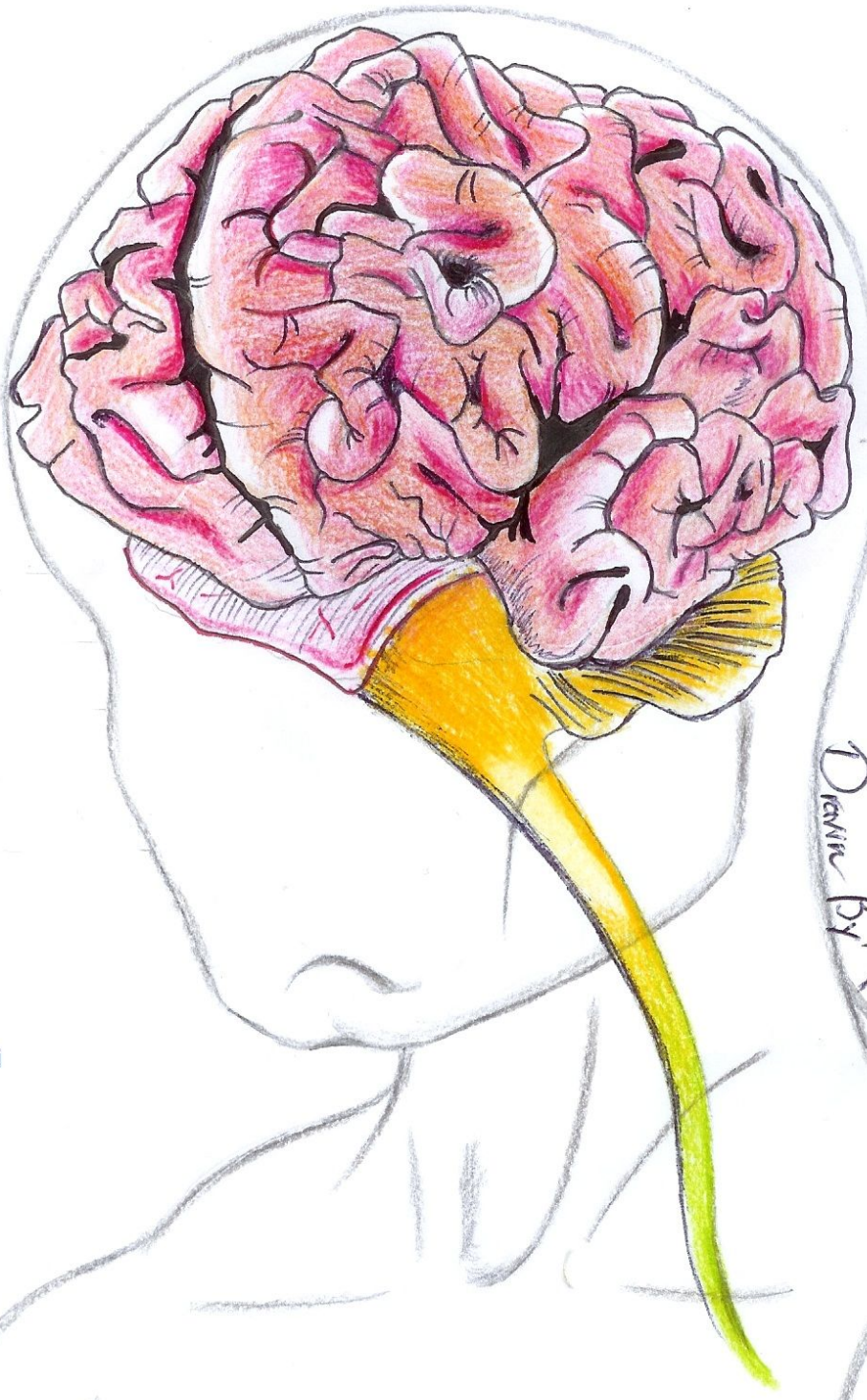
CENTRAL NERVOUS SYSTEM



Drawn By Tariq Bushnaq...

- ○ Handout
- ★ Sheet
- ○ Slide

- ★ Anatomy
- ○ Physiology
- ○ Pathology
- ○ Biochemistry
- ○ Microbiology
- ○ Pharmacology
- ○ PBL

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Lec #: **8**

Neocerebellum (Cerebrocerebellum) :

- It is the part of cerebellum that regulates the movement before it occurs . " planning movement " ..
  - How does Neocerebellum regulate the movement before it occurs ?
    ANS / Neocerebellum influences the association cortex where the commands arise .

INPUT to Cerebro cerebllum : (1;25 – 2;25)

- Neocerebellum receives inputs from wide areas of the cerebral cortex including area 4 , area 6, area (3,1,2,) , area (5,7) and association cortex though the cortico-ponto-cerebellar tract .
- Now in details How the input cerebral cortex reaches the dentate nucleus in the cerebro-cerebellum ?

Look at the figure (1) and see the description below it :-

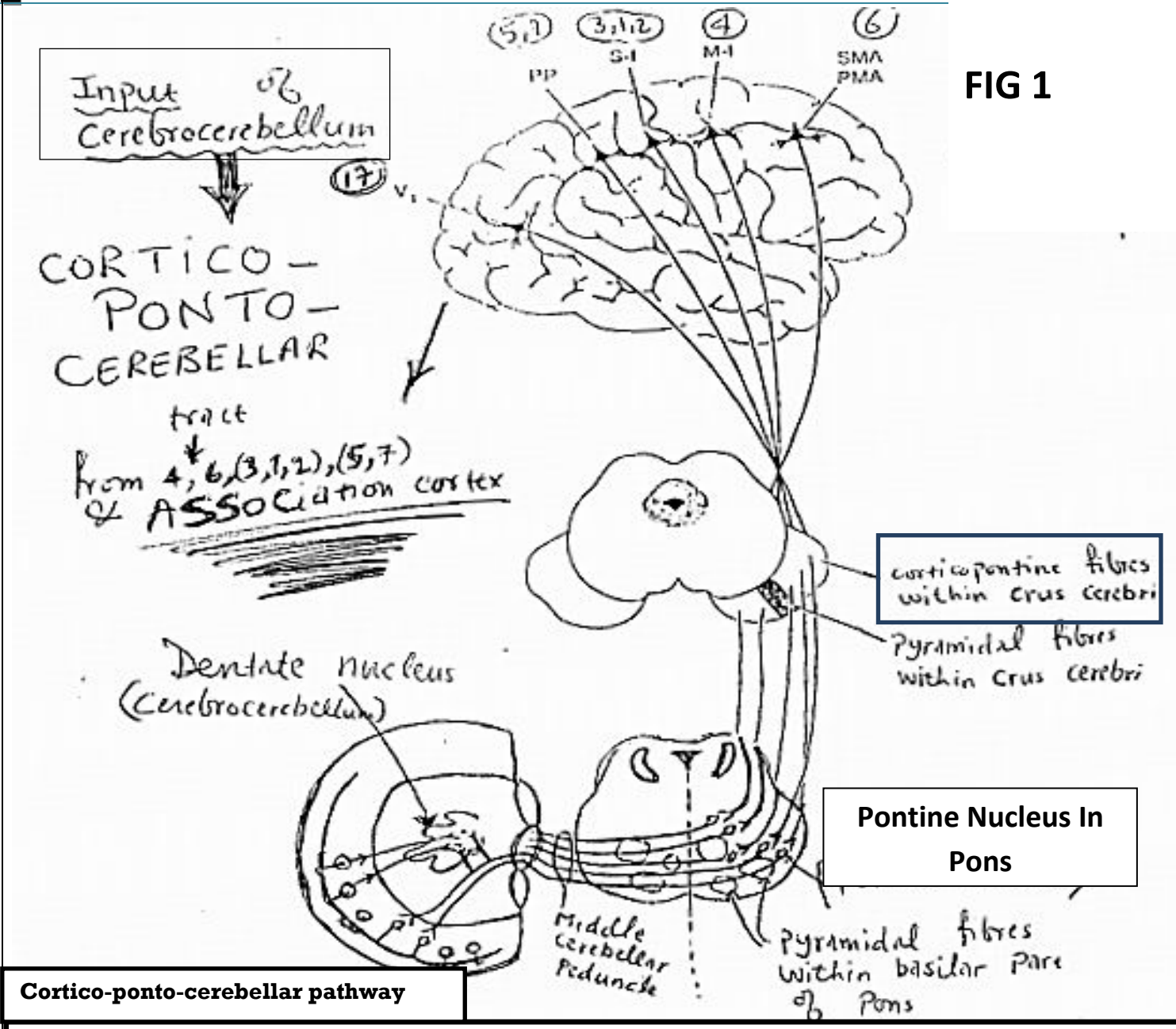


FIG 1

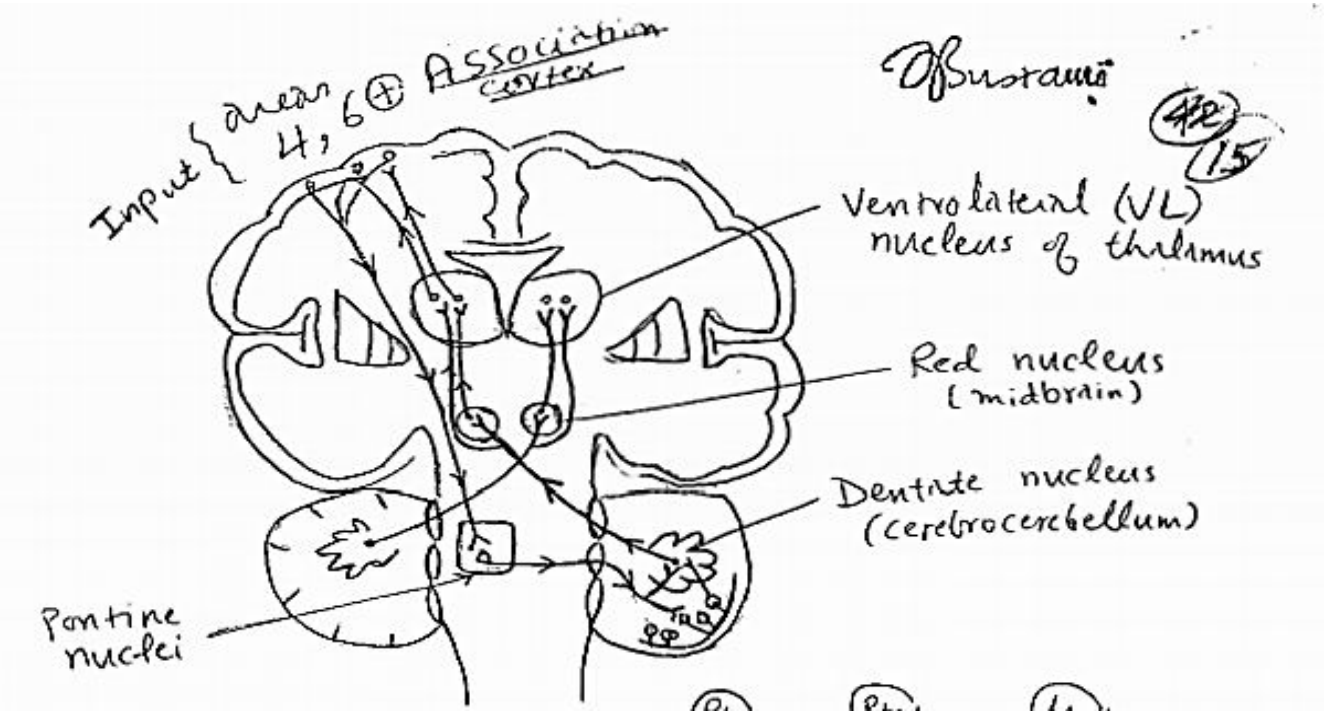
Cortico-ponto-cerebellar pathway

Dr.Faraj <3 : The input from cerebral cortex (from the aforementioned areas) reach the cerebellum by the cortico-ponto-cerebellar tract . The input enters the cerebellum as mossy fibers which synapse with granule cells that eventually synapse with purkinje cells .

From the handout : Input to the cerebrocerebellum from cerebral cortex is carried by corticopontine fibers within crus cerebri to reach the pontine nuclei in the pons . 2- The Axons of pontine nuclei enter the cerebellum and end as mossy fibers ➔Mossy fibers in dentate nucleus synapse with granule cells which in turn synapse with purkinje cells .

Output of the cerebrocerebellum :

The output of cerebrocerebellum follow the Dentato-rubro-thalamo-cortical pathway as shown in the following steps : See figure 2 and look at the description : See figure 2 and look at the



description :

Output from purkinje cells pass into the dentate nucleus in cerebrocerebellum . The output comes out from the dentate nucleus passing through and around the red nucleus and decussate . Fibers carrying the output from the dentate nucleus into the red nucleus will decussate near the superior cerebellar peduncle . Some of these fibers synapse in the red nucleus while other fibers pass around it. Both of these fibers will synapse with " VL " Ventrolateral nucleus of the thalamus . Finally , the output leaves the thalamus to the premotor cortex " area 6 " and primary motor cortex area 4 . any damage to the superior cerebellar peduncle causes worst type of ataxia (will see this later) .

- The output from cerebro-cerebeullum runs within the superior cerebellar peduncle . therefore , any damage in the superior cerebellar peduncle will result in the worst type of ataxia ترنح " الحركة " why ? (3:10 – 4:20)
  - Because The input and output of the cerebrocerebellum allow it to regulate the commands before the occurrence of the commands ". Therefore , it acts as a feed-forward control system . in contrast to spinocerebellum and vestibulocerebellum, they acts as typical feedback control systems .they receive information about actual movement and then regulate it .so, The output from vestibulocerebellum and spinocerebellum regulate actual movement while it is in progress . the Cerebrocerebllum regulates the movement before its occurrence .

Function of cerebrocerebelum (4:34 -5:50) : Regulation of Ballistic movement " skilled movement " . Cerebrocerebellum is responsible for learning and storage the sequential component of skilled movement like playing Piano and typing . in playing piano , there is flexion , extension , adduction and abduction of several muscles . These rapid movements have a sequence . this sequential movement is regulated by the cerebrocerebllum .

Now let's start with clinical aspects related to cerebellum :

Let's start with some important facts before discussing the clinical aspects

- Cerebellum acts as a regulatory system that regulates motor acts initiated by areas outside the cerebellum .
- Lesion in the cerebellum never causes paralysis nor paresis . it causes ataxia which is defined as a disturbance of movement due to loss of synergy .
- the main functions of cerebellum :

A- Synergy , coordination between different muscle groups mainly the agonists and antagonists . " most Important "

B- Maintains the Equilibrium .

C- Plays a role in regulating Muscles tone . How ?
Stretch reflex regulate the muscle tone , an important part of stretch reflex is alpha and gamma motor neurons system , the gamma motor neurons activity is regulated by cerebral cortex via the descending motor pathways , the cerebellum affects the cerebral cortex .thefore , the cerebellum affects the muscle tone . so hypotonia results from a lesion in cerebellum (because cerebellum is not ordering cortex properly)

D- Sending corrective signals (42:58 – 43:19) .
Cerebrocerebellum and spinocerebellum receive input from the cerebral cortex and send output . if the output that is sent from cerebrocerebellum and spinocerebellum failed " not sent " , worst type of ataxia will be developed .

Deficits associated with lesion of the cerebellum can be grouped into 3 main classes :

1-Asynergia " Disturbance of Synergy :

It is loss of coordination between different muscle groups . e.g. loss of coordination between agonists and antagonists .
Synergy : the coordination between different muscle groups
how synergy occurs ?
Ans / at the beginning of the movement , the cerebellum regulates the movement by sending commands to the muscles indirectly through the pyramidal tracts of the cerebral cortex causing excitation of agonist muscles . at the end of the movement , the cerebellum sends commands to the antagonistic muscles through the pyramidal tracts to stop the movement at the desired point by stimulating the antagonist).

2- Disturbance of Tone : (I gonna write what Dr.Faraj said and what's written in the handout :

- **Dr.Faraj** : The Stretch reflex in muscles is responsible for the organizing muscle tone . Alpha and Gamma motor neurons are important components of stretch reflex .The cerebral cortex regulate the activity of gamma motor neurons through the descending pathways How ?
  Answer / The cerebellum sends impulses to the cerebral cortex through the dentate-rubro-thalamo-cortical pathway ➔ it will affect area 4 and area 6 in the cerebral cortex , these areas give rise to the descending pyramidal tracts ➔The pyramidal tract will influence the activity of alpha and gamma motor neurons which will affect the stretch reflex .
- any lesion in the cerebellum will lead to an inappropriate control of alpha and gamma ➔ less effect on alpha and gamma ➔ reduced activity of gamma neurons ➔ less or slow stretch reflex ➔ hypotonia . so , hypotonia is developed when there is absence of feedback control from cerebellum on cortically initiated movement.
- **Handout** : insufficient signals 're sent via the dentate-thalamo-cortical system to the motor cortex resulting in inappropriate control of gamma neurons via the descending motor pathways , this will lead to a deficiency in tonic stretch reflex and causes hypotonia

3- Disturbance of equilibrium :

- It is the inability to maintain upright position without support .by other words , it is inability to stand without support .
- It is caused by a lesion of vestibulocerebellum.

Now let's discuss different kinds of lesions affecting the cerebellum :

1) Lesion of Vestibulocerebellum : (8:10-10:11)

Clinical correlation : The lesion results in :

A- Disequilibrium " loss of equilibrium " :

- Loss of equilibrium : it is the inability to stand without support .
- Vestibulocerebellum mainly regulates the action of the axial muscles , the muscles of vertebral column , which is responsible

for maintaining the upright posture " standing position " . if these axial muscles don't work properly there will be loos of equilibrium.

B- Staggering ataxic gait with a tendency to fall toward the side of the lesion (يميل نحو الناحية المصابة)

C- Nystagmus : it is loss of coordination between extraocular muscles . The eyes move slowly in one direction then moves rapidly in the other direction .

Remember from the last lecture : The output from vestibulocerebellum will be transmitted through the **MLF** to the nucleus of the 3rd, 4th, and 6th cranial nerves and will coordinate the head movement with eye movement. So if there is a lesion or a disease affecting the vetibulocerebellum, the patient will develop nystagmus .

Nystagmus have several causes . we will mention only 2 :

1- Congenital nystagmus : you might have a case of healthy patient with congenital nystagmus. " healthy patient " it is kinda weired :P
2- a disease affecting the vestibulocerebellum.

Lesions of cerebellum ; (

Here there is 2 concepts ; The new concept and the old concept :

The old concept : lesions of the **cerebrocerebllum** " posterior lobe " and the **spinocerebellum** " anterior lobe " mostly have the same signs and symptoms . so it is difficult to differentiate between a lesion affecting the **cerebrocerebllum and lesions affecting the spinocerebellum .**

The New Concept : there are certain signs and symptoms for posterior lobe lesions " Cerebrocerebellum" and certain signs and symptoms for spinocerebellar lesions .

The Doctor takes in consideration the both concepts .

What are the signs of spinocerebellar and cerebrocerebellar injury " lesion ?

1- Cerebellar Ataxia

Ataxia: it is the difficulty in initiation , execution and termination of movement causing clumsy movements .

- The term ataxia is used clinically when there is incoordination of gait " عدم اتزان المشي "

Cerebellar ataxia : The patient staggers because the cerebellum is unable to coordinate the muscles of walking .

2- Dysmetria : it is the inability to arrest muscular movement at a desired point .e.g. if you ask the patient to put the tip of his right index on the tip of his left index , the patient won't be able to do this in a proper time or there will be overshoot or undershoot .

Overshoot ➔ hypermetria . Undershoot ➔ hypometria .

3- Dysdiadochokinesia :it is the inability to perform rapid alternating " successive " movements (e.g., rapid supination and pronation of the hands).

- **Dysmetria and Dysdiadochokinesia** result from absence of proper timing in initiation and termination of movements .
  - Stimulation of antagonist is responsible for **termination** of movement. The **delay in termination** of the movements produced by a **delay in the intervention of the antagonistic muscle to check the movements** and this will results In dysmetria
- A delay in **initiation** of 2 successive movement leads to Dysdiadochokinesia . so,

Delay in termination of 2 successive movements ➔ Dysmetria .

Delay in initiation of 2 successive movements ➔ Dysdiadochokinesia

But both are caused by absence of proper timing .

4- Intension tremor : it occurs during a purposeful movement and it worsen at the end of the movement . It is a result of cerebellar disease .intension tremor is absent during rest .

- Intension tremor mostly is worst when there is a lesion in the superior cerebellar peduncle . why ?

  Superior cerebellar peduncle carries feed-back control from the cerebellum on the cortex , absence of this feed-back control will make the cortex not functioning properly .

- **N.B.** Rest tremor occurs during rest . it is caused by Parkinson disease , a disease in basal ganglia and related nuclei . Intension tremor is caused by a cerebellar disease.
- Intension tremor is caused by absence of the damping function of the cerebellum as we will see later on .

Damping Function of the cerebellum :

Damping function of the cerebellum : (21:20 – 24:57)

- All voluntary movements develops momentum " a force that keep organ moving " " عزم " قوة دافعة, this would cause overshooting of the movement beyond the intended point . To overcome this , the cerebellum limits momentum " extra power " by sending signals to stop the momentum at the desired point How ? Ans / By stimulating antagonist muscles to work at the end of movement . (
- If there is cerebellar damage or disease , there will be no stimulation of antagonist at the end of the movement and overshooting will occur . Now , using your eyes, the cerebral cortex recognizes the error " overshooting " and tries to correct it initiating a movement in the opposite direction .

E.g. A patient with cerebellar damage tries to put his arm on the tip of his nose . There will be overshooting due to the momentum but this overshooting is not regulated due to cerebellar damage . the cerebral cortex tries to correct this overshooting and brings the arm into the opposite direction . now , the patient start the movement again , the arm again overshoots due to its momentum and the correcting signals are again sent from the cortex , this forms back and fro movement which is considered as the basis of the " INTENTION TREMOR .

- **Another Example of intension tremor : tremor** occurs when the patient is trying to drink water ,at the end of this movement , once the cup reaches his mouth, there will be to and fro movement ➔ there is intension tremor .
-

5 th sign of spinocerbellum and cerebrocerebellum injury is hypotonia

Pendular stretch reflex : it is closely related with hypotonia . if you perform knee jerk test for a patient with cerebellar disease by striking the patellar tendon , the leg will move forward due to contraction of quadriceps then the leg will move back and forth like a pendulum due to lack of tone that controls the leg .

The normal response of knee jerk: there will be rapid contraction of quadriceps ➔ the leg will move forward followed by rapid relaxation of the quadriceps muscle.

Pendular reflex and hypotonia are related signs , it is caused by lack of feedback control from cerebellum on cerebral cortex and its pyramidal tracts which lead to decreases activity of gamma motor neuron and thus there will be a decrease in muscle tone

Quick summary for this point: gamma is not working properly, why? Because cortex (pyramidal) is not working properly, why? Because there's no feedback control from cerebellum on cortex (pyramidal).

6- Dysarthria : Difficulty of speech due to absence of coordination between muscles of speech , muscles used in speaking like respiratory muscles , laryngeal muscles and tongue muscles)

- **In dysarthria ,** The speech is slurred and explosive with a telegram – staccato speech (pauses in wrong places كلام متقطع).

Now let's discuss the cerebellar lesion according to the new concept:

1) Anterior lobe syndrome :

- The most common cause is malnutrition accompanying chronic alcoholism . Malnutrition leads to damage purkinje cells of the cerebellum which is considered as the major neuron in the cerebellum .
- The patient suffer from loss of coordination chiefly in **the lower limb** . the patient walks like if he/she is drunk .
- **Heal-shin test** , it is a test used to diagnose anterior lobe syndrome . the patient is asked to pass the heel of one foot slowly down the

shin of the other leg and move it up and down (from the knee to the ankle) . once the patient raise his leg to put his ankle down the shin of the other leg , the raised leg will show clumsy movement to the right and left " ataxia " .

- If there is degenration or damage in cerellum progresses into the posterior lobe the patient will show intension tremor and stacatto speech (late signs) .

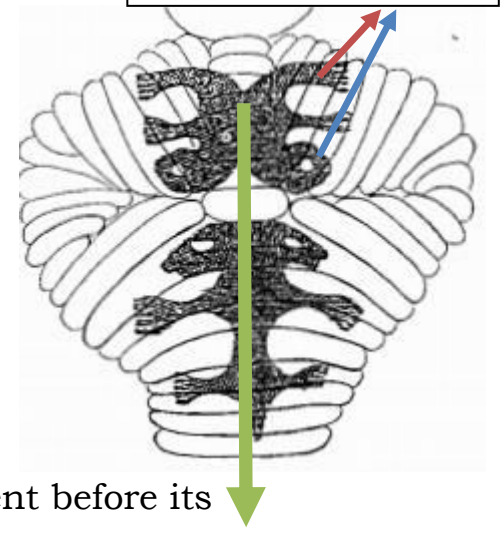
2- Posterior lobe syndrome " Neocerebellar syndrome :

- Commonly caused by CVA (cerbrobrvascualr accident whether it is embolic . thrombotic or hemorrhagic) or caused by tumors , traumas or degenerative disease .
- Mostly manifested as ataxia in **the upper limb** and intention tremor at the **end** of purposeful movement .
- The patient is not able to direct the limb to the target because there is progression of swaying to and fro movement .
- Other late signs of posterior lobe syndrome are : dysmetria , dysdiadochokinesia and speech disturbances .

Representation of the body in the different Parts of the cerebellum : (10:13 -11:26)

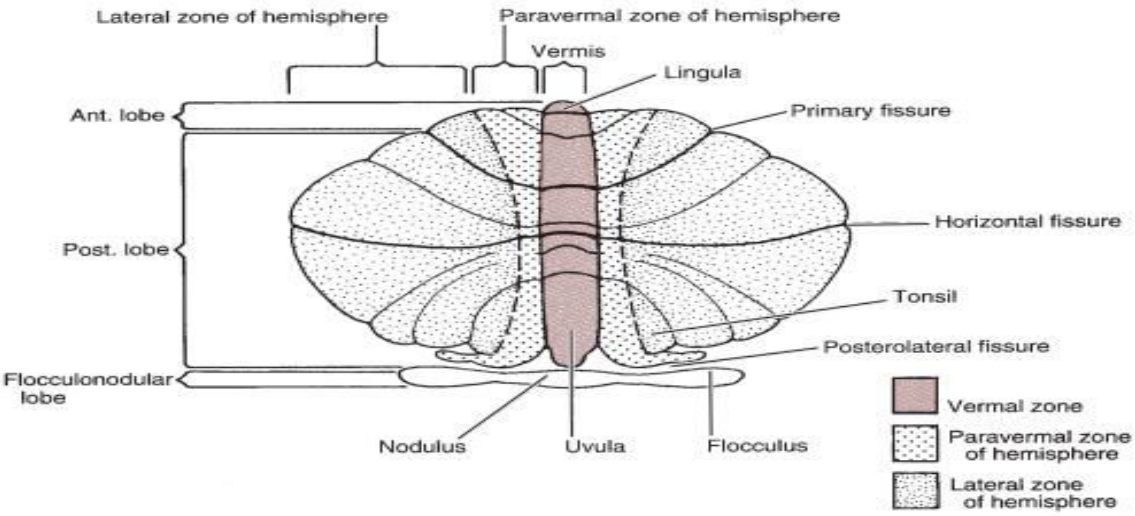
- There are 2 separate representations .in the anterior lobe , the body is represented upside down while it is erect in the posterior lobe .
- The axial muscles are represented In the vermis
- The face and limbs are represented in the paravermis
- The lateral zone of hemisphere " posterior Lobe " has no representation because it doesn't influence actual movement. it influences movement before its occurrence .

The face and limbs are represented in Para vermis



In the vermis , the axial portions of the body are represented

Now you gonna ask yourself how the posterior lobe is not represented and it is written and mentioned in the recording that it is represented in erect or straight way ? I did ask the doctor and he replied " ya ebny , qadeeman konna ne7ky enoo el posterior lobe represented straight or erect . Hall2 mne7ky enno it is not represented. asasan kol el –cerebellum el mfrod not represented as it doesn't give rise to any sensation or movement " silent area " .



The Doctor quickly revised the parts of cerebellum mentioned in the previous lecture and they are show in this figure

TheCerebellum as a silent area : (11:28 -12:44)

- The cerebellum always described as a silent area , stimulation of any part of the cerebellum will not give rise to any sensation or any movement why ?
  - Because the cerebellum doesn't act directly on alpha and gamma even through internurones . The cerebellum sends orders to the cerebral cortex and the cerebral cortex will send the impulses to the alpha and gamma motor neurons ➔ no direct connection between cerebellum with alpha and gamma .
  - In the spinocerbellum , the output is sent to the reticular formation . the reticular formation will send this output to the alpha and gamma neurons .there is no direct connection between cerebellum with alpha and gamma .
  - there is no cerebellospinal tract . if you stimulate cerebellum , you will not get any movement

Medulloblastoma : (12:44 -13:47)

- A type of tumor seen in young children . Medulloblastoma is arising in the roof of the fourth ventricle of the cerebellum , part of the vestibulocerebellum .
- The child affected with medulloblastma Is suffering from ataxia .
- In medulloblastoma, lesion or damage in any part of vestibulocerebellum or part of the vermis will occur. both of them influence the activity of the axial muscles . as long as The child has no control over the axial muscles ➔ the child attempts to walk on a wide base and the truck is constantly reeling and swaying " ترنح " . this is called truncal ataxia .

Ataxia :

it is the difficulty in initiation , execution and termination of movement causing clumsy movements .

- The term ataxia is used clinically when there is incoordination of gait " عدم اتزان المشي ", the posture also is abnormal .

We mentioned 2 types of ataxia :

1- Cerebellar ataxia : mentioned before .
2- Sensory ataxia : it is caused by a lesion affecting the dorsal column of spinal cord “gracile and cuneate, dorsal column medial leminsical system “ or a lesion affecting the dorsal root .
   - The patient with sensory ataxia staggers because he lacks conscious proprioception . what does this mean ?
     Ans /. The patient can’t feel the position of his/her joint .
   - There are 2 types of proprioception :

   A- Unconscious proprioception: when the sense of position reaches the cerebellum and here you can’t feel your position .
   B- conscious proprioception : If the sense of position reaches the thalamus and cortex here we can feel our position .

How can we differentiate between the 2 types of ataxia ?

Ans/ ? by doing Romberg's test .

Romberg's test : To perform Romberg's rest. ask the patient to stand with his or her feet together and assess his or her stability. Next, ask the patient to close his or her eyes

Now the patient of cerebellar ataxia will not fall because the ataxia is the same weather his eyes are opened or closed .

The patient with sensory ataxia : he will fall down once he/she closes his/her eyes because the patient can't receive the position or movement of the joint and compensate that with visual guidance and once the patient close his / her eyes , he / she will fall down .

- Romberg test is highly positive in patients with sensory ataxia and negative in the patient of cerebellar ataxia .

The Doctor revise some important notes :

1- The Dr revised the Functions of the cerebellum , The most important function of the cerebellum is " synergy" , the coordination between different muscle groups like agonists and antagonists and the other important function is sending corrective signals .

2- Posterior lobe doesn't receive input from the muscle spindles . posterior lobe receives input from cerebral cortex and send output to the cerebral cortex . so posterior lobe deals with cerebral cortex exclusively . Remember : posterior lobe " neocerebellum receives input through "**cortico** – ponto- cerebellar " tract and sends output through Dentato-rubro-thalamo-**cortical** tract .

3- regulates the movement before its occurrence . especially skilled component of skilled movement .

4- Spinocerebellum and vestibulocerebellum receive input from the muscles (43:52 –43:58) . spinocerebellum receives 2 inputs , the first input is recieved from muscle spindle and Golgi tendon organ about actual movement . the second input is received from cerebral cortex about intended movement . Now , Spinocerebllum compares

the 2 inputs and if there is a fault in the movement, spinocerebellum will send corrective signals that cross the superior cerebellar peduncle and control rate , range , force and direction .

5- Superior cerebellar peduncle contains output from dentate nucleus that serves the cereebrocerebllum and contains output from interpositus that serves the spinocerbellum . The most common diseases causing interruption of superior cerebellar peduncle is multiple sclerosis . Degeneration of the superior cerebellar peduncle due to multiple sclerosis causes the worst type of ataxia . Infarction of the midbrain that contains the red-nucleus which is included in pathway (Dentato-rubro-thalamo-**cortical** tract) will also cause the worst type of ataxia . (important)

What are the differential diagnosis of the worst type of ataxia " possibilities ?

1- Degeneration of the superior cerebellar peduncle (multiple sclerosis)
2- Infarction of the mid-brain which means degeneration of the red nucleus .
3- Lesion of the cerebrocerebellum or the spinocerebellum ➔ no corrective signals ➔ worst type of ataxia .

- remember , the red nucleus receives input from the cerebral cortex though the cortico-rubro-spinal pathway " extrapyramidal " . it also receives fibers from the cerebellum through dentate-rubro-thalamo-cortical tract " output of cerberocerebellum " and interpositus – rubro-thalamo-cortical tract " output from spinocerebellum into the red nucleus .
- The red nucleus sends output through rubrospinal tract which affects the distal as well as proximal muscles .

The following point is not important but the doctor explain it as there are lot of students ask about it :

- Rubrospinal descends very close with the lateral corticospinal tract and mainly affecting the distal muscles of the limbs and partly affecting the proximal muscles and axial muscles

  how does rubrospinal tract affect the distal muscles of the limbs or even axial muscles ?

  Ans / some fibers project from the red nucleus reaching the reticular formation . Now , from reticular formation the reticulospinal tract araises and it which affects the proximal and distal muscle . it has a twin tract called rubrobulbar
- The vermis of cerebellum controls the movement of neck muscles , trunk muscles and proximal muscles bilaterally (very important) .
- The paravermis and the cerebellar hemisphere influence the activities ipsilaterally
- Each cerebellar hemisphere controls the muscles of the body ipselaterally.
- The right cerebellar hemisphere output " dentate-rubro-thalamo-cortical) will affect the left cerebral cortex

2 decussations are responsible for the fact that each cerebellar hemisphere control the ipsilateral muscles these decussations :

1- Decussation at the superior cerebellar peduncle in the midbrain
2- Decussation of the pyramidal tract in medulla

Basal Ganglia :

- Basal ganglia participates in initiation and control of movement involving axial and proximal muscles that are responsible for posture
- Main action of basal ganglia : setting or keeping the postural background during phasic limb movement . بتخللي الجذع ثابت خلال الحركة السريعة للأطراف Phasic is the opposite of tonic

How does basal ganglia act ?

(Functional organization of the basal ganglia) in the handout

- Basal ganglia exert their motor action through reciprocal connection with cerebral cortex . it doesn't deal with alpha and gamma .
- Part of basal ganglia called " striatum " receives input from the cerebral cortex .
- Basal ganglia output is sent from striatum to the globus Pallidus , globus pallidus sends signal to the thalamus and then to the motot and premotor areas of the cerebral cortex
  Now why we call it reciprocal ?
  Ans / Because it receives input from the cerebral cortex and sends output to the cerebral cortex .

The End

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Past paper questions :

all of the following are positive heel-shin test except :

a- posterior cerebellar lobe <<<

b- walk as if drunk

c- instability of gait d- tremor