CHAPTER 15 – SPECIAL SENSES: THE EAR

OBJECTIVES

On completion of this chapter, you will be able to:

- Describe the anatomical structures of the ear.
- Describe the external ear.
- Describe the middle ear.
- Describe the inner ear.
- Analyze, build, spell, and pronounce medical words.
- Comprehend the drugs highlighted in this chapter.
- Describe diagnostic and laboratory tests related to the ear.
- Identify and define selected abbreviations.
- Describe each of the condition presented in the Pathology Spotlights.
- Review the Pathology Checkpoint.
- Complete the Study and Review section, and the Chart Note Analysis.

OUTLINE

I. Anatomy and Physiology Overview

The ear is the site of hearing and equilibrium. The specially designed anatomical structures of the ear are connected to the sensory areas of the brain by specialized fibers that come from the eighth cranial nerve. The purpose of these structures is to:

- Receive sound vibrations.
- Be sensitive to the force of gravity.
- React to the movement of the head.

There are three major divisions of the ear.

A. External Ear (Fig. 15–1, p. 501) – the appendage on the side of the head consisting of the:

1. Auricle or Pinna – collects sound waves and passes them on through the auditory canal to vibrate the tympanic membrane.

2. External Acoustic Meatus or Auditory Canal – an S-shaped tubular structure lined with glands that secrete cerumen or earwax to lubricate and protect the ear.

3. Tympanic Membrane or Eardrum – separates the external ear from the middle ear.

B. Middle Ear – a tiny cavity in the temporal bone of the skull beyond the tympanic membrane. The cavity contains three small bones or ossicles instrumental to hearing. They ossicles are as follows:

1. Malleus (hammer)
2. Incus (anvil)
3. Stapes (stirrup)
Sound vibrations from the tympanic membrane are transmitted to the malleus, to which it is attached, through the incus to the stapes, which attaches to a thin membrane covering the oval window, the beginning of the inner ear. The cavity of the middle ear has five openings:

- One covered by the tympanic membrane
- One to the auditory or Eustachian tube
- One to the mastoid cells
- Two to the inner ear, the oval and round window (Fig. 15–1, p. 501)

The cavity of the middle ear is lined by mucous membrane that is continuous with that found in the mastoid cells, the eustachian tube, and the throat. The three functions of the middle ear are:

- Transmission of sound vibrations.
- Equalization of external/ internal air pressure on the tympanic membrane.
- Control over potential damaging or disruptive loud sounds through reflex contractions of the stapedius and tensor tympani muscles.

C. Inner Ear – consists of a membranous labyrinth or mazelike network of canals, located within a bony labyrinth collectively called labyrinths. The bony labyrinth is named because of its complicated shapes and located within the temporal bone, consists of the cochlea, vestibule and semicircular canals.

1. Cochlea (Fig. 15–2, p. 502) – a spiral-shaped bony structure containing the cochlear duct and is so named because it resembles a snail shell. The spiral cavity of the cochlea is partitioned into three tubelike chambers that run the entire length of the spiral, which is filled with the fluid, endolymph. The two membranes that form these tubelike areas are:

- Basilar Membrane – forms the lower channel or scala tympani. This is the location of the organ of Corti, which contains hair cell sensory receptors for the sense of hearing; filled with the fluid perilymph.
- Vestibular Membrane or Reissner’s Membrane – forms the upper channel, which is called the scala vestibuli; filled with the fluid perilymph.

a. Hearing Process in the Inner Ear (Fig. 15–3, p. 503) – The scala vestibuli and scala tympani open to the middle ear through the oval and round windows, respectively. The stapes fits into the round window and causes vibration of the perilymph, which in turn, vibrates the basilar membrane and endolymph of the cochlear duct, thereby exciting the nerve endings contained on the organ of Corti. These nerve endings transmit the sounds, via the eighth cranial nerve, to the auditory areas of the brain. The sound waves,
having excited the fluid of the cochlear duct, then pass on to the perilymph of the scala tympani, and are dissipated against the membrane covering the round window. Sound travels in waves from the outer ear, through the middle ear, and into the cochlea of the inner ear. These waves are transmitted by nerve fibers to the auditory region of the brain where sensations of sound are perceived within the cerebral cortex.

2. Vestibule – a bony structure located between the cochlea and the three semicircular canals. It contains the utricle and saccule, membranous pouches that contain perilymph. The utricle communicates with the semicircular canals and contains hair cell sensory receptors connected to fibers from the eighth cranial nerve. The hair cells react to the force of gravity and movement of otoliths, and are a part of the sense of equilibrium.

3. Semicircular Canals – located at right angles to each other are the superior, posterior, and inferior semicircular canals. Contains an enlargement called an ampulla, which contains nerve endings in the form of hair cells. Changes in the position of the head cause the fluid in the canals to move against these sensory receptors, which, in turn, report such movement to the brain through fibers leading to the eighth cranial nerve. Dizziness and motion sickness are associated with rapid or erratic movement and the resulting sensory sensation sensations in these areas.

II. Life Span Considerations

A. The Child (Figure 15–4, p. 504) – at 40 weeks, the fetus exhibits firm ear lobes. In newborns, the walls of the ear canal are pliable because of underdeveloped cartilage and bone. The Eustachian tube in infants is shorter and straighter than in older children and adults. Because of this, an infant or young child is more predisposed to developing an ear infection. When this occurs, the child’s ears should be examined very carefully. Verbal stimulation is crucial to the development of the development of later thinking and language skills.

B. The Older Adult – changes occur in the external, middle, and inner ear. The skin of the auricle may become dry and wrinkled. Cerumen production diminishes and is dryer. The external canal becomes dry causing itching. External ear hairs become course and long, especially in men. Eardrum thickens and bony joints in the middle ear degenerate. Changes in the inner ear affect sensitivity to sound, understanding of speech, and balance. Degenerative changes include atrophy of the cochlea, the cochlear nerve cells, and the organ of Corti. These changes lead to the hearing loss, presbycusis, which is common in the older adult.
III. Building Your Medical Vocabulary
A. Medical Words and Definitions – this section provides the foundation for learning medical terminology. Medical words can be made up of four types of word parts:
1. Prefix (P)
2. Root (R)
3. Combining Forms (CF)
4. Suffixes (S)
By connecting various word parts in an organized sequence, thousands of words can be built and learned. In the text, the word list is alphabetized so one can see the variety of meanings created when common prefixes and suffixes are repeatedly applied to certain word roots and/or combining forms. Words shown in pink are additional words related to the content of this chapter that have not been divided into word parts. Definitions identified with an asterisk icon (*) indicate terms that are covered in the Pathology Spotlights section of the chapter.

IV. Drug Highlights
A. Analgesic – used to relieve pain without causing loss of consciousness.
B. Antipyretic – an agent that reduces fever.
C. Antibiotics – used to treat infectious disease. They may be natural or synthetic substances that inhibit the growth of or destroy the growth of or destroy microorganisms, especially bacteria.
1. Penicillins – act by interfering with bacterial cell wall synthesis among newly formed bacterial cells. Penicillins are contraindicated in patients who are known to be allergic or hypersensitive to any of its varieties, or to any of the cephalosporins.
2. Cephalosporins – are chemically and pharmacologically related to the penicillins. They act by inhibiting bacterial cell wall synthesis, thereby promoting the death of developing microorganisms. Hypersensitivity to cephalosporins and/or penicillins may result in an allergic reaction.
3. Tetracyclines – primarily bacteriostatic and active against a wide range of gram-negative and gram-positive microorganisms. They inhibit protein synthesis in the bacterial cell. These drugs are contraindicated in children 8 years of age and younger because they cause permanent discoloration of tooth enamel.
4. Erythromycin – works by inhibiting protein synthesis in susceptible bacteria. These drugs can be used for patients allergic to penicillin.
D. Drugs Used to Treat Vertigo – vertigo is an illusion of movement. Vertigo can be caused by a lesion or other process affecting the brain, the eighth cranial nerve, or labyrinthine system of the ear. Drugs used for vertigo include anticholinergics, antihistamines, and antidopamines.
V. Diagnostic and Lab Tests

A. **Auditory-evoked Response** – response to auditory stimuli that can be measured independent of the patient’s subjective response. Using an electroencephalograph, the intensity of sound and presence of response can be determined.

B. **Electronystagmography (ENG)** – recording of eye movement in response to specific stimuli. Used to:
   - Determine the presence and location of a lesion in the vestibule of the ear.
   - Help diagnose unilateral hearing loss of unknown origin.
   - Help identify the cause of vertigo, tinnitus, and dizziness.

C. **Falling Test** – test to observe the patient for marked swaying or falling. Marked swaying or falling may indicate vestibular and cerebellar dysfunction.

D. **Past-pointing Test** – the patient is instructed to reach out and touch the examiner’s index finger, which is held at shoulder level, then to lower the arm, close the eyes, and touch the finger again. Degree and direction of past-pointing is observed.

E. **Otoscopy** – visual examination of the external auditory canal and the tympanic membrane via an otoscope. In pneumatic otoscopy, a special attachment is used on the otoscope to allow the examiner to direct a light stream of air towards the eardrum. The directed air current should then cause the tympanic membrane to vibrate. With dysfunction there is little or no vibration noted.

F. **Tuning Fork Test** – method of hearing by the use of a tuning fork. Two types of hearing loss, conductive and perceptive, can be distinguished through the use of this test. There are several types of test which use a tuning fork:
   - **Weber Test**
   - **Bing Test**
   - **Schwabach Test**
   - **Rinne Test** – most commonly used test.

G. **Tympanometry** – measurement of the movement of the tympanic membrane and pressure in the middle ear. Used to detect middle ear disorders.

VI. Abbreviations (p. 513)

VII Pathology Spotlights

A. **Hearing Loss** (Fig. 15–10, p. 514) – sustained noise over 85 decibels (db, dB) can cause permanent hearing loss. Risk doubles with each 5-decibel increase. Noise can get in the way of learning and cause stress. Research shows that noise can cause anger, aggression, poor performance, and insomnia. May be a factor in hypertension and cardiovascular and digestive problems. The word *sound* can be used to remember things that cause ear problems:
1. Sensory overload.
2. Old age – age-related hearing loss usually does not lead to deafness but leads to auditory isolation.
3. Undiagnosed tumors or undertreated infections.
4. Nonfunctioning ear canal or bones.
5. Damage from drugs, trauma, or pressure.

B. Ménière’s Disease – an abnormality of the inner ear causing symptoms that are associated with a change in fluid volume within the labyrinth it can occur suddenly and arise daily or as infrequently as once a year. These symptoms can include:

1. Vertigo – often the most debilitating symptom of Ménière’s disease, typically involves a whirling dizziness that forces the sufferer to lie down. Vertigo attacks can lead to severe nausea, vomiting, and sweating and often come with little or no warning.
2. Tinnitus – the sensation of ringing or roaring sounds in one or both ears.
3. Sensation of Pressure or Pain in the Affected Ear
4. Hearing Loss Lasting Several Hours

There is no cure for Ménière’s disease. However, the symptoms are often controlled by reducing the body’s retention of fluid through dietary changes or medication.

C. Otitis Media (OM) – inflammation or infection of any part of the outer, middle, or inner ear. The inflammation often begins when viral or bacterial infections that cause sore throats, colds, or other respiratory or breathing problems spread to the middle ear. Otitis media affects children more often than adults. There are many reasons that children are more likely to suffer from otitis media than adults:

1. Children have problems fighting infections because their immune systems are underdeveloped.
2. Eustachian tubes are shorter and straighter. A eustachian tube that cannot open regularly to ventilate or replenish air in the middle ear may allow fluid from tissue that lines the middle ear to accumulate. Tube also equalizes middle ear pressure in response to air pressure changes in the environment. However, a eustachian tube that is blocked by swelling of its lining or plugged with mucus from a cold or for some other reason cannot open to ventilate the middle ear, which may allow fluid from the tissue that lines the middle ear to accumulate.
3. Adenoids, which are composed of lymphocytes that help fight infection, are larger in children than in adults. They are positioned in the back of the upper throat near the eustachian tubes. If they enlarge, they block the tube openings. If they become infected, the infection may spread into the eustachian tubes.

As fluid increases, the child may have trouble hearing because the eardrum and middle ear bones are unable to move as freely as they should. As the infection worsens, some children experience severe
ear pain while others do not. Otitis media is often difficult to detect because most children affected by this disorder do not yet have sufficient speech and language skills to tell others what is bothering them. Common symptoms of otitis media are:

- Unusual irritability; fussiness.
- Difficulty sleeping; night awakening.
- Tugging or pulling at one or both ears (Fig. 15–11, p. 516).
- Fever.
- Fluid draining from the ears.
- Loss of balance.
- Unresponsiveness to quiet sounds or other signs of hearing difficulty.

D. **Tinnitus** – the sensation of ringing or roaring in one or both ears is a symptom associated with damage to the auditory cells in the inner ear. It can also be a symptom of other health problems. It is estimated that at least 12 million Americans have tinnitus. Of these at least 1 million experience it so severely that it interferes with their daily activities. Diagnosis is made with the help of an **otolaryngologist** and/or an **audiologist**, who test the patient’s hearing. There are several possible causes of tinnitus:

1. **Hearing Loss** – people with several different kinds of hearing loss, primarily from presbycusis or trauma-related damage to the inner ear, also have tinnitus.
2. **Loud Noise** – too much exposure to loud noise can cause noise-induced hearing loss and tinnitus.
3. **Medicine** – more than 200 medications can cause tinnitus.
4. **Other Health Problems** – allergies, tumors, and problems in the heart and blood vessels, jaw, and neck can cause tinnitus.

A patient may be referred to an otolaryngologist, for diagnosis, and/or an audiologist, who will test the patient’s hearing. There is no cure for tinnitus but the following treatments may provide some relief:

- **Hearing Aids** – wearing a hearing aid makes it easier for some people to hear the sounds they need to hear by making them louder.
- **Maskers** – small electronic devices that use sound to make tinnitus less noticeable.
- **Medicine or Drug Therapy** – medicines such as antiarrhythmics and antidepressants can help suppress tinnitus.

VIII. **Pathology Checkpoint**

IX. **Study and Review** (pp. 519–523)
X. Practical Application: SOAP: Chart Note Analysis