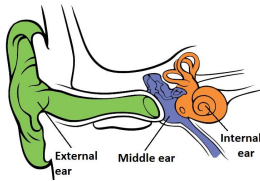




Ear I&II



Objectives:

1. Ear I
 - Gross applied anatomy of the ear
 - Nerve supply of the external and middle ears and the principles of referred earache
 - Central connection of the vestibulo- cochlear nerve
 - Physiology of the external, middle and inner ears

1. Ear II
 - Recognize the congenital anomalies of the external ear
 - Diagnose and treat wax accumulation
 - Diagnose and treat the common external ear inflammatory conditions
 - Discuss the pathology, clinical features and management of AOM

Resources: Team 436, Doctor Slides

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[Color index: **Important** | **Notes** | Extra | **437A**]

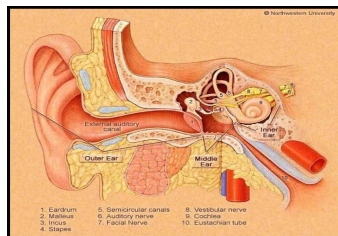
Anatomy of the Ear

it has 3 parts:

1. **External ear:** From the outer part till the eardrum (tympanic membrane). It contains the Squamous part of tympanic membrane.
2. **Middle ear:** (tympanic cavity); From the eardrum till the stapes footplate. It contains the mucosal part of tympanic membrane.
3. **Internal ear:** Cochlea and vestibule (**semicircular canals for angular acceleration and the saccule for linear acceleration**).

There are two sets of end organs in the inner ear or labyrinth:

- The **semicircular canals**, which respond to rotational movements (**angular acceleration**).
- The utricle and saccule within the **vestibule**, which respond to changes in the position of the head with respect to gravity (**linear acceleration**), utricle"horizontal" & saccule"vertical"



1-External ear:

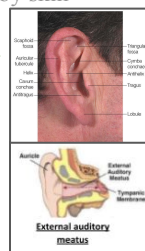
- Formed of Auricles (pinna) and External auditory meatus (auditory canal) and both are lined by skin (Auricle and meatus).
- **Auricle:** is fibrous cartilage "thin" (except lobule area-no cartilage) lined by skin

● what is its significance?

- In case of **Perichondritis lobule is spared but perichondrium is affected**, in case of **Erysipelas all of auricle is affected**. Auricle is attached to temporomandibular

joint, so movement of this joint will aggravate the pain in case of inflammation of pinna. once we separate any perichondrium from a cartilage the cartilage will die (necrosis) so if we have hematoma of the ear (trauma, piercing, etc) and we did not treat it immediately we will end up with necrosis, the septum will separate from the cartilage (the main blood supply to the cartilage) and necrosis of the cartilage will happen.

- If we want to do tympanoplasty or septoplasty what type of graft can we use? the cartilage from the inner part of the tragus, cymba concha & cavum conchae, why? bc unlike the scaphoid or triangular fossa, these cartilages are attached directly to the skull, thus there won't be any change of the normal shape of the pinna.



(Perichondritis: redness, discharge)
(Erysipelas: skin infection with staph and there is redness)



-The external auditory meatus not straight, If you didn't pull the ear **upward & backward** and make it straight you will hit the canal exactly in the isthmus which is the narrowest part, where the area of cartilaginous part meets the bony part, to protect the eardrum and middle ear, normally we must hump one superior and one posterior. In infant **downward and backward**.

-In pediatric it might be straight but in adult it's curved (it's also could be straight if canaloplasty was done)

External Auditory Canal (EAC is 2.5 cm long) consists of:



➤ **Lateral third (outer 1/3) of canal length:**

- Cartilaginous
- Hair follicles
- Ceruminous glands
- Sebaceous glands
- Contains small amount of subcutaneous tissue
- Appendages formed by elastic cartilage and contains ceruminous glands (secrete wax), hair follicles, sebaceous and apocrine glands all together called (apopilosebaceous unit).

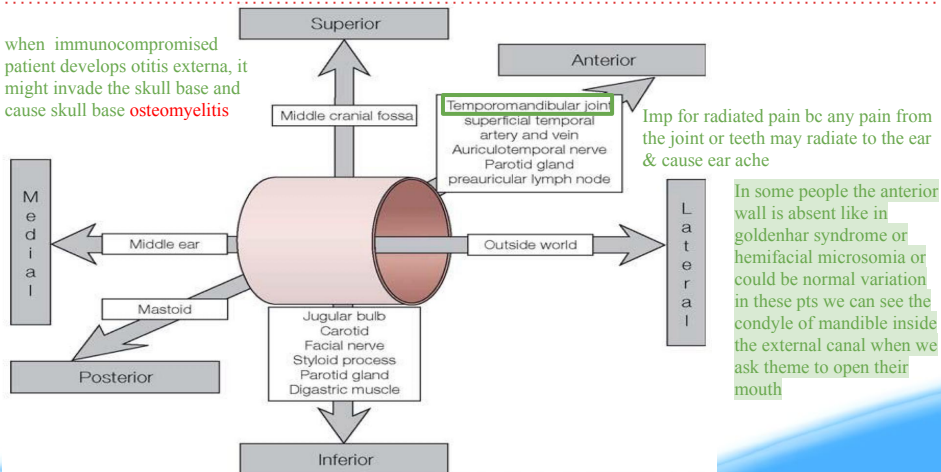
➤ **Medial two thirds (inner 2/3) is osseous:**

- Bony
- Develops after birth
- Doesn't have hair follicles, sebaceous or ceruminous glands.
- The narrowest portion is at the bony-cartilaginous junction. No subcutaneous tissue or appendages
- The skin is thin(0.2mm) skin over bone and easy to be injured during examination. Natural constriction. Another area of constriction is at the tympanic membrane.

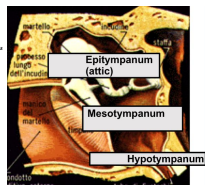
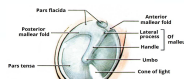
- Most ear wax emerges spontaneously from the external canal while in other people it doesn't and they need to get it removed by a doctor. The reason of this is due to the incorrect use of Q-tip, for example someone may go further into the external canal, and they'll end up pushing the wax inside which would get stuck on the bony part, and might accumulate with time.

• **Anatomical relations of external auditory canal: IMPORTANT**

when immunocompromised patient develops otitis externa, it might invade the skull base and cause skull base **osteomyelitis**



Tympanic Membrane (TM):



- It separates the external ear from middle ear
- The Tympanic Membrane is divided into 2 parts:
 - Pars Tensa 80%
 - Pars Flaccida 20% (The weakest area for -ve pressure, which cause it to retract and go inside & it's also the most common site of cholesteatoma)*
- It's a Fibroelastic Membrane has 3 layers :
 - Epithelial "Epidermal" layer: outer layer stratified squamous epithelium (skin), ectodermal origin.
 - Fibrous layer: middle layer or lamina propria fibrous layer, mesodermal origin. (present only in pars tensa which makes pars flaccida more prone for perforation)
 - Mucosal layer: inner layer of endodermal origin, comprising the middle ear mucosa.
- We could also divide the TM to 3 parts:
 - Epitympanum: superior aspect of the tympanic membrane. Most common site for acquired cholesteatoma
 - Mesotympanum: area of the middle ear medial to the tympanic membrane. Most common site for congenital cholesteatoma (not related to -ve pressure)
 - Hypotympanum: area of the middle ear inferior to the tympanic membrane. cholesteatoma may extend to it, which is an area we might forget to check.

→ TM supplied mainly by V3 (Mandibular) anterior, and X (Vagus) posterior on lateral (outer) aspect, IX (Glossopharyngeal) on medial (inner) aspect.

*Cholesteatoma is not a tumor or high cholesterol, basically it's a normal skin in abnormal place (mucosa.) It will eat the bone. Pars flaccida has no annulus so cholesteatoma can happen through it also.

- How can we determine this is right or left ear? By the angle of cone of light and handle of malleus:

- Right → right ear
- Left → left ear.

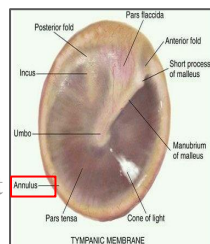


left ear

in the exam they may ask you which side is this ear

- In case there was retraction of the tympanic membrane → narrowing of the light cone, and if it was bulging (fusion) → widening of the light cone.

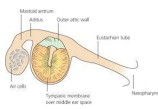
- Annulus is a fibrous band around the pars tensa that holds the TM. if we do tympanoplasty, we do refreshment of the edge then I will take graft and put it under it. Why? for epithelialization, the graft will prevent the epithelialization from going inside making it in one line. So if I did not elevate the annula and fix it again in its place it will be lateralized /blunt and wont give me the normal picture.



- Why it's important to be at the same place? because the sound when it stuck to the tympanic membrane and there is vibration it will not transmit to the ossicles. but if the tympanic membrane is thick we will have conductive hearing loss.
- If it's affected through marginal perforation that means the (stratified squamous) skin that is inside the external ear canal can go inside and induce a cholesteatoma.

2-Middle Ear:

- Lining of the middle ear: Mucous membrane: ciliated columnar anteriorly, and cuboidal or flat elsewhere, which changes to pseudostratified ciliated epithelium around the mouth of the Eustachian tube.
- **Middle ear cleft formed of:**
 - a. Eustachian (Pharyngo-tympanic) Tube
 - b. Tympanum (Middle Ear Cavity/proper)
 - c. Mastoid Antrum and Air Cells



In OR you see opening from middle ear to mastoid is called Auditus (bridge).
But From mastoid to middle ear is called antrum (largest air cell in mastoid)

Middle Ear Function:

- Conduction of sound
- The middle ear plays an important role in the process of impedance matching between the air-filled middle ear and the fluid-filled inner ear to allow for efficient sound transmission (Impedance matching):
 - Area ratio between the TM and the stapes footplate (20:1)
 - Ossicular Coupling: lever ratio
- Transformer mechanism: Hydraulic action - Ossicular leverage 1.3x amplification due to size difference between malleus and incus Stapes alone increase sound by 2000 hz, any problem in stapes we will find the audiogram fall at 2000 hz
- Protection to the inner ear: Stapedial reflex, If the sound very loud it contracts to reduce the sound energy

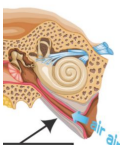
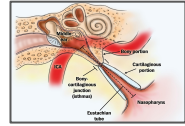
Contents of middle ear cavity:

- **Air**
- **Ossicles “Bones”:** Malleus, Incus, & Stapes (The smallest bones in the body)
- **Muscles:** Tensor Tympani & Stapedius
- **Nerves:** Chorda Tympani & Tympanic Plexus **nerve 7 and 8**
 - **Chorda tympani is a branch of the facial nerve and it innervates the anterior 2/3 of the tongue** this is why when we injure both nerves (right & left) the patient will lose taste sensations
 - Course of facial nerve:
 - Brain stem → temporal bone → and before it exit the stylomastoid foramen it crosses 3 segments: labyrinthine, tympanic & mastoid segments.
 - Dehiscence of the facial nerve will happen in the labyrinth segment (40%) where surgical injuries (iatrogenic) mostly occur in the mastoid segment
 - **What are the 3 parts inside the temporal bone?**
 1. labyrinthine → in bell's palsy usually edema is in the narrowest part which is here
 2. tympanic horizontal segment → in the middle ear
 3. mastoid vertical segment → in the mastoid bone

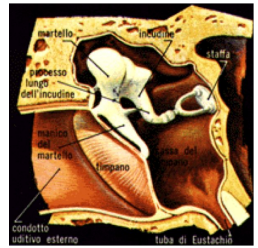


A. Eustachian (Pharyngo-tympanic) Tube:

- Connect the middle ear cavity with nasopharynx “nasal cavity” (upper aerodigestive tract).
- Lies adjacent to the ICA (internal carotid artery).
- Is the conduit through which air is exchanged between the middle ear space and upper aerodigestive tract & open at torus tubarius .
- Parts of Eustachian Tube:
 - Proximal 1/3 is bone.
 - Distal 2/3 is fibrocartilaginous, That is collapsed at rest
 - Junction between 2 parts is isthmus, narrowest part of the tube.
- When you are at the plane and have URTI, and the pilot landed very fast .so what can we do ? chew, steroid or atropine spray (decongestant)
- The tube permits aeration of the middle ear and if it is obstructed fluid may accumulate in the middle ear causing deafness.
- Normally always closed. But in case of: Yawning, eating, Swallowing (When you swallow sometimes your ear make sound this is ET) → the ET open up actively by contraction of salpingopharyngeus muscle & passively by Tensor tympani. (it releases the tension in tubal cartilage).
- What are the **muscles** that control the opening of the eustachian tube? (1) tensor veli palatini, (2) levator veli palatini, (3) salpingopharyngeus muscle.
- It also opens when there’s change in pressure to equalize the pressure in the middle ear.
- Closed by elastic recoil of elastin hinge + deforming force of Ostmann’s fat pad.
- Patulous Eustachian Tube is when the eustachian tube is opened all the times and it sometimes occur in people who undergo sleeve surgery, bc they’ll lose a lot of weight, thus losing the fat. We first wait for a couple of months until they gain a bit more weight and it will become better. But in case it doesn’t we will treat them with fat injection at the site or fillers
- **The tube is shorter, wider and more horizontal in the infant than in the adult.**
- Secretions or food may enter the tympanic cavity more easily when the baby is supine particularly during feeding.
- The tube is normally closed and opens on swallowing because of movement of the muscles of the palate. This movement is impaired in cleft palate children “bc the absence of tensor palatini muscle” who often develop accumulation of middle-ear fluid (otitis media with effusion).



B. Tympanic Cavity (Middle Ear Cavity):



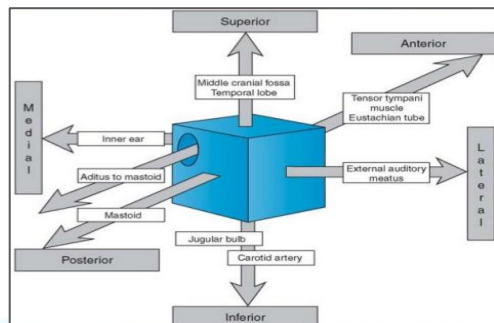
- **Walls of tympanic cavity:**
 - Roof “tegmen tympani”
 - Floor
 - Anterior wall
 - Posterior wall
 - Lateral wall
- What are the muscles that are present in the middle ear?
 - Stapedius (stronger contractions) & Tensor tympani
 - Their function is to control the sound, how? when there's a loud sound, these muscles will contract (the stapedius' contractions are stronger) to decrease the vibrations reaching the ossicle to prevent noise trauma
- The neck of **Stapes** receives the insertion of stapedius muscle. Contraction of the stapedius muscle restrict the movement of the stapes (this is considered as a physiologic reflex that protects the inner ear from very loud sounds (stapedial reflex or acoustic or attenuation reflex). Neck of **Malleus** receives the insertion of Tensor tympani muscle.
- Importance? We sometimes want to to check whether the stapes is fixed, stable or if it has otosclerosis, therefore we do stapedial reflex test. The presence of involuntary muscles contractions in response to loud sound means the patient is normal or might have mild conductive hearing loss. if it's absent it means the patient might have severe conductive hearing loss (25-30 dB) (This will be explained in details in the audiology lecture)
- Round window is important for cochlear implants and the stapes is important for patients with otosclerosis.
- The facial canal that has the facial nerve runs above the stapes.
- In patients with otosclerosis (fixed stapes) we surgically treat them by creating a small opening to transfer the sounds from the outer ear to the inner without being affected by the fixation of the stapes. But 40% of these patients have discent and prolapse of the facial nerve which is a contraindication of the surgery. .

Nerve supply:

- **Sensory nerve supply** of the middle ear mucosa:
 - Tympanic branch of the glossopharyngeal nerve.
 - Auriculotemporal branch of the trigeminal nerve.
- **Motor nerve supply** of the middle ear muscles:
 - Stapedius muscle supplied by the stapedial branch of the facial nerve.
 - Tensor tympani supplied by the mandibular division of the trigeminal nerve.

Anatomical relations of middle ear:

- Floor: internal jugular vein and common carotid
- Roof: skull
- Lateral: tympanic membrane
- Posterior: mastoid air cells
- Medial: promontory of the cochlea



- ◀ Clinical importance of walls of middle ear:
- Fracture of temporal bone (roof of middle ear cavity) will be presented by either CSF otorrhea or rhinorrhea.
- Lateral sinus thrombosis secondary to otitis media (posterior wall).
- The middle cranial fossa of the brain is separated from the middle ear cavity by the tegmen tympani and from mastoid cavity by tegmen mastoideum.
- 1st turn of the cochlea forms the promontory
- Chorda tympani is a branch of CN7
- The canal of the carotid a. doesn't go into the middle ear but it's adjacent to it.
- How many nerves passes through? Facial, Jacobson (branch of 9th CN), chorda tympani. Facial pass on top of the stapes, Jacobson passing through promontory, chorda tympani in the middle ear and supply the lingual nerve for anterior 2/3 of the tongue.
- Facial nerve come from nucleus in pons go to internal auditory canal along with 8th CN, then passes into three canals (Labyrinth, tympanic "the most dehiscent [without bone coverage] part of the facial nerve", mastoid) then it leaves the canal through stylomastoid foramen and turns into 5 branches (temporal, zygomatic, buccal, marginal mandibular, cervical).
- Why this is important? During any ear surgery especially in the stapes, the adhesive part of the facial nerve could be collapsed preventing the surgery

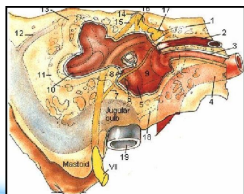
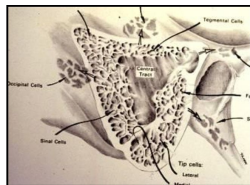
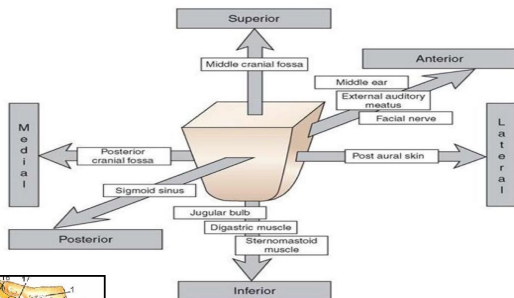
C. Mastoid Antrum & Air Cells:

- ❖ Air-containing cells of the mastoid process are continuous with the air in the middle ear.
- ❖ Pneumatization is complete between the sixth and twelfth years of life.
- ❖ Normal tubal function is a prerequisite for biologically active, healthy middle ear mucosa, and thus for the normal process of pneumatization.

مدخل من الماستويد الي يدخل فيه للمدل اير الفتحة حقتة اسمها antrum
 - طبيب أنا في المدل اير ويدخل على الماستويد الفتحة الي يدخل فيها اسمها aditus. لما نفحص الاذن ونشوف flasidis para
 - نعددها هذي aditus

- Why do we have air cells/sinuses? to make the skull light

Anatomical relations of mastoid antrum:



Sensory Supply of Middle & External Ear:

- ❖ Greater auricular nerve Cervical II & III (lobule, lateral/inferior auricle)
- ❖ Lesser occipital nerve Cervical II (medial surface of pinna)
- ❖ V cranial nerve (auriculotemporal) tragus, anterior helix, Ant canal wall
- ❖ IX cranial nerve (tympanic or Jacobson's)
- ❖ TM supplied mainly by V3 (anterior) and X (posterior) on lateral aspect, IX on medial aspect
- ❖ X cranial nerve (auricular or Arnold's) (concha, Post canal wall)
 - Important if you put cotton inside the ear you will feel tingling in pharynx this is vagus
- ❖ VII cranial nerve (concha, Post canal wall (if you have infection in facial nerve palsy you have to look in the ear you may see vesicles)



Referred Earache : important 50% of ear pain is from outside the ear.

Pain in the ear due to a disease in an area supplied by a nerve that also supply the ear.

- ❖ Cervical II & III: Cervical spondylosis, neck injury (disc, muscle spasm) etc.
- ❖ V (Trigeminal) cranial nerve: Dental infections, sinonasal diseases “maxillary sinus” etc.
- ❖ IX (Glossopharyngeal) cranial nerve (branch of CN 9 called jacobson in the promontory): Tonsillitis, pharyngitis, laryngitis , laryngeal cancer , esophageal foreign body, post-tonsillectomy, carcinoma etc.
- ❖ X (vagus) cranial nerve: Tumors of hypopharynx, larynx & esophagus.
 - One of the signs of recurrence tumors in larynx & pharynx is ear pain.
 - Auriculotemporal nerve (V3): any patient that has dental issue or TMJ, tonsillitis ,URTI so when they present with ear pain I have to examine those, dental, pharynx,oropharynx, cervical

- How sound is transmitted? we have two windows in cochlea oval window & round window. are they important? the sound wave goes to the tympanic membrane , then the membrane moves and vibrate the bones (ossicles), and changes from sound wave to mechanical, then It reach pestim (in the oval window) so it moves it in this way. Inside the cochlea there is fluid that is divided into three rooms, upper room is “scale vestibule”, in the middle “scala media”, lower “scala tympani” (it has the round window). so when moves the scala vestibuli the fluid goes into the cochlea swims and goes again to the scala tympani producing some movement in the round window.

لو ما كانت فيه هذه الاراحة (ازاحة الصوت) كان الفلود ما تحرك من جوا. يعني لو ماكان في مساحة شيء ميكانيكي بحيث مساحة الفلود الداخلية كان ما تحرك الي في الوسط الي هو release to أنه يدخل ويطلع. عشان كذا عندنا ويندو membrane basilar

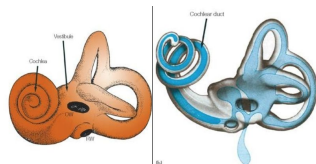
3-Inner ear:

- Consists of: Osseous Labyrinth and Internal auditory canal.

A) Labyrinth consists of:

Osseous Labyrinth its parts:

- Bony Cochlea 35 mm long, 2.5 turns.: for hearing
- Vestibule
- Bony semicircular canals.: for angular balance

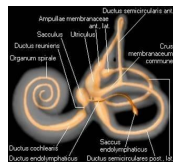


Contents of bony labyrinth:

Perilymph fluid (outside the inner ear) extracellular-like fluid; found in scala tympani and vestibuli.

Membranous labyrinth:

- Cochlear duct
- Sacculle (inferior) and utricle (superior) > both form the endolymphatic duct extended to the dura laterally (its important in meniere's disease "increased perilymph" we used it for shunt placement).
 - They're important for linear acceleration
 - If you're on your phone inside an elevator, how do you know whether your're going up or down without looking? Due to the hair cells present inside the sacculle.
 - Same thing if applies if you're in a car, how do you know whether your're moving forward or backward? hair cells present inside the utricle.
 - 1- Macule of the utricle : plan horizontal
 - 2- Macule of the sacculle: plan vertical
- Membranous semicircular ducts.



Contents of membranous labyrinth:

Endolymph



- Inside the inner ear
- It's the fluid filtered from CSF, when the production increase or excretion decrease the volume of endolymph will increase causing dizziness, fluctuating hearing loss & tinnitus.(Meniere's Disease)
- intracellular-like fluid; found in scala media; contributes to positive DC resting potential of 80 mV in scala media; produced from perilymph by marginal Membranous Labyrinth cells of stria vascularis; absorbed within the endolymphatic sac. (K + = 144 mEq/L, Na+ = 13 mEq/L)

Sensory epithelium: IMPORTANT IN EXAM

- **Cochlea: Organ of Corti:** rests on basilar membrane and osseous spiral lamina; major components include:
 - Outer and inner hair cells
 - Supporting cells: provide structural and metabolic support
 - Tectorial membrane
 - Reticular lamina
- **Utricle & saccule: maculae.** (linear acceleration). Fluid can move right & left
- **Semicircular canals: cristae** (angular acceleration). Fluid can move right & left

B) Internal Auditory Canal: contains cochleovestibular nerve, and facial nerve.

The vestibulo-cochlear nerve:

Central Connections of Cochlear Nerve	Central Connections of Vestibular Nerve
<p>The principal human auditory cortex is located deep within the sylvian fissure on the superior surface of the temporal lobe The primary auditory cortex is often referred to as Brodmann area 41.</p> 	<p>- 2 parts superior & inferior: the inferior supplies the sternocleidomastoid and ocular muscle.</p> <p>- How can we test the vestibular nerve? by testing the sternocleidomastoid & inferior ocular muscle</p> 

Benign Positional Vertigo: Most common disease of the inner ear

- Within the labyrinth we have small calcium carbonate (crystals) called otolith or otoconia, these crystals are inappropriately displaced into the semicircular canals of the vestibular labyrinth, which contains fluid thus the patient will develop the symptoms.
- Treatment:
 1. Repositioning
 2. Tell the patient to keep their eyes open & hold onto smth, why? bc balance relies on proprioceptors & vision so when they do this instead of closing their eyes, they'll have 2 inputs other than the ear which will help decrease the intensity of the symptoms (nausea & dizziness)

In case of dizziness related to ear problem; it's either due to effect in the vestibular nerve (called -vestibular neuritis due to URI) or Benign positional vertigo (inside the vestibule there are fluid and gelatinous material that has Ca particles within it ; with minor trauma or any minor head concussion these Ca particles will go out from the gelatinous material to the fluid > once the pt. Moves his head up > movement of these Ca particles rapidly "when it was in the gelatinous material its movement was slowly" > vertigo not imbalance > treated by repositioning exercise after checking the type of nystagmus "horizontal = lateral Semicircular canal , rotatory= superior (geogravic) and posterior (ageogravic) (Semicircular canals the pt. have

Cochlea:

The cochlea is divided into 3 parts (scala tympani, scala media and scala vestibuli)

Most important is scala media; where hearing takes place.

- It contains hair cells and tectorial membrane.
- The sounds wave vibrate the tympanic membrane → the ossicles move (Thus the sound wave is changed to a mechanical vibration). → it moves the fluid inside the cochlea → the fluid will reach the organ of corti resulting in movements of the hair cells against the tectorial membrane causing it vibrate → will produce electrical energy or impulses and pass it to through the spiral ganglion to the 8th nerve.

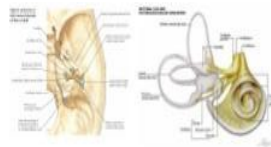
In patients with conductive hearing loss (ossicles problem) and we will implant a hearing aid, how would we know if it works? we move the tympanic membrane and watch the round window to see if it reflexes or not due to the movement of fluid. If it's present this means it works. Same with stapes surgery in otosclerosis patients, we will check for round window reflexes to confirm.

Inner Ear:

High frequency sounds or tones affects the **basal** portion of Cochlea

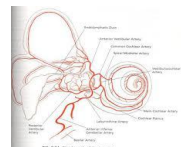
Low frequency sounds or tones affect the **apical** portion of Cochlea

Mid frequency sounds or tones affect the **mid** portion of Cochlea



Blood supply of inner ear:

Anterior inferior cerebellar artery → Labyrinthine artery → Common cochlear & anterior vestibular



◆ Inner canal:

- Consist of cochlea has two window (round & oval) , and semicircular canal
- Membranous part Why its important ? here is Scala vestibule ,media and tympani
- Inside the membranous part is fluid (perilymph) inside it there is crystal “calcium tubercles “ inside each semi-circular canal . They give the sense of going up & down depending on gravity
- Like in BPV(benign positional vertigo) in people who had road traffic accident or prolonged surgery and during transportation the head has been shaken forcefully. Trauma to the head concussion of the inner ear
- فيها مادنتين وحدة سائلة وتحتها مادة جيلائنه. البارنكلز موجودة في المادة الجيلائنية حيث لما تلتفين راسك تتحرك بشويش اذا طلعت من المادة الجيلائنية وصارت تسبح في المادة السائلة. وش بصير؟ مع اي حركة تحسبن ان الدنيا تقلب وتدور مثلا لما تتروش وترفع راسها فوق تقول الدنيا تقلب على ورا أو ولما تنزل تربط الجزمة الدنيا تلف تقعد لها دقيقة كأنها في ملاهي
- so we do maneuvers to put them back in place (epley maneuvers)
- المانوفرز منتو مطالبين تعرفون كيف تتسوى بس حلو تفهمون معناها، نثبت الراس على حسب السمي سيركلز كنال ونلف
- high very is reflex 45 درجة وننزلة تحت السرير نشوف اذا عنده سنطاقمس او لا العين والاذن مشتبهين مع بعض فلما بصير عندنا اي امبالس للكرستلز نشوف السنطاقمس بعده اتهدا ونغير البوزشن نرجعها مكانها لما ocular-vestibulo نعيد التست وماطلعت السنطاقمس معناها انها تعدلت
- So its not medical treatment its re-positioning
- Scala media has ticular membrane and hair cells so with the fluid movement itw will move and produce sound
- Each part of the inner ear has sensory organ “important”
- In the utricle and saccule we have organ that moves and cause inflation and deflation with up & down movement its called Macula
- semicircular canal has bulla at the end that had crystal
- the lateral Semicircular canal is the most prominent one so it's the first can be effected by diseases because the most close to external so any ear diseases that eat the bone or cholesteatoma it is the first to be effected.
- So what will happen (for the vestibule) once we have stimulation its goes to the brain stem the to the brain it gives two part one to the spine and one to the oracular muscle
- So we have nystagmus and imbalance this is for the vestibule
- So how can I know that its only vestibular diseases?
- We know balance is dependent on three thing : proprioception (joint & muscle) & vision & vestibule Stand on pillow or spongy thing and close the eye .you are testing the vestibule alone you. If you did not find anything you can ask him to step. It is called “Vocada test”.One of the vestibular examination

Function of the inner ear:

- Hearing Function: ○ Transduction of sound to action potentials Some cases they have the round window closed, once we open it they listen.
- Vestibular Function :
- ◆ Participate in maintaining body balance, the mechanisms of maintaining body balance: (see up for more info)
- ◆ Brain stem: is the center of balance. It's connected to:
 - Cerebellum to coordinate muscle tone and Cerebral cortex for the feeling of space.
 - Input: Proprioceptive (sensation), Visual and Vestibular
 - Output: gives information to: Postural muscles and Ocular muscle

Functions

External Ear

- Protection of the middle ear (from any infection): Curvature, Cerumen
- Auditory functions: Sound conduction, Increase sound pressure by the resonance function

Eustachian Tube

- Protection: From anything that comes from the nasopharynx to go into the middle ear (any nasal secretion)
- Ventilation: to equalize the pressure
- Drainage: in case of acute OM or any regular discharge from the middle it won't go to the nose but down to the nasopharynx



Middle Ear

- Conduction of sound
- Transformer mechanism
 - Hydraulic action
 - Ossicular leverage
- Protection to the inner ear:
 1. (Stapedial reflex): In case of loud sound the muscle will contract to reduce the sound reaching the inner ear to avoid noise trauma
 2. Amplification of sound by the ossicles: الصوت اللي نسمعه مو نفس اللي يوصلنا

Inner Ear

- Hearing Function: Transduction of sound to action potentials
- Vestibular Function: Participate in maintaining body balance

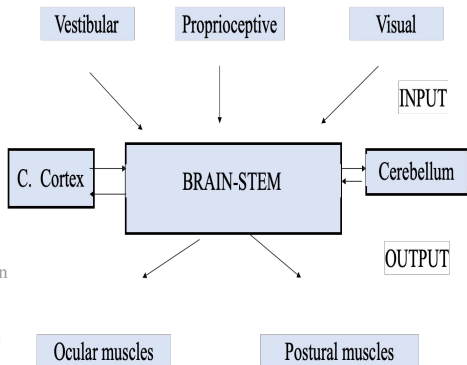
• The Balance System:

Brain stem: is the center of balance. It's connected to:
 - Cerebellum to coordinate muscle tone and Cerebral cortex for the feeling of space.

- Input: Proprioceptive (sensation), visual & vestibular

- Output: gives information to: postural muscles and ocular muscle
 - So, you have to make sure when someone came to you with imbalance it's not b/c of the cerebellum by testing it, then roll out the (peripheral) proprioception

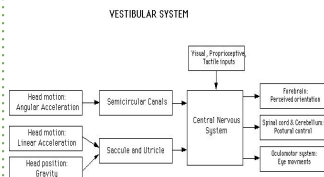
- Testing the vision > by closing the eye - Testing the proprioception > by asking him - to stand on sponge When you do so (closing the pt. Eyes and making him stand on sponge) you're eliminating the vision and the proprioception effects and after it you can make sure you're testing only the vestibule.



how to differentiate between central and vestibular causes of imbalance?

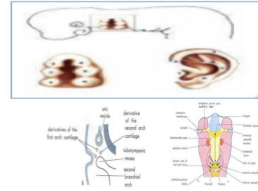
Vestibular: only have N/V in the beginning then it goes away as they adapt to it, also they will have very bad dizziness at the beginning and with time the nerve will become fatigue and it will become less severe.

Central: always have N/V, never become fatigue severity is the same from the beginning and doesn't go until you treat it



Development of the ear:

- ❖ External ear: 1st pharyngeal cleft & arch
- ❖ Middle ear: 1st pharyngeal pouch & 1st and 2nd arches
- ❖ Inner ear: Ectoderm of hindbrain



The inner ear unlike the external and middle doesn't come from pharyngeal arches so usually anomalies of both external and middle ear occur together and inner ear normal vice versa

Diseases of the External Ear

Congenital Diseases:

❖ Anotia (Atresia):

- **Definition:** It's the total absence of the (pinna) auricle most often with narrowing or absence of the external auditory meatus.
- CT; to check if there is other malformations (internally).
- Bone conduction is preserved Treatment: bone hearing aid (B.A.H.A)on mastoid.
- No auricles + canal atresia. (no external ear)
- **Treatment:**
 - We reconstruct the ear.
 - Prosthetic ear, usually used in tumor patients
 - Good sensory hearing → bone hearing aid.



❖ Microtia:

- **Definition:** underdeveloped pinna. It's a condition in which the external portion of the ear (the auricle) is malformed. There is also narrowing or absence of the external auditory canal.(a little pedicle)



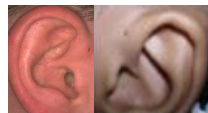
❖ Accessory Auricle:

- It's a type of ear anomaly in the tragus area. as if skin tag
- **Treatment:** Plastic reconstruction, B.A.H.A (bone anchored hearing aid). It can present with no effect. usually in syndromes



❖ Preauricular Sinus:

- The most common congenital external ear malformation characterized by a nodule, dent or dimple located anywhere adjacent to the external ear.
- Most common embryological defect,un in families.
- **Susceptible to infection.**
- **Treatment:** (If got infected twice you must take out the whole tract by first testing its pathway through methylene blue injection or CT scan with contrast, but in the time of inflammation (abscess) we do incision and drainage).
 - Systemic antibiotics.



❖ Protruding Ear (Bat ear):

- The scaphoid fossa is concave instead of it's normal convex shape
- Antihelix pulls ear back while helix pushes it forward; Antihelix is absent.
- **Treatment:** An incision behind the ear is made to reshape the cartilage (setback otoplasty)
- Cosmetic” Pinnaplasty or otoplasty. Do if after age of school.
- Note: There is no direct blood supply to the cartilage!



Trauma to the Auricle:

- ❖ Lacerations
- ❖ Hematoma auris blood inside
- ❖ Complication : Cauliflower ear
- ❖ Treatment: Excise fibrous tissue, apply pressure, dressing, drain.
- ❖ When we treat hematoma? Immediate incision and drainage! So, don't develop into cauliflower ear (necrosed cartilage).



Cauliflower ear

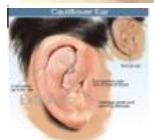
Perichondritis of the Pinna:

- ❖ **Definition:** **Perichondritis** is inflammation of the perichondrium, a layer of connective tissue, which surrounds cartilage (helix, anti-helix, and concha) **with spared lobule area IMP.**

Usually follow trauma to the cartilage (hematoma auris, surgical “mastoid surgery”, frostbite, burn) or otitis externa & piercing (particularly with the modern trend for multiple perforations that go through the cartilage).

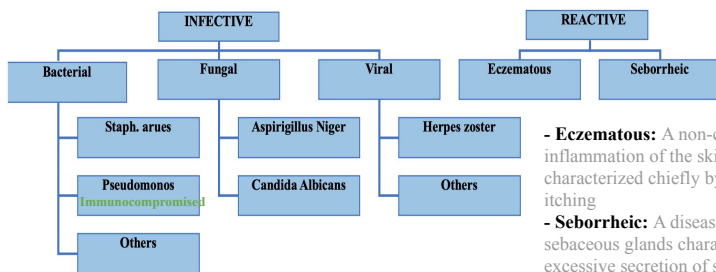
- ❖ **Etiology:** commonly caused by *Pseudomonas* & *staph aureus*
- ❖ Symptoms: Fever, pain, redness and swelling (causes narrowing and further low hearing level).
- ❖ **Treatment:** **immediately by parenteral antibiotics & drainage**
- ❖ Any cartilaginous organ that forms a hematoma must be drained as early as possible)
- ❖ If it is due to piercing the stud should be removed.
- ❖ **Complications of Perichondritis or Trauma:**

- **Cauliflower ear** (End stage of untreated haematoma).
- The ear can be exposed to trauma and lacerations leading to the **formation of Hematoma**, so if anything happens between the skin and cartilage → Hematoma (Number 1 killer of the cartilage, why? Because the blood will not be able to reach the cartilage) → Ischemia → Necrosis → Ear deformity



Otitis Externa

- An acute (Less than 3 months) or chronic (more than 3 months) infection of the whole or a part of the skin of the external ear canal. Any pathology affecting skin can also affect external ear.
- Organisms enter the apo pilosebaceous unit by break in skin
- Commonly caused by fingernail or Q-tip to relieve itching
- Periosteal lining of bony canal displaced by swelling
- Subacute or chronic develops if AOE not treated adequately



- **Eczematous:** A non-contagious inflammation of the skin, characterized chiefly by redness, itching

- **Seborrheic:** A disease of the sebaceous glands characterized by excessive secretion of sebum or an alteration in its quality, resulting in an oily coating, crusts, or scales on the skin. It's usually painless

Clinical Features:

- Itching
- **Pain:** could be very severe because of underlying cartilage, evoked by movement of the jaw, because the ear auricle and external canal is attached to the TMJ (temporomandibular joint) pain can radiate to the throat!
- Fullness
- **Tenderness and swelling, absent in otitis media.**
- **Otorrhea:** Ear discharge (very little and scanty, not mucoid. Large discharge in otitis media. Not mucus discharge because the skin does not contain mucus-secreting cells. If the discharge doesn't contain mucus, then it is from the External ear however if it contains mucus it is originating from the middle ear)
- **Deafness (Hearing loss):** deafness caused by external ear needs to be completely obstructed, which is rare in otitis externa.
- Changes in the lumen and skin of EAM (external auditory meatus)

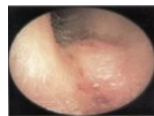
Physical Exam:

- Redness, swelling, sometimes you can't see the TM because of the swelling, protrusion, discharge, preauricular or face or neck extension
- Gently tug up and back: if true AOE, patient will not tolerate
- Clean canal thoroughly and examine under Microscope

Clinical Types:

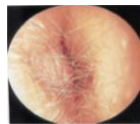
Localize O.E (furuncle)

- Small rounded swelling in the external canal & it's localized to the hair follicle
- Staphylococcus aureus



Diffuse infective O.E.: (swimmer's ear)

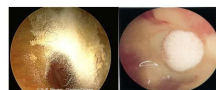
- Staphylococcus aureus
- The ear canal may be very swollen making the canal very narrow(you cant see well) thus it will be hard for topical ear drops to penetrate and reach the infected area, thus we use ear wick and soak it with ear drops which will help the medication reach the infected area.



علشان كذا لما نبي ندخل لهم قطرات نستخدم شاش ندخله داخل الأذن ونصير نبيلة بالقطرات علشان توصل داخل وقت الانفيكشن ما نسوي أي تدخل جراحي لأنه يسبب ادهيجن وفابيروسيس

Otomycosis: white patches

- Fungal infection (More in those who take Abx for a long time)
- How to differentiate between aspergillus & candida?
 - Aspergillus has black heads (spores forming, hyphae) while candida is totally white (cheesy, cotton like)
- Fungal vs. Bacterial
 - o Fungal: Less pain, more itching & NO fever.
- **Management:** suction then antifungal cream



Bullous Myringitis:

- Inflammatory condition involves the lateral surface of the TM and the medial portion of the canal wall causing separation of one layer of the tympanic membrane "bullous"
- It typically occurs in association with upper respiratory (viral) infections and is more common in winter
- **Clinical feature:** Severe otalgia - Serosanguinous otorrhea - Hearing loss
- **Treatment:** analgesics, topical antibiotic/steroid drops to prevent bacterial superinfection. Do not touch, if we open we will make it bacterial



The hallmark clinical finding is: **bullae** over the TM and medial canal with serous or serosanguinous fluid

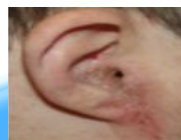
Herpetic O.E:

- Herpes zoster oticus is a specific form of herpes zoster that presents with pre-eruptive ("pre-herpetic") lesion reactivated from either the trigeminal or cervical ganglions.
Characterized by: PAINFUL vesicles
- Management: Steroids + Acyclovir
- Complications: Facial n. paralyisi
- **Small vesicles + facial weakness + discharge = Ramsay Hunt syndrome or HSV**



Eczematous and seborrheic: O.E.

- Swelling, redness, crust formation and oozing of discharge.
- If the eczema is only in the canal, keep on mind tympanic membrane perforation due to discharge. Painless

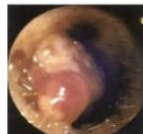


Management Otitis Externa (to all clinical types):

- History and Physical examination.
- Swab for culture sensitivity
- Ear toilet: frequent cleaning of any discharge. Meticulous debridement of debris, pus and cerumen
- Keep the ear dry. Suction cleaning (especially the fungal infection = Suction, Suction, Suction) the antifungal won't go inside so we have to take the debris out.
- Local medications: antibiotics: Anti-pseudomonal drops – Ciprodex
 - Ear wick (best used after shower not in dry ear without pushing more than the length of the cotton > to avoid injury, infection and cotton dislodge)
 - Local analgesia to control pain. Not all E.O need oral or parenteral tx.
- Systemic medications: in immunocompromised as in diabetics.
- Surgery may be required in chronic cases (narrowing, fibrosis or medialization of the TM) bc of failure of treatment because there is usually thickening in of the skin and closure of the canal.
- Avoid using Q-tips and if you must use it don't insert it further into the bony part.
- Recommendations regarding prevention
 1. Avoid instrumentation
 2. Keep H2O out of the ear when possible
- IN CASE OF:
 - Aspergillus Niger → Give antifungal drops.
 - Herpetic O.E Tx: → Acyclovir if < 3 days, Steroids to reduce inflammation.

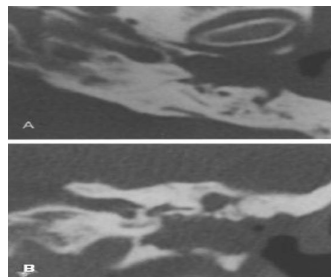
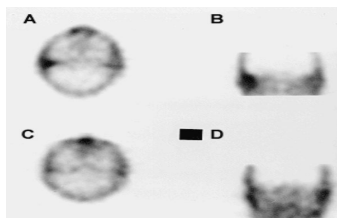
Acute Necrotizing (malignant is not a cancer) Otitis Externa

- An acute Pseudomonas infection of the skin of the external ear canal which has spread to the adjacent bone. It occurs mostly in elderly diabetic patients. (Deep seated pain for more than a month).
- Skull base Osteomyelitis: Important Infection of the roof of the EAC and skull base affected.
- Life-threatening; osteomyelitis of temporal bone
- AOE can spread via fissures of Santorini or tympanomastoid fissure
- **Complications:** It could spread anywhere: superiorly → intracranial complications, posteriorly → mastoid complications, anteriorly → tympanic complications and inferiorly → causes abscess at the neck.
- **Diagnosis:** CT scan showing lots of bone erosions and bone scan showing active infection to rule out other pathology such as cholesteatoma
- **Clinical Features:** Diabetes, advanced age, severe otalgia > 1 month (at night), granulation tissue, cranial nerve involvement, radiology
- It has a triad:
 1. Ear discharge “Several weeks of purulent otorrhea with granulations”,
 2. Headache (esp at night),
 3. Immunocompromised patients: HIV, uncontrolled DM or elderly.
- It occurs mostly in elderly diabetic patients. (Immunocompromised) **Important!**



- **Clinical/Radiographic Findings:**

- Lower Cranial nerve palsies (VIII, IX, X, XI, XII) (check the gag reflex), and **25% VII**
- No signs of acute inflammation & No swelling.
- On Ex: **Granulation tissue in EAC**, sequestra and Foul-smelling discharge from the floor of the external Auditory canal.
- It can infect the base of the skull, the cranium Causing meningitis, brain abscess.
- **Almost always caused by Pseudomonas; can be fungal in HIV**
- Radiology: always we do CT although it doesn't tell us the definitive dx, that's why we rely on nuclear scan Bone (Petrous) scan to rule out osteomyelitis. **Bony erosion on contrast-enhanced CT**
- **MRI useful for soft-tissue diagnosis, but not for F-U**
- **Bone scan is sensitive, but not specific (Tc-99m most sensitive)**
- Granulation tissue at the junction of the bony and cartilaginous portions of the canal + -immunocompromised pt → Dx as Malignant Otitis Externa!



- **Medical Treatment:**

- Should culture and biopsy.
- Antipseudomonal antibiotic. At least 6 weeks
- Blood-sugar control. (most important part of treatment)
- Frequent debridement and anti-pseudomonal ear drops (local treatment).
- **ID and Endocrinologist should be involved.**

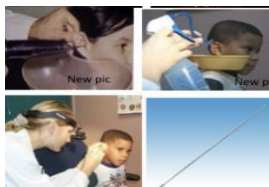
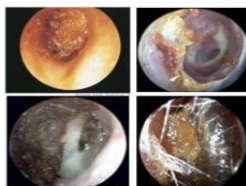
- **Surgical Treatment:**

- Reserved for clear failures of above medical treatment
- The role of surgery remains controversial (e.g. if we need to take biopsy)

Miscellaneous Conditions of the External Ear

Wax:

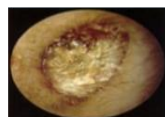
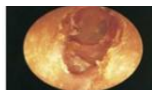
- Mixture of ceruminous and sebaceous glands secretion
- We always remove wax before examination
- Could be liquidy soft, scaly, hard
- Normally is expelled from the canal aided by movements of the jaw
- When accumulated it may cause deafness, earache or tinnitus
- **Function:** Protect the ear from some bacterial & fungal infections (its acidic)
- Irritative cleaning of the ear may result in eczematous or seborrheic otitis externa
- Wax on tympanic membrane is very dangerous, it could be hiding retraction behind especially in parus flaccida or cholesteatoma
- **Treatment:** is by removal using syringing very rare nowadays → anything you do it in ear will (cause vasovagal + there will be stimulation to the lateral semicircular canal bc of the water temperature that we are using), suction or instrumentation
- In irrigation we insert water in the ear to washout the wax but we have to make sure of the temperature of the water is the same as the body temperature to avoid dizziness
- Crocodile forceps/ ear forceps Hock.



Crocodile forceps

Keratinosis Obturans:

- Excessive accumulation of desquamated epithelium (skin not wax) in the bony canal. (the difference b/w it and cholesteatoma that in the later one we have normal ski in abnormal place).
- It is excessive scaling of the skin causing very hard wax
- This is how we differentiate with external ear cholesteatoma
- It may be associated with sinusitis, bronchiectasis, or primary ciliary dyskinesia. (hair cell syndromes)
- Unlike cholesteatoma, it doesn't cause bony erosions but it lead to compression "pressure necrosis" and widening of the canal. so, periosteum and cortex is intact.
- Usually cause deafness and pain.
- Treatment is periodic removal



Acute Otitis Media

- Acute infection of the mucous membrane lining of the middle ear cleft.
- The definition is specific to infection because in chronic Otitis media it can be due to infection of normal inflammation.
- Most common bacterial infection of childhood. Estimated 85% of all children experience at least one episode of AOM (Acute Otitis Media).

Predisposing Factors:

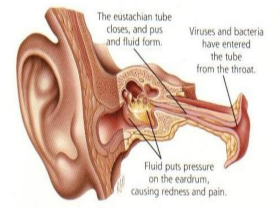
- **Age:** common in children as their Eustachian tube is more horizontal, wider and shorter in relation to their head.
- Male sex
- **Bottle feeding:** more likely to have milk regurgitation (because children tend to drink while lying) in middle ear
- Allergic Rhinitis
- Crowded living conditions (one infected will infect others)
 - For example in kindergarten bc the infection rate is increased
- Smoking within the home
- Heredity
- Climate: increase in humidity increase the risk
- Associated conditions:
 - Cleft palate, why? tensor palatini muscle is absent in cleft palate and its job to open ET when you swallow. The muscles of the palate are affected and not well developed, so in cleft palate surgery ENT come to put tube to avoid otitis media with effusion for life.
 - Immunodeficiency, ciliary dyskinesia, down syndrome & cystic fibrosis.

Route of Infection:

- Eustachian tube, external auditory canal (rupture): rare & bloodborne.

Bacteriology:

- Streptococcus pneumonia (Most common)
- Haemophilus influenzae
- Moraxella (branhamella) catarrhalis
- Streptococcus pyogenes & Staphylococcus aureus



Pathophysiology:

The patient has an antecedent event (viral URI or allergy) → the event results in Congestion of the respiratory mucosa of the nose, nasopharynx, and Eustachian tube → Congestion of the mucosa in the Eustachian tube obstructs the narrowest portion of the tube, the isthmus → obstruction of the isthmus causes negative pressure followed by accumulation of secretions produced by the mucosa of the middle ear → these secretions Have no egress and accumulate in the middle ear space → viruses and bacteria that colonize the upper respiratory tract can reach the middle ear via aspiration, reflux, or insufflation → microbial growth in the middle ear secretions may result in suppuration.

Clinical Picture:

- Tubal occlusion:** produces early signs of acute otitis media.
 - Discomfort / Autophony (feeling own sounds) / Retracted drum (opposite of bulging) caused by pressure difference / There is mild deafness / Tinnitus in children, not adults.
 - First thing to happen in otitis media is redness/congestion → bulge (severe pain) → rupture if untreated → pus → abnormal/normal healing or perforation.
- Suppurative inflammation of the middle ear:** Fever, severe earache, deafness, congestion and bulging drum, pus behind it.
- Tympanic membrane rupture:** Otorrhea, Temperature subside. & earache subside (pain relief), perforated drum and Mucopurulent (discharge) if not treated
- Resolution:** Either the rupture will persist, and it will discharge from time to time (chronic otitis media) Or close spontaneously (“retraction”) common
 - Tympanosclerosis “if not treated will retract if it was severe > adhesive otitis media (tympanic membrane reaching the promontory” or the cochlea
 - The patient can present to you at any stage (mostly the congestion and bulging) and the treatment will be the same. However, the complications are different.
 - The patient will be in severe pain before the rupture of tympanic membrane due to the nerve stimulation and irritation by tension.

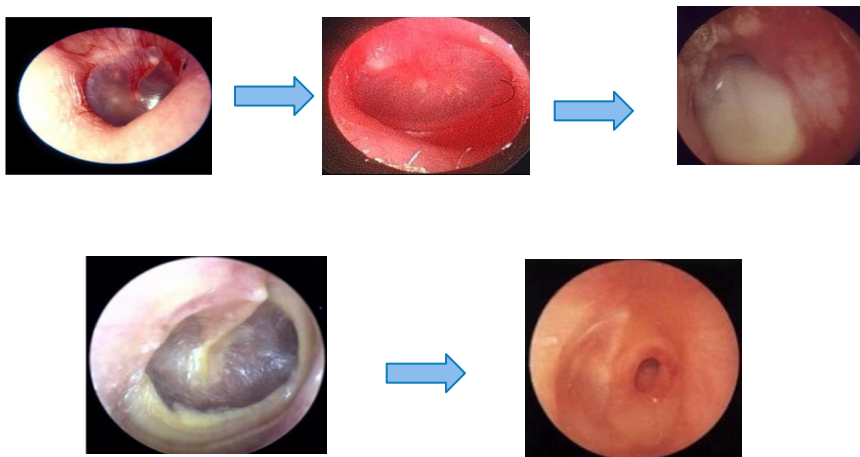
Complication of acute and chronic OM:

- Extracranial:
Acute mastoiditis, Chronic mastoiditis, Postauricular abscess, Bezold abscess, Temporal abscess, Petrous apicitis, Labyrinthine fistula, Facial nerve paralysis, Acute suppurative labyrinthitis.
- Intracranial:
Meningitis, Brain abscess, Subdural empyema, Epidural abscess, Lateral sinus thrombosis, Otitic hydrocephalus, Encephalocele and cerebrospinal fluid leakage.

Treatment:

- Symptomatic
- Antimicrobials.
 - Amoxicillin (1st line) if allergic to penicillin & cephalosporins you give clarithromycin
 - Amoxycillin/clavulanic acid (B-lactamase bacteria) 2nd line.
 - Trimethoprim-Sulfamethoxazole.
 - Cefaclor, cefixime.
 - Erythromycin-sulfisoxazole
- Decongestant. (to help open the eustachian tube and get rid of the pus in the middle ear)
- Myringotomy (in severe cases) +/- tube.
- Ear toilet and local antibiotics.
 - Bulging + severe pain + adult > open small opening to relieve the pain
 - If not → nasal steroid spray so eustachian tube opens and remove the pus + oral ABx

Clinical Picture:



Tubal occlusion → Bulging → Suppurative inflammation (redness) → Rupture of the tympanic membrane (discharge) → It either resolve totally or it is still perforated

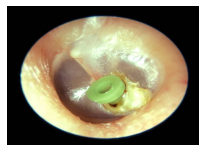
Recurrent Acute Otitis Media:

- **Three or more attacks over a 6-months period** or (six attacks in a year).
- - O.M. + diffusion > **sterile fluid in the middle ear**, or dysfunctioning Eustachian tube like in down syndrome or cleft palate.

Treatment:

- Long-term low dose antimicrobials
- **Ventilation tube insertion**, in the inferior part which allows the air to enter the middle ear and drainage of fluid from the Eustachian tube.

in exams: identify the right ear and left ear



→ (Myringotomy with pressure equalization tube) Most common in acute otitis media after resolving there will be fluids. Pediatrics last for 3-6 weeks if more it will affect speech, so we drain through eustachian tube (myringotomy) by putting a tube between the External Canal and middle ear we put it in anterior inferior to avoid ossicles' injury