

# Eye Movements

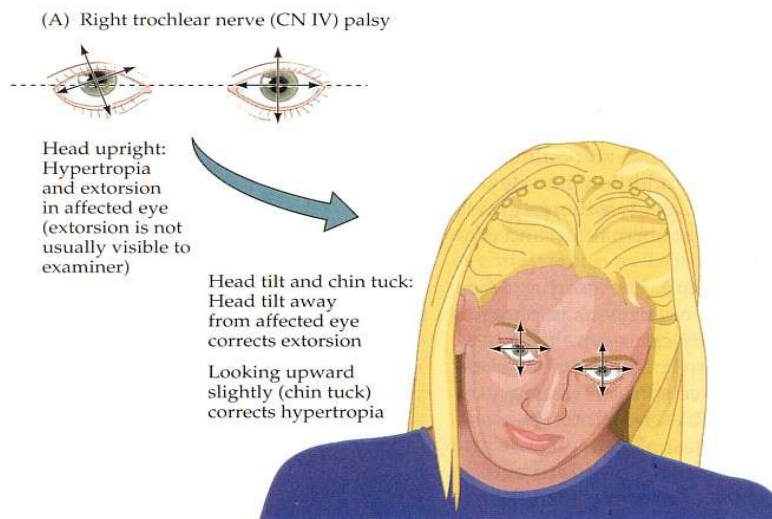
## The eye movement:

All the muscles of the eye are supplied by the oculomotor nerve ,except the superior oblique by the trochlear (fourth nerve ),and lateral rectus by the abducent (sixth nerve).

You should know the action of each one of these muscles (refer to the pictures in the slides).

\*third nerve palsy ,(superior oblique and lateral rectus still working )external squint will happen –the eye will be down and outward. .

\*trochlear nerve palsy :function of the sup oblique is looking in then downward, so here will have extorsion and and elevation of the affected eye ,as a result for this shifting there will be a compensatory head movement ,if we suppose the right eye is affected so the patient will tilt the head to the left side ,tucks the chin till the axis of the right eye shift and align with the left eye .



The dr said that the eye will be lateral and out and tilted a little, and when our colleagues asked him why, he said because the other 5 muscles are still working, so there will be unorganized forces.

\*abducent nerve palsy, if the right affected, he cant look to the right ,but he can look to the left .



Pic in the slides we can see the trochlear nucleus behind it the MLF(in the picture you can find it above the trochlear nucleus.(slide 8)

and look to the next slide (slide 9) to see the nuclei of the abducent and the facial nerve.

\*orders for the eye movement comes from the cortex (its voluntary movement) :

- Parietal eye field
- Supplementary eye field
- The frontal eye field

Remember that its voluntary movement, and that the basal ganglia is involved in its action ,too.

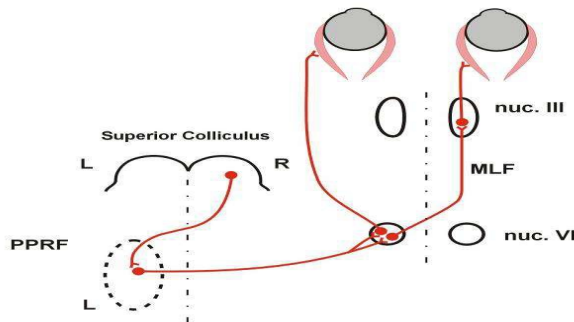
The main control and coordination happens through the superior colliculus.

Through the sup colliculus ,the fibers of these three areas will give orders to the brainstem, mainly indirectly through many circuits; the vertical gaze center -more rostral- (3<sup>rd</sup> and 4<sup>th</sup> ), and horizontal gaze center (3<sup>rd</sup> and 6<sup>th</sup> ),for coordination and voluntary eye movement.

The connection between the abducent nucleus and the oculomotor nucleus is mediated by the MLF for the Horizontal Conjugate Movement.

\*for the horizontal conjugate eye movement ,fibers from the sup colliculus descend to the contralateral parabducent nucleus ,which give

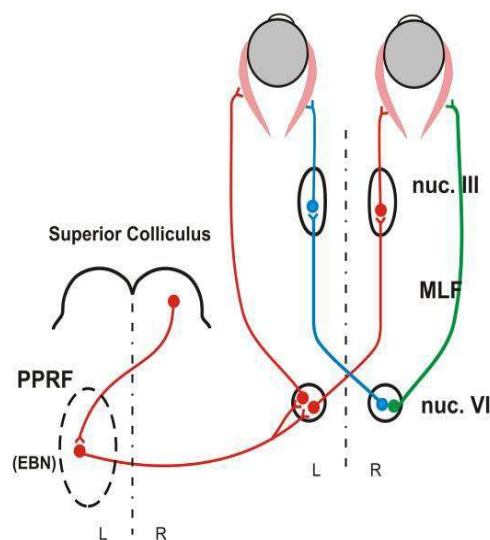
fibers for the abducent nucleus in the same side (main effector in the horizontal pathway ) and to the oculomotor nucleus to the opposite side through the MLF .(so by looking to the right ,the right abducent works and the left oculomotor works, so both eyes look to the same direction).



\*for convergence (disconjugated eye movement ):the orders come to the oculomotor nerve on both sides. (convergence for near objects ).

\*if we cut the MLF this will result in **internuclear ophthalmoplegia** .(if the right MLF ,by looking to the left the left eye will move but the right will not). Remember that disconjugated is still intact !!

\*if the lesion was large enough to include the abducent and the two MLF,this is called **(one and a half syndrome )**>>if the left abd is affected the left eye cant move neither out nor in ,but the right eye outward but not in,but also can do convergence since the oculomotor nerve is intact .

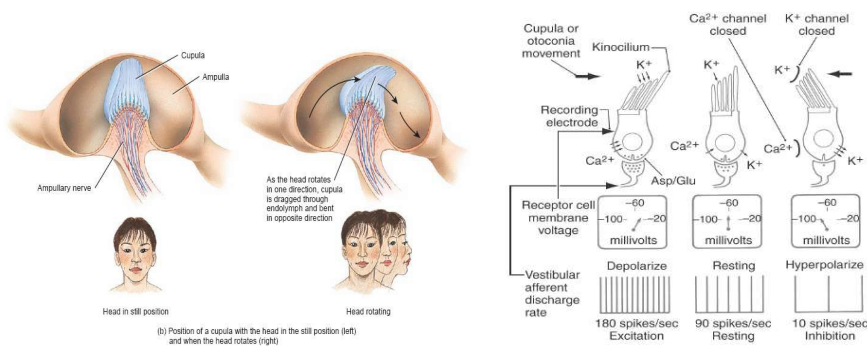


# The vestibular system

\*the vestibule like the cochlea is bony structure formed of five parts:

- Three semicircular canal
- Utricle
- Saccule

\*the three semicircular canal ,each one lie in one direction (horizontal\_tilted 30 degrees from the horizon-,anterior ,posterior ),each contain two compartment ,outer containing the perilymph ,and a major internal compartment the (semicircular duct)containing **the endolymph** ,which is **rich in K+**. the left and right horizontal work together ,but the left anterior work with the right posterior ,and the right anterior with the left posterior .inside the end of the duct we have enlargement called **THE AMPULLA** ,inside it there is a gelatinous material called the **CUPULA** ,below it hair cells have cilia(hairy extensions) which lie in one direction .during the angular acceleration –rotation of the head-,the endolymph will move ,moving the cupula ,bend the hair cells ,opening the potassium channels and Ca entry ,depolarization and neurotransmitters release.



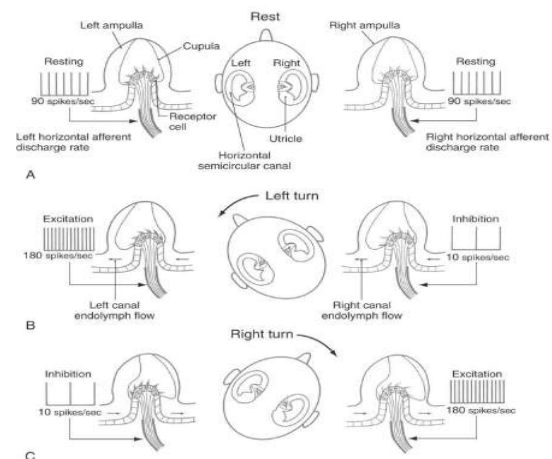
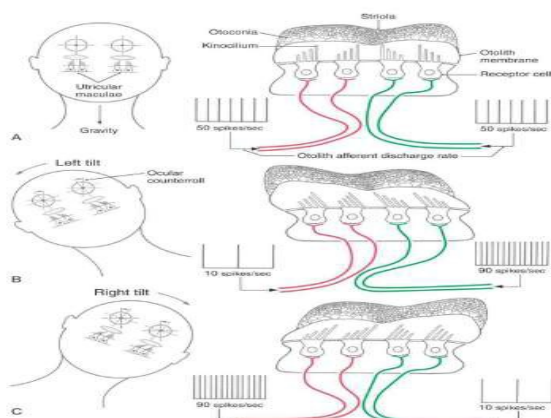
\*right pic ,if the bending was in the direction of the long cilia ,opening K<sup>+</sup> channels and depolarization .BUT if the bending was in the direction of the short cilia ,K<sup>+</sup> and Ca channels are closed so

hyperpolarization and inactivation .in the middle with no movement they will have a baseline activity .

\*For MOST rotatory movements, for example: rotation of the head to the left, the endolymph on the left cause excitation, and on the right will cause inhibition (as the pairs we mentioned previously) so a message go to the brain that the head is rotating to the left. Mostly here the horizontal semicircular canal will work, BUT with complex rotation all of the three canals will work with different directions, as pairs. -look to the picture in the next page-.

\*However, in linear acceleration –non rotating movement –specially the movement against the gravity (like tilting the head ,get in the car ,moving inside the car)we need here **the utricle and saccule** .

\*both are enlargement at the base of the vestibule ,also here are lined by perilymph ,and full of endolymph ,also gelatinous material, setting on hair cells ,BUT here the cilia are multidirectional ,for better sensation of the movement (this require the gelatinous material to be heavy ,and this is done by the Ca ++ deposits called the otolith .if we look to the anatomy of **the utricle is straight** ,responsible for the horizontal movement and tilting of the head ,while the **saccule is vertical** ,so used for vertical head movement like elevation .by tilting the head tilt to the left the left utricle in the left ear will have half excitation and half inhibition ,and also the right ear half excitation and half inhibition ,because its multidirectional cilia .



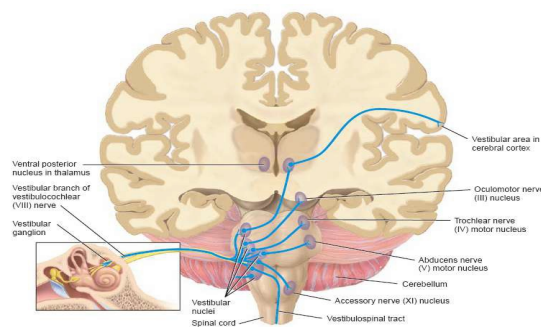
## The vestibular pathway

\*from the four vestibular nuclei fibers go to 6 targets :

- The accessory nerve nucleus (for the head movement )
- Spinal cord to control posture (medial and lateral )
- The cerebellum (the most important one , fibers here go directly coordination and eye movement )
- To the other vestibular nuclei to inhibit its function (superior to the superior nuclei , inferior to the inferior and so on )
- 3<sup>rd</sup> , 4<sup>th</sup> 6<sup>th</sup> nuclei also for coordination of the head with the eye movement

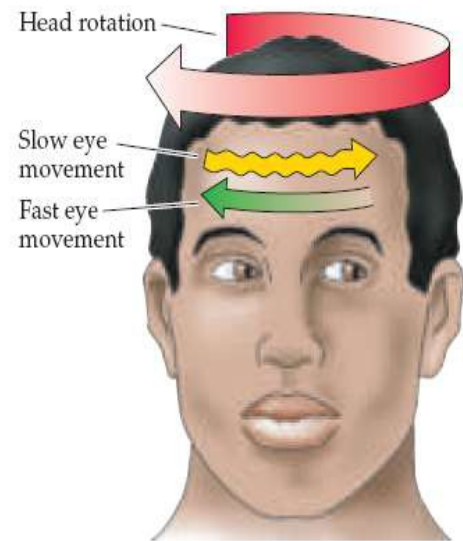
Finally to the thalamus and then to the cortex here five areas in the cortex are involved : 1- the somatosensory cortex specially in the face area . 2- prefrontal (frontal eye field ) . 3- area 7 in the parietal cortex . 4- parietal eye field . 5- insular cortex for multiple processing (many nuclei ) . multiple connections go to hippocampus for spatial information processing

##almost these pathways go from the vestibular nuclei to their targets in the contralateral side .



\***the vestibuloocular reflex:** these reflexes are compensatory for the head movement , we have rotational reflex and linear reflex , but whatever the head movement was , if we want to fix our eyes on an object while moving the head , this is done by the vestibuloocular reflex (when you walk or inside a car your head is moving but still you can fix your gaze on a sign for example).

\***the horizontal vestibuloocular reflex**(ex.to the right- stimulation to the right side) ,the vestibular nuclei will send mainly through the abducent nucleus activation to the left eye and inhibition to the right eye ,by that the contralateral abducent will move the eye to the left .here if you rotate the head to the right ,you can move your eyes (SLOWLY) till 90 degrees,after that(after the object get out from the field) ,the eye will move with the head on the same side (RAPIDLY),this is called physiological nystagmus ( Nystagmus is named after the fast eye moving phase, so here it's a **rightward beating nystagmus**),if the beating is continues this is abnormal nystagmus .

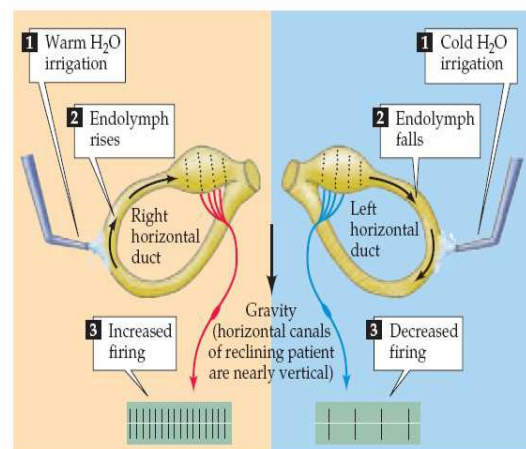


(carrying a child and rotating him 360 degrees,when you stop ,he will have beating since the endolymph still moving)

\*Abnormal Nystagmus is indicative of a problem in the vestibular system. Without rotation, if one side is injured, the person will suffer from nystagmus, dizziness, and vertigo. This is due to the baseline activity in the unaffected vestibular apparatus.

### **The caloric test:**

In this test we introduce warm water or cold water through the external auditory meatus ,all the neurons have baseline activity ,in a normal person warm water will cause activation and beating of the eyes toward the ear used ,and the cold water will cause inhibition so beating away from the used ear .sometimes its called **COWS**.Cold water produce beating to the **Opposite** side ,but **Warm** water produce beating to the **Same** side .this test is used for testing the brainstem in unconscious patient ,and





for testing the vestibular function ,if there is unilateral lesion in the vestibular system the nystagmus-beating-will be reduced or even absent at the affected side.

\***meniere disease** :a disease result from disruption in the endolymph volume (usually increase ),so changes in the function on both sides, with unequal activity .

Symptoms:vertigo , positional nystagmus (when the head in a particular position ), nausea ,vomiting ,tinnitus ,inability to make head movements ,inability to stand ,low frequency hearing loss.

Treatment :administration of diuretics and salt restriction ,or surgically to decrease the endolymph pressure and volume.

\***benign paroxysmal positional vertigo:**

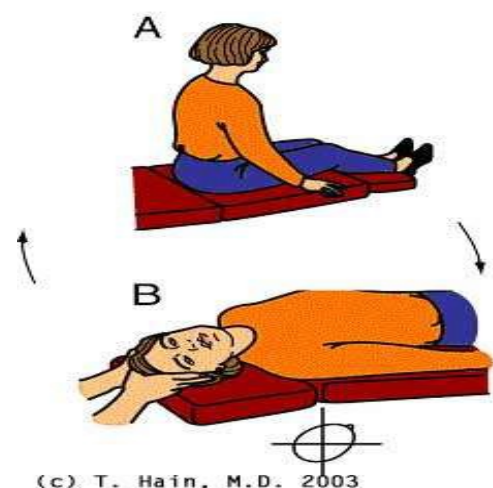
This patient will have vertigo and vestibular symptoms when he moves in a certain direction, movement ,or particular body position ,there are two suggestive mechanism for this disease :

1-maybe the otolith will be lodged in the cupula ,mainly in the posterior canal ,so the movement is not equal in the posterior canal .

2-any other abnormalities in the vestibular canal or inflammation of the vestibular nerve.

\*testing for this disease **is DIX-HALLPIKE**

**test:**we put the patient in multiple positions and see when the vestibular symptoms will happen ,and observation for the nystagmus, when moving his head (please see slide 50).





\*the most important vestibular lesion symptoms are :

1-**dizziness**: non specific term ,means spatial disorientation ,and maybe caused by factors other than the vestibular lesions.

2-**vertigo**:specific term ,false sensation of rotation or the thing around are rotating ,

3-**tinnitus**:non specific term,can be caused by hypertension ,diabetes ,loud music ,tumors ,thyroid conditions ,and medications .

- ***the semicircular canal dehiscence (opening)***:

>>thing in the bony labyrinth ,so will be exposed to the extra dural space,the patient will have vertigo in a certain position or standing ,and the solution is surgical closure of the defective bone .

-vestibular neuritis :inflammation of the vestibular nerve ,maybe viral infection with edema in the nerve or the ganglion .

*Try and try again ,you will reach success .*