Medical Academy named after S.I. Georgievsky of Vernadsky CFU

Department of Neurology and Neurosurgery

Lesson 2

Motor System.
Upper and Lower Motor Neurons. Pyramidal Tracts. Reflexes.
Aids to the examination of the voluntary movements.
Central and Peripheral Paralysis.
Motor Deficits due to Lesions at Specific Sites along the Motor Pathways.

Key points:

1. *Types of movements.*
2. *Anatomical basis of voluntary movements.*
3. *Reflexes. Reflex arc. Normal and Pathological reflexes.*
4. *Corticospinal (Pyramidal) Tract and Corticonuclear (Corticobulbar) Tract.*
5. *Other Central Components of the Motor System.*
6. *The technique of examination of the muscle strength, muscle tone, reflexes, pathological reflexes, etc.*
7. *Paralysis Due to Upper Motor Neuron (UMN) Lesions – Central Paralysis. Symptoms of Central Paralysis and their pathogenesis.*
8. *Paralysis Due to Lower Motor Neuron (LMN) Lesions – Peripheral Paralysis. Symptoms of Peripheral Paralysis and their pathogenesis.*

Questions for students:

Define the following terms:
Reflexes, voluntary movements, primary motor cortex, motor homunculus, upper motor neuron, lower motor neuron, Betz cell, lateral corticospinal pathway, anterior corticospinal pathway, pyramidal tract, decussation of pyramids, corticonuclear pathway, anterior horn, anterior root, peripheral nerve, motor unit, central paralysis, peripheral paralysis, paresis, plegia, monoparalysis, hemiparalysis, paraparalysis, tetraparalysis, spasticity, flaccidity, muscle power, muscle tone, muscle bulk, deep tendon reflexes, superficial reflexes, Babinski reflex, Oppenheim reflex, Gordon reflex, clonus, MRC scale, Jacksonian seizures, fasciculations, muscular hypotrophy, muscular atrophy, hyporeflexia, hyperreflexia, motor nucleus, motor cranial nerve, mixed cranial nerve, unilateral, bilateral, contralateral.

1. What are the steps involved in the motor exam?
2. Where are the cell bodies of the upper motor neurons (UMN) located?
3. Where are the cell bodies of the lower motor neurons (LMN) located?
4. What is the function of cortical upper motor neurons?
5. What do lower motor neurons (alpha motor neurons) do?
6. What is pyramidal pathway?
7. What is paralysis?
8. What are the major symptoms of central paralysis?
9. What are the major symptoms of peripheral paralysis?
10. How to distinguish central paralysis from peripheral one?
11. What is a reflex?
12. What is the function(s) of reflexes?
13. Which types of reflexes do exist?
14. How to exam motor system?

REFLEXES are subconscious stimulus-response mechanisms. The reflexes are extremely important in the diagnosis and localization of neurologic lesions.

SIMPLE REFLEX ARC includes a ***receptor*** (eg, a special sense organ, cutaneous end-organ, or muscle spindle, whose stimulation initiates an impulse); the ***afferent neuron***, which transmits the impulse through a peripheral nerve to the central nervous system, where the nerve synapses with lower motor neurons (LMN) or an intercalated neuron; one or more ***interneurons***, which for some reflexes relay the impulse to the efferent neuron; the ***efferent neuron*** (usually an LMN), which passes outward in the nerve and delivers the impulse to an effector; and an ***effector*** (eg, the muscle or gland that produces the response). Interruption of this simple reflex arc at any point abolishes the response.

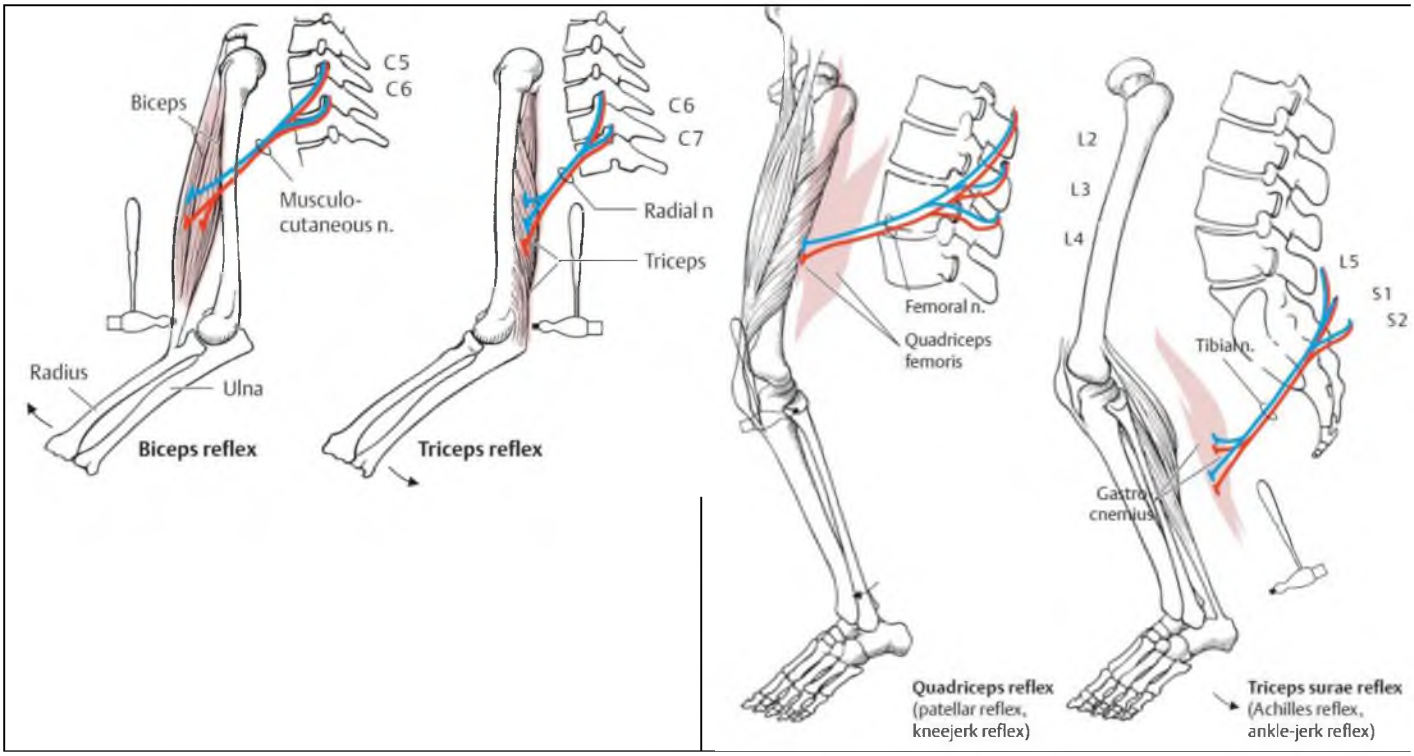
TYPES OF REFLEXES The reflexes of importance to the clinical neurologist may be divided into four groups: ***superficial*** (skin and mucous membrane) reflexes, ***deep tendon*** (myotatic) reflexes, ***visceral*** (organic) reflexes, and ***pathologic*** (abnormal) reflexes (Table 5-5). Reflexes can also be classified according to the level of their central representation, for example, as spinal, bulbar (postural and righting reflexes), midbrain, or cerebellar reflexes.

Reflexes	Afferent Nerve	Center	Efferent Nerve
Superficial reflexes			
Corneal	Cranial V	Pons	Cranial VII
Nasal (sneeze)	Cranial V	Brain stem and upper cord	Cranials V, VII, IX, X, and spinal nerves of expiration
Pharyngeal and uvular	Cranial IX	Medulla	Cranial X
Upper abdominal	T7, 8, 9, 10	T7, 8, 9, 10	T7, 8, 9, 10
Lower abdominal	T10, 11, 12	T10, 11, 12	T10, 11, 12
Cremasteric	Femoral	L1	Genitofemoral
Plantar	Tibial	S1, 2	Tibial
Anal	Pudendal	S4, 5	Pudendal
Tendon reflexes			
Jaw	Cranial V	Pons	Cranial V
Biceps	Musculocutaneous	C5, 6	Musculocutaneous
Triceps	Radial	C7, 8	Radial
Brachioradialis	Radial	C5, 6	Radial
Patellar	Femoral	L3, 4	Femoral
Achilles	Tibial	S1, 2	Tibial
Visceral reflexes			
Light	Cranial II	Midbrain	Cranial III
Accommodation	Cranial II	Occipital cortex	Cranial III
Ciliospinal	A sensory nerve	T1, 2	Cervical sympathetics
Oculocardiac	Cranial V	Medulla	Cranial X
Carotid sinus	Cranial IX	Medulla	Cranial X
Bulbocavernosus	Pudendal	S2, 3, 4	Pelvic autonomic
Bladder and rectal	Pudendal	S2, 3, 4	Pudendal and autonomics
Abnormal reflexes			
Extensor plantar (Babinski)	Plantar	L3–5, S1	Extensor hallucis longus

THE MYOTATIC REFLEX (see the Table and Figure below) is a monosynaptic and ipsilateral muscle stretch reflex (MSR). Like all reflexes, the myotatic reflex has an afferent and an efferent limb. Interruption of either limb results in areflexia.

THE FIVE MOST COMMONLY TESTED MUSCLE STRETCH REFLEXES

Muscle Stretch Reflex	Cord Segment	Muscle
Ankle jerk	S-1 - S-2	Gastrocnemius
Knee jerk	L-2 - L-4	Quadriceps
Biceps jerk	C-5 and C-6	Biceps
Forearm jerk	C-5 and C-6	Brachioradialis
Triceps jerk	C-7 and C-8	Triceps



Central Components of the Motor System

CENTRAL PORTION of the motor system for voluntary movement consists of the primary motor cortex (area 4) and the adjacent cortical areas (particularly the premotor cortex, area 6), and the corticobulbar and corticospinal tracts to which these cortical areas give rise (Figs. 3.1 and 3.2).

Motor Cortical Areas

PRIMARY MOTOR CORTEX (***precentral gyrus***, Fig. 3.1) is a band of cortical tissue that lies on the opposite side of the central sulcus from the primary somatosensory cortex (in the postcentral gyrus) and, like it, extends upward and past the superomedial edge of the hemisphere onto its medial surface.

MOTOR HOMUNCULUS. The area representing the throat and larynx lies at the inferior end of the primary motor cortex; above it, in sequence, are the areas representing the face, upper limbs, trunk, and lower limbs (Fig. 3.2).

MOTOR NEURONS are found not only in area 4 but also in the adjacent cortical areas. The fibers mediating fine voluntary movements, however, originate mainly in the precentral gyrus. This is the site of the characteristic, large pyramidal neurons (***Betz cells***), which lie in the fifth cellular layer of the cortex and send their rapidly conducting, thickly myelinated axons into the pyramidal tract.

The ***motor neurons of area 4*** subserve fine, voluntary movement of the ***contralateral half of the body***; the pyramidal tract is, accordingly, crossed. Direct electrical stimulation of area 4, as during a neurosurgical procedure, generally induces contraction of an individual muscle, while stimulation of area 6 induces more complex and extensive movements, e.g., of an entire upper or lower limb.

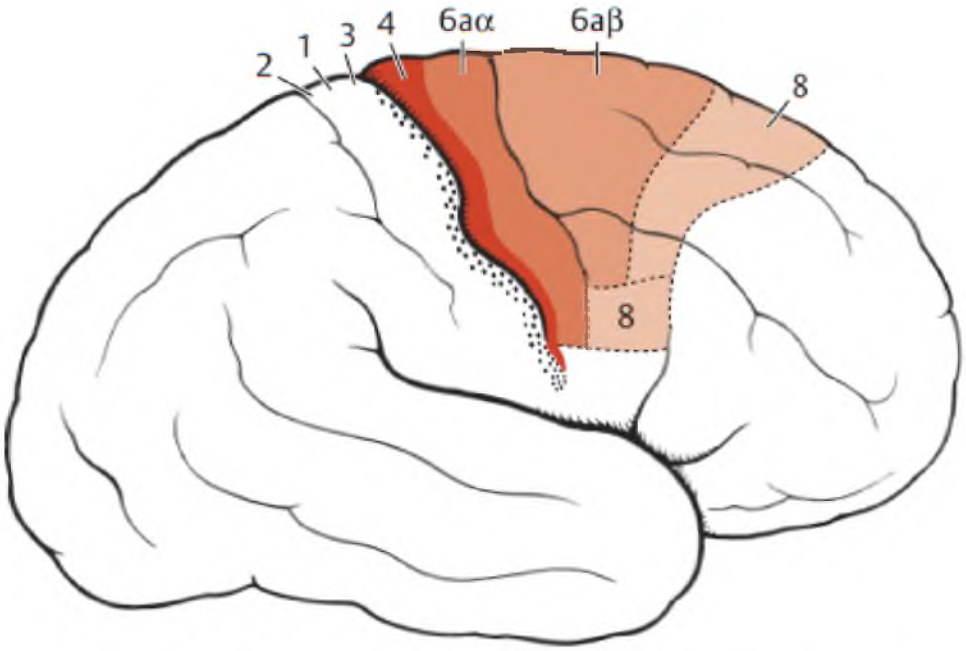


Fig. 3.1 **Primary motor area/precentral gyrus** (area 4), **premotor cortex** (area 6), and **prefrontal eye field** (area 8). For the functions of these areas, see text.

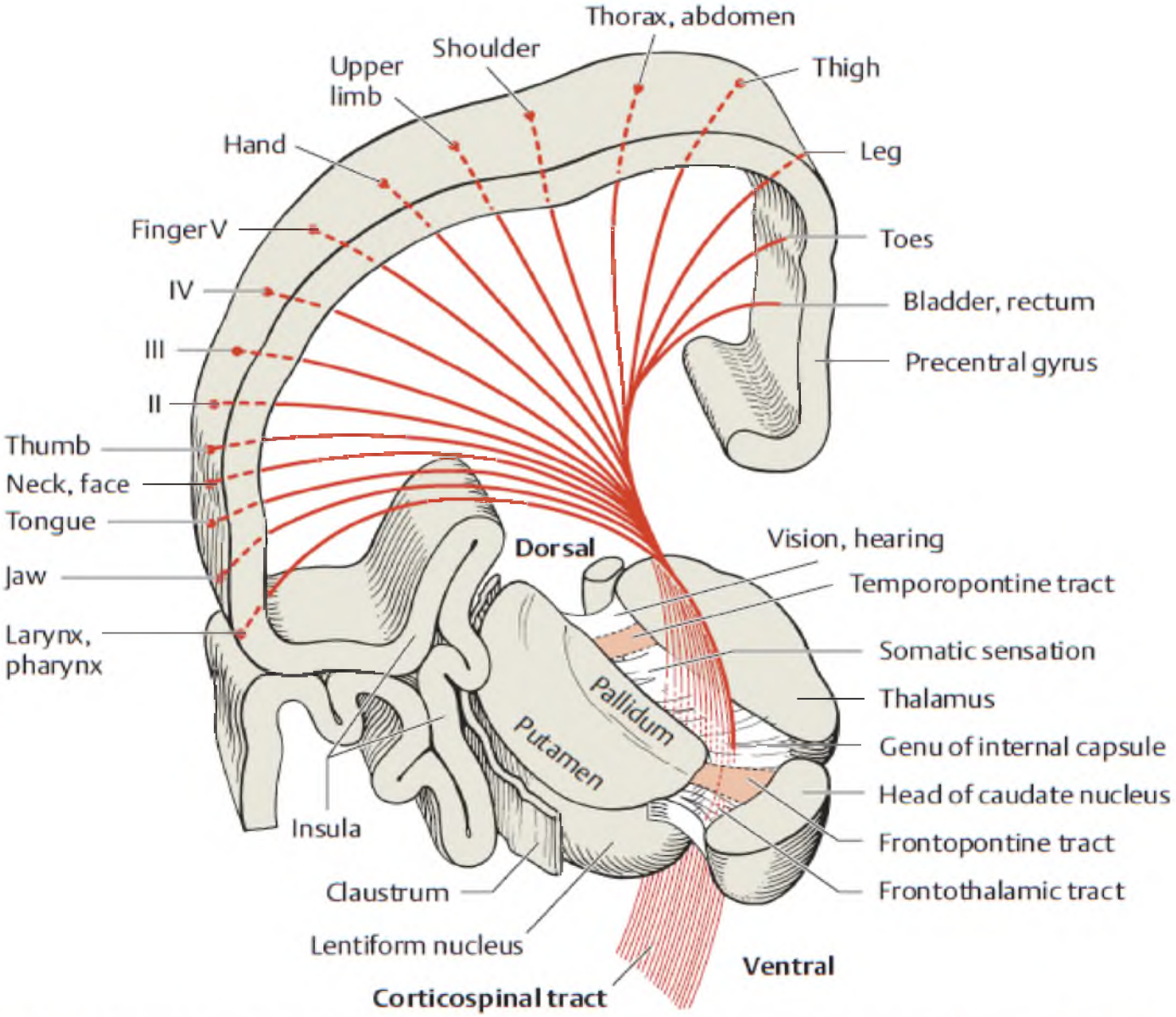


Fig. 3.2 **Course of the pyramidal tract**, upper portion: the corona radiata and internal capsule

Lateral Corticospinal Tract (Pyramidal Tract)

A. FUNCTION. The lateral corticospinal tract mediates voluntary skilled motor activity, primarily of the upper limbs. It is not fully myelinated until the end of the second year (Babinskis sign).

B. FIBER CALIBER. Approximately 90% of the fibers lie between 1 and 4 μ and 4% lie above 20 μm (from the giant cells of Betz).

C. ORIGIN AND TERMINATION

1. Origin. The lateral corticospinal tract arises from layer V of the cerebral cortex from three cortical areas in equal aliquots:

a. The premotor cortex (Brodmann's area 6).

b. The primary motor cortex, or precentral gyrus (Brodmann's area 4).

Arm, face, and foot areas. The arm and face areas of the motor homunculus arise from the lateral convexity; the foot region of the motor homunculus is found in the paracentral lobule (see Figure 3.2).

c. The primary sensory cortex, or postcentral gyrus (Brodmann's areas 3, 1, and 2).

2. Termination. The lateral corticospinal tract terminates contralaterally, through interneurons, on ventral horn motor neurons.

D. COURSE of the lateral corticospinal tract

1. Telencephalon. The lateral corticospinal tract runs in the posterior limb of the internal capsule in the telencephalon.

2. Midbrain. The lateral corticospinal tract runs in the middle three-fifths of the crus cerebri in the midbrain.

3. Pons. The lateral corticospinal tract runs in the base of the pons.

4. Medulla. The lateral corticospinal tract runs in the medullar)' pyramids. Between 85% and 90% of the corticospinal fibers cross in the pyramidal decussation as the lateral corticospinal tract. The remaining 10% to 15% of the fibers continue as the ***anterior corticospinal tract***.

5. Spinal cord. The lateral corticospinal tract runs in the dorsal quadrant of the lateral funiculus.

E. TRANSECTION OF THE LATERAL CORTICOSPINAL TRACT

1. Above the motor decussation, transection results in contralateral spastic paralysis.

2. In the spinal cord, transection results in ipsilateral spastic paralysis.

About 90% of all pyramidal tract fibers end in synapses onto interneurons, which then transmit the motor impulses onward to the large ***α-motor neurons*** of the anterior horn, as well as to the smaller ***γ-motor neurons*** (Fig. 3.4).

Corticonuclear (Corticobulbar) Tract

CORTICONUCLEAR FIBERS project ***bilaterally*** to all motor cranial nerve nuclei EXCEPT the lower part of the motor facial nucleus and hypoglossal nucleus. The division of the facial nerve nucleus that innervates the upper face (the orbicularis oculi muscle and above) receives bilateral corticonuclear input. The division of the facial nerve nucleus that innervates the lower face receives only contralateral corticonuclear input. Hypoglossal nucleus also receives only contralateral corticonuclear input.

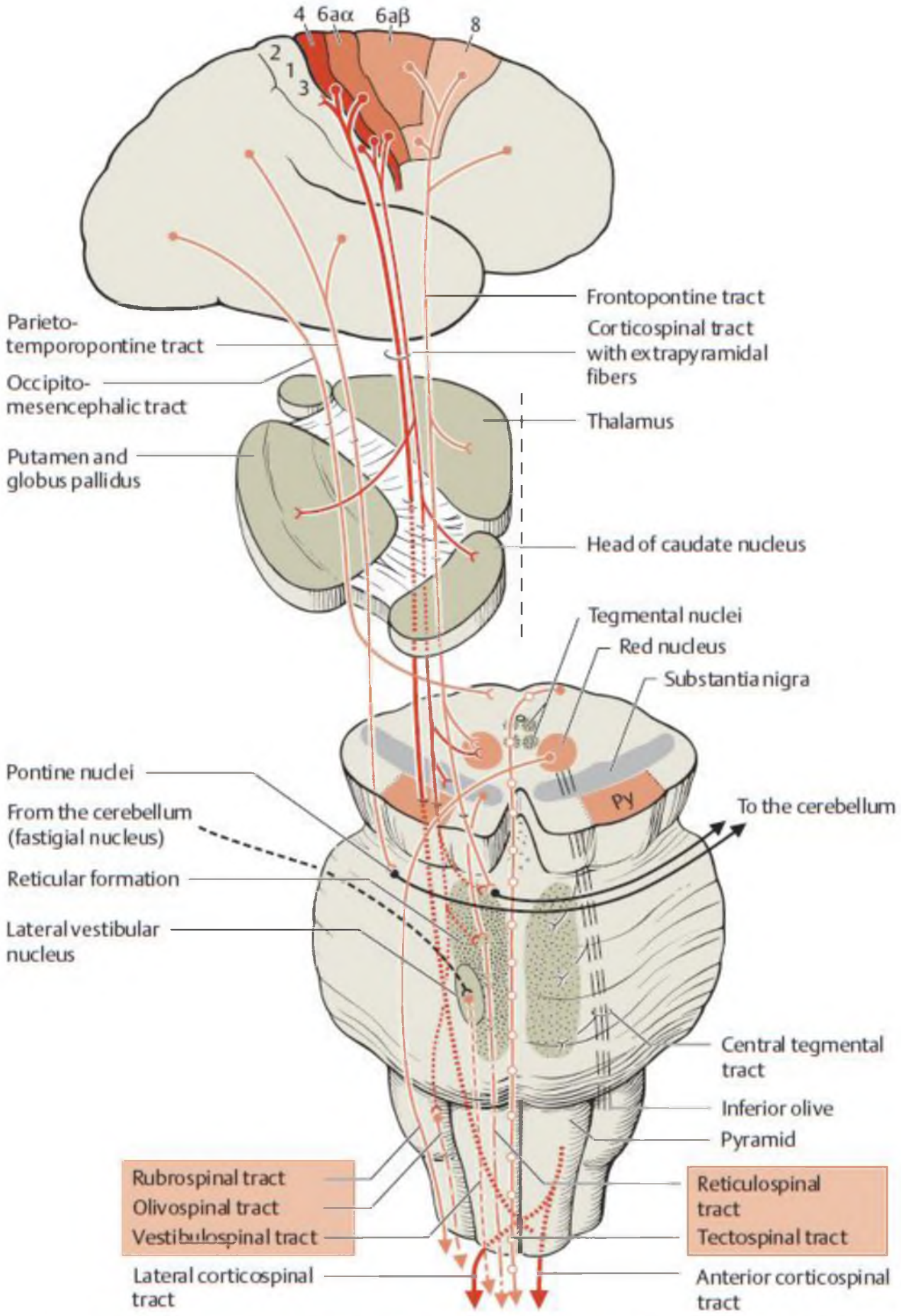


Fig. 3.5 **Brain structures involved in motor function and the descending tracts that originate in them**

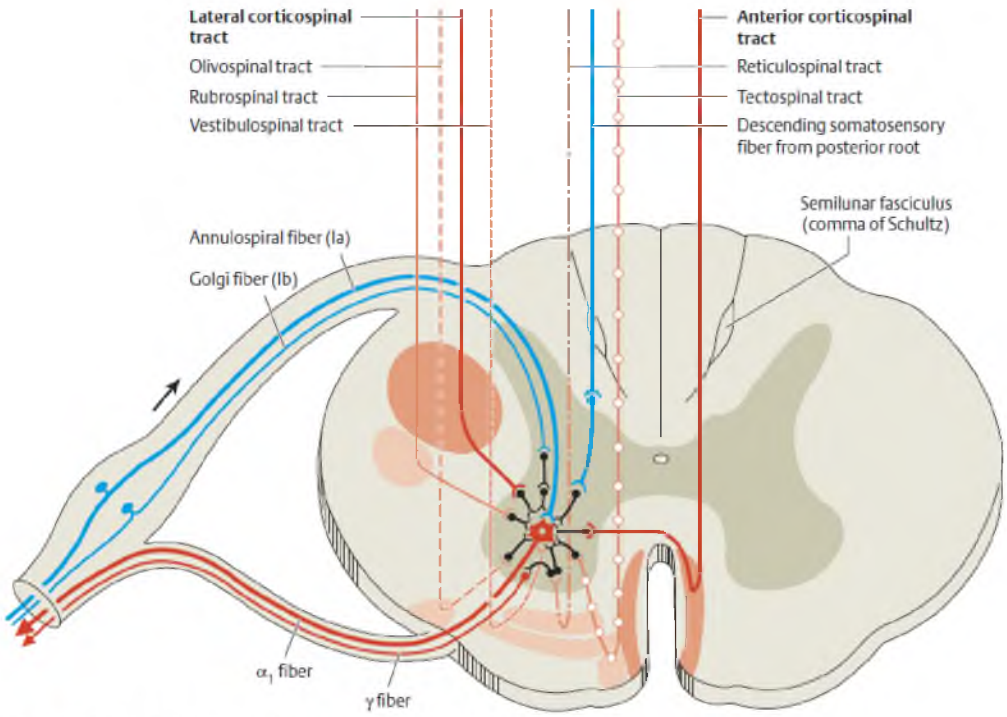


Fig. 3.6 Synapses of the descending motor tracts onto anterior horn neurons

Peripheral Components of the Motor System

PERIPHERAL PORTION OF THE MOTOR SYSTEM comprises the *motor cranial nerve nuclei* of the brainstem, the motor *anterior horn* cells of the spinal cord, the *anterior roots*, the cervical and lumbosacral *nerve plexuses*, the *peripheral nerves*, and the *motor end plates* in skeletal muscle.

ANTERIOR HORN CELLS (α and γ motor neurons). The fibers not only of the pyramidal tract but also of the non-pyramidal descending pathways as well as afferent fibers from the posterior roots, terminate on the cell bodies or dendrites of the larger and smaller α motor neurons. Fibers of all of these types also make synaptic contact with the small γ motor neurons, partly directly, and partly through intervening interneurons and the association and commissural neurons of the intrinsic neuronal apparatus of the spinal cord (Fig. 3.6). Some of these synapses are excitatory, others inhibitory. The thin, unmyelinated neurites of the γ motor neurons innervate the intrafusal muscle fibers. In contrast to the pseudounipolar neurons of the spinal ganglia, the anterior horn cells are ***multipolar***. Their dendrites receive synaptic contact from a wide variety of afferent and efferent systems (Fig. 3.6).

ANTERIOR ROOTS. The neurites of the motor neurons exit the anterior aspect of the spinal cord as rootlets (fila radicularia) and join together, forming the anterior roots. Each anterior root joins the corresponding posterior root just distal to the dorsal root ganglion to form a spinal nerve, which then exits the spinal canal through the intervertebral foramen.

PERIPHERAL NERVE AND MOTOR END PLATE. There is one pair of spinal nerves for each segment of the body. The spinal nerves contain afferent somatosensory fibers, efferent somatic motor fibers, efferent autonomic fibers from the lateral horns of the spinal gray matter, and afferent autonomic fibers. At cervical and lumbosacral levels, the spinal nerves join to form the nerve plexuses, which, in turn, give rise to the peripheral nerves that innervate the musculature of the neck and limbs.

MOTOR UNIT. An anterior horn cell, its neurites, and the muscle fibers it innervates are collectively termed a motor unit. Muscles participating in finely differentiated movements are supplied by a large number of anterior horn cells, each of which innervates only a few (5-20) muscle fibers; such muscles are thus composed of ***small motor units***. In contrast, large muscles that contract in relatively undifferentiated fashion, such as the gluteal muscles, are supplied by relatively few anterior horn cells, each of which innervates 100-500 muscle fibers (***large motor units***).

Lesions of Central Motor Pathways

SYNDROME OF CENTRAL (SPASTIC) PARALYSIS. This syndrome consists of:
- Diminished muscular strength and impaired fine motor control
- Spastic increased muscle tone
- Abnormally brisk deep tendon reflexes, possibly with clonus
- Hypoactivity or absence of exteroceptive reflexes (abdominal, plantar, and cremasteric reflexes)
- Pathological reflexes (Babinski, Oppenheim, Gordon reflexes)
- Preserved muscle bulk

Localization of Lesions in the Central Motor System

LESION INVOLVING MOTOR CORTEX (***a*** in Fig. 3.7), such as a tumor, an infarct, or a traumatic injury, causes weakness of part of the body on the opposite side (***contralateral monoparesis***). Monoparesis is seen in the face or hand more frequently than elsewhere, because these parts of the body have a large cortical representation. An irritative lesion at site (***a***) can cause focal (Jacksonian) seizures.

LESION INVOLVING INTERNAL CAPSULE (***b*** in Fig. 3.7) e.g. by hemorrhage or ischemia causes ***contralateral spastic hemiplegia***. The corticonuclear tract is involved as well, so that a contralateral facial palsy results, accompanied by a central hypoglossal nerve palsy and central facial nerve palsy. No other cranial nerve deficits are seen, however, because the remaining motor cranial nerve nuclei are bilaterally innervated.

LESIONS AT THE LEVEL OF CEREBRAL PEDUNCLE (***c*** in Fig. 3.7), such as a vascular process, a hemorrhage, or a tumor, produce ***contralateral spastic hemiparesis***, possibly accompanied by an ipsilateral oculomotor nerve palsy (Weber syndrome).

PONTINE LESIONS involving the pyramidal tract (***d*** in Fig. 3.7; e.g., a tumor, brainstem ischemia, a hemorrhage) cause ***contralateral hemiparesis*** possibly accompanying ipsilateral trigeminal nerve deficit or abducens palsy.

LESIONS OF THE PYRAMIDAL TRACT IN THE SPINAL CORD. A lesion affecting the pyramidal tract at a ***cervical level*** (***f*** Fig. 3.7; e.g., a tumor, myelitis, trauma) causes ipsilateral spastic hemiplegia: ipsilateral because the tract has already crossed at a higher level, and spastic because it contains nonpyramidal as well as pyramidal fibers at this level. A bilateral lesion in the upper cervical spinal cord can cause quadriparesis or quadriplegia. A lesion affecting

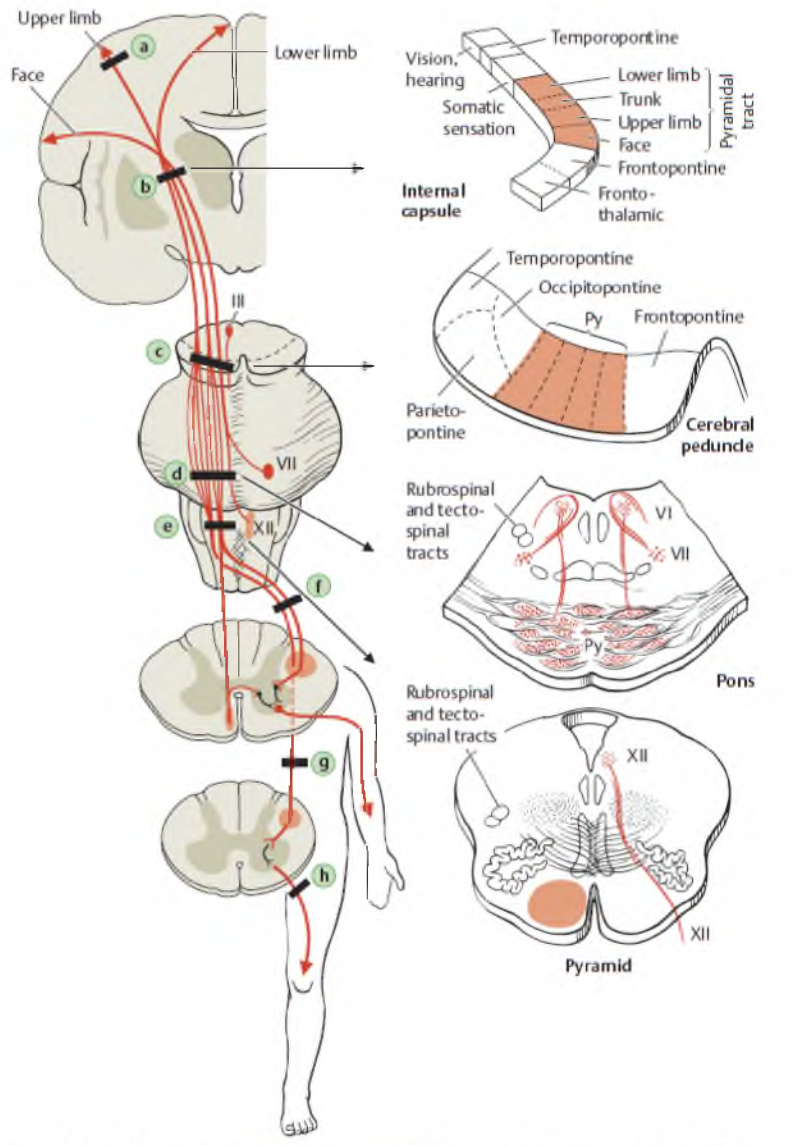


Fig. 3.7 **Sites of potential lesions of the pyramidal tract.** For the corresponding clinical syndromes, see text.

the pyramidal tract in the ***thoracic spinal cord*** (***g*** in Fig. 3.7; e.g., trauma, myelitis) causes spastic ipsilateral monoplegia of the lower limb. Bilateral involvement causes paraplegia.	

Clinical Syndromes of Motor Unit Lesions

SYNDROME OF PERIPHERAL (FLACCID) PARALYSIS. This syndrome consists of:
The syndrome of flaccid paralysis consists of the following:
- Diminution of raw strength
- Hypotonia or atonia of the musculature
- Hyporeflexia or areflexia
- Muscle atrophy
- Fasciculation

The lesion can usually be localized more specifically to the anterior horn, the anterior root(s), the nerve plexus, or the peripheral nerve with the aid of electromyography and electroneurography (nerve conduction studies). If paralysis in a limb or limbs is accompanied by somatosensory and autonomic deficits, then the lesion is presumably distal to the nerve roots and is thus located either in the nerve plexus or in the peripheral nerve.

COMPONENTS OF MOTOR EXAMINATION:

1. ***Abnormal involuntary movements***
2. ***Posture***
3. ***Muscle bulk***
4. ***Muscle tone***
5. ***Power***
6. ***Reflexes***

Abnormal involuntary movements, posture and bulk

Examination Technique:
a) patient should be sufficiently undressed but draped to preserve modesty
b) compare left to right and proximal to distal
c) observe for asymmetry, atrophy or hypertrophy
d) observe for abnormal involuntary movements

Muscle tone

Examination Technique:
a) ensure the patient is relaxed
b) for assessment in the upper extremities, the patient may be lying or sitting. In the lower extremities, tone is best assessed with the patient lying down
c) explain the examination technique to the patient before proceeding
d) spasticity (clasp knife) is velocity dependent and should be assessed by a quick flexion/extension of the knee or the elbow or quick supination/pronation of the arm
e) rigidity (lead pipe) is continuous and not velocity dependent and the movement should be performed slowly
f) "activated" rigidity; minor degrees of rigidity may be enhanced by having the patient activate the opposite limb
g) rigidity in the neck can be assessed by slow flexion, extension and rotation movements

Normal Response:
a) normally minimal, if any resistance to passive movement is encountered

Abnormal Response:

1.1. spasticity is a feature of an upper motor neuron lesion and maybe minor such as a spastic catch or a very stiff limb that cannot be moved passively. Accompanying features may include spasms, clonus, increased deep tendon reflexes and an extensor plantar response
1.2. rigidity is a continuous resistance to passive movement and is seen in extrapyramidal disorders such as Parkinson's disease
1.3. rigidity may be continuous or ratchety (cogwheeling). Cogwheeling is typically seen at the wrists
1.4. hypotonia (flaccidity) or decreased tone is more difficult to appreciate but is seen with lower motor neuron or cerebellar lesions

Power

Examination Technique:

a) power or strength is tested by comparing the patient's strength against your own
b) start proximally and move distally
c) compare one side to the other
d) grade strength using the Medical Research Council (MRC) scale
e) where possible, palpate the muscle as the patient activates it
f) strength in the lower extremities is best assessed with the patient supine

Grade strength using the Medical Research Council (MRC) scale

MRC Scale	
Grade	**Description**
0	no contraction
1	flicker or trace of contraction
2	active movement with gravity eliminated
3	active movement against gravity
4*	active movement against gravity and resistance
5	normal power

* grades 4 -, 4 and 4+ maybe used to indicate movement against slight, moderate and strong resistance respectively

Deep tendon reflexes

Examination Technique:

a) the patient should be relaxed
b) explain to the patient the examination technique
c) use a neurological hammer for examination
d) before concluding that reflexes are absent, have the patient re-enforce by performing an isometric contraction of other muscles (e.g. clench teeth or opposite limb for upper extremity reflexes or pull hooked fingers apart for lower extremity reflexes)
e) before concluding that ankle reflexes are absent, position the patient in a chair by having them kneel where one would normally sit, squeeze the back of the chair for reinforcement, on your count of three, just as you deliver the strike to the Achilles' tendon which should be gently stretched by passive dorsiflexion of the ankle

Deep tendon reflexes tested:

a) Upper extremities: biceps (C5, C6), brachioradialis (C5, C6), triceps (C6, C7), finger flexors (C6-T1)
b) Lower extremities: knee or patellar (L2, 3, 4), ankle (S1, S2)

Reflexes are graded using a 0 to 4+ scale:

Grade	Description
0	absent
1+	hypoactive
2+	normal
3+	hyperactive without clonus
4+	hyperactive with clonus

Clonus

If reflexes are hyperactive, test for ankle clonus.

Examination Technique:

a) ask the patient to relax
b) support the knee in a partly flexed position
c) quickly dorsiflex the foot and observe for rhythmic clonic movements

Abdominal Reflexes

Examination Technique:

a) explain the examination technique
b) the patient should be lying down and relaxed with their arms by their side
c) a blunt object such as a key or tongue blade may be used (A safety pin may also be used as long as the stimulus is delivered lightly)
d) stroke the abdomen lightly on each side in an inward direction above and below the umbilicus
e) note the contraction of the abdominal muscles and deviation of the umbilicus towards the stimulus

Abdominal reflexes tested:

- above umbilicus (T8, T9, T10) and below umbilicus (T10, T11, T12).

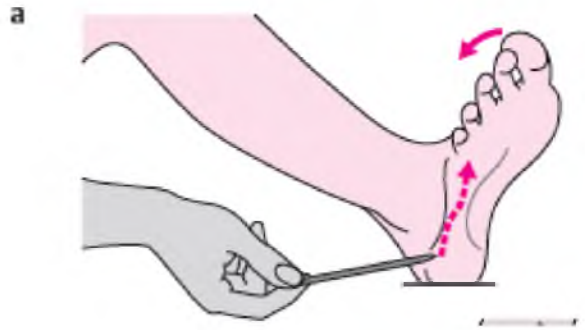
Normal Response:

a) Some studies indicate that up to 10% of people with no nervous system disease may have absence of one or more of the deep tendon reflexes. In general however, deep tendon reflexes are rarely absent in normal persons if the technique of eliciting them is adequate. Note that the reflex response depends on the force of the stimulus. Reflexes should be symmetrical
b) some individuals especially young anxious people may have brisk reflexes which are not necessarily pathological. There should be no asymmetry
c) usually clonus is abnormal although a few beats of non-sustained transient clonus may occasionally be seen
d) abdominal reflexes are usually obtainable in healthy non-obese individuals. They may be absent in obese individuals or those with lax abdominal musculature. Local diminishment or absence, suggests a disturbance in the continuity of the reflex arc (afferent nerve, motor center, efferent nerve). Loss, when associated with exaggeration of deep tendon reflexes implies a pyramidal tract lesion

Babinski response

Examination Technique:

a) explain the examination technique to the patient and ask them to relax.
b) stroke the lateral aspect of the sole of each foot and then come across the ball of the foot medially with a sharp object.



Oppenheim reflex

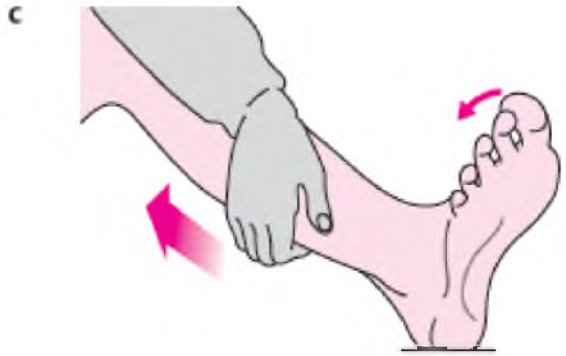
Examination Technique:

a) explain the examination technique to the patient and ask them to relax.
b) stroke downward with the examiner's thumb on the patient's shin

Gordon reflex

Examination Technique:

a) explain the examination technique to the patient and ask them to relax.
b) squeeze the patient's calf muscles



QUESTIONS FOR SELF-EDUCATION

1. Which of the following are true about DEEP REFLEXES (choose applicable):
    1. They are also called muscle stretch reflexes
    2. They are also called myotatic reflexes
    3. They are also called reflexes from the skin
    4. They are also called pathological reflexes
    5. Spinal reflexes are mediated at spinal level
    6. They include Babinski and Gordon reflexes
    7. Accessed by tapping the muscle tendon with reflex hammer and observing response
    8. Accessed by squeezing the patient's calf muscles and observing response
    9. They include Biceps and Triceps reflexes
    10. They include all abdominal reflexes
    11. They can be changed only due to lesions of upper motor neurons (UMN)
    12. They can be changed only due to lesions of lower motor neurons (LMN)
    13. They can be changed due to lesions of both motor neurons – UMN and LMN
    14. They have both afferent and efferent components
    15. They have neither afferent nor efferent components

2. Which of the following are true about SUPERFICIAL REFLEXES (choose applicable):
    1. They are also called muscle stretch reflexes
    2. They are also called myotatic reflexes
    3. They are also called reflexes from the skin
    4. They are also called pathological reflexes
    5. Accessed by stroking of the abdomen around the umbilicus and observing response
    6. They include Babinski and Gordon reflexes
    7. Accessed by tapping the muscle tendon with reflex hammer and observing response
    8. Accessed by squeezing the patient's calf muscles and observing response
    9. They include Biceps and Triceps reflexes
    10. They include all abdominal reflexes
    11. They can be changed only due to lesions of upper motor neurons (UMN)
    12. They can be changed only due to lesions of lower motor neurons (LMN)
    13. They can be changed due to lesions of both motor neurons – UMN and LMN
    14. They have both afferent and efferent components
    15. They have neither afferent nor efferent components

3. Which of the following are true about SIMPLE REFLEX ARC (choose applicable):
    1. It includes an effector
    2. It includes an interneuron
    3. It includes fibers of spinothalamic pathway
    4. It includes neurons located in the grey matter of the spinal cord
    5. It includes an efferent neuron
    6. It can be monosynaptic
    7. It can be polysynaptic

4. Indicate all types of reflexes (choose applicable):
    1. Deep tendon reflexes
    2. Pathological reflexes
    3. Undifferentiated reflexes
    4. Abnormal reflexes
    5. Reflexes from mucosae
    6. Myotatic reflexes
    7. Wasted reflexes
    8. Visceral reflexes
    9. Floating reflexes

5. Which of the following are true about BABINSKI REFLEX (choose applicable):
    1. Babinski reflex is a normal plantar response in adults
    2. Babinski reflex is a normal plantar response in newborns
    3. Babinski reflex is also called reflex from the skin
    4. Babinski reflex is tonic dorsiflexion of the great toe on stimulation of the lateral sole of the foot
    5. Babinski reflex is accessed by stroking of the abdomen around the umbilicus
    6. Babinski reflex is accessed by tapping the muscle tendon with reflex hammer
    7. Babinski reflex is accessed by squeezing the patient's calf muscles
    8. Babinski reflex is curving of the great toe down and inwards on stimulation of the lateral sole of the foot
    9. Babinski reflex indicates lesion of the lower motor neuron (LMN)
    10. Babinski reflex indicates lesion of the upper motor neuron (UMN)
    11. Babinski reflex indicates lesion of the pyramidal pathway

6. The MOTOR SYSTEM is responsible for the control of the following (choose applicable):
    1. Proprioception
    2. Timing of voluntary movements
    3. Position sense
    4. Direction of voluntary movements
    5. Amplitude of voluntary movements
    6. Deep sensation (including vibration sense)
    7. Coordination of voluntary movements
    8. Frequency of involuntary movements
    9. Amplitude of involuntary movements

7. What is true about the UPPER MOTOR NEURON (choose applicable):
    1. It is located in the postcentral gyrus
    2. It is located in the thalamus (VPL and VPM nuclei)
    3. It is located in the cerebral cortex
    4. It is located in the anterior horns of the spinal cord
    5. It is located in the precentral gyrus
    6. It is a place of origin of the pyramidal tract
    7. It is a place of origin of the fasciculus cuneatus and gracilis
    8. It's impairment is resulted in peripheral paralysis
    9. It's impairment is resulted in central paralysis

8. What is true about the LOWER MOTOR NEURON (choose applicable):
    1. It is located in the precentral gyrus
    2. It is located in the dorsal spinal ganglia
    3. It is located in the cerebral cortex
    4. It is located in the anterior horns of the spinal cord
    5. It is located in the anterior roots
    6. It is located in the posterior horns of the spinal cord
    7. It is a place of origin of the pyramidal tract
    8. It's impairment is resulted in peripheral paralysis
    9. It's impairment is resulted in central paralysis

9. Indicate functions of deep tendon reflexes (choose applicable):
    1. Adjust for unexpected changes in posture or position
    2. Transmit sensory information (deep sensation) to the thalamus
    3. Organize movement patterns - reciprocal inhibition and autogenic facilitation
    4. Organize information flow from muscles to the cortex
    5. Allow for rapid protection from painful or damaging stimulation

10. Reflex arcs below are correct EXCEPT (choose applicable):
    1. Biceps reflex: C6 – C7
    2. Triceps reflex: C7 – C8
    3. Biceps reflex: C5 – C6
    4. Knee reflex: L4 – L5
    5. Triceps reflex: C5 – C7
    6. Brachioradialis reflex: C5 – C6
    7. Ankle reflex: S1 – S2
    8. Knee reflex: L3 – L4
    9. Ankle reflex: S3
    10. Brachioradialis reflex: C7 – C8

11. Indicate motor nerve cells which send their axons to skeletal muscles (choose applicable):
    1. Interneurons in the spinal cord
    2. Lower motor neurons
    3. Pseudounipolar neurons
    4. Receptors in muscles
    5. Betz cells
    6. Alpha motorneurons
    7. Upper motor neurons
    8. Purkinje cells
    9. Central motor neurons
    10. Peripheral motor neurons

12. Indicate motor nerve cells which send their axons to the different types of motor nuclei in the brainstem and gray matter of the spinal cord (choose applicable):
    1. Interneurons in the spinal cord
    2. Lower motor neurons
    3. Pseudounipolar neurons
    4. Receptors in muscles
    5. Betz cells
    6. Alpha motorneurons
    7. Upper motor neurons
    8. Purkinje cells
    9. Central motor neurons
    10. Peripheral motor neurons

13. Corticospinal pathway travels through the following structures (choose applicable):
    1. Betz cells
    2. Corona radiata
    3. Upper motor neurons
    4. Thalamus (VPM and VPL)
    5. Posterior limb of the internal capsule
    6. Posterior horns of the spinal cord
    7. Vermis of the cerebellum
    8. Anterior limb of the internal capsule
    9. Base of the medulla oblongata
    10. Spinal cord

14. Corticospinal pathway decussates at the level of (choose applicable):
    1. Upper part of the spinal cord
    2. Cervical level of the spinal cord
    3. C2 – C3 spinal segments
    4. Anterior horns of the spinal cord
    5. Caudal part of the medulla oblongata
    6. Thalamus
    7. Anterior grey commissure of the spinal cord
    8. Base of the pons
    9. Anterior white commissure of the spinal cord
    10. It does not decussate and descend ipsilaterally

15. Indicate motor nuclei of cranial motor and mixed nerves which receive motor information from both (left and right) cerebral motor areas (choose applicable):
    1. Optic nerve nuclei
    2. Oculomotor nerve motor nucleus
    3. Upper part of the facial nucleus
    4. Motor nucleus of the trigeminal nerve
    5. Motor nucleus of the vagus nerve
    6. Lower part of the facial nucleus
    7. Hypoglossal nerve nucleus
    8. Motor nucleus of the glossopharyngeal nerve
    9. Abducens nerve nucleus
    10. Trochlear nerve nucleus

16. Slight paralysis or weakness affecting one side of the body (choose applicable):
    1. Hemiplegia
    2. Total paralysis
    3. Paraplegia
    4. Hemiparesis
    5. Quadriparalysis
    6. Ataxia
    7. Monoparesis
    8. Tetraparesis
    9. Monoplegia
    10. Paraparesis

17. Paralysis of both legs and the lower part of the body (choose applicable):
    1. Hemiplegia
    2. Total paralysis
    3. Paraplegia
    4. Hemiparesis
    5. Quadriparalysis
    6. Ataxia
    7. Monoparesis
    8. Tetraparesis
    9. Monoplegia
    10. Paraparesis

18. Severe paralysis affecting only one side of the body (choose applicable):
    1. Hemiplegia
    2. Total paralysis
    3. Paraplegia
    4. Hemiparesis
    5. Quadriparalysis
    6. Ataxia
    7. Monoparesis
    8. Tetraparesis
    9. Monoplegia
    10. Paraparesis

19. Severe paralysis of all four extremities (choose applicable):
    1. Hemiplegia
    2. Total paralysis
    3. Paraplegia
    4. Hemiparesis
    5. Quadriparalysis
    6. Ataxia
    7. Monoparesis
    8. Tetraparesis
    9. Monoplegia
    10. Paraparesis

20. Slight paralysis or weakness affecting only one arm or one leg (choose applicable):
    1. Hemiplegia
    2. Total paralysis
    3. Paraplegia
    4. Hemiparesis
    5. Quadriparalysis
    6. Ataxia
    7. Monoparesis
    8. Tetraparesis
    9. Monoplegia
    10. Paraparesis

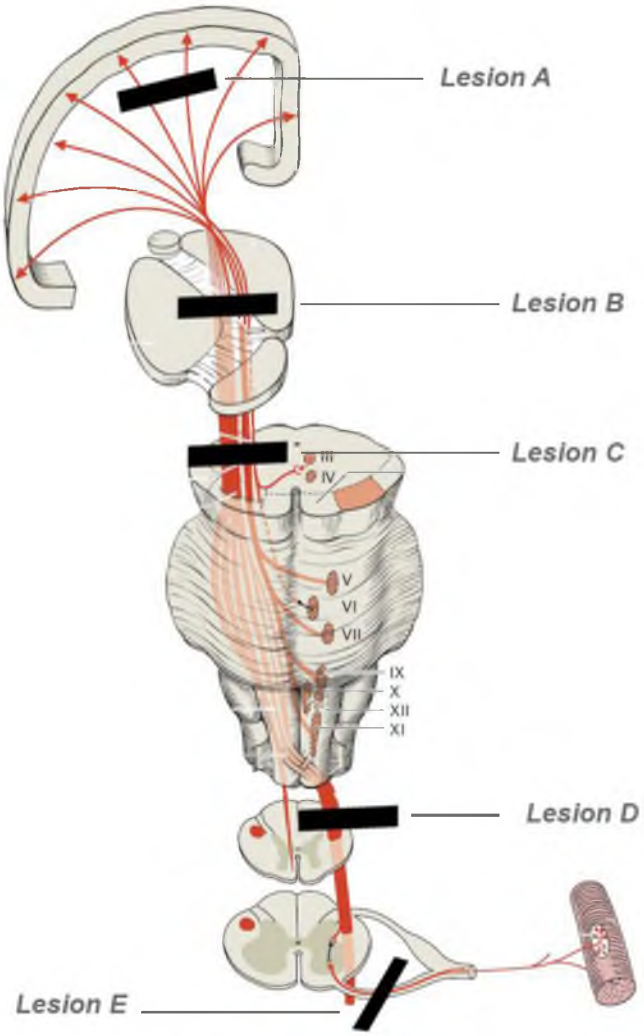
21. What does a lower motorneurone lesion produce (choose applicable):
    1. Hemiplegia or hemiparesis
    2. Peripheral paralysis of innervated muscles
    3. Increased deep tendon reflexes with clonuses
    4. Ataxia of stance and gait
    5. Muscle atrophy
    6. Positive Babinski reflex
    7. Fasciculations in muscles
    8. Decreased or absent deep tendon reflexes
    9. Increased muscle tone
    10. Decreased muscle strength
    11. Decreased muscle tone
    12. Absence of muscle atrophy

22. What does an upper motorneurone lesion produce (choose applicable):
    1. Muscle atrophy
    2. Increased deep tendon reflexes with clonuses
    3. Ataxia of stance and gait
    4. Decreased muscle tone
    5. Positive Babinski reflex
    6. Fasciculations in muscles
    7. Absence of muscle atrophy
    8. Decreased or absent deep tendon reflexes
    9. Increased muscle tone
    10. Decreased muscle strength
    11. Peripheral paralysis of innervated muscles

23. Why are reflexes important? (choose applicable):
    1. Control of posture
    2. Control of involuntary movements
    3. Control of locomotion
    4. Control of equilibrium
    5. Automatic and regulatory functions

24. Where are lower motorneurons located? (choose applicable):
    1. Premotor area of the brain
    2. Motor area of the brain
    3. Corona radiata
    4. Motor nuclei of the cranial nerves
    5. Thalamus (VPM and VPL)
    6. Posterior horns of the spinal cord
    7. Anterior limb of the internal capsule
    8. Base of the medulla oblongata
    9. Anterior horns of the spinal cord

25. Where are upper motorneurons located? (choose applicable):
    1. Motor area of the brain
    2. Corona radiata
    3. Precentral gyrus
    4. Motor nuclei of the cranial nerves
    5. Postcentral gyrus
    6. Posterior horns of the spinal cord
    7. Anterior limb of the internal capsule
    8. Base of the medulla oblongata
    9. Anterior horns of the spinal cord



26. Using the figure on the left side of the table indicate all possible motor findings due to LESION A (choose applicable):

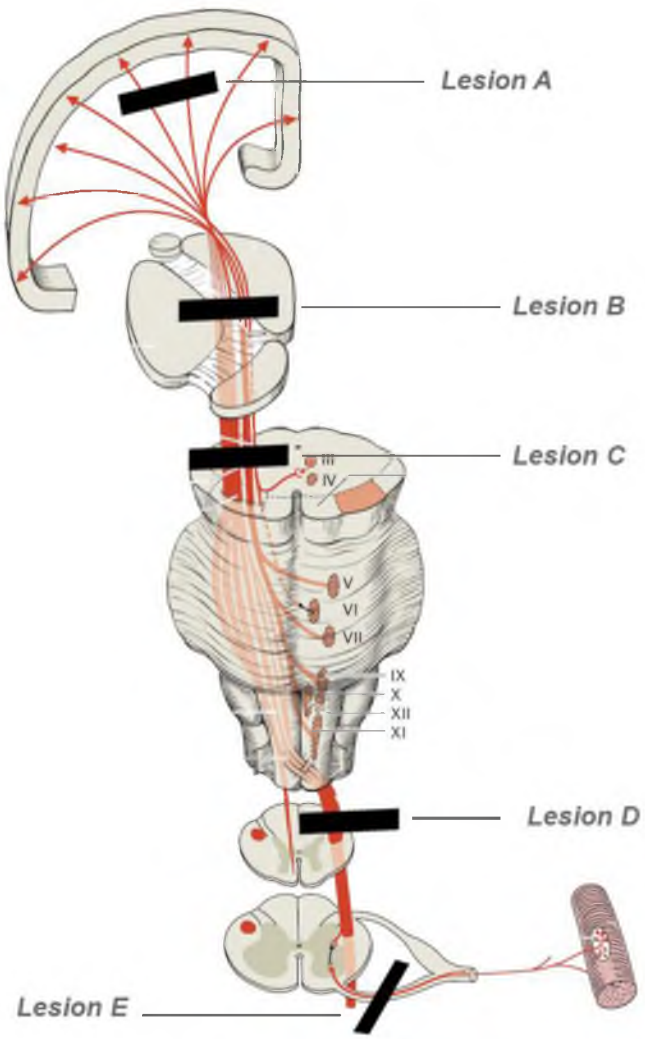
1. Peripheral contralateral paralysis
2. Decreased muscle strength
3. Increased muscle strength
4. Central contralateral hemiparalysis
5. Increased muscle tone
6. Decreased deep tendon reflexes
7. Positive Babinski reflex
8. Central contralateral monoparalysis
9. Peripheral ipsilateral paralysis
10. Fasciculations
11. Central ipsilateral hemiparalysis
12. Increased deep tendon reflexes
13. Decreased muscle tone
14. Clonuses
15. **Decreased superficial reflexes**

27. Using the figure on the left side of the table indicate all possible motor findings due to LESION B (choose applicable):

1. Peripheral contralateral paralysis
2. Decreased muscle strength
3. Increased muscle strength
4. Central contralateral hemiparalysis
5. Increased muscle tone
6. Decreased deep tendon reflexes
7. Positive Babinski reflex
8. Central contralateral monoparalysis
9. Peripheral ipsilateral paralysis
10. Fasciculations
11. Central ipsilateral hemiparalysis
12. Increased deep tendon reflexes
13. Decreased muscle tone
14. Clonuses
15. **Decreased superficial reflexes**

28. Using the figure on the left side of the table indicate all possible motor findings due to LESION C (choose applicable):

1. Peripheral contralateral paralysis
2. Decreased muscle strength
3. Increased muscle strength
4. Central contralateral hemiparalysis
5. Increased muscle tone
6. Decreased deep tendon reflexes
7. Positive Babinski reflex
8. Central contralateral monoparalysis
9. Peripheral ipsilateral paralysis
10. Fasciculations
11. Central ipsilateral hemiparalysis
12. Increased deep tendon reflexes
13. Decreased muscle tone
14. Clonuses
15. Decreased superficial reflexes



29. Using the figure on the left side of the table indicate all possible motor findings due to LESION D (choose applicable):

1. Peripheral contralateral paralysis
2. Decreased muscle strength
3. Increased muscle strength
4. Central contralateral hemiparalysis
5. Increased muscle tone
6. Decreased deep tendon reflexes
7. Positive Babinski reflex
8. Central contralateral monoparalysis
9. Peripheral ipsilateral paralysis
10. Fasciculations
11. Central ipsilateral hemiparalysis
12. Increased deep tendon reflexes
13. Decreased muscle tone
14. Clonuses
15. Decreased superficial reflexes

30. Using the figure on the left side of the table indicate all possible motor findings due to LESION E (choose applicable):

1. Peripheral contralateral paralysis
2. Decreased muscle strength
3. Increased muscle strength
4. Central contralateral hemiparalysis
5. Increased muscle tone
6. Decreased deep tendon reflexes
7. Positive Babinski reflex
8. Central contralateral monoparalysis
9. Peripheral ipsilateral paralysis
10. Fasciculations
11. Central ipsilateral hemiparalysis
12. Increased deep tendon reflexes
13. Decreased muscle tone
14. Clonuses
15. Decreased superficial reflexes