CNS

Doctor 2021

Anatomy

Sheet (2)

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As quick recap :

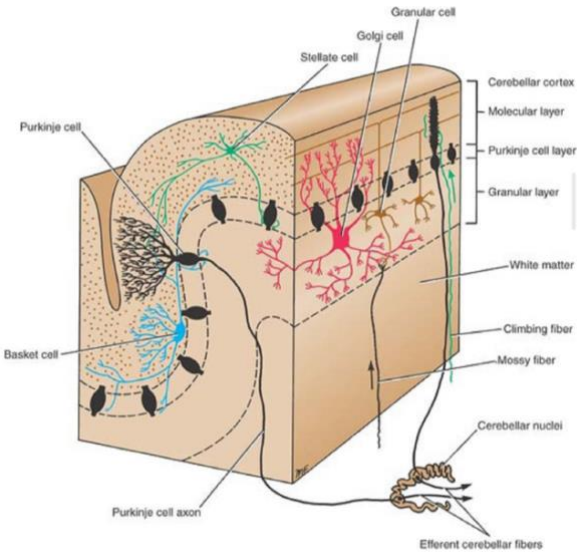
Remember The structure of cerebellar cortex:

1. **molecular layer**

- **stellate cell**
- **basket cell**
- **consisting of axons of granule cells (parallel fibers) and dendrites of Purkinje cells**

2. **Purkinje cell layer large neuronal cell bodies (Purkinje cells) Flask shaped cells**
3. **granular layer**

- **small neurons called granular cells**
- **Golgi cells: (Inhibitory)**



CEREBELLAR CORTICAL MECHANISM

Input to the cerebellar cortex:

1- Climbing fibers: terminal fibers of the olivocerebellar tracts

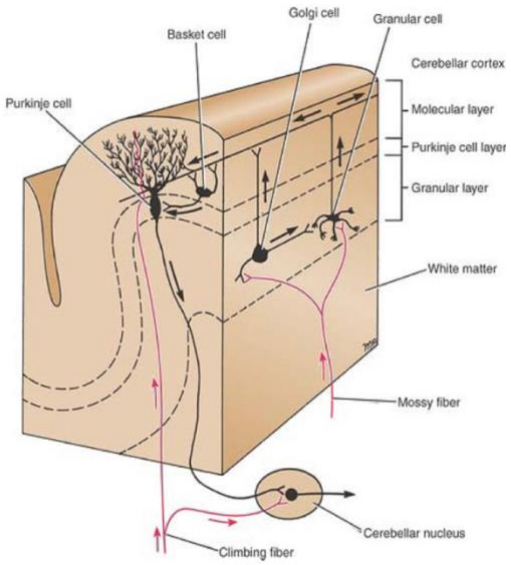
2- Mossy fibers: terminal fibers of all other cerebellar afferent tracts

- **Both are excitatory to purkinje cells.**

Directly: olive—>climbing fibers—>purkinje cells

Indiretly: mossy fibers—>granular cells—>purkinje cells

- **a single purkinje neuron makes synaptic contact with only one climbing fiber**
- **one climbing fiber makes contact with one to ten purkinje neurons**
- **a single mossy fiber may stimulate thousands of purkinje cells through the granule cells**
- **Granule cells receive input from mossy fibers and project to the Purkinje cells**
- **Purkinje Cells - the only output neuron from the cortex utilizes GABA to inhibit neurons in deep cerebellar nuclei**



The journey:

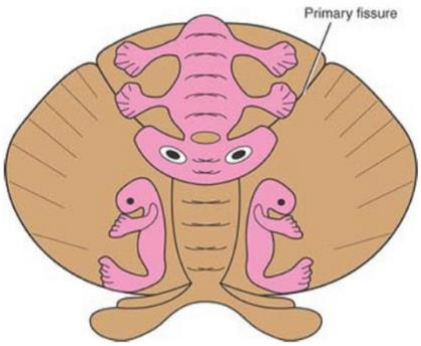
Mossy or climbing fibres will activate both the purkinje cells (located in the outermost layer) and the deep cerebellar nucleus **(excitatory)**—>then purkinje cells will project back inhibitory signals to the deep cerebellar nuclues **(inhibitory)**

The net balance between excitatory input and inhibitory output will produce the fine tuning or coordination to the skeletal muscles movement

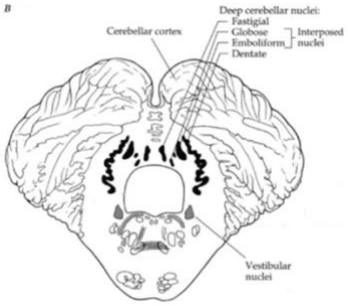
- **Granule Cells- intrinsic cells of cerebellar cortex; use glutamate as an excitatory transmitter; excites Purkinje cells via axonal branches called "parallel fibers"**
- **Basket Cells and stellate cells**(modulatory)**- inhibitory interneuron; utilizes GABA to inhibit Purkinje cells**

CEREBELLUM FUNCTIONAL ANATOMY

Functionally the cerebellum is divided into 3 parts:



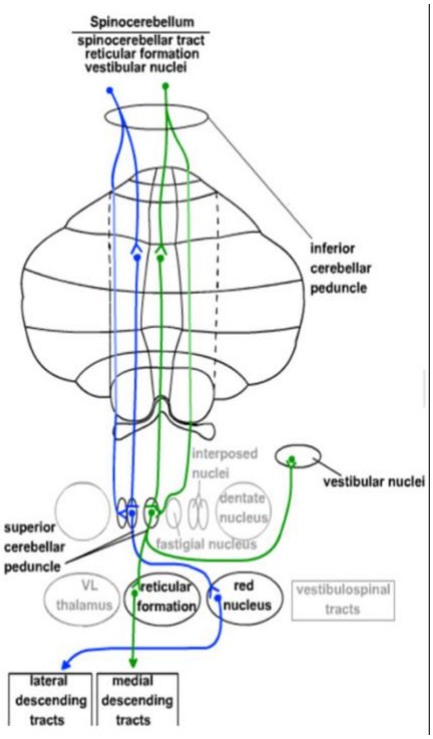
A. **Spinocerebellum**
   - **most of the vermis of the posterior and anterior cerebellum plus the adjacent intermediate zones on both sides of the vermis.**
B. **Cerebrocerebellum**
   - **lateral zones of the cerebellar hemispheres, lateral to the intermediate zones**
C. **Vestibulocerebellum**
   - **small flocculonodular cerebellar lobes and adjacent portions of the vermis**



- Note that each deep cerebellar nuclei projects to its side of cerebellum
  - ➢ So the fastigial nucleus projects to the vermis(at midline)
  - ➢ Globose and emboliform nuclei (interposed nuclei) projects to the intermediate zone
  - ➢ Dentate nucleus (the most lateral one) projects to the lateral hemisphere

SPINOCEREBELLUM

- **comprises the vermis + intermediate hemisphere of the cerebellar cortex, as well as the fastigial and interposed nuclei.**
- **projects through fastigial**(to vermis) **and interposed nuclei**(to intermediate zone)
- **has a somatotropic organization**(homunculus)
- **it receives major inputs from the spinocerebellar tracts.**(The mossy fibres entering mainly through inferior cerebellar peduncle)

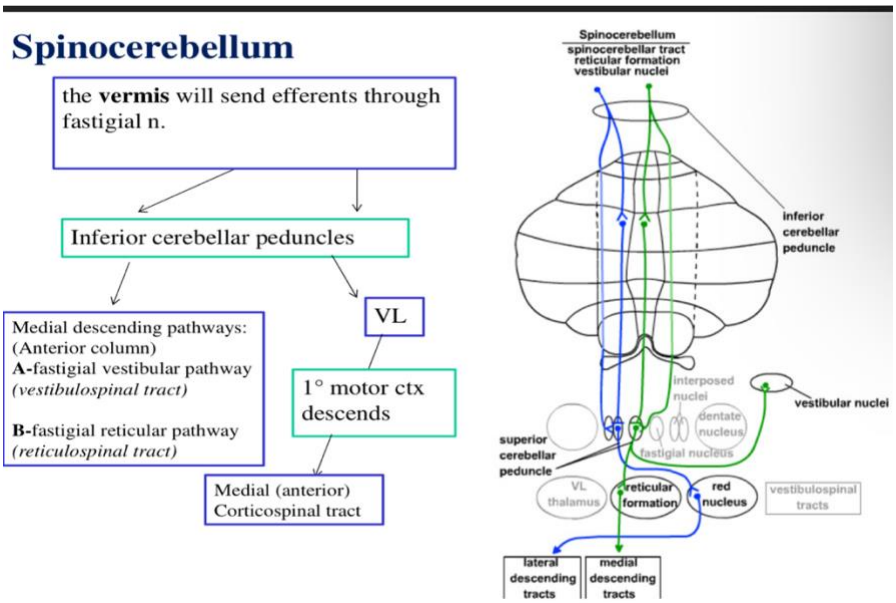


- **Its output projects to rubrospinal, vestibulospinal, and reticulospinal tracts**
- **It is involved in the integration of sensory input with motor commands to produce adaptive motor coordination**
- **controls posture and movement of trunk and limbs.**
- We will divide spinocerebellum into 2 parts

1-one related to axial muscles(medial descending tract)

2-the other related to distal muscles(lateral descending tract)

1. **medial motor system (related to vermis and fastigial nuclues)**



- Axial muscles fibres will enter the vermis in cerebellum cortex through inferior cerebellar peduncle—>activating the fastigial nuclues and purkinje cells**(excitatory)—>** the purkinje cells will send efferent fibres back to fastigial nucleus(**inhibitory)—>** then their are 2 paths:

A. First path (through extrapyramidal tracts)

- Fastigial vestibular pathway (vetibulospinal tract)
- Fastigial reticular pathway(pontine-reticulospinal)

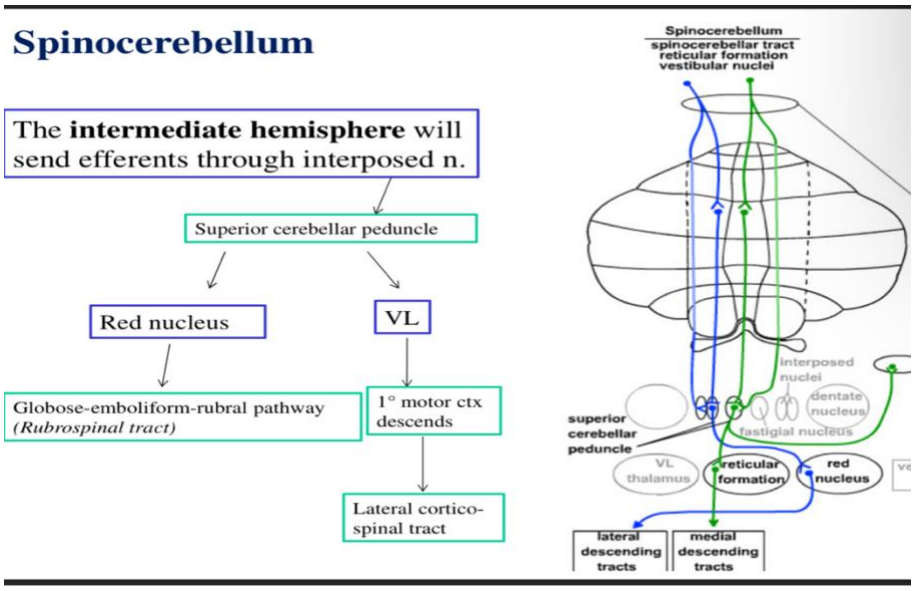
B. second path (through pyramidal tract)

- Reaching the VL (one of thalamic nuclei) remember that the thalamus is the cerebrum secretary, so usually nothing reaches the cerebrum without going through the thalamus first—>primary motor cortex —>anterior corticospinal tract

- If you notice collectively: The part of spinocerebellum tract going through vermis and fastigial nucleus(both near the midline)—> will control the muscles near the midline(axial muscles)

- Lets see the other part of spinocerebellum

2. **lateral motor system (related to Intermediate hemisphere and interposed nuclei):**

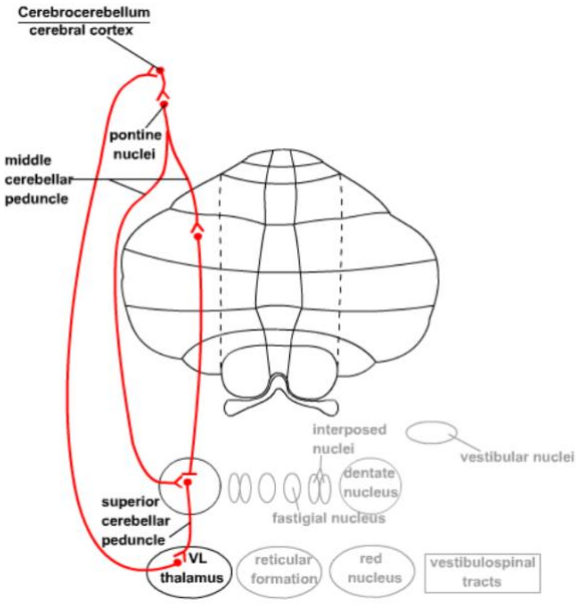


- Lateral muscels fibers will enter Intermediate hemisphere in cerebellum cortex through inferior cerebellar peduncle**—>**activating purkinje cells and interposed nuclei **(excitatory) —>**purkinje cells will send efferent fibres to interposed nuclei through superior cerebellar peduncle**(inhibitory)—>** then 2 paths

1) First path(extrapyramidal)
   - To red nucleus—> globose-emboliform-rubral pathways(rubrospinal tract)
   - Remember:(Rubrospinal tract) the only extrapyramidal tract related to lateral muscels(distal flexors)
2) second path(pyramidal)
   - To VL—>primary motor cortex—>lateral corticospinal tract

To sum up: As we said in the motor pathway lecture:

- lateral motor system that controls distal muscles is composed of (lateral corticospinal and rubrospinal), these 2 pathways receive information from the interposed nuclei in the cerebellum
- Medial motor system that controls the axial muscles is composed of (anterior corticospinal, reticulospinal and vestibulospinal), these pathways receive information from the fastigial nucleus in the cerebellum



CEREBROCEREBELLUM

- participates in the planning of movement
- located in the lateral hemisphere
- projects to the dentate nucleus

- **from its extensive connections with the cerebral cortex, via the pontine nuclei (afferents) and the VL thalamus (efferents). It is involved in the planning and timing of movements.**
- comprising the lateral hemispheres and the dentate nuclei

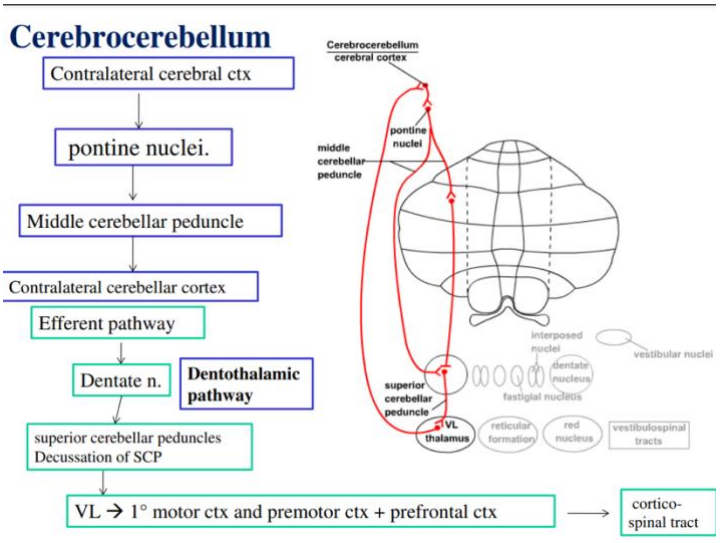
-- Afferent input : from entire contralateral cerebral cortex

-- Efferent pathway : thalamus

Let's explain the order of this pathway , its easy don't worry

- Starts from the *contralateral cerebral cortex* into pontine nuclei located in the basilar part of the pons (found anterior to the trapezoid body) then it enters the cortex of the cerebellum this pathway is called the cerebro-ponto-cerebellar pathway , which was mentioned before in the mid exam material.

*contralateral cerebral cortex : right cerebral cortex into the left cerebellar cortex and the opposite.



- The cerebro-ponto-cerebellar pathway passes through the middle cerebellar peduncle, which is as stated priorly excitatory to Purkinje cells, moreover it only passes through the lateral hemisphere of cerebellum → planning of sequential movements of the entire body.
- The efferent fibers will project into dentate nucleus then back into thalamus.(dentothalamic pathway)
- Dentothalamic pathway is found in the midbrain precisely in the decussation of superior cerebellar peduncle.
- Those fibers continue there path to 1° motor cortex , premotor cortex & prefrontal cortex. Then from there it descends as the corticospinal tract.

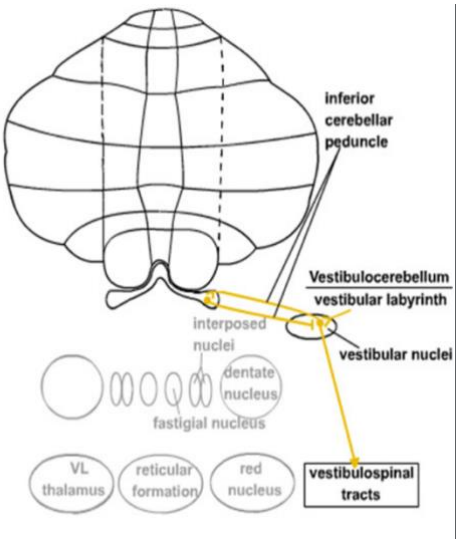
VESTIBULOCEREBELLUM

- **functions in maintaining balance and controlling head and eye movements.**
- **located in flocculonodular lobe.**
- **projects to vestibular nuclei.**

- **it is involved in vestibular reflexes (such as the vestibuloocular reflex) and in postural maintenance.**
- **comprises the flocculonodular lobe and its connections with the lateral vestibular nuclei**

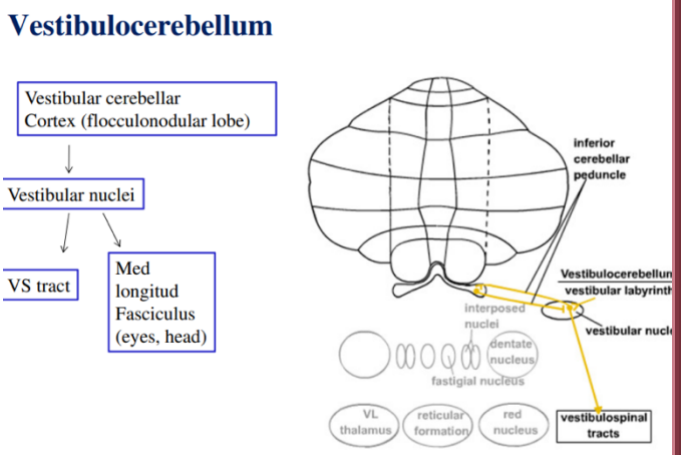
-- Afferent input: vestibular nerve and vestibular nuclei.

-- Efferent path vestibular nuclei



Before we start with the order of this tract a want to clarify a point for you:

- ✓ Vestibular nuclei; we mentioned it as a sensory nuclei in the brainstem but in the context of vestibulocerebellum tract , it acts as a deep cerebellar nucleus, how???
- ✓ Well, anatomically the vestibular nucleus is not far from the true deep cerebellar nucleus.its precisely located on the sides of the floor of the 4th ventricle.

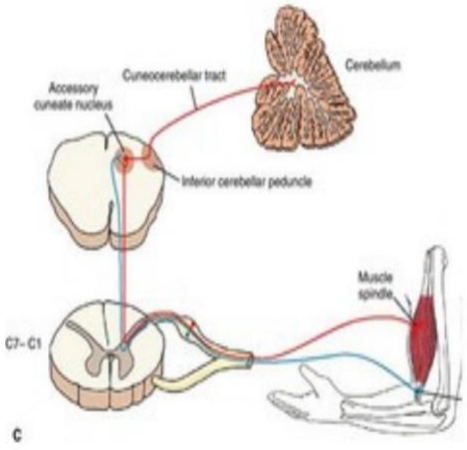


Now we can start with the pathway of this tract:

- ➢ Starts from the vestibular nerve directly into the Vestibular cerebellar Cortex (flocculonodular lobe) or from the vestibular nuclei. Either ways it will go back into the vestibular nuclei, from there it will have 2 options

A. Into the vestibulospinal tract; an extrapyramidal tract functioning in the inhibition of flexors muscle and excitation of extensors helping in overcoming gravity.
B. Into the medial longitudinal fasciculus; explained before in the midterm material, it extends from the vestibular nuclei & motor nucleas of 3 cranial nerves(3rd,4th,&6th) which are involved in eyeball movement and upper cervical segments control of the movement of the head.

Cuneocerebellar tract



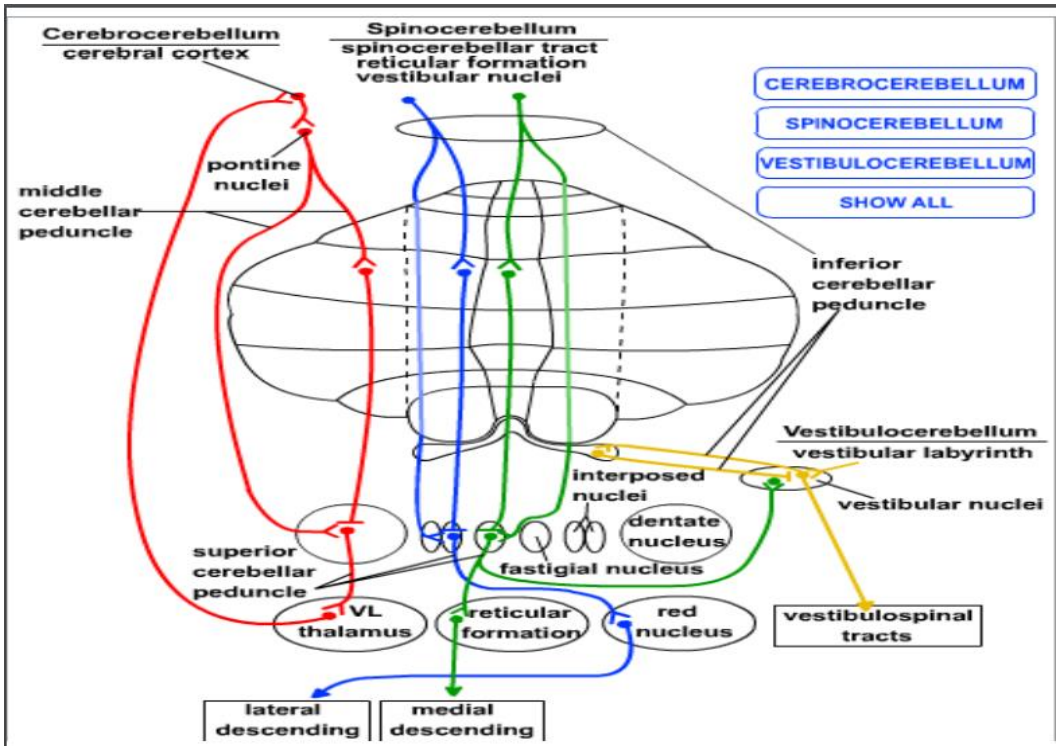
- **Originate in nucleus cuneatus (**in lower part of) **medulla oblongata.**

which is part of the posterior column system, it has some collaterals that reaches cerebellum forming the cuneocerebellar tract.

- **Enter the ICP (ipsilateral)**
- **Receives proprioception (musclejoint sensations) from the upper limb and upper part of thorax**

*remember cuneatus was more lateral then gracilis →related to upper part of the body.

This picture is a summary of all tracts ponder it well.



You can do it ☺

CEREBELLAR AFFERENT FIBERS

- **From vestibular nerve**
- **From spinal cord:**

1. Anterior spinocerebellar tract

2. Posterior spinocerebellar tract

3. Cuneocerebellar tract

- **From cerebral cortex:**

1.corticopontocerebellar pathway

2.cerebro-olivocerebellar pathway

3.cerebroreticulocerebellar pathway

- Other afferents

1. Red nucleus 2. Tectum

CEREBELLAR EFFERENT FIBERS

- Dentothalamic pathway
- Globose-emboliform-rubral pathway
- Fastigial vestibular pathway
- Fastigial reticular pathway

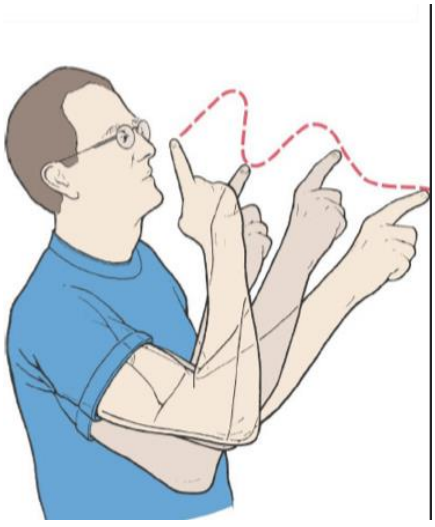
- ✓ The inferior cerebellar peduncle: primarily contains **afferent** fibers from the medulla mainly spinocerebellar tract, precisely posterior one

  as well as **efferents** to the vestibular nuclei.
- ✓ The middle cerebellar peduncle: primarily contains **afferents** from the pontine nuclei. Mainly cerebropontocerebellar pathway
- ✓ The superior cerebellar peduncle: primarily contains **efferent** fibers from the cerebellar nuclei, as well as some **afferents** from the spinocerebellar tract anterior spinocerebellar tract

SIGNS AND SYMPTOMS OF CEREBELLAR DISEASE

¬A lesion in one cerebellar hemisphere gives rise to signs and symptoms that are limited to the **same side** of the body.

A general rule: cerebellum receives from the same side of the body, even in case of crossing in spinal cord, there will be crossing back within cerebellum



¬ Hypotonia: decrease in muscle tone: (Loss of the deep cerebellar nuclei, particularly of the interposed nuclei& fastigial nucleus*)

¬Dysmetria (past pointing): movements ordinarily overshoot their intended mark; then the conscious portion of the brain overcompensates in the opposite direction for the succeeding compensatory movement.

As indicated in the picture hand is trying to touch the nose. But the motor system in general tends to overshoot. What do you mean??

When the patient is trying to touch something he or she wont be able to touch it from the first time, the patient will attempt to touching the object but will skip it , cause they tend to overshoot. the patient will notice that he or she couldn't touch, so repeat. The patient will have to do the work of the cerebellum at the conscious level.

Normally, at the subconscious level your cerebellum adjusts into the appropriate amount, and then successfully attempt the touch.

¬Ataxia (inaccuracy and disturbances of voluntary movement).

The explanation same as the prior point

¬Tremors: involuntary oscillations of limbs ("intention tremor"), results from cerebellar overshooting and failure of the cerebellar system to "damp" the motor movements

Only when patient moves → tremors , related to overshooting too.

Note that tremors in cerebellum disease are considered intentional tremors-only with movment-, different than parkinson tremors which are static tremors

Postural changes and alteration of gait (widebased gait) to compensate for loss of muscle tone(hypotonia related)

Related to spinocerebellar tract(interposed nuclei). Hypotonia will results in compensatory mechanism to keep the upright position through spreading the legs which in physics gives the patient a higher chance to keep standing.

¬ Failure of Progression

♣ Dysdiadochokinesia (difficulty performing rapid alternating movements) due to failure to predict where the different parts of the body will be at a given time during rapid motor movements.

♣ Dysarthria: Disorders of speech

Nystagmus: rhythmic oscillations of the eyes. It occurs especially when the flocculonodular lobes(vestibulocerebellum) **of the cerebellum are damaged; Postural changes and alteration of gait (widebased gait) to compensate for loss of muscle tone**

*note : important role of cerebellum in the performing of complicated rapid alternating movements, like speech cause its motor rapid movment. It calculates the motor activity, it compares the current position of the body with the intended position , a problem in this role of cerebellum will cause failure of progression.

THANK YOU

- اللهم سخر لأهل غزة ملائكة السماء وجنود الأرض .
- اللهم بردًا وسلامًا على أهل غزة .
- اللهم بحق عينك التي لا تنام وعزك الذي لا يُضام أرنا عجائب قدرتك في نصرهم.

PAST PAPERS:

- 1-Fibers that leave the interposed nucleus to reach the red nucleus pass through which of the following ?

A. Inferior cerebellar peduncle.
B. Superior cerebellar peduncle.
C. Middle cerebellar peduncle.
D. Pyramids.
E. Thalamus.

- 2-The term dysdiadokinesia literally means ?

A. Disorder of speech.
B. Rythmic oscillation of the eye.
C. Struggling of performing fast alternating movements.
D. Alteriation of gait.
E. Loss muscle tone.

- 3-The word nystagmus means ?

A. Rhythmic oscillations of the eyes.
B. Difficulty performing rapid alternating movements.
C. Disorders of speech.
D. Involuntary oscillations of limbs.
E. Past pointing.

- 4-The function of the vermis is to ?

A. influences the movements of the long axis of the body.
B. Control muscles of the distal parts of the limbs.
C. concerned with planning of sequential movements of the entire body.
D. Short memory.
E. Emotions.

Answers:
1-b
2-c
3-a
4-a

V1