Vestibular Physiology

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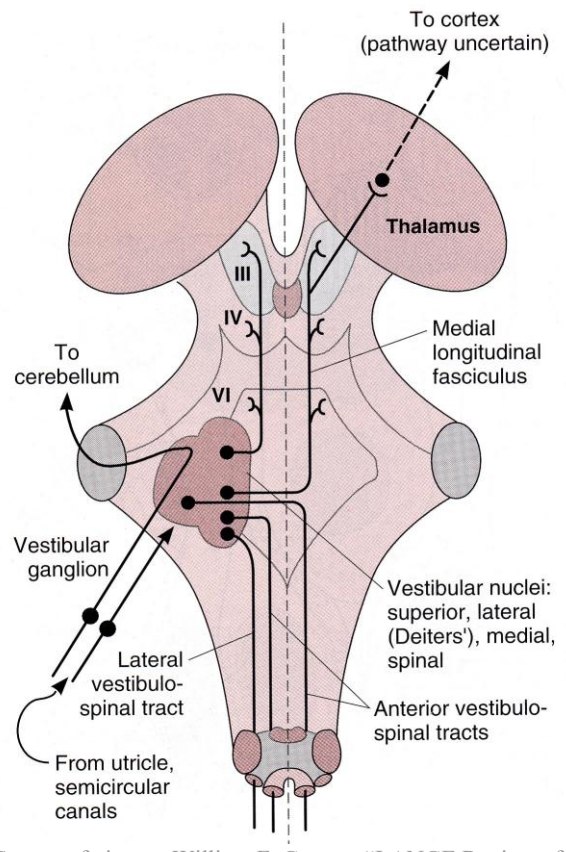
CENTRAL VESTIBULAR PATHWAYS 1
ROTATIONAL ACCELERATION 1
LINEAR ACCELERATION 1
LABYRINTHECTOMY 1

Although most of responses to stimulation of vestibular receptors are ***reflex*** in nature, vestibular impulses also ***reach cerebral cortex*** - conscious perception of motion + orientation in space.

CENTRAL VESTIBULAR PATHWAYS

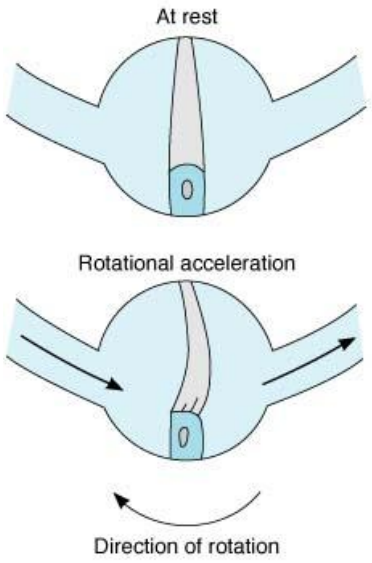


Source of picture: William F. Ganong "LANGE Review of Medical Physiology", 21st ed. (2003); Publisher: McGraw-Hill / Appleton & Lange; ISBN-10: 0071402365; ISBN-13: 978-0071402361 >>

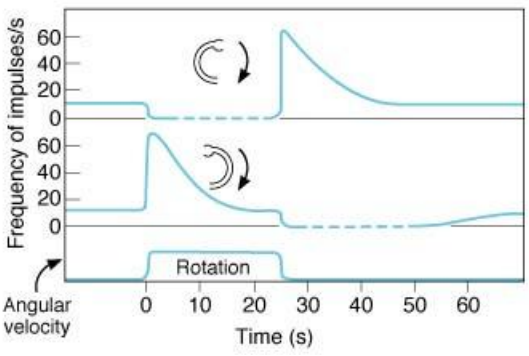
ROTATIONAL ACCELERATION

ROTATIONAL ACCELERATION in plane of given semicircular canal stimulates its **AMPULLAR CRISTA**.
[**LINEAR ACCELERATION** fails to displace cupula and therefore does not stimulate cristae].

Movement of cupula in one direction causes ***increased spike rate*** in single nerve fibers from its crista, whereas movement in opposite direction ***inhibits neural activity***.
Since canals on one side of head are *mirror image* of those on other side, endolymph is displaced toward ampulla on one side and away from it on other.



Cupula on crista top closes off ampulla and is flexible.



Average time course of impulse discharge from ampulla of two semicircular canals during rotational acceleration, steady rotation, and deceleration.

- <u>when rotation is STARTED</u>, **endolymph**, because of its inertia, is displaced in ***direction opposite to rotation*** → fluid pushes on cupula, deforming it → this bends processes of hair cells.
- <u>when constant speed of rotation is reached (NO ACCELERATION)</u>, fluid spins at same rate as body and cupula swings back into upright mid position.
- <u>when rotation is STOPPED</u>, deceleration produces displacement of endolymph in ***direction of rotation*** → cupula is deformed in direction opposite to that during acceleration → returns to mid position in 25-30 seconds.
- start and end of rotation are accompanied by ***NYSTAGMUS*** (see p. Eye64 >>) - it is consequence of **vestibulo-ocular reflex** that maintains visual fixation on stationary points while body rotates, although it is not initiated by visual impulses and is *present even in blind individuals*.
- ***VERTIGO*** is sensation of rotation in absence of actual rotation and is prominent symptom when one labyrinth is inflamed.
- semicircular canals can be stimulated experimentally by ***caloric irrigation test*** (see p. S30 >>) – this causes nystagmus, vertigo, nausea [to avoid these symptoms when irrigating ear canals in treatment of ear infections, it is important to use fluid at body temperature].

LINEAR ACCELERATION

LINEAR ACCELERATION stimulates utricular and saccular **MACULAS**.

- UTRICLE responds to ***horizontal acceleration*** and SACCULE to ***vertical acceleration***.
- **otoliths** are more dense than endolymph, and acceleration in any direction causes them to be displaced in opposite direction, distorting hair cell processes + maculae also discharge tonically in ***absence of head movement*** (because of gravity pull on otoliths).
- excessive stimulation causes ***MOTION SICKNESS***.

LABYRINTHECTOMY

<u>UNILATERAL LABYRINTHECTOMY</u> → unbalanced discharge from remaining normal side.

- *rats* develop abnormal body postures and roll over and over as they continuously attempt to right themselves.
- postural changes are less marked in *humans*, but ***symptoms are distressing***; motion aggravates symptoms, but efforts to minimize stimulation by lying absolutely still are constantly thwarted by waves of nausea, vomiting, diarrhea; fortunately, compensation occurs and ***after 1-2 months symptoms disappear completely***.

BILATERAL LABYRINTHECTOMY → defects of orientation in space.

- especially *hazardous during diving* – vision is the only remaining tool to orient where water surface is (water pressure sensed by cutaneous receptors is equal over the body); if vision is obscured, drowning may occur due to disorientation.

BIBLIOGRAPHY for ch. "Otology" → follow this LINK >>