

12.14: The Human Ear

Anatomy of the Ear

Hearing is the transduction of sound waves into a neural signal by the structures of the ear. See Figure 12.14.15^[28] for an image of the anatomy of the ear. The large, fleshy structure on the lateral aspect of the head is known as the **auricle**. The C-shaped curves of the auricle direct sound waves toward the ear canal. At the end of the ear canal is the **tympanic membrane**, commonly referred to as the eardrum, that vibrates after it is struck by sound waves. The auricle, ear canal, and tympanic membrane are referred to as the external ear. The middle ear consists of a space with three small bones called the malleus, incus, and stapes, the Latin names that roughly translate to “hammer,” “anvil,” and “stirrup.” The malleus is attached to the tympanic membrane and articulates with the incus. The incus, in turn, articulates with the stapes. The stapes is attached to the inner ear, where the sound waves are transduced into a neural signal. The middle ear is also connected to the pharynx through the Eustachian tube that helps equilibrate air pressure across the tympanic membrane. The Eustachian tube is normally closed but will pop open when the muscles of the pharynx contract during swallowing or yawning. The inner ear is often described as a bony labyrinth because it is composed of a series of semicircular canals. The semicircular canals have two separate regions, the cochlea and the vestibule, that are responsible for hearing and balance. The neural signals from these two regions are relayed to the brain stem through separate fiber bundles. However, they travel together from the inner ear to the brain stem as the **vestibulocochlear nerve** (cranial nerve VIII).^[29]


 Illustration showing the ear, with labels for structures

Figure 12.14.15: The Ear

Hearing

Sound waves cause the tympanic membrane to vibrate. This vibration is amplified as it moves across the malleus, incus, and stapes and into the cochlea. Within the inner ear, the cochlear duct contains sound-transducing neurons. As the frequency of a sound changes, different hair cells within the cochlear duct are sensitive to a particular frequency. In this manner, the cochlea separates auditory stimuli by frequency and sends impulses to the brain stem via the cochlear nerve. The cochlea encodes auditory stimuli for frequencies between 20 and 20,000 Hz, the range of sound that human ears can detect.^[30]

Balance

Along with hearing, the inner ear is also responsible for the sense of balance. Semicircular canals in the vestibule have three ring-like extensions. One extension is oriented in the horizontal plane, and the other two are oriented in the vertical plane. Hair cells within the vestibule sense head position, head movement, and body motion. By comparing the relative movements of both the horizontal and vertical planes, the vestibular system can detect the direction of most head movements within three-dimensional space. However, medical conditions affecting the semicircular canals cause incorrect signals to be sent to the brain, resulting in a spinning type of dizziness called vertigo.

 Video Review of Anatomy of the Ear^[31]



Common Ear Disorders

Hearing Loss

Hearing loss is classified as conductive hearing loss or sensorineural hearing loss. **Conductive hearing loss** occurs when something in the external or middle ear is obstructing the transmission of sound. For example, cerumen impaction or a perforated tympanic membrane can cause conductive hearing loss. **Sensorineural hearing loss** is caused by pathology of the inner ear, cranial nerve VIII, or auditory areas of the cerebral cortex. **Presbycusis** is sensorineural hearing loss that occurs with aging due to gradual nerve degeneration. **Ototoxic medications** can also cause sensorineural hearing loss by affecting the hair cells in the cochlea.

Acute Otitis Media

Acute otitis media is the medical diagnosis for an middle ear infection. Ear infections are a common illness in the pediatric population. Children between the ages of 6 months and 2 years are more susceptible to ear infections because of the size and shape of their Eustachian tubes. Acute otitis media typically occurs after an upper respiratory infection when the Eustachian tube becomes inflamed and the middle ear fills with fluid, causing ear pain and irritability. This fluid can become infected, causing purulent fluid and low-grade fever. Acute otitis media is diagnosed by a health care provider using an otoscope to examine the tympanic membrane for bulging and purulent fluid. If not treated, acute otitis media can potentially cause perforation of the tympanic membrane. Treating early acute otitis media with antibiotics is controversial in the United States due to the effort to prevent antibiotic resistance. However, the treatment goals are to control pain and treat infection with antibiotics if a bacterial infection is present.^[32]

Some children develop recurrent ear infections that can cause hearing loss affecting their language development. For children experiencing recurring cases, a surgery called myringotomy surgery is performed by an otolaryngologist. During myringotomy surgery, a tympanostomy tube is placed in the tympanic membrane to drain fluid from the middle ear and prevent infection from developing. If a child has a tympanostomy tube in place, it is expected to see clear fluid in their ear canal as it drains out of the tube. See Figure 12.14.16^[33] for an image of a tympanostomy tube in the ear.^[34]


 Illustration showing middle ear infection and a tympanostomy tube in place to alleviate symptoms.

Figure 12.14.16: Tympanostomy Tube

Otitis Externa

Otitis externa is the medical diagnosis for external ear inflammation and/or infection. See Figure 12.14.17^[35] for an image of otitis externa. It is commonly known as “swimmer’s ear” because it commonly occurs in swimmers, especially in summer months. Otitis externa can occur in all age groups and causes an erythematous and edematous ear canal with associated yellow, white, or grey debris. Patients often report itching in the ear canal with pain that is worsened by pulling upwards and outwards on the auricle. Otitis externa is treated with antibiotic drops placed in the ear canals.^[36]


 Photo showing ear infected with otitis externa, or swimmer's ear

Figure 12.14.17: Otitis Externa

Cerumen Impaction

Cerumen impaction refers to a buildup of earwax causing occlusion of the ear canal. This occlusion often causes symptoms such as hearing loss, ear fullness, and itching. See Figure 12.14.18^[37] for an image of cerumen impaction. Cerumen can be removed via

irrigation of the ear canal, ear drops to dissolve the wax, or manual removal.^[38] In outpatient settings, nurses often assist with ear irrigation to remove cerumen impaction according to agency policy. See Figure 12.14.19^[39] for an image of an ear irrigation procedure.


 Photo showing an ear canal that is plugged with cerumen

Figure 12.14.18: Cerumen Impaction


 Photo of person having ear canal irrigated with liquid to help remove cerumen build up

Figure 12.14.19: Ear Irrigation to Remove Cerumen Impaction

Tinnitus

Tinnitus is a ringing, buzzing, roaring, hissing, or whistling sound in the ears. The noise may be intermittent or continuous. Tinnitus can be caused by cerumen impaction, noise trauma, or ototoxic medications, such as diuretics or high doses of aspirin. Military personnel have a high incidence of tinnitus due to noise trauma from loud explosions and gunfire. There are no medications to treat tinnitus, but patients can be referred to an otolaryngologist for treatment such as cognitive therapy or noise masking.^[40]

Vertigo

Vertigo is a type of dizziness that is often described by patients as, “the room feels as if it is spinning.” Benign positional vertigo (BPV) is a common condition caused by crystals becoming lodged in the semicircular canals in the vestibule of the inner ear that send false movement signals to the brain. BPV can be treated by trained professionals using a specific set of maneuvers that guide the crystals back to the chamber where they are supposed to be in the inner ear.^[41]

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