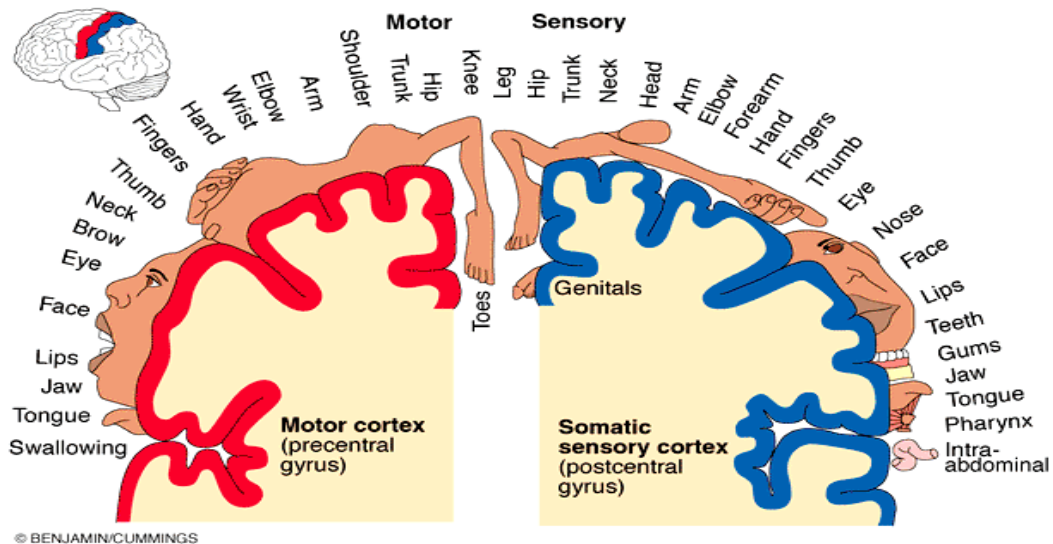




- Motor and sensory somatotopy:

- **Pre-central gyrus:** is the motor area.
  - **Post-central gyrus:** is the sensory area.
- Somatotopy: there is a map of the body in each of these areas. Each part of these areas is corresponding to a specific part of the body (see the image below).



- Cerebellar lesions:

- **There is no paralysis (Why?)** → because the motor system (corticospinal tract) is not affected.
- **There is no sensory loss (Why?)** → because the cerebellum is not involved in transmitting sensations.
- **These lesions will produce ipsilateral effect.** The dorsal spinocerebellar tract is reaching the cerebellum without crossing. Ventral spinocerebellar tract will cross at the level of entry to the spinal cord but it will recross again within the cerebellum (converting back to ipsilateral).
- **There is hypotonia (decrease in muscle tone)** → because the cerebellum is involved in producing balance and maintaining posture through production of muscle tone.
- **Vestibular effects (vomiting, nausea, unsteadiness and nystagmus):** the 8<sup>th</sup> cranial nerve is projecting from the vestibular system in inner ear → passing to vestibular nucleus (in medulla) → and then to cerebellum → aiding in maintenance of balance.
- **Incoordination of movements known as ataxia:**
  - ✓ Truncal ataxia: tested by tandem gait.
  - ✓ Appendicular ataxia: tested by finger-nose test.
- **Intention tremor.** Not that there are 2 types of tremor:
  - ✓ Resting tremor: occurring with lesions in extrapyramidal tracts or basal ganglia (Parkinson's disease).
  - ✓ Intention tremor (which is happening during movement): occurring with lesion to the cerebellum.
- **Dysmetria:** it is described as an inability to judge distance or scale so there will be lack of coordination of movement typified by the undershoot or overshoot of intended position with the hand, arm, leg or eye.
- **Dysarthria:** condition in which problems effectively occur with the muscles that help produce speech, often making it very difficult to pronounce words.
- **Tendon reflexes may be pendular (متدلي)** due to hypotonia or they might not be affected.



- A lesion in the medial part of the cerebellum (vermis or fluculonpodular lobe → producing axial/trunkal ataxia.
- A lesion in the lateral part of the cerebellum (lateral to vermis) → producing appendicular ataxia (incoordination of fine movements mediated by the limbs).
- **Dysdiadochokinesia**: difficulty in performing rapid alternating movements (supination/pronation).

- Origin of cranial nerves (2,2,4,4):

- 2: in the cerebrum → olfactory and optic nerves.
- 2: in the midbrain → oculomotor and trochlear nerves.
- 4: in the pons → trigeminal, abducens, facial and vestibulocochlear nerves.
- 4: in the medulla → glossopharyngeal, vagus, accessory and hypoglossal nerves.

- There can be lateral medullary/pontine syndrome or medial medullary/pontine syndrome depending on different blood supply of medial and lateral parts of either pons or medulla.

- If the following cranial nerves are affected:

- 3<sup>rd</sup> CN: oculomotor.
- 6<sup>th</sup> CN: abducens.
- 12<sup>th</sup> CN: hypoglossal.

**This indicates medial syndrome. If other cranial nerves are affected this indicates the presence of lateral syndrome.**

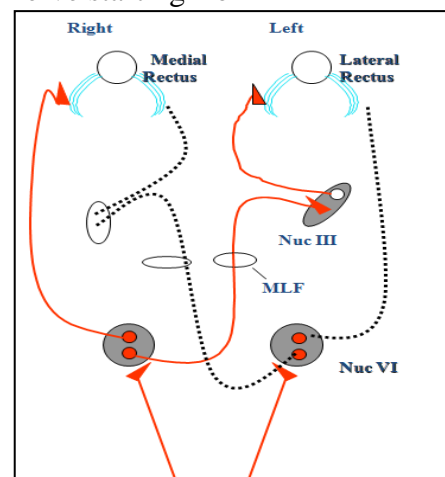
- Which cranial nerves are sensory and which of them are motor in function?

- Memorize: **Some Say Marry Money But My Brother Says Bad Business Marrying Money**:

- ✓ Each word in this sentence is corresponding to a cranial nerve starting from 1<sup>st</sup> cranial nerve and so on..
- ✓ S: sensory – M: motor – B: both.

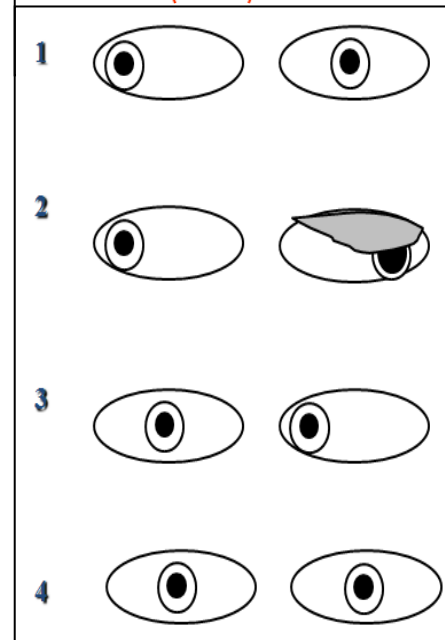
- Voluntary gaze shift:

- **When you ask a person to look to the right side** → the left frontal eye field will be responsible for this movement/action:
  - ✓ Input will pass from left frontal eye field to right paramedian pontine reticular formation → then to the nucleus of 6<sup>th</sup> cranial nerve in the right side → causing contraction of lateral rectus muscle of the right eye.
  - ✓ The nucleus of the 6<sup>th</sup> cranial nerve in the right side will also send a branch which will travel through medial longitudinal fasciculus → to reach the nucleus of the 3<sup>rd</sup> cranial nerve at the left side → causing contraction of medial rectus muscle of the left eye.



- Lesions causing abnormal movement of the eye:

- If you ask the patient to look to the right side → and you notice that his **right eye is moving but the left eye does not** → this indicates that the lesion is in the medial longitudinal fasciculus (fibers coming from nucleus of 6<sup>th</sup> cranial nerve at the right side are not reaching the nucleus of the 3<sup>rd</sup> cranial nerve at the left side).
- If you ask the patient to look to the right side → and you notice that the **right eye is moving but the left eye does not**, has ptosis and dilation of the pupil → this indicates that the lesion is in the nucleus of the 3<sup>rd</sup> cranial nerve at the left side.
- If you ask the patient to look to the right side → and you notice that his **right eye does not move while the left eye is moving** → this indicates that the lesion is in the abducens





- nerve fiber going to lateral rectus muscle of the right eye (not in the nucleus of the 6<sup>th</sup> cranial nerve).
- If you ask the patient to look to the right side → and you notice that **both eyes are not moving** → this indicates that there is a lesion in the right paramedian pontine reticular formation.
- **Types of stroke:**
- **Primary hemorrhage (15% of cases): this is further classified to:**
    - ✓ Intracerebral hemorrhage.
    - ✓ Or subarachnoid hemorrhage.If the patient has this type of stroke:
    - ❖ He will be presented with history of hypertension or fight!
    - ❖ Clinical manifestations: vomiting and headache.
    - ❖ Treatment: anti-hypertensive drugs (example: thiazide diuretics + ACE inhibitors).
  - **Ischemic (85% of cases): this is further classified to:**
    - ✓ Atherosclerotic disease: 20%
    - ✓ Cardioembolism: 20%
    - ✓ Lacunar: 25%
    - ✓ Other/unknown: 35%Patient with ischemic stroke will be treated mainly with thrombolytics and statins.
- **If a patient is presented with hemiplegia of right side of the body** → this indicates that the lesion is in the left corticospinal tract (it is a medial syndrome). There will be sensory loss at contralateral side (in medial syndrome).
- **Medial syndrome: affecting the pyramidal tract and medial lemniscus.**
- **Corticospinal tract:** is considered as the upper motor neuron (UMN) for spinal nerves.
- **Corticobulbar tract:** is considered as the upper motor neuron (UMN) for cranial nerves.
- **The corticobulbar tract going to nuclei of 3<sup>rd</sup>, 4<sup>th</sup> and 6<sup>th</sup> cranial nerves is controlling the eye → bilaterally.**
- **If a patient is presented with an eye going medially** → this indicates a lower motor neuron lesion of the 6<sup>th</sup> cranial nerve (which is present in the medial part of pons). The lesion will be in the same side of the affected eye (ipsilateral).
- **If a patient is presented with an eye going laterally, has ptosis and dilated pupil** → this indicates a lower motor neuron lesion of the 3<sup>rd</sup> cranial nerve (which is present in the medial part of the midbrain). The lesion will be in the same side of the affected eye (ipsilateral).
- **12<sup>th</sup> cranial nerve paralysis:**
- **If you ask the patient to protrude his tongue → and the tongue is deviated to the right side → look to the tongue:**
    - ✓ If there is atrophy and fasciculation → this indicates a lower motor neuron lesion in the right side (same side). You have to expect that the dorsal column will be damaged too.
    - ✓ If there is no atrophy or fasciculation → this indicates an upper motor neuron lesion in the left side (opposite side) above the level of the medulla.
- **In lateral syndrome:**
- There is loss of spinothalamic sensations contralaterally.
  - Lesions in the sympathetic chain (ipsilateral horner's syndrome characterized by: partial ptosis, anhidrosis and constricted pupil).
  - May affect peduncles resulting in ataxia (this condition is resembling an injury/lesion to the cerebellum).
  - **Example: a lesion in the vestibulocochlear nerve will produce lateral syndrome. Remember that medial syndrome is produced only with lesions to the following cranial nerves: 3<sup>rd</sup>, 6<sup>th</sup> and 12<sup>th</sup>.**



- **Weber's syndrome:**
  - Occurring in the midbrain.
  - **Producing:** ipsilateral CN III palsy and contralateral hemiplegia (e.g. if the lesion is in the right side → the right eye is affected and there will be hemiplegia of the left side of the body).
- **Brain death:**
  - There is a lot of evidence proving that many people were diagnosed dead but actually they were not!! Therefore, diagnosis of death is a serious issue and it is difficult especially if you are diagnosing a person who is in coma (respiration is very shallow and heart beats are very slow).
- **Relationship of organ function:**
  - **Heart:** it can beat automatically (with or without commands from the brain!). therefore, heart beat will be present as long as there is oxygen and nutrients.
  - **Breathing:** although breathing is an involuntary process → it will not occur without inputs coming from breathing center which is present in the brainstem and enhanced with PCO<sub>2</sub> level.
  - **Possibilities:**
    - ✓ Patient in coma (concussion):
      - ❖ Cerebrum is normal – brainstem is normal
      - ❖ Breathing spontaneously and heart is beating.
    - ✓ Patient in coma (with cortical death):
      - ❖ Cerebrum is damaged – brainstem is normal
      - ❖ Breathing spontaneously and heart is beating.
      - ❖ If patient wakes up → he will suffer from severe retardation.
    - ✓ Patient in coma (with brain death):
      - ❖ Cerebrum is dead – brainstem is dead
      - ❖ Patient has no spontaneous breathing and his heart will beat only for limited hours → therefore, patient is replaced on a ventilator which will provide oxygen so the heart continues beating.
- **Vegetative state:**
  - It is a disorder in which the patient has severe brain damage and is not responding to environmental stimuli but brainstem function is preserved.
    - ✓ < 4 wks = vegetative state.
    - ✓ > 4wks = persistent vegetative state.
    - ✓ > 1 yr = permanent vegetative state.
- **Criteria to diagnose brain death:**
  - **Coma:**
    - ✓ In which there is no response to painful stimuli which can be tested by:
      - ❖ Applying deep pressure to nail bed.
      - ❖ Or applying pressure to supra-orbital ridge.
  - **Absence of brainstem reflexes (notice that each reflex is indicating which part of the brainstem is damaged):**
    - ✓ papillary light reflex: means that if you illuminate one eye → the pupil will constrict. The pupil of the other eye will constrict too.
      - ❖ How does parasympathetic constriction of eye occur?
        - ✚ When you illuminate the right eye → this is going to be transmitted by the right optic nerve to both Edinger-Wesphal nuclei → activating in turn both oculomotor nerves leading the the direct constriction of the right pupil and indirect constriction of the left pupil.
          - If there is a lesion to the right optic nerve → direct and indirect constriction of pupils will not occur when you illuminate the right eye but if you project the light to



the left eye (where the left optic nerve is intact) constriction of pupils in both eyes will occur.

- If there is a lesion to the right oculomotor nerve → if you shine the light to the right eye there will be no direct constriction of the right pupil but there will be indirect constriction of the left pupil. If you shine the light to the left eye there will be direct constriction of the left pupil but there will be no indirect constriction of the right pupil.

✓ Oculocephalic reflex (Doll's eye):

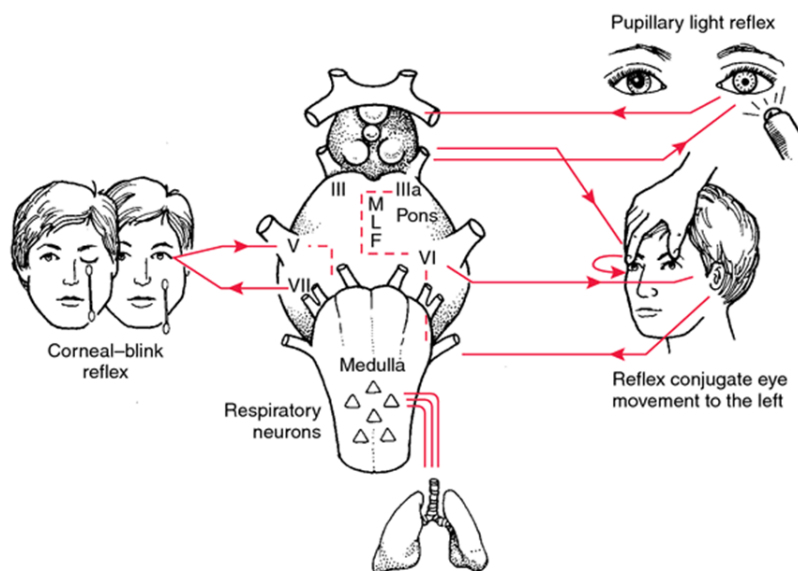
- ❖ If you move the head of a patient who is in coma → the normal response is → that his eyes will move to the opposite side of his head movement at the same velocity (in brain death, there is no eye movement with head movement).
- ❖ Cold calorics: irrigate both tympanic membranes with iced water:
  - ✚ Normal response: eyes will move toward the side where you apply cold water and then return back.
  - ✚ Response of a patient in coma: eye will move toward the side where you apply cold water but they will not return back.
  - ✚ In brain death: there is no eye movement at all.

✓ Corneal reflex:

- ❖ Touching the cornea by cotton-tipped swab → normal response → both eyes will blink.
  - ✚ If there is a lesion to the ophthalmic division of trigeminal sensory nerve → both eyes will not blink.
  - ✚ If there is a lesion to the facial nerve of the right eye or the left eye → there will be no direct closure of the stimulated eye but there will be indirect closure of the other eye.

✓ Gag and cough reflexes are absent in patients with brainstem damage

- ❖ Gag reflex: tested by stimulation of the posterior pharynx using a tongue plate → this will lead to stimulation of both nuclei ambiguus resulting in direct and indirect gag reflex.
- ❖ Cough reflex: it is tested by endotracheal tube.



- Light Ref:** Optic (2) ---- Oculomotor (3)
- Oculocephalic:** Vestibular (8) ---- Extraocular Ms nerves (3,4 and 6)
- VestibuloOcular** (Ocular caloric test): Vestibular (8) ---- 3,4,6<sup>th</sup>
- Corneal ref:** Trigeminal (5) ---- Facial (7)
- Gag Ref :** Glossopharyngeal (IX) ---- Vagus (X)
- Cough Ref:** Vagus ---- Vagus (motor)



- **Apnea: complete cessation of breathing:**
  - ✓ Testing for apnea: administrating 100% oxygen to the patient → removing ventilator → and then measuring PCO<sub>2</sub> in the blood → if it increases → this means that the brain stem is not functioning (brain death).

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### ADDITIONAL INFORMATION

- **It is important to differentiate between medial and lateral medullary syndromes:**
  - **Medial medullary syndrome:** the patient will be presented with hemiplegia, loss of dorsal column sensations (fine touch, vibration, conscious proprioception and 2-point-discrimination). In addition, the following nerve is affected in medial medullary syndrome (12<sup>th</sup>). Notice that the side of the lesion will be opposite to the side of hemiplegia.
  - **Lateral medullary syndrome:** it is involving the spinothalamic tract (so the patient will be presented with loss of pain and temperature sensations). In addition, the spinocerebellar tract or cerebellar peduncles might be affected resulting in incoordination of movement. Notice that if sympathetic chain is affected → this will result in Horner's syndrome which is characterized by:
    - ✓ Ptosis.
    - ✓ Miosis.
    - ✓ Anhidrosis.
  - **Sometimes, the patient might be presented with a combined condition (lateral + medial medullary syndrome):** this is characterized by the presence of hemiplegia, loss of dorsal column sensations, damage to spinocerebellar tract and bulbar palsy.
- **Cerebellar lesions are ipsilateral (in the same side)** → the patient might be presented with dysdiadokinesia, dysmetria, truncal/appendicular ataxia or pendular reflex.
- **In a lesion of corticobulbar tract (upper motor neuron lesion), cranial nerves are not affected except for facial (7<sup>th</sup>) and hypoglossal (12<sup>th</sup>) which are not completely bilaterally innervated.**
- **If a patient is presented to you and he is not paying attention to the surrounding** → he might suffer from hemispatial neglect (a lesion in the parietal lobe).
- **A thrombus in the superior sagittal sinus (which is present in the superior border of falx cerebri and drains cerebrospinal fluid from subarachnoid space) will result in increased intracranial pressure** → resulting in epilepsy, pressure on cranial nerves, convulsions, bradycardia, nystagmus and papilledema.