensive.Broadly, we can characterize the elements as central or peripheral.

The central nervous system includes the brain and spinal cord.

The peripheral nervous system (PNS) incorporates nerve roots, plexi, peripheral nerves, neuromuscular junctions and muscles.

Dysfunction originating from each of these locations can translate into distinctive examination findings (table) ; recognizing characteristic patterns is often the key to localizing a deficit.

TABLE 1-1. Localizing Patterns of Sensorimotor Abnormalities

Location of Lesion	Characteristic Distribution
Brain	Right or left hemi-body (face, arm, and leg)
Brainstem	Crossed face and limbs (e.g., right face, left limbs)
Spinal cord	At a sensory level on one or both sides of the posterior torso (at or above the site of the lesion)
Nerve root	Along an individual nerve root (i.e., a dermatome if a sensory change, or a myotome if weakness)
Plexus	Patchy in affected upper or lower extremity
Peripheral nerves (polyneuropathy)	Distal, symmetric sensorimotor changes
Neuromuscular junction	Fatigable weakness
Muscle	Proximal, symmetric weakness

Using this approach , the exam can help determine whether left hand weakness stems from carpal tunnel syndrome, a brachial plexus injury, cervical radiculopathy, or a middle cerebral artery stroke.

These distinctions are important because the diagnostic steps, prognoses, and therapies differ for each of these conditions.

3. **Findings should be interpreted in the context of the history**

In performing a comprehensive neurologic examination, it is not uncommon to detect incidental abnormalities.

Particularly at the start of one's career, it can be difficult to discern whether certain abnormalities are important.

One should assign greater weight to findings related to the presenting symptoms or a patient's medical history.

For instance,abnormal sensation in a football-shaped region over the anterolateral thigh may be a key finding in an obese person who developed burning sensation in this area after wearing tight-fitting pants , but an unimportant (or untrustworthy) discovery in an individual who presents with an acute change in mental status.

III) ELEMENTS OF THE EXAMINATION(Table)

1. MENTAL STATUS

Performed to identify cognitive deficits related to specific regions in the brain.

The 1st step is to assess level of consciousness , which can range from awake and alert to unarousable even with noxious stimulation.

Rather than using medical terms such as stuporous or obtunded in the latter setting, it is more helpful to describe what external stimuli are required to arouse a patient or to maintain wakefulness.

The level of consciousness frames further testing of cognitive function.

TABLE 1-2. Commonly Performed Elements of the Neurologic Examination

Mental Status	
Attention	Serial backward tasks (months of the year, digit span)
Language	Fluency of speech, repetition, comprehension of commands, naming objects, reading, writing
Memory	Recall of words after 5 minutes
Visuospatial function	Clock drawing; complex figure copying
Neglect	Line bisection, double simultaneous stimulation
Frontal lobe function	Generation of word lists; performance of learned motor sequence; test of inhibition
Cranial Nerves	
II	Visual acuity, fields, pupils, funduscopic exam
III, IV, VI	Extraocular movements
V, VII	Facial sensation and movement
IX, X, XII	Palate and tongue movement
Motor	
Bulk	Inspection for atrophy
Tone	Evaluation for rigidity, spasticity
Power	Observational tests (pronator drift, rising from chair, walking on heels and toes), direct confrontation strength testing
Reflexes	
Muscle stretch reflexes	Assessment at sites including biceps, brachioradialis, triceps, knee, ankle
Babinski sign	Stroking lateral sole of foot
Sensory	
Pinprick and temperature	Mapping of pinprick, cold sensation
Vibration and joint position sense	Timing appreciation of tuning fork stimulus at joints, assessing perception of location of limbs in space
Romberg sign	Unsteady, when standing with feet together, then closing eyes
Coordination	
Accuracy of targeting	Finger-to-nose, heel-to-shin tests
Rhythm of movements	Rapid alternating movements, rhythmic finger or heel tapping
Gait	
Stance	Evaluation of narrow or wide base
Stride and arm swing	Assessment for shuffling, decreased arm swing
Ataxia	Evaluation of ability to tandem walk

Attention

Tested by asking patients to recite spans of numbers, months,or words such as “ world”, forward and backward.

A specific form of inattention is referred to as neglect.

Patients with dense neglect may fail to describe items on one side of a picture or of their surroundings or fail to bisect a line properly .

Subtle neglect may manifest as extinction to double simultaneous stimulation; in this scenario , a patient can sense a single visual or sensory stimulation on either side of the body, but reports it on the non-neglected side alone when bilateral stimuli are presented.

In some cases, it is not possible to perform formal tests of attention because patients become focused on one detail or task and keep repeating it (“ perseveration”).

Deficits in attention are important to recognize because they can compromise the ability to complete other tasks in the mental status examination.

Orientation is tested by asking a patient to identify his or her name as well as the day,date, month, year, and current situation.

Memory is assessed by asking patients to repeat several words immediately and again after intervals (e.g. 30 seconds and 3 minutes).

The examiner should make note of whether the patient is aware of current events.

Language is assessed in several ways: by listening to the fluency and prosody of spontaneous speech, identifying word substitutions (i.e paraphasic errors) , and assessing the ability to repeat phrases, read,write, and name common and uncommon objects.

Furthermore, the examiner can ask the patient to name as many words as possible starting with the letter " F","A", or "S" in 1 minute, paying attention not only to the number of words generated but also to the manner in which they are named.

For example, does the patient recognize whether she or he repeated words? Were words volunteered in identifiable categories? In addition to insight into language function ,these details provide insight into how well patients can plan and organize information (i.e. frontal lobe executive function).

Calculation ability can be tested by asking patients to perform simple arithmetic (example the number of quarters in 1.5 JD).

One can check for apraxia by asking patients to pantomime a learned motor task-optimally one that requires use of both hands, for example, cutting a loaf of bread.

Visuospatial function and nonverbal learning can be tested in a variety of ways.Patients can be asked to draw numbers in a circle to form a clock ; alternatively,they can be asked to copy a complex figure drawn by the examiner (figure).

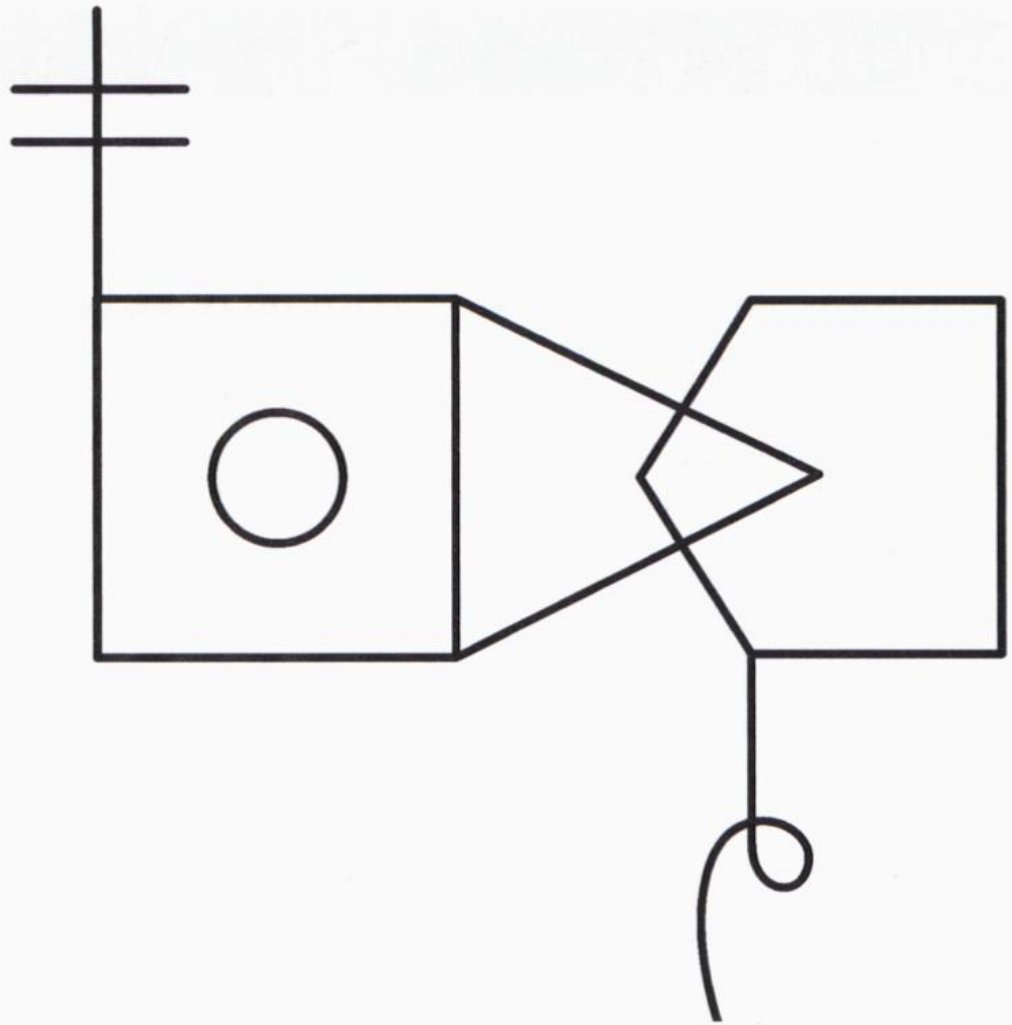


FIGURE 1-1. Example of a complex figure to be copied by the patient as test of visuospatial function.

Other tests of frontal lobe function include learning and then repeating a simple motor sequence of hand postures (e.g . The Luria manual sequencing task) .

Another test of appropriate inhibition , the go/no go test , comprises tapping the table when only one letter (e.g “ B”) is said aloud in a string of letters.

Perseveration is also considered a frontal lobe deficit.

If cognitive impairment emerges as a concern,the examiner should consider looking for the presence of primitive reflexes , which are signs of " frontal release" or disinhibition.

Examples include the palmo-mental, snout, and rooting reflexes.

The examiner should be careful not to overinterpret these reflexes, because they can occur in normal subjects with age or may not be relevant to the presenting problem.

2. CRANIAL NERVES

One way to test cranial nerves is to start at eye level and move down the face in approximate numerical order (table).

Olfaction (I) is rarely tested .When patients report alterations in the ability to smell, each nostril should be tested separately.A non-noxious stimulus , such as coffee or vanilla can be used.

TABLE 1-3. The Cranial Nerves

Nerve	Name	Exit through the Skull	Function
I	Olfactory	Cribriform plate	Olfaction (test using nonnoxious substance)
II	Optic	Optic canal	Vision (acuity, fields, color), afferent limb of pupillary reflex
III	Oculomotor	Superior orbital fissure	Superior rectus, inferior rectus, medial rectus, inferior oblique, levator palpebrae, efferent limb of pupillary reflex
IV	Trochlear	Superior orbital fissure	Superior oblique of contralateral eye
V	Trigeminal	Superior orbital fissure (V1), foramen rotundum (V2), foramen ovale (V3)	Muscles of mastication, tensor tympani, tensor veli palatini, facial sensation, afferent limb of corneal reflex
VI	Abducens	Superior orbital fissure	Lateral rectus
VII	Facial	Internal auditory meatus	Muscles of facial expression, stapedius, taste on anterior two-thirds of tongue, efferent limb of corneal reflex
VIII	Vestibulocochlear	Internal auditory meatus	Hearing, vestibular function
IX	Glossopharyngeal	Jugular foramen	Movement of palate, sensation over palate and pharynx, taste over posterior one-third of tongue, afferent limb of gag reflex
X	Vagus	Jugular foramen	Movement of palate; sensation over pharynx, larynx, and epiglottis; efferent limb of gag reflex; parasympathetic function of viscera
XI	Accessory	Jugular foramen	Sternocleidomastoid and trapezius movement
XII	Hypoglossal	Hypoglossal foramen	Tongue movement

Optic nerve(II) function is assessed in several ways:

- visual acuity is investigated with a near card .

- visual fields are tested by having the patient cover one eye and focus on the examiner's nose; they are then asked to signal when they can appreciate a small red object enter the field of view from each of 4 quadrants when the object is held halfway between the patient's eye and the examiner's (the limits of the patient's visual field should correspond to those of the examiner's).

- Direct visualization of the optic nerve can be achieved by funduscopy.

- The afferent limb of the pupillary light reflex is mediated by the optic nerve; the efferent limb is subtended by cranial nerve III.

Extraocular movements (III, IV and VI) are tested in 3 main ways:

- by having the patient pursue a moving target (e.g., an examiner's finger drawing of the letter " H" in front of the face i.e pursuit) ;

- by directing the patient's gaze to various stationary targets or directions (saccades);

- and by having the patient fixate on an object while the head is turned passively (vestibulo-ocular movements).

The presence of nystagmus should be noted.

Muscles of mastication (V) are tested by assessing the strength of jaw opening and palpating the contraction of the masseter when the jaw is clenched.

Facial sensation can be tested to all modalities over the forehead (V1) , cheek (V2) and jaw (V3) regions.

The afferent limb of the corneal reflex is mediated by cranial nerve V; the efferent limb is controlled by cranial nerve VII.

Muscles of facial expression (VII) are tested by having patients raise the eyebrows, squeeze the eyes shut, puff the cheeks, or show the teeth.

Though uncommonly tested, taste over the anterior 2/3 of the tongue is mediated by this nerve and can be evaluated with sugar or other non-noxious stimulus.

Hearing (VIII) may be evaluated in each ear simply by whispering or rubbing fingers; more detailed assessment of hearing loss may be accomplished with the Weber and Rinne tuning fork (512 Hz) tests.

Vestibular function can be tested in many ways, including evaluation of eye fixation while the patient's head is turned rapidly or by observation for a gradual rotation of gait direction while the patient is walking in place with the eyes closed.

Palate elevation should be symmetric, and the voice should not be hoarse or nasal (IX and X) .

Failure of the right palate to elevate implies pathology of the right glossopharyngeal nerve (IX).

The gag reflex is also mediated by these nerves.

Sternocleidomastoid strength is tested by having the patient turn the head against resistance;weakness on turning to the left implies a right accessory nerve (XI) problem.

The trapezius muscle is tested by having patients shrug the shoulders.

Tongue protrusion should be in the midline. If the tongue deviates toward the right, the problem lies with the right hypoglossal nerve (XII)

3. MOTOR EXAM

First, bulk is assessed by observing and palpating the muscles and comparing each side to the other and the patient's overall muscle bulk to that expected for age.

Tone is one of the most important parts of the motor exam.In the arms, tone is checked by moving the patient's arm, flexing and extending at the elbow, moving the wrist in a circular fashion, and pronating and supinating the forearm rapidly using a handshake grip.

Abnormalities of tone are spasticity and rigidity.

Tone in the legs can be tested well only with the patient supine.The examiner lifts the leg up suddenly under the knee;in the presence of increased tone, the heel comes off the bed.

Increased tone can be characterized further as rigid or spastic.

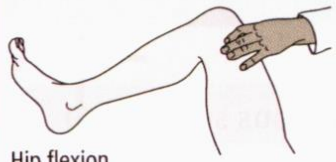
In rigid limbs, the examiner can sense increased resistance throughout the passive movements, but spasticity is speed dependent, with abnormalities emerging with quick movements (e.g. , elbow extension).

Strength is assessed by both observation and direct confrontation (fig)

A pronator drift may be observed in an arm held supinated and extended in front of the body.

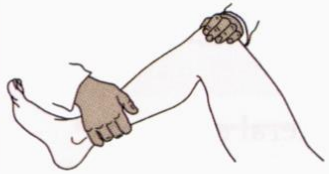
The patient may be asked to rise from a chair without using the arms or to walk on the heels and toes.

The power of individual muscles as assessed by direct confrontation is most often graded according to the Medical Research Council (MRC) scale(table).

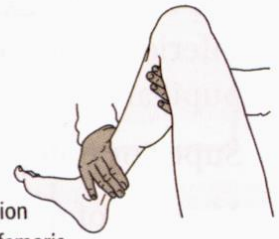


Hip flexion
Iliopsoas
Lumbar plexus and
femoral nerve
L1/L2

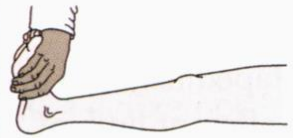
Hip extension
Gluteus maximus
Inferior gluteal nerve
L5, S1, S2



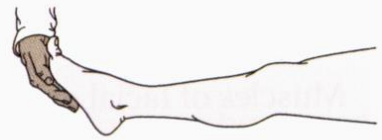
Knee flexion
hamstrings
Sciatic nerve
L5, S1, S2



Knee extension
Quadriceps femoris
Femoral nerve
L3, L4



Ankle dorsiflexion
Tibialis anterior
Deep peroneal nerve
L4, L5



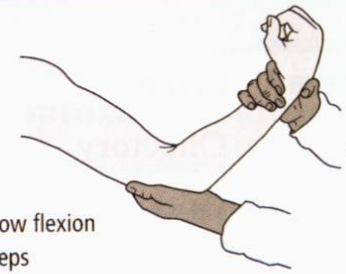
Ankle plantar flexion
Gastrocnemius and soleus
Sciatic nerve
S1, S2

Dorsiflexion of great toe
Extensor hallucis longus
Deep peroneal nerve
L5

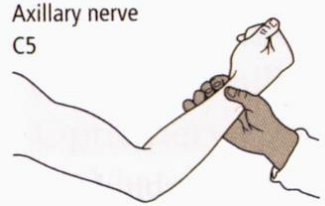
Ankle inversion
Tibialis posterior
Tibial nerve
L4, L5

Ankle eversion
Peronei
Superficial peroneal nerve
L5, S1

Shoulder abduction
Deltoid
Axillary nerve
C5

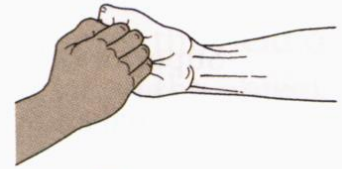


Elbow flexion
Biceps
Musculocutaneous nerve
C5, C6

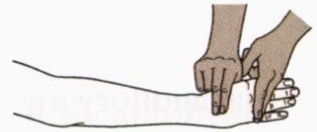


Elbow extension
Triceps
Radial nerve
C7

Wrist extension
Extensors carpi radialis,
C6 and ulnaris, C7,
Radial nerve



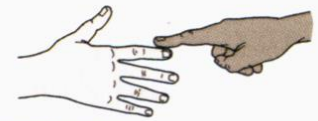
Wrist flexion
Flexors carpi radialis,
C7, median nerve and
ulnaris, C8,
ulnar nerve



Finger extension
Extensor digitorum
Radial nerve
C7

Finger flexion
Flexors digitorum
profundus and
superficialis
Median and ulnar nerves
C8

Thumb abduction
Abductor pollicis brevis
Median nerve
T1



Finger abduction
Dorsal interossei
Ulnar nerve
T1

TABLE 1-4. Medical Research Council Grading of Muscle Power

0	No contraction of muscle visible
1	Flicker or trace of contraction visible
2	Active movement at joint, with gravity eliminated
3	Active movement against gravity
4	Active movement against gravity and some resistance
5	Normal power

In some settings, such as the ICU, it is not possible to perform detailed motor assessments.

In this case, the examiner can look to see if there is symmetry to voluntary limb movements.

Another approach is to evaluate whether the patient can withdraw meaningfully (i.e. , pull the examined limb away from a mildly noxious stimulus such as a pinch).

The presence of involuntary abnormal movements should be noted.

For instance, fasciculations appear as small twitches underneath the skin.

Myoclonus and asterixis can cause a limb to jump or transiently lose tone from a given posture.

Chorea has a writhing quality.

Tremor can appear as an alternating movement of the arm, leg, or head.

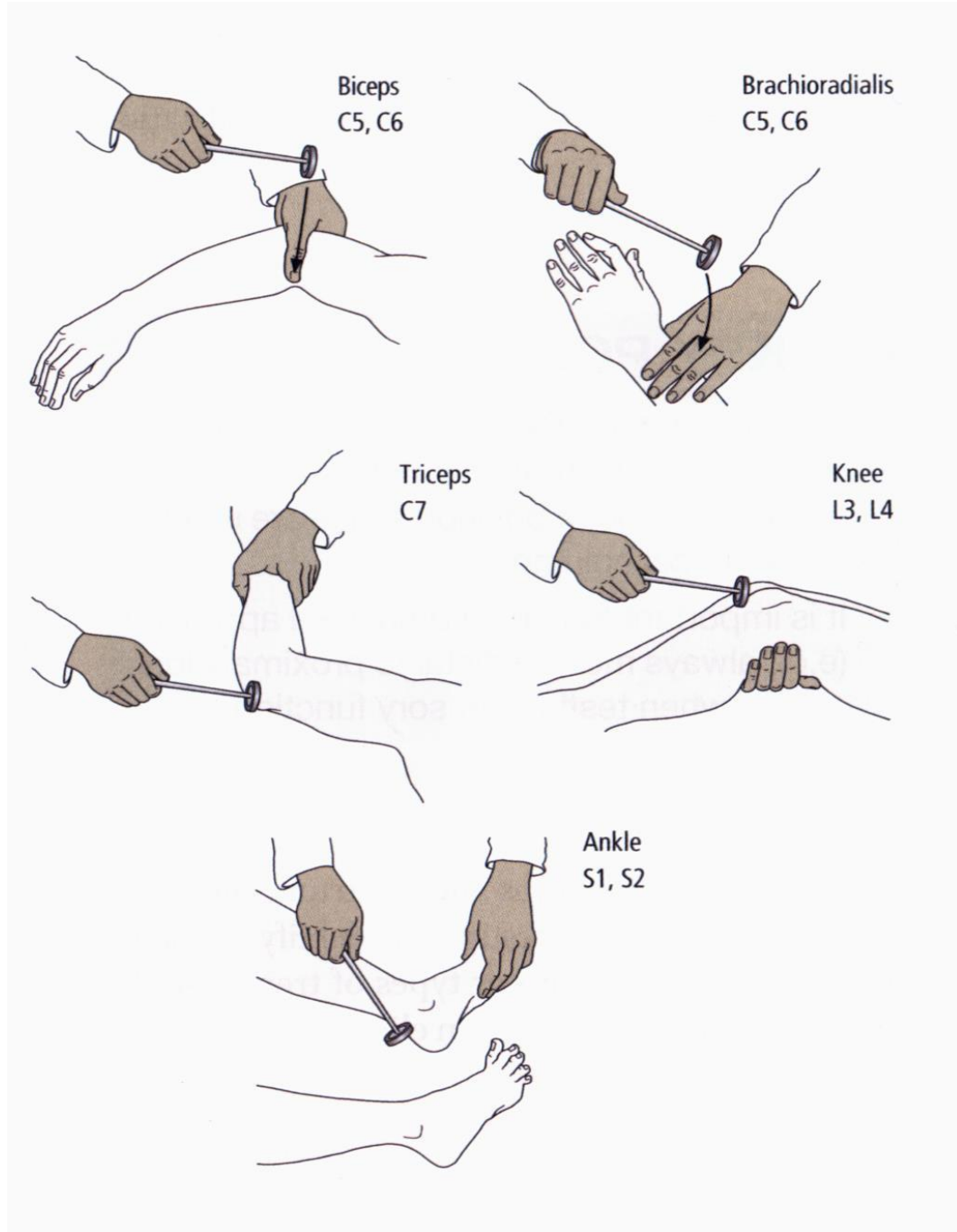
4. REFLEXES

Muscle stretch (or “ deep tendon”) reflexes can be useful aids in localizing or diagnosing both central and PNS problems (figure).

In the arms, the biceps, brachioradialis, and triceps reflexes are most commonly tested.

A pectoral reflex can be assessed by tapping the pectoralis muscle and looking for adduction of the proximal arm.

Thumb flexion stimulated by flicking the distal phalanx of the middle finger is a positive Hoffmann sign, an indication of hyperreflexia.


Biceps
C5, C6
Brachioradialis
C5, C6
Triceps
C7
Knee
L3, L4
Ankle
S1, S2

In the legs,patellar (knee jerk) and ankle reflexes are commonly tested.

The adductor reflex can also be tested by striking the medial thigh and looking for thigh adduction.

The Babinski sign is sought by stroking the lateral sole of the foot while observing for extension of the great toe.

Clonus, if present, can be elicited by forcibly dorsiflexing the ankle when it is relaxed.

In some cases, an exaggerated jaw jerk can localize a problem above the level of the cervical spine.

5. SENSORY EXAM

The sensory examination assesses small fiber (pinprick, temperature) and large fiber (vibration, proprioception) function.

Pinprick and temperature information is carried in the spinothalamic tract.

Vibration and proprioception require dorsal column tract integrity.

It is generally helpful to start distally and move proximally when testing each modality because polyneuropathy , one of the most common causes of sensory abnormality, generally shows up first in the toes.

Nevertheless, it makes sense to test sensory function more extensively in any affected limb-even if more distal function is normal-to look for other patterns of abnormality.

Pinprick: Using a sterile instrument (e.g. , special pins designed for the neurologic exam), the examiner starts to prick the toes and gradually moves up the leg to assess if there is a gradient to sensation.

The process can be repeated starting in the fingers , and moving up the arm.

If there is concern for a spinal cord lesion, it is important to perform pinprick along the length of the torso to identify a “ level” where sensation transitions from abnormal to normal .

If the patient reports facial symptoms, the pin should be used to assess sensation in areas representing each branch of the trigeminal nerve.

Temperature: Using a similar approach, a cold tuning fork can be used to assess temperature sensation.

Vibration: After striking the 128 Hz tuning fork, the stem is placed against a joint, and the duration for which the stimulus is appreciated is recorded.In general, the great toe is tested first, with the examiner testing increasingly proximal joints if the distal findings are abnormal.

Proprioception: Proprioception, or joint position sense, is tested in an order similar to that used for vibration assessment.

Usually, the examiner starts by holding the sides of the great toe and asking the patient to report when it is moved upward and downward by a few millimeters.

Light touch is often not useful to test in isolation because it relies on a combination of pathways.By itself it is unlikely to provide clues to localization or diagnosis.

6. COORDINATION

Coordination of the limbs and the trunk should be assessed.

Finger-to-nose testing can identify dysmetria (inaccuracy of targeting) or types of tremor in the arms.

Heel-to-shin testing can elicit incoordination in the legs.

To test axial abnormalities, the patient can be asked to sit upright and unsupported, with the eyes closed.

Rapid alternating movements , rhythmic finger tapping, and heel tapping are particularly sensitive to coordination problems.

In some disorders, such as Parkinson's disease , there can be a hesitation, decremental slowing (i.e. , damping) , or increasingly small excursions with repetitive movements.

Patients may also have trouble with the timing, or cadence , of these movements.

Dysdiadochokinesis is the term used to describe difficulty with rapid alternating movements.

7. GAIT

Ambulation is one of the most important elements of the neurologic examination.

Normal gait requires the proper functioning of many different parts of the nervous system,so it is one of the most sensitive ways to detect an abnormality.

Furthermore, some patterns of gait abnormality herald the presence of specific disorders(e.g. , Parkinsonism).

Routinely, posture, base,initiation, stride length, turning, arm swing, and overall balance are considered.

Posture should be upright.

The patient with a normal base, or stance, maintains the feet at about hip-width apart.

In general healthy individuals start walking without any hesitation.

Stride length should be full, with clearance of the feet from the floor.

Short-stepped and shuffling gaits are characterized by decreased stride length and limited excursion of the feet from the ground.

The arms normally swing fully in the opposite direction from their respective legs during ambulation.

Decreased arm swing is often a feature of extrapyramidal disorders.

A normal turn can be executed in 2 steps ; patients with Parkinson's disease may take multiple small steps to turn " en bloc".

Ataxia of gait results in an inability to walk in a straight line;patients may stagger from one side to the other or list consistently to one side.

Ataxia is typically associated with a wide-base stance.

Ataxia can be brought out most obviously by having the patient attempt to walk heel to toe (tandem).

A Romberg sign is present when the patient maintains a steady stance with feet together and eyes open but sways and falls with feet together and eyes closed.

Its presence usually implies a deficit of joint position sense, not cerebellar dysfunction.