

PHYSIOLOGY OF BRAINSTEM

Objectives:

- ❖ **Components** of Brain stem.
- ❖ Important structures in brain stem.
- ❖ **Functions** of the Brain Stem.
- ❖ **Signs & Symptoms** of brain stem lesion.
- ❖ Brain stem function tests.

Done by:

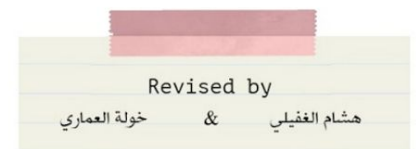
- **Team leader:** Malak AlHamdi - Shahad AlEnezi - Rawaf AlRawaf - Omar AlOtaibi
- **Team members:** Raghad AlMansour - Norah AlRomaih - Bedoor Julaidan - Monirah Alsalouli - Abdullah Aldhibaib.

Edited & Revised by: Malak AlHamdi - Shahad AlEnezi.

WE STRONGLY ADVISE YOU TO STUDY THE ANATOMY LECTURE FIRST.

★ References:

- 435 girls and boys slides and notes.



Color index: Important - Further explanation - Doctors Notes - Numbers.

* This lecture is so important in the USMLE exam especially the lesions part.

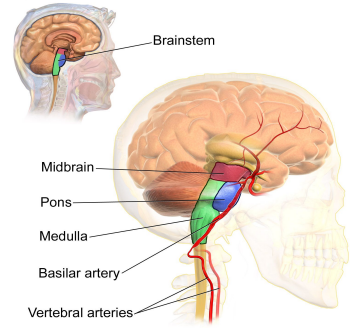
** we advise you to study the anatomy of brainstem, the ascending and descending tracts before studying this lecture.

*Please check out [this link](#) before viewing the file to know if there are any additions or changes.

The Brainstem

❖ Definition:

- The brainstem is the **lower** part of the brain, adjoining and structurally continuous with the **spinal cord**. (lies in the basilar part of the occipital bone).
- The **midbrain**, **pons** and **medulla** connect to the cerebellum via the superior, middle and inferior peduncles respectively.



Components of the Brainstem

❖ Midbrain:

- The **cerebral aqueduct** runs through the midbrain, beneath the colliculi.
- The midbrain is divided into **three** parts:

1. The Tectum¹(the posterior part) includes: (the colliculi)

The superior colliculus:	The inferior colliculus:
involved in the special sense of vision (visual reflexes).	It is involved in the special sense of hearing (auditory reflexes) example: turning the head towards the source of sound.
Sends its superior brachium to the lateral geniculate body of the thalamus .	Sends its inferior brachium to the medial geniculate body of the thalamus .

2. The Tegmentum(the middle) :

- **Ventral** to the cerebral aqueduct.
- Several nuclei, tracts and the **reticular formation** is contained here.

3. Cerebral Peduncles (crus cerebri):

- The ventral side is comprised of paired Cerebral Peduncles.
- These transmit axons of **UMN (Upper Motor Neuron)**.

¹ "roof" in latin

- (cerebral NOT Cerebellar, don't confuse between the two terms. CerebeLLar peduncles connect the brainstem to the cerebellum)

● Midbrain internal structures:

1. Periaqueductal Gray:

- Located around the cerebral aqueduct, contains neurons involved in **analgesia** and **pain desensitization**.

2. Oculomotor Nerve (CN² III) nucleus.

3. Trochlear Nerve (CN IV) nucleus.

4. Red Nucleus:

- This is a **motor nucleus** that sends a **descending tract (Rubrospinal tract)** to the lower motor neurons.

5. Substantia Nigra:

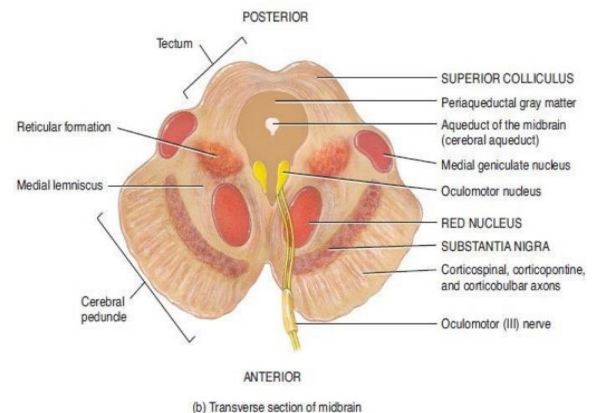
- This is a concentration of neurons in the ventral portion of the midbrain that is involved in **motor function**. It is a part of the basal ganglia.
- They **secrete dopamine**.
- Degeneration of Substantia Nigra is **associated with Parkinson's disease**. (nigra means black and it is black due to melanin pigments)

6. Central Tegmental Tract:

- Directly **anterior** to the floor of the **4th ventricle**, this is a pathway by which many tracts project up to the **cortex** and down to the spinal cord.

7. Reticular Formation:

- A large area that is involved in various **important functions of the midbrain**:
 - It contains **LMN**(Lower Motor Neuron).
 - It is involved in the **pain desensitization** pathway. (like periaqueductal gray)
 - It is involved in the arousal and consciousness systems (fatigue = sleep).



- It contains the *locus ceruleus*, which is involved in intensive alertness modulation and in **autonomic** reflexes.

❖ **Pons:**

- At the level of the mid pons (middle of the ventrolateral aspect), the large trigeminal nerve (**CN V**) emerges.
- Between the basal pons, **cranial nerve 6 (abducens)**, **7 (facial)** & **8 (vestibulocochlear)** emerge (medial to lateral).

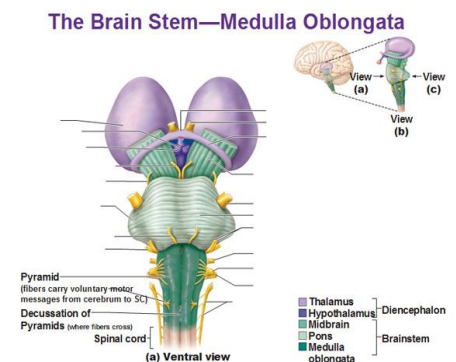
❖ **Medulla Oblongata:**

❖ **Ventral view:**

- The most medial part of the medulla is the **anterior median fissure**.
- Moving laterally on each side are the **pyramids**. They contain the fibers of the **corticospinal** (pyramidal) tract as they head inferiorly to synapse with lower motor neuronal cell bodies within the ventral horn of the spinal cord.
- The **anterolateral sulcus** is lateral to the pyramids.
- Emerging from the **anterolateral sulci** are the hypoglossal nerve (**CN XII**) rootlets.
- Lateral to these rootlets and the anterolateral sulci are the **olives**. They are swellings in the medulla containing underlying **inferior olivary nuclei** (containing various nuclei and **afferent fibers**).
- Lateral (and dorsal) to the olives are the rootlets for glossopharyngeal (**IX**) & vagus (**X**) cranial nerves.

❖ **Dorsal view:**

- The most medial part of the medulla is the **posterior median fissure**.
- Moving laterally on each side is the **fasciculus gracilis**.



- Lateral to that is the **fasciculus cuneatus**.
- Superior to each of these, are the **gracile** and **cuneate tubercles**, respectively. Underlying these are their **respective nuclei**.
- In the midline is the **vagal trigone** and superior to that is the **hypoglossal trigone**. Underlying each of these are **motor nuclei** for the respective cranial nerves.

 [Brain stem](#) (khan academy / Duration:8:01 Min)

Functions of the Brainstem

1. Conduct functions.

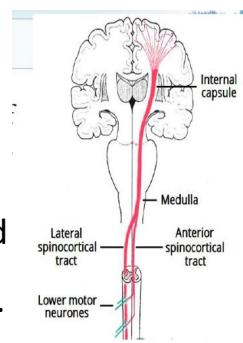
- All information related from the body to the cerebrum and cerebellum and vice versa, must traverse the **brain stem**.

a) The ascending sensory pathways coming from the **body** to the **brain** includes:

The spinothalamic tract	for pain and temperature sensation.
The dorsal column(fasciculus gracilis,fasciculus cuneatus)	for touch, proprioceptive and pressure sensation

b) Descending tracts

- **The corticospinal tract (UMN)**: runs through the **crus cerebri**³, the basal part of the **pons** and the **medullary pyramids**; **70-90 %** of fibers cross in the pyramidal decussation to form the **lateral corticospinal tract**, destined to synapse on **lower motor neurons** in the **ventral horn** of the spinal cord.
- **Upper motor neurons** that originate in the **brainstem** from:



1. Vestibular nucleus 2. Red nucleus 3. Reticular nuclei, which also descend and synapse in the spinal cord.

2. Provides the origin of the cranial nerves (CN III-XII).

- The brain stem provides the **main motor and sensory** innervation to the **face** and **neck** via the cranial nerves (CN III-XII).

³ anterior portion of the cerebral peduncle which contains the motor tracts

- The fibers of cranial nerve nuclei either originating from, or terminating in, the cranial nerve nuclei in brainstem. **Except** for **olfactory & optic** nerves which are in the cerebral hemispheres.

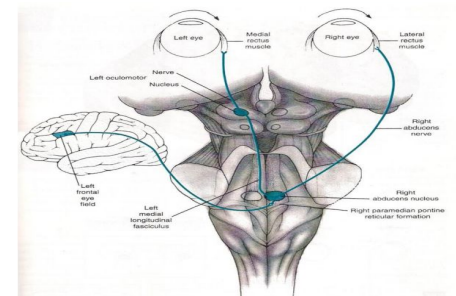
3. Conjugate eye movement. الدكتورة طولت بشرح النقطة هذي

- (refers to motor coordination of the eyes that allows for **bilateral fixation on a single object**)



[USMLE Tutorial - Conjugate Gaze Explained](#) (Duration:7:51 Min) very helpful video!

- **The frontal eye field (FEF)** projects to the opposite side at the midbrain-pontine junction, and then innervates the paramedian pontine reticular formation (PPRF) (the right frontal eye field will go to the left paramedian pontine reticular formation and vice versa) . From there, projections directly innervate the lateral rectus (**contralateral to FEF**) and the medial rectus muscle (**ipsilateral to FEF**). (it means that it will innervate the lateral rectus muscle from the same side, and the medial rectus muscle from the opposite side)
- **The left FEF** command to trigger a saccade culminates in conjugate eye movements to the right.

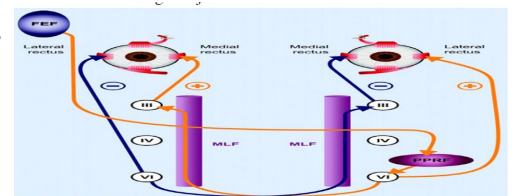


❖ Horizontal conjugate gaze is controlled by :

- Nuclei of **3rd** and **6th** Cranial nerves.
- Paramedian Pontine Reticular Formation.
- Nucleus prepositus hypoglossi-medial vestibular nucleus.

❖ Vertical conjugate gaze is controlled by:

- Nuclei of **3rd** and **4th** Cranial nerves.



4. Integrative functions.

- It controls **consciousness & sleep cycle** (alertness and arousal) through **reticular formation**.

- It has got center for **cardiovascular (M.O), respiratory (M.O and Pons) & autonomic** nervous system.
- It has centers for **cough, gag, swallow, and vomit.** أيش الفرق؟ القاق هي ردة الفعل قبل الاستقراغ ومو شرط يجي بعدها استقراغ فعلي، مثل لما الدكتور يشوف الحلق، أما الفوميت هو تفريغ محتويات المعدة
- Sense of **body balance** (Vestibular functions) .
- **Substantia Nigra** which is a part of the **basal ganglia** is involved in control of **movement**.
- Midbrain also contain **red nucleus** which regulate the **motor activity** through cerebellum.
- **Pain sensitivity control:** Periaqueductal grey matter of mesencephalon is an area which is rich in endogenous **opioid** and is important in modulation of painful stimuli

Functional Organization and Lesions of the Brain Stem

- **Ventral layer** of brainstem is **motor** in function. (contains the motor tracts).
- **Middle layer** is **sensory** in function & contains **medial lemniscus** which conveys sensory information from dorsal column. (internal arcuate fibers continue and ascend as medial lemniscus)

Function of Midbrain	<ul style="list-style-type: none"> • Nerve pathway to cerebral hemispheres. • Auditory and Visual reflex centers. 	
Cranial Nerves	CN III - Oculomotor [motor] .	(Eye Movement) . Moves the eyes. constricts the pupils, accommodates.
	CN IV - Trochlear [motor] .	(Eye Movement) Superior oblique muscle of the eye which rotates (moves) the eye down and out.
Signs and symptoms of midbrain lesions	→ CN (Cranial Nerve) Deficits: <ul style="list-style-type: none"> ◆ Ipsilateral⁴ palsy⁵ and ptosis⁶ (drooping) to the CN III, CN IV. 	

⁴ belonging to or occurring on the same side of the body.

⁵ paralysis

⁶ drooping of the upper eyelid due to paralysis or disease

	<p>→ Pupils:</p> <ul style="list-style-type: none"> ◆ Size: Midposition to dilated⁷. ◆ Reactivity: Sluggish⁸ to fixed⁹. (How to examine? by pointing a light to the pupils and see if it is going to constrict or not) <p>→ Movement: Abnormal extensor.</p> <ul style="list-style-type: none"> ● Respiratory: Hyperventilating. ● Loss of consciousness (LOC): Varies
--	---

Function of Pons:	<ul style="list-style-type: none"> ● Respiratory Center. 	
Cranial Nerves (in Pons we have 5th, 6th, 7th, 8th nerves)	CN V - Trigeminal [motor and sensory].	(Skin of face, tongue, teeth) (muscle of mastication) . Chews and feels front of the head.
	CN VI - Abducens. [motor] .	Lateral rectus muscle of eye which rotates (moves) eye outward .
	CN VII - Facial [motor and sensory]	(Muscles of expression) . Moves the face, Tasting, Salivation, Crying (lacrima) . ANS functions .
	CN VIII - Acoustic [sensory] .	(Hearing) Hears, regulates balance . Purely sensory
Signs and symptoms of pons lesions	<p>→ CN Deficits:</p> <ul style="list-style-type: none"> ◆ CN V, CN VI, CN VII, CN VIII. <p>→ Pupils size:</p> <ul style="list-style-type: none"> ◆ Pinpoint (constricted and small) <p>→ Movement:</p> <ul style="list-style-type: none"> ◆ Abnormal extensor. <p>→ Respiratory:</p> <ul style="list-style-type: none"> ◆ Apneustic (Abnormal respiration marked by sustained inhalation). ◆ Hyperventilation. <p>→ Loss of consciousness (LOC):</p> <ul style="list-style-type: none"> ◆ Semi-coma. 	

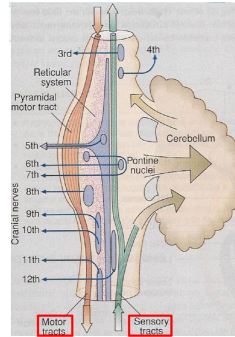
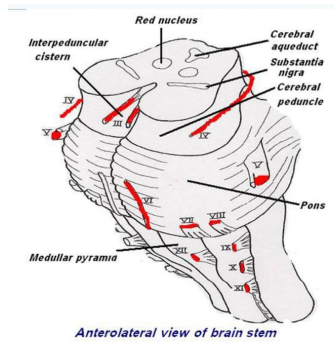
⁷ Mydriasis

⁸ Slow-moving or weak response

⁹ No response

Function of Medulla	<ul style="list-style-type: none"> ● Crossing of motor tracts. ● Cardiac Center. ● Respiratory Center. ● Vasomotor Center (nerves having muscular control of the blood vessel walls) ● Centers for cough, gag, swallow, and vomit. 	
Cranial Nerves (in MO we have 9th, 10th, 11th, 12th nerves)	CN IX - Glossopharyngeal [mixed]	(Muscles & mucous membranes of pharynx, the constricted openings from the mouth & the oropharynx and the posterior third of tongue). Tastes, salivates, swallows, monitors carotid body and aortic sinus .
	CN X - Vagus [mixed].	(Pharynx, larynx, heart, lungs, stomach). Tastes, swallows, lifts palate (soft palate) , talks , communication to and from thoracoabdominal viscera.
	CN XI - Accessory [motor]	(Rotation of the head and shoulder) . (supplies sternocleidomastoid and trapezius muscles)
	CN XII - Hypoglossal [motor] .	Moves Intrinsic muscles of the tongue .
Signs and symptoms of medulla lesions	<ul style="list-style-type: none"> → CN Palsies: <ul style="list-style-type: none"> ◆ Inability to control movement. Absent cough, gag. → Pupils: <ul style="list-style-type: none"> ◆ Size: Dilated. ◆ Reactivity: Fixed. → Movement: <u>Ipsilateral</u> paralysis. because of the nerve crossing, if the lesion is under the crossing then it's contralateral. → Respiratory: Abnormal breathing patterns. → LOC: Comatose. 	

Sensory (1,2,8)	Motor (3,4,6,11,12)	Mixed (5,7,9,10)
CN I, CN II, CN VIII	CN III, CN IV, CN VI, CN XI, CN XII	CN V, CN VII, CN IX, CN X



Brain stem function tests

To Test For:	Look for\ Ask about:
Reticular Formation	Alertness, Consciousness & Sleep كيف نعرف؟ اما نسأل المريض عن نمط نومه وإذا كان المريض بغيوبه نحاول نسأله بشأن نشوف مقدار انتباهه
Corticospinal Tract	Motor power, reflexes
Pain Response	Facial grimacing on firm pressure over the supraorbital ridge اضغط ع المنطقة واشوف تعابير وجهه اذا بدأت تتغير نتيجة الالم
Respiratory Centre	look for the normal pattern of respiration, whether he has hypo or hyperventilation
Cardiovascular Centre	Look for normal circulatory function
Brainstem Reflexes	<ul style="list-style-type: none"> ● Pupillary and corneal reflexes. (Corneal reflex: by touching the cornea by a small wisp of cotton “just like what we did in the clinical skills sessions”. Pupillary reflex: by applying light and seeing the pupil reaction) ● Vestibulo-ocular reflex: Injection of iced water into the ear will produce eyes movement. If no eye movement → Brain Stem death\injury. ● Gag reflex.: (Absent in brain death) ● Cough reflex: (Absent in brain death) ● Oculo-cephalic reflex: Eyes rotate to the opposite side to the direction of head rotation <ul style="list-style-type: none"> - Rapidly turn the head 90° on both sides - Normal response = deviation of the eyes to the opposite side of head turning - Brain death = oculocephalic reflexes are absent (no Doll's eyes) = no eye movement in response to head movement