The Middle Ear

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Learning outcomes

- Describe the basic structures of the middle-ear and its purposes.
- Recognize some of the etiologies and treatments of common disorders that produce conductive hearing loss.
- Predict the typical audiometric results for middle-ear pathologies discussed in this chapter.
- Make a reasonable attempt at stating the etiology of a conductive hearing loss based on audiometric and other findings.

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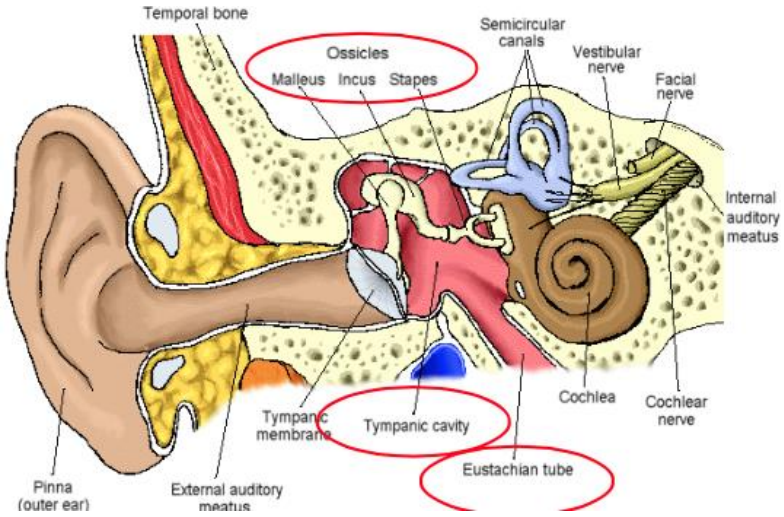
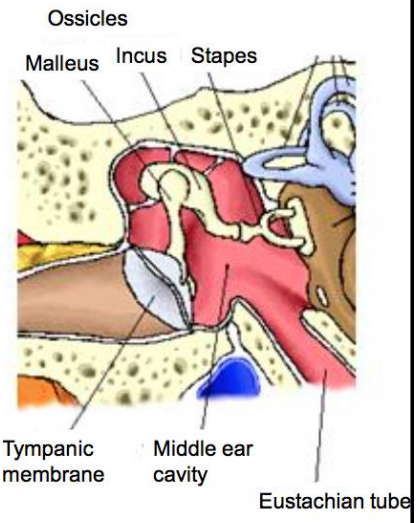
Middle Ear



Middle Ear

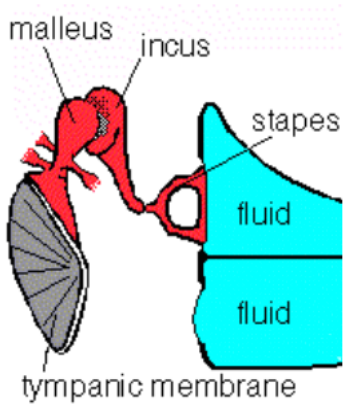
- Components:

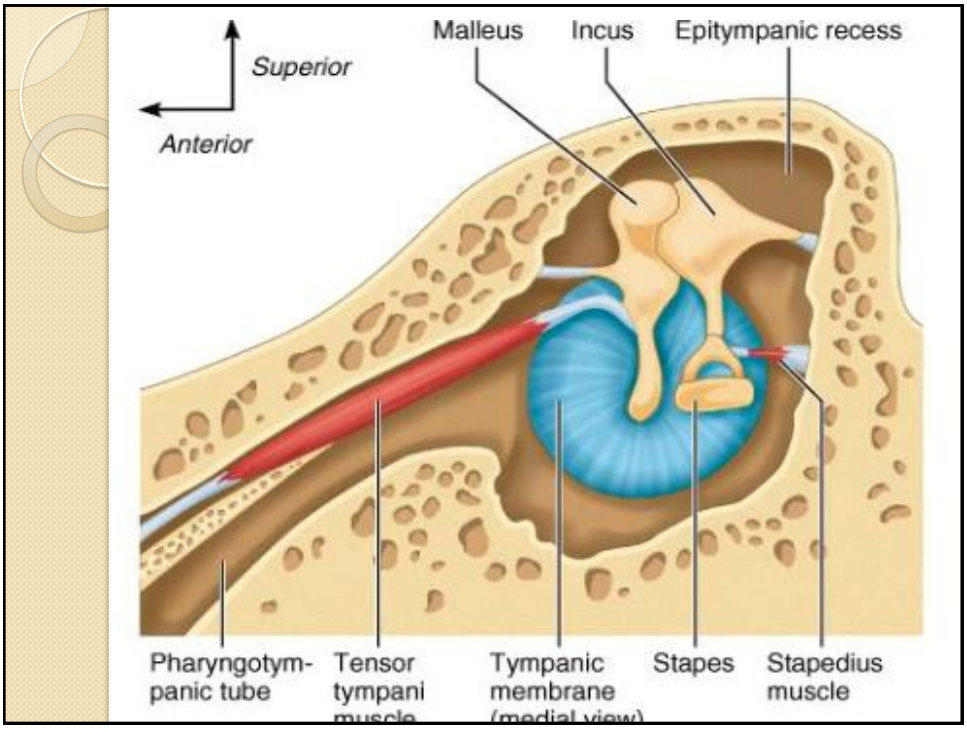
1. Ossicles (malleus incus,stapes)
2. Middle ear muscles (not shown)
3. Eustachian tube



Middle Ear Function

- Transmits sound vibrations from the outer ear to fluid vibrations in the cochlea.





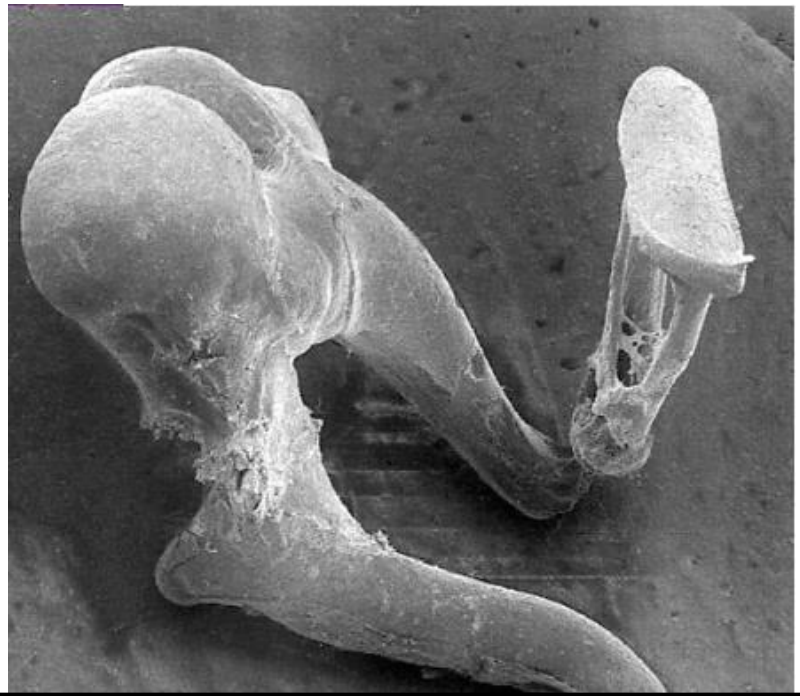
The Eustachian Tube ET

- Channel connecting the tympanic cavity with the nasopharynx, runs downwards, forward & medially.
- Enters the middle ear anteriorly at a 30 degree angle and passes down into the nasopharynx.
- 36 mm long; lateral (ear) is bony and medial (nose) is cartilagenous.
- 3 muscles attached – tensor palati, levator veli palatini, salpingopharyngeus.
- Closed at rest, opens during swallowing, yawning, sneezing or when excessive air pressure is applied from the nose.
- Its function:

To keep the pressure equal on both sides of the TM to maximize its mobility.

Bones in the Middle Ear (Ossicles)

- Mallues :handle attached to TM and head to incus body
- Incus :lentiform process at tip of long process attaches to stapes head
- Stapes : footplate attached to margins of OW by annular ligament



The Middle-ear Impedance Matcher

- Allows for more efficient transmission of sound (air vibrations) from the outer ear to fluid vibrations in the cochlea.
- Acoustic impedance can be thought of as a measure of how easily sound can travel through a substance.
- Liquids are much denser and stiffer than gases, and sound travels more quickly through them. They have a much higher acoustic impedance – more force needs to be applied to get it moving.
- Impedance
- Sound transmission between materials that have different impedances is poor:
- 99.9% of the sound energy is reflected rather than transmitted
- Equivalent to approximately 30dB loss in efficiency
- If sound was transmitted directly from the outer ear (air filled) to the cochlea (fluid filled), most of the sound would be reflected rather than transmitted.

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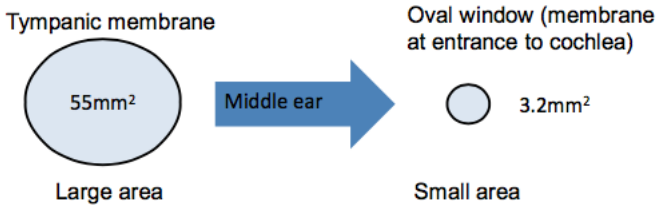
Impedance matching: area effect

- The middle ear allows the efficient transmission of sound from the outer ear to fluid vibrations in the cochlea by a process called impedance matching.



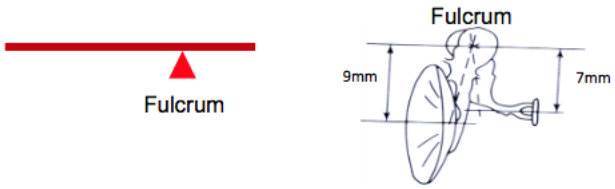
Pressure = force/area

Thus pressure gain = 55/3.2 = **17** or in dB = $20\log_{10}(17)$ = **24.6 dB gain**

- A greater pressure is exerted at the oval window than at the tympanic membrane, as the same force is applied to a smaller area.

Impedance matching: lever effect

- The ossicles act as a lever, amplifying the force exerted on the tympanic membrane by a factor of around 1.3.



Lever ratio = 9/7 = 1.3, or in dB = $20\log_{10}(1.3)$ = 2.3 dB gain

- The combination of these two effects mean that almost 74% of the sound energy is transmitted to the cochlea (compared with 0.1% without impedance matching).

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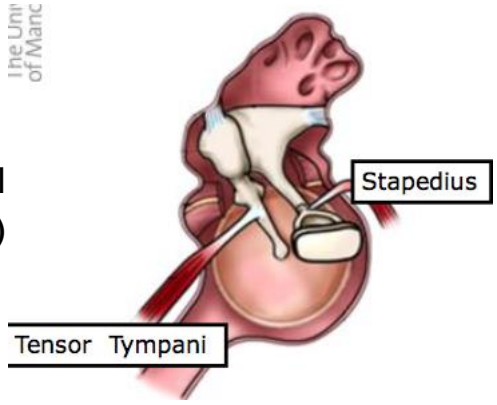
Nonauditory Structures in the Middle ear

- The falloppian canal is a bony channel covered with mucous membrane and containing a portion of the facial nerve (VII cranial nerve).
- The chorda tympani nerve is a branch of the facial nerve that passes through the middle-ear space and carries information about the sensation of taste from the anterior two-thirds of one side of the tongue.

The Middle Ear Muscles

- There are two muscles in the middle ear: the tensor tympani, which is connected to the malleus, and the stapedius, which is connected to the stapes.
- The facial nerve innervates the Stapedias Muscle And the trigeminal (Vth cranial nerve) innervates the tensortympani



Acoustic Reflex

- Both muscles contract in response to very loud continuous sounds, stiffening the ossicular chain, and reducing low-frequency sound transmission through the middle ear. This is known as the 'acoustic reflex' or 'stapedius reflex' (mainly a stapedius effect in humans).
- This protects the inner ear from damage due to sound over-exposure. This mechanism only works for loud continuous sounds, as the muscles do not contract fast enough to protect against sounds that start suddenly (e.g. a gun shot).
- The stapedius muscle contracts just before and relaxes just after we speak. This reduces transmission of the sound of our own voice to the inner ear.

Development of the Middle Ear

- During embryonic development, the middle ear and ET form from the pharyngeal arch system.
- At about 29 to 32 days, tissue forms that will become the malleus and incus.
- At the 12th fetal week, the ossicles differentiate and are fully formed by the 16th week as cartilaginous structures begin to ossify.
- At 21 st week total ossification of the malleus and incus. While, the 24th week shows rapid ossification of the incus and stapes.

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Hearing Loss and the Middle Ear

- Abnormalities of the middle ear produce conductive hearing loss.
- According to the amount of attenuation produced by the disorder, the air-conduction level drops.

Disorders of the Middle Ear and Their Treatments

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Negative Middle-Ear Pressure

- Poor function of the Eustachian tube (ET) is responsible for many middle-ear disorders.
- Two most common causes of eustachain-tube dysfunction (ETD) are:

1. Edema of the ET secondary to infection or allergy.
2. Blockage of the ET by hypertrophied (overgrown) adenoids.

- ETD will result in a drop in pressure within the middle ear, this causes the tympanic membrane to be retracted as the pressure in the external canal is higher than the pressure in the middle ear. The retraction from the ETD interferes with the normal vibration of the TM and may produce a slight conductive hearing loss.

Otitis Media

- Otitis media (OM) is any infection of the mucous membrane lining of the middle-ear cleft.
- One of the most common disorders of the middle ear causing conductive hearing loss.
- Nearly 70% of the United States children who are under 2 years are experiencing OM, with more than half of these children having recurrent episodes.
- Risk factors:

1. ETD
2. Barotrauma (sudden changes in air pressure, as when flying or diving)
3. Abnormalities in the mucous membrane
4. Craniofacial abnormalities affecting the Eustachian tube (Down's, Turner's) in children
5. Age (OM is more common in children)
6. Race (commoner in Chinese, Eskimos and Native Americans and less common in Whites, while in Blacks it is least common)
7. Gender (more common in males than in females)
8. Socioeconomic factors
9. Individual's immune system
10. Exposure to cigarette smoke or other fume (external factor)
11. Seasonal effects (OM is most common in the winter months)

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Otitis Media

- Diagnosis (proper diagnosis result in appropriate therapy)
- Otoscopy will reveal the retraction of the TM
- Tympanometry - type C
- Pure tone audiometry - slight CHL
- "Red ear" refers to the inflammation of the middle ear and TM

Suppurative Otitis Media

- In Suppurative otitis media, the mucosa becomes filled with blood, the superficial cells break down, and pus accumulates.
- Symptoms:

1. Pain in the ear
2. Pulse rates and body temperatures become elevated
3. Visibly ill

- If pressure from the pus goes up, necrosis will occurred (death of the mucosa, submucosa, and TM)
- Further increase in pressure will cause rupture in the TM
- Pus may reach the mastoid causing mastoiditis

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Suppurative Otitis Media

- Chronic and Acute suppurative otitis media
- Chronic otitis media refers to a long standing condition
- Acute otitis media generally develop rapidly and include swelling, redness, and bleeding
- Pure tone audiometry – Conductive hearing loss (degree of hearing loss related to the accumulation of fluid in the middle ear and the configuration is rather flat across all frequencies)
- Treatment:
- Antibiotics for bacterial infections
- Pus removal
- If recurrence - grommets — a tube surgically implanted in the TM to drain fluid from the middle ear
- If complicated, surgery

Dormant Otitis Media

- Refers to exacerbation of the same condition of otitis media experienced earlier. Many patients discontinue their own antibiotics treatments when their symptoms of OM abate, leaving some of the bacteria alive which will cause the condition to flare up again. Stronger strain of bacteria will result (side effect of antibiotics) that is less susceptible to medication.

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Serous Effusion of the Middle Ear

- Definition

Inflammation of the middle ear cleft characterised by the presence of non purulent fluid and without any features of infection

- Meniscus: the fluid line that reveals the presence of fluids and can be seen in the otoscopic examination
- When the meniscus rises above the superior margin of the TM, the condition at this stage is difficult to diagnose visually.

Serous Effusion of the Middle Ear

- Treatment:
- Decongestant-antihistamine combinations will help to restore normal middle-ear pressure that results from ETD. However, these treatments are found to be useless in infants and small children as ET is less efficient in those groups.
- Antibiotics are not indicated as with serous effusion, the middle ear is not infected.
- Surgical treatment

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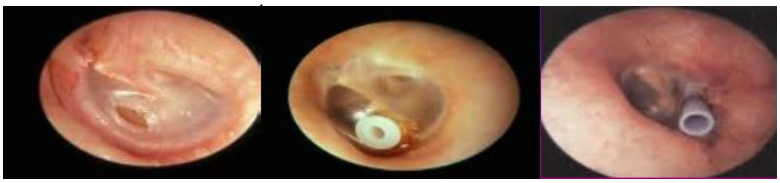
Surgical Treatment for Middle-Ear Fluid

- Myringotomy or myringostomy which include performing incision into the TM to relieve the fluid pressure and suction out the remaining fluid. A plastic pressure-equalizing (P.E.) tube is inserted through the incision in the TM to keep the middle ear apparent.



Cholesteatoma

- The condition refers to the presence of a pseudotumor which is occurred whenever skin is introduced to the middle-ear space.
- Cholesteatoma form as a sac, with onionlike rings. yellow
- A primary acquired cholesteatoma occurred without a history of OM if the epithelium of the attic of the middle ear becomes modified. This alteration may occur if the pars flaccida of the TM becomes sucked into the middle ear through negative pressure and then opens, revealing the skin from the outer portion of the TM to the middle ear.
- In patients with perforated TM, the skin may enter the middle ear through the perforations. This invasion produce a secondary cholesteatoma.
- The best treatment for cholesteatome is surgery.
- The condition spreads rapidly, so during the surgery all the cholesteatomatous material must be removed.
- Most ears with the condition are secondarily infected and produce foul-smelling discharge that drain from the ears (otorrhea).

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Otosclerosis

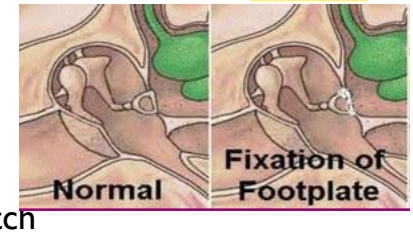
- Definition

Localised lesion of the the stapedial footplate or the cochlea of one or both ears where normal bone is replaced by spongy bone

- Common cause of hearing loss in adults
- Etiology
- Probably genetic (in at least 70%of all cases)
- Fixation of stapes footplate is the cause of symptoms
- 50% of adult CHL
- The incidence in women approximately twice than in men and usually between 20 and 30
- More common in white race
- Rare among children

Otosclerosis

- Symptomatology and diagnosis
- CHL – gradual and usually bilateral; may be severe
- Mixed if cochlea affected
- Patients often exhibit a bluish cast to the whites of their eyes
- they complain of difficulty hearing while chewing
- Paracusis Willisii
- Tinnitus and vertigo
- TM normal but may show Schwartze's sign (flamingo pink tinge)
- PTA with Carhart's notch



*Condition found among patients with conductive hearing loss in which they understand speech better in noisy than in quiet surroundings

Otosclerosis

- Management
- Conservative with monitoring and amplification
- Surgery when indicated – stapedotomy with prosthesis usually made of teflon – not without complications – usually closes the air bone gap and abolishes the Carhart's notch

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