MOTOR TRACTS

Objectives:

- Appreciate what is upper motor neuron and lower motor neuron.
- Explain the origin , course and functions of the following motor tracts:
  1- Pyramidal tracts: (Corticospinal and Corticobulbar tracts).
  2- Extrapyramidal tracts: (Rubrospinal, Vestibulospinal, Reticulospinal, Olivospinal and Tectospinal tracts).

Done by

هشام الغفيلي

[Color index | Important | Explanation]

Since it is the second lecture in your CNS block you are not supposed to know all the terminologies in this lecture, I tried to explain the meanings only with no details, It is a very easy lecture 6 pages only.

References

435 Slides (Boy's & Girl's), Kaplan Anatomy and Costanzo.

Introduction

For performance of voluntary movements:

To perform a voluntary movement(a contraction of the skeletal muscle) we need two levels of neurons.

First: Upper motor neurons (UMN):

These are the motor neurons whose cell bodies lie in the higher motor centers , and their axons pass to brainstem and spinal cord to activate the cranial (brain stem neurons) and spinal motor nuclei.

The UMNs are located in: 1- The cerebral cortex. 2- The brainstem.

Second: Lower motor neurons (LMN):

These are the motor neurons of the spinal cord (AHCs) and brainstem motor nuclei of the cranial nerves that innervates skeletal muscle directly. (Alpha and Gamma motor neurons)

So the course of the signal when you want to flex your arm is:

UMNs in the Cerebral cortex → through a motor tract → toward the LMNs in the AHCs of the SC → Axons of the LMNs pass toward the Biceps muscle → NMJ → then the contraction :)

Classification

The following are the important sets of descending motor tracts, named according to the origin of their cell bodies and their final destination:

1- Pyramidal tracts:

- CorticoSpinal tract. So notice that please: Cortico(cortex)-Spinal(Spinal cord) so it starts from the Cortex and descends toward the Spinal cord.
- Cortico-Bulbar tract. (Bulbar means Brainstem)

2- Extrapyramidal tracts:

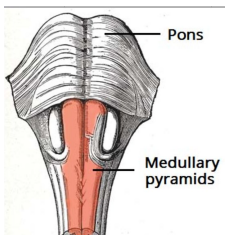
- Rubrospinal tract
- Reticulospinal tracts
- Vestibulospinal tracts
- Tectospinal tract
- Olivospinal tract

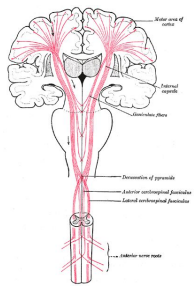
The descending motor pathways(Motor tracts): What do we mean by Pyramidal?

1- pyramidal tracts.

2- extrapyramidal tracts.

This classification is based on: the finding that the motor tract which originates from the cerebral cortex and descends to the spinal cord passes through the pyramids of the medulla, and therefore has been called the "The pyramidal tract".





The rest of the descending motor pathways: do not travel through the medullary pyramids, and are therefore collectively gathered under the heading: "The extrapyramidal tracts".

Motor Areas

Just imagine it as a story of signal, now our signal's story will **start** from these points.

1- The primary motor area (M1 or Motor area 4): This area Initiate the motor activities.

- occupies the precentral gyrus(an area in the brain) & contains large , highly excitable Betz cells.
- M1 of one side controls skeletal muscles of the opposite side of the body.
- Area of representation is proportional with the complexity of function done by the muscle. So, muscles of hands and tongue occupies 50% of this area. For example: All what you can do with your elbow joint is the Flexion and Extension, while your face muscles? You can do a lot of movements and expressions "Crying expressions when you have exam :) or Smiling when you get A+ :)"
- The neurons of this area arranged in vertical Columns.

Each column has six distinct layers of cells, The pyramidal cells that give rise to the Corticospinal fibers all lie in the fifth layer of cortical surface

Each column of cells functions as a unit, operate as an integrative - processing system, using information from multiple inputs to determine the output response from the column.

2- The premotor area

- lies in front of the primary motor area & below supplementary motor area.
- Stimulation of the premotor area produces complex coordinated movements, such as setting the body in a certain posture to perform a specific task.
- It works in association with the supplemental motor area, establishing the motor programs necessary for execution of complex movements

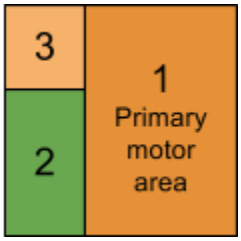
A few highly specialized motor centers have been found in the premotor areas of the human cerebral cortex:

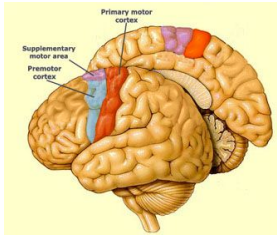
- Broca's Area for Speech: This area form the program of the movement of the muscles that makes you speak, if you don't have it YOU CAN NEVER SAY A WORD!
- The Frontal Eye Movements Area: located above Broca's area in the frontal lobe controls voluntary movements of the eyes toward different objects in the visual fields
- Head Rotation Area:located just above the eye movement area in the motor cortex. directing the head toward different visual objects .
- Area for Hand Skills.

3- The Supplementary motor area

- Lies in front of area 4 and above the premotor area.
- Stimulation of this area leads to bilateral grasping movements of both hands simultaneously.
- This area make motor programs for axial muscles.

- How to memorize the locations? ☺ 2 is taller so he's standing up.





Motor tracts (Pyramidal system)

1- The Corticospinal tract: (We will explain the origin + the course + the function)

Cells of origin:

30% originate from the primary motor area.

30% from the premotor area , and supplementary motor area.

40% from the somatic sensory areas posterior to the central sulcus. (Precentral Gyrus area)

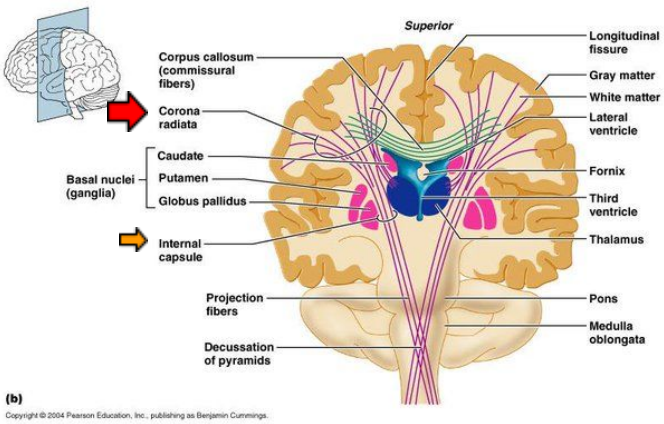
The fibers:

- 3% of the fibres are large myelinated fibres, derived from the large , highly excitable pyramidal Betz cells of M1. These fibers form monosynaptic connections with motor neurons of the spinal cord.
- But most of pyramidal fibers are unmyelinated

The course of the tract:

Fibers from the cerebral cortex descend in corona radiata to reach the posterior limb of internal capsule (between caudate and putamen nuclei of the basal ganglia)

Explanation: Fibers from the Cerebral cortex → Corona radiata "هذه منطقة تحتوي كل الفايبرس اللي طالعه من السيريبرال كورتيكس مافيه الانتيرنال كابسول زي المدخل يجمع كل" → Posterior limb of the internal capsule "فايبر يطلع من السيريبرال كورتيكس او يدخل له الا يمر بهذه المنطقة الفايبرس بشكل مرتب".

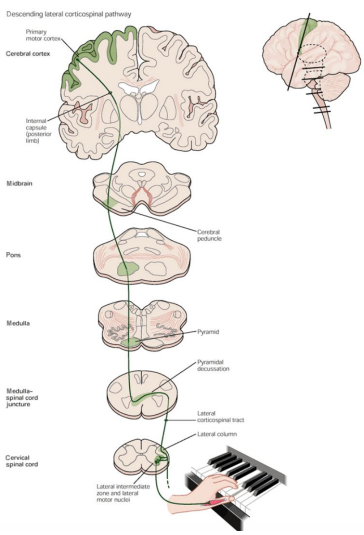


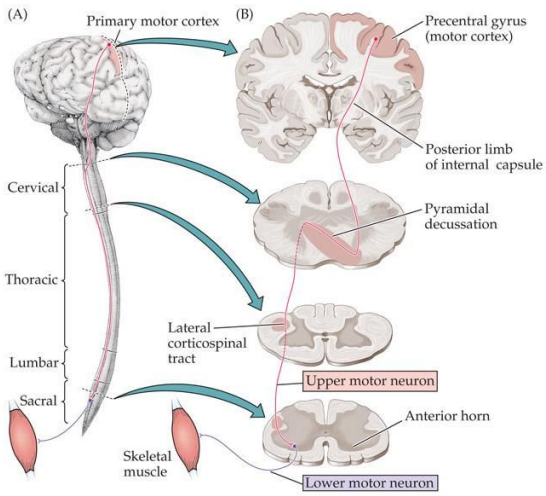
Then descend through the midbrain and pons. → Some fibers cross in brainstem to supply contralateral cranial nerve nuclei constitute the Corticobulbar tract .

In the lower medulla around 80% of the fibres cross to the opposite side → and descend in the lateral column of spinal cord as the and these 80% fibers called:

- Lateral Corticospinal Tract : They synapse on the contralateral spinal motor neurons (LMNs) , or on interneurons.

<u>These 80% fibers controls and initiates fine discrete skilled movement of fingers and hands.</u>

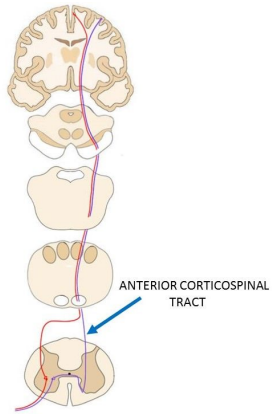




The remaining 20 % of corticospinal fibers do not decussate in the medulla → They descend ipsilaterally (in the same side) in the ventral column of the spinal cord white matter, These 20% fibers constitute:

- The ventral (Anterior) Corticospinal Tract: Finally they decussate (cross to the opposite side) and synapse on the contralateral spinal motor neurons

These fibers control the axial and proximal limbs muscles so it concern with control of posture.



*In the males slides you can find a diagram that explains the course from the beginning.

In a nutshell: Corticospinal tract gives 3 tracts:

Some fibers: Corticobulbar. 80% of the fibers LCST. 20% of the fibers VCST.

Functions of the pyramidal system:

1) Initiation of voluntary movements in the contralateral side of the body.
2) The lateral corticospinal tract fibers that descend in the spinal cord for control of muscles of the distal parts of the limbs, especially the hand and digits muscles, which subserve fine skilled movements used in manipulation by hand and fingers, and other accurate motor actions done by the limbs.
3) The ventral corticospinal tracts control posture of axial and proximal muscles for balance, climbing and walking.
4) Facilitation of muscle tone through gamma motor neurons.
5) those fibers originate from parietal lobe(Precentral gyrus) are for sensory-motor coordination
6) Corticobulbar tracts:control face & neck muscles & facilitate their tone, and are involved in facial expression, mastication, swallowing. Hence: it synapse with LMNs in the brainstem where the cranial nerves motor nuclei are located.

Removal of the Primary Motor Cortex (Area Pyramidalis)

Removal of the area that contains the giant Betz pyramidal cells (Area Pyramidalis) causes varying degrees of paralysis of the represented muscles.

- If the caudate nucleus(part of the basal ganglia) and adjacent premotor and supplementary motor areas are not damaged, gross postural and limb "fixation" movements can still occur, but there is a loss of voluntary control of discrete movements of the distal segments of the limbs especially of the hands and fingers. That means the discrete movements done by the Betz!

So area pyramidalis is essential for voluntary initiation of finely controlled movements, especially of the hands and fingers.

Effects of Lesions in the Motor Cortex or in the Corticospinal Pathway(The stroke)

The motor control system can be damaged by the "stroke which is: loss of blood supply to the cortex or to the corticospinal tract where it passes through the internal capsule."

- Muscle Spasticity Caused by Lesions That Damage Large Areas Adjacent to the Motor Cortex:

- The primary motor cortex normally exerts a continual tonic stimulatory effect on the motor neurons of the spinal cord; when this stimulatory effect is removed, hypotonia results. "Low muscle tone"
- Most lesions of the motor cortex, especially those caused by a stroke, involve the primary motor cortex & adjacent parts of the brain such as the basal ganglia. In these instances, muscle spasm occurs in the muscles on the opposite side of the body (because the motor pathways cross to the opposite side).

Motor tracts (Extrapyramidal system)

Recall: Mention the names of the extrapyramidal tracts? And why do we call them "Extra"?
If you don't know the answer revise and ياويلك مني ☺

1- Rubrospinal tracts:

The course:

After emerging from Red Nucleus(Rubro) in midbrain, fibers decussate at same level of red nucleus
It receives afferent connections from:
1- Ipsilateral cortical motor area (corticobulbar pathway) 2-Contralateral side of cerebellum 3-Basal ganglia. → Descend with the lateral corticospinal tract(LCST) → In spinal cord, tract occupies the lat. white column → fibers synapse on the contralateral AHCs.

Functions of the Rubrospinal tract: Remeber its relation with the LCST they love each other ☺

1) an additional pathway for transmission of cerebral cortical motor commands to the lower motor neurons similar to those of the corticospinal tract.
2) facilitatory to the Alpha and Gamma MNs of the distal flexor muscles, but they are inhibitory to extensor muscles.

So activation of the Red nucleus results in: activation of flexor muscles and inhibition of extensor muscles.

- Rubrospinal tract lies in the lateral columns of the spinal cord, along with the corticospinal tract, and terminates on the interneurons and motor neurons that control the more distal muscles of the limbs.
- Therefore, corticospinal & rubrospinal tracts together are called the **lateral system of the cord**, in contradistinction to a vestibulo-reticulospinal system Will be explained in a while. which lies mainly medially in the cord and is called the **medial motor system** of the cord.

2- Vestibulospinal tracts:

The course:

Vestibular Apparatus detects changes in head position → Sends fibers to Vestibular Nuclei in Pons + to Cerebellum → Correction of body position + moves eyes to help in correction (correction consciously by vision).
Vestibular nuclei tracts are always excitatory to Gamma Efferents (whereas Red nucleus is always inhibitory).

Functions of Vestibulospinal Tracts:

- Vestibulospinal tracts control reflexes e.g. Postural & righting (which correct body position) + control eye movements.
- **The lateral vestibulospinal:**
  Cells of origin: Lateral Vestibular Nucleus
  Axons descend in the ipsilateral ventral white column of spinal cord.
  This tract mediates excitatory influences upon extensor motor neurons to maintain posture.
- **The medial vestibulospinal tract :**
  Cells of origin : Medial Vestibular Nucleus
  As its axons descend ipsilaterally in the ventral white column of spinal cord, they form part of the Medial Longitudinal Fasciculus.
  The medial longitudinal fasciculus consists of both ascending & descending fibers that link vestibular nuclei to nuclei supplying the extraocular muscles for coordination of head and eye movements. **It's Imp. to know the medial longitudinal fasciculus, u will go through it in other lectures.**

3- Reticulospinal tracts:

Divisions	Medial reticulospinal tract	Lateral reticulospinal tract
Origin	neurons of the "**pontine** reticular formation"	neurons of the "**Medullary** reticular formation"
Descent to	All levels of the spinal cord	
Termination	On interneurons in the spinal gray matter which **excite** the medially situated Alpha and Gamma MNs innervating the **antigravity muscles**, that is, the muscles of the vertebral column and the extensor muscles of the lower limbs. وش الفايدة قال Medially situated؟ لان اللاتر الي سيتيو اتيد يتحكمون بالاطر اف لكن الميديالي سيتيو اتيد يتحكمون بالبروكسميال مسلس او بالاصح Trunk muscles!	Synapse with interneurons that **inhibit** the Alpha and Gamma MNs of antigravity and extensor muscles , but they facilitate the Alpha and Gamma MNs of flexor muscles.
Functions	Strong **facilitatory** effect on the motor neurons of the **antigravity** and extensor muscles to **support the body posture against gravity.**	**Activate** the **medullary inhibitory system**, which can thus counter-balance the facilitatory effect of the pontine reticular formation on the antigravity muscles.

4- Tectospinal tracts:

Originates in: Superior Colliculus in midbrain then decussate in the dorsal tegmentum.

The course:

Axons descend in ventral white column of spinal cord. → And terminate on Contralateral **cervical** AHCs.

Functions of Tectospinal Tracts:

This tract produces reflex turning of the head and neck (in response to visual and auditory stimuli)toward the direction of the stimulus. VISUAL THREAT.

5- Olivospinal tracts:

Originates in Inferior Olivary Nucleus of the medulla is found only in the **cervical** region of the spinal cord.

Functions of Olivospinal tracts:

is uncertain; but thought to facilitate muscle tone.

IN A NUTSHELL
(Very imp. To know)

- The tracts that makes you stand up (**Extension**) and they are UNCROSSED fibers:
  1- Vestibulospinal tract.
  2- Medial reticulospinal tract.
- The tracts that make you sit down (**Flexion**)
  1- Rubrospinal tract.
  2- Lateral reticulospinal tract.

Good luck!