EVALUATING THE CRANIAL NERVES, PART VIII

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INTRODUCTION

As mentioned in the previous articles, a thorough neurological examination includes evaluation of a patient's mental status and speech, motor system, sensory system, reflexes, and cranial nerves. Cranial nerves I-VII have been discussed in the previous articles; this article will present Cranial Nerve VIII, which innervates portions of the ear involved with hearing and equilibrium. Some cranial nerves contain only sensory fibers; those that contain both sensory and motor fibers are called mixed nerves.

CRANIAL NERVE VIII

Vestibulocochlear Nerve (Sensory)

The vestibulocochlear nerve (also known as the acoustic nerve) consists of two distinct parts.

The vestibular portion of Cranial Nerve VIII, which is concerned with equilibrium, arises in the semicircular canals, saccule, and utricle of the inner ear. Fibers extend to the vestibular ganglion (ganglion of Scarpa) where they synapse with fibers that travel to a nucleus in the medulla and pons, and finally terminate in the thalamus. Some fibers also travel directly to the cerebellum.

The cochlear portion of Cranial Nerve VIII, which is concerned with hearing, arises in the spiral organ of Corti in the cochlea of the inner ear. Fibers pass through the spiral ganglion to the thalamus, where they eventually synapse with neurons that convey the neural impulses to the auditory regions of the cerebral cortex.

Physiology of Equilibrium

The vestibular portion of CN VIII is involved with two kinds of equilibrium: static and dynamic. Static equilibrium is the orientation of the body relative to the ground; dynamic equilibrium is the maintenance of

body orientation when subjected to sudden movements, such as rotation, acceleration or deceleration.

Static Equilibrium

The walls of the utricle and saccule have specialized regions called maculae. Anatomically perpendicular to one another, each macula contains specialized neuroepithelial cells with tiny cilia (hair cells) that project into an overlying, gelatinous layer called the otolithic membrane. On top of the otolithic membrane rests a layer of dense calcium carbonate crystals or otoliths. The rest of the utricle and saccule is filled with a fluid called endolymph.

When you tilt your head, the otolithic membrane responds to gravity and slides down across the hair cells. As a result, the hair cells are bent, which generates a nerve impulse to the vestibular branch of CN VIII. Similarly, if an action is sudden, inertial reaction of the otolithic membrane comes into play. For example, in a rear-end automobile collision where the head is suddenly pushed forward, the otolithic membrane moves backward—relatively speaking. Once again, the bending of hair cells transmits a nerve impulse to the vestibular branch.

Various neural pathways between the vestibular nuclei, cerebellum, and cerebrum transmit a continuously updated flow of sensory information that helps the body maintain static equilibrium by regulating the tone of specific skeletal muscles.

Dynamic Equilibrium

The 3 semicircular ducts are involved in maintaining dynamic equilibrium. See Figure 1. Because the ducts are positioned at right angles in 3 planes to each other, imbalance in all three dimensions can be detected. At the dilated portion of each duct, there is a raised area called a crista. Each crista contains a group of hair cells with an overlying gelatinous substance called the cupula. During head movement, the endolymph flows over the cristae and bends the hair cells. The generated neural impulses follow the same pathways as the ones involved in static equilibrium and eventually are trans-

Figure 1: Right frontal section of the structure of the auditory apparatus showing the external ear, auditory canal, tympanic membrane, middle ear, and the bony labyrinth of the inner ear.

mitted to specific skeletal muscles to maintain body balance.

Physiology of Hearing

Sound waves are alternately compressed and rarefied regions of air molecules that result from a vibrating

object. Humans can hear from 20 Hertz (cycles per second) to 20,000 Hz, but hear best between 1,000 and 4,000 Hz.

The greater the force of vibration, the louder the sound. Loudness is measured in units called decibels (dB); common sounds range from 0 dB to 120 dB. See Figure 2. The human ear can detect a 1 decibel change in loudness, but because decibels are logarithmic, each increase of 10 dB means a tenfold increase in loudness. For example, an increase from 10 dB to 20 dB is not just twice as loud, it's 10 times as loud. At 120 dB, sound is a trillion times louder than the threshold of hearing and causes pain; at 140 dB sound can permanently harm ears, which many past or present loud music lovers will eventually discover.

Sound waves that reach the ear are directed into the external auditory canal. When the sound strikes the tympanic membrane, the membrane vibrates with a frequency and displacement relative to the frequency and force (loudness) of the sound waves. The membrane relays its vibrations through the malleus (hammer), which relays its vibrations through the incus (anvil), which relays its vibrations through the stapes (stirrup), which finally relays its vibrations to the oval window in the inner ear. The in and out movement of the oval window pushes the perilymph in the cochlea back and forth, stimulating hair cells to generate neural impulses that travel through the cochlear branch of CN VIII and eventually end up in the auditory area of the temporal lobe of the cerebral cortex.

<u>Decibels</u>	<u>Source</u>
0	Threshold of hearing
20	Soft whisper
30	Quiet room
40	Average office
50	Vacuum cleaner
60	Average street traffic
85	Pneumatic drill
90	Heavy traffic
117	Full volume disco
120	Loud shot from 1 ft.
135	Jet engine
140	Air raid siren

Figure 2: Typical sound intensities.

Symptoms of CN VIII Disorders

Vestibular Branch.

1. Vertigo is a disoriented giddiness involved with a loss of equilibrium. It is often a sign of labyrinthine disease involving the middle or inner ear, but lesions of CN VIII, or reflex phenomena such as mal de mer (seasickness) may also induce vertigo. Patients often confuse vertigo with dizziness, but vertigo is an illusion of movement—either as objective vertigo, where the external world seems to revolve around the patient or subjective vertigo, where the patient himself seems to revolve in space. Anyone who has ever imbibed too much aqua vitae is familiar with such symptoms.
2. Nystagmus is a rhythmic, involuntary, rapid back-and-forth ocular movement. In vestibular disease, the eye movement usually demonstrates a slow pull with an accompanying rapid return jerk. Nystagmus is a reflex disturbance of the ocular muscles, which is a control function of the semicircular canals, and may include horizontal, vertical, rotatory, or mixed motions.
3. Labyrinthine involvement may present other generalized symptoms like nausea and vomiting, excessive sweating, tachycardia, and lowered blood pressure (think motion sickness).

Cochlear Branch.

1. Tinnitus is an internalized noise in the ears, such as ringing, buzzing, roaring, clicking, or hissing, which usually indicates peripheral cochlear disease. Much more rare is central tinnitus, which may sound like music, and sometimes bruits can be transmitted from sclerotic cerebral vessels or aneurysms to CN VIII.
2. Deafness is categorized into two types: nerve deafness or conduction deafness. Nerve deafness results from an interruption of CN VIII; conduction deafness results from middle or outer ear disorders or physical obstruction. Cortical lesions cause deafness only if they are bilateral.

CLINICAL TESTS

Vestibular Division

Several variations of vestibular testing, called caloric tests, involve douching the ear with cold or warm water to induce convection currents in the semicircular canals, an action that causes nystagmus. The fast component of nystagmus is in the direction of the ear being tested

with warm water; with cold water, the fast component is toward the opposite ear. A useful mnemonic, COWS (cold, opposite; warm, same) is often used to remember the directions. A difference in reaction between ears, or an absent, reduced, or otherwise improper response is indicative of vestibular disease.

The caloric tests, which are beyond the scope of this article, are rather involved, time-consuming, and may induce vomiting by the patient.

Cochlear Division

First, to determine if the patient can hear, the examiner holds a ticking watch (or rubs his fingers together) near the ear being tested, while the patient covers the ear not being tested.

A good quality tuning fork with a frequency of 256 Hz or 512 Hz should be used for additional hearing tests. Never strike a tuning fork on a hard surface; not only does it damage the tuning fork, it produces harmonic overtones that may confuse the tests. Instead, tap it on your palm or stroke the tines between your thumb and index finger. Tests are performed near threshold sound levels, so the fork should not vibrate too strongly.

When a vibrating tuning fork is placed on the vertex of a patient's skull, sound waves are transmitted through the skull and endolymph to cause the sensation of hearing. If both ears are normal, the sound is not lateralized, i.e., the sound has equal loudness in both ears. This phenomenon is the basis of the Weber test.

Similarly, when a vibrating tuning fork is placed on a patient's mastoid, sound travels through the skull and endolymph to cause the sensation of hearing. If the tuning fork remains on the mastoid, the sound dies down and eventually disappears as the tuning fork's energy dissipates. When the sound disappears, the tuning fork (without reactivating it) is placed in front of the ear. The sound will again be heard, eventually diminishing until it disappears, which demonstrates that sound waves are normally heard longer through air than through bone (many sources quote approximately twice as long). This phenomenon is the basis of the Rinne test.

External or Middle Ear Problem Test

Conduction or sensorineural loss is tested by the Weber test. Assuming the patient has normal hearing in the opposite ear, the sound will lateralize to the poor ear if it's a conduction problem, such as an obstruction in the

external ear or a lesion in the middle ear. Visual inspection can easily determine if excess cerumen or a foreign object is the cause of blockage.

The reason for the effect is that the poor ear is not distracted by ambient noise (which brings up an interesting point: if there is no ambient noise, the lateralization effect disappears). If the examiner performs the Weber test on himself while occluding one ear with a finger, a normal lateralization effect can be easily demonstrated.

In the same patient, if there is sensorineural loss instead, the sound will lateralize to the good ear.

Another way to test whether conduction or sensorineural loss is the problem is by using the Rinne test. Normally, sound can be heard longer through air than through bone; if sound is heard longer through bone, it's because the sound bypasses the obstruction in the auditory canal or middle ear, and is directly transmitted to the inner ear.

By convention, a positive Rinne test is when the patient hears longer through air conduction than through bone conduction ($AC > BC$); conversely, a negative test is the opposite ($AC < BC$).

The vibrating tuning fork is held on the mastoid until the patient no longer hears it. The tuning fork is then held in front of the ipsilateral ear. If there is a conduction problem, the patient will not hear the tuning fork: a negative test ($AC < BC$). To further clinch the diagnosis, alternate the sequence by first holding the tuning fork in front of the ear until it can't be heard, and then

hold it on the mastoid. If the sound can be heard from the mastoid, a negative test is confirmed ($AC < BC$).

If there is a sensorineural loss, the patient will hear the sound longer through the air than through the mastoid: a positive test ($AC > BC$).

Meniere's Syndrome

A disorder of some interest is paroxysmal labyrinthine vertigo, usually known as Meniere's Syndrome. It is a chronic recurrent disorder of CN VIII that persists for years. Encountered most often in men 40–60 years old, the syndrome is characterized by recurrent episodes of severe vertigo with vertigo and tinnitus. The principal symptom is vertigo so severe it appears to throw the subject to the ground. Spinning sensations, nausea, vomiting and profuse sweating are often noted and may last from a few minutes to hours. Headaches, sensorineuronal hearing loss, and tinnitus persist between attacks. There is some thought that Vincent van Gogh might have suffered from Meniere's syndrome, which could explain his apparent madness. Was his bizarre act of cutting off an ear an attempt to escape from his debilitating symptoms? We can only speculate.

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