# INTRODUCTION

Tympanic membrane(TM) perforation is a condition as old as the evolution of human species. It is one of the most common causes of hearing impairment. Infection is the principle cause of TM perforation. It may be acute or chronic. Perforations due to acute infections usually heal if treated timely. Perforation of TM is frequent manifestation of injury and may be due instrumentation injuries such as ear picking habits, probing, syringing, post ventilation tube insertion etc. and with compression forces such as in slapping, diving, head injuries, blast injuries etc. Most of these perforations cause conductive hearing loss except some due to head injury, blast injuries infection such as mumps measles meningitis Electrical injury Menieres disease ototoxic drugs perilymph fistula multiple sclerosis coagulopathies may cause inner ear injury and SNHL. Majority of post acute infection and traumatic tympanic membrane perforations however heal spontaneously or with conservative treatment. **(Güneri EA, et al 2003)**

The perforation as stated generally involves pars tensa, however can involve both pars tensa and pars flaccida or pars flaccida alone. Pars flaccida perforations are also known as attic perforations. Again if the perforations cross the annulus they are called marginal perforations. In case of CSOM

generally the pars tensa perforations with intact annulus ring are called the tubotympanic type and the ones involving attic or annulus ring are called atticoantral disease, which may or may not be occluded by cholesteatoma, granulation tissue and may be associated with osteitis. Therefore, the hearing assessment in such perforations (e.g. attic, marginal, total) may not correlate directly with the progression of disease .The pars tensa (central) perforations on the other hand can be better assessed are morphologically classified arbitrarily by the demarcation with aline passing through the handle of malleus and line on passing perpendicularly to the first line through umbo into (a) Anteriosuperior (b) Anterioinferior (c) Posteriosuperior (d) Posterioinferior**(Onal K,et al 2005)**

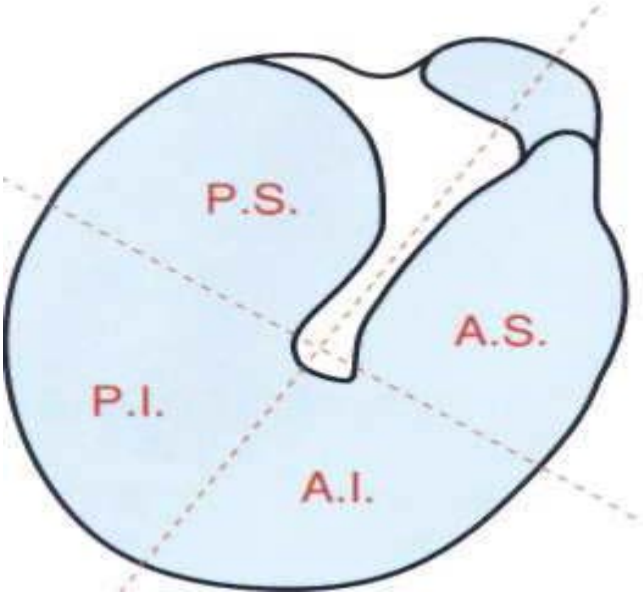


**Figure (1) : Right ear. Division of the tympanic membrane**

into four quadrants: A.S. = anterosuperior; A.I. = anteroinferior; P.S. = posterosuperior; P.I. = posteroinferior. This division facilitates the description of different pathologic affections of the tympanic membrane

Also the tympanic membrane Perforation includes

1-Small centeral perforation 2-medium size central perforation

3-large centeral perforation 4-subtotal 5-Neartotal

6- Total 7-Marginal 8-Attic

According to size of the perforation, these are classified as:

(a) Small (area involving one quadrant)

(b) Medium (area involving 2-3 quadrants)

(c) Large (subtotal)

In general, larger the perforation, the greater is the hearing impairment, but this relationship is not constant and Level of hearing can be divided into normal to hearing impairment in progressive order into minimal, mild, moderate, moderately severe, severe and profound hearing loss.

**(Hung T, et al 2004)**

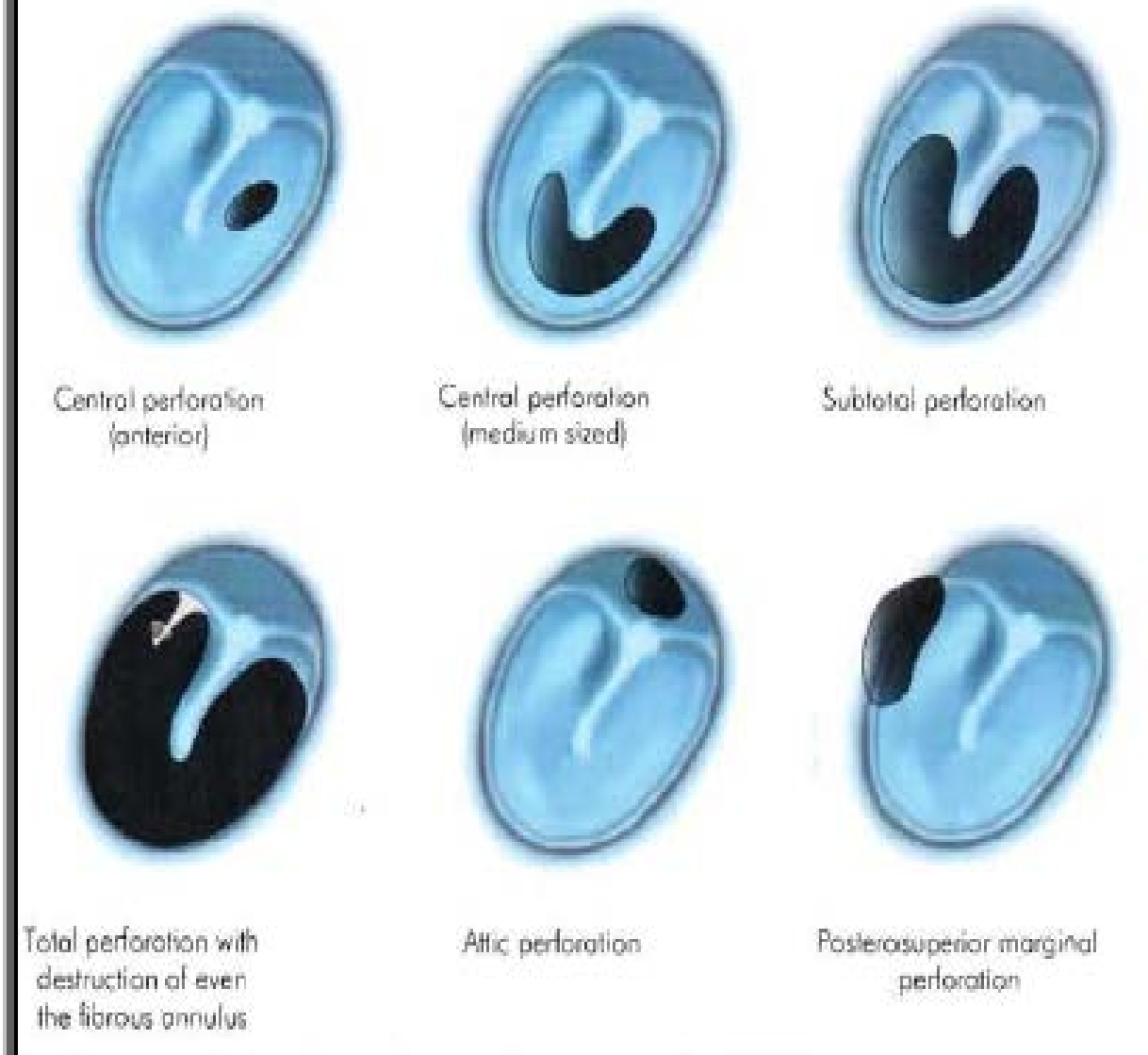


**Figure (2)** ***sites of tympanic membrane perforation***

# ***Aim of work***

1. To assess the effect of size and site of tympanic membrane perforation, on degree of hearing loss.

2. To evaluate the effect of duration of tympanic membrane perforation on hearing.

# Embryology and ANATOMY OF THE EAR

## Ear embryology

During embryonic formation the ear develops into three different structures: the inner ear, the middle ear and the outer ear. **( Drake, Richard L, 2010)** The inner ear consists of the vestibulocochlear organ. The middle ear is made up of a tympanic cavity and an epytimpanic recess**.( Moore,et al 2009)** The external ear consists of the auricle and the external acoustic meatus. Each structure originates form different germinative layers or tissues: ectoderm, endoderm and mesenchyme.**(Tortora, G,2011)** The ear begins to appear during the 22nd day of embryonic development.**( Guyton, A.C.,2010)**

## Development of different parts of the ear

### Inner ear

The first part of the ear to develop is the inner ear.Its appearanceccurs around the 22nd day of the embryo's development. It originates from the germinative layer ectoderm. **(Sadler, T.W.,2010)** Specifically the inner ear derives from a set of placodes called otic placodes. Each otic placode forms the otocyst or otic vesicle. This epithelial mass will immerse itself and eventually be surrounded by mesenchyme to form the otic capsule. Before any of the vital components of the inner ear can be formed a group of sensory cells called a saccule forms the inner ear's epithelia. Part of the saccule will eventually give rise and connect to the cochlear duct. The

cochlear duct appears approximately during the sixth week and connects to the saccule through the ductus reuniens. As the cochlear duct's mesenchyme begins to differentiate, three cavities are formed: the scala vestibule, the scala tympani and the scala media. Both the scala vestibule and the scala tympani contain an extracellular fluid called perilymph. The scala media contains endolymph.**( Moore, Keith L.,2008)** A set of membranes called the vestibular membrane and the basilar membrane separate the cochlear duct from the scala vestibule and the scala tympani. A spiral ligament and a cartilaginous process called the modiolus connect and support the cochlear duct to the rest of the cartilaginous structures that surround it. The organ of Corti is made up of sensory cells and a tectorial membrane. The utricule and saccule generate sensory areas called the maculae acusticae. The otic vesicle in turn forms the statoacoustic ganglion. The structures of the inner part work together in the adult ear to convert the signals that they receive from the middle and external ears and transfer them to the brain where they can be processed. **(UNSW Embryology,2013)**

## Middle ear

The middle ear, which includes the tympanic cavity and the auditory tube, originates from the first pharyngeal pouch. More specifically the tubotympanic recess originates from the distal part of the pouch while the eustachian tube from the proximal part. This last structure will establish the final connection between the tympanic cavity and the nasopharynx. The auditory ossicles (malleus, incus and stapes), originate to form the second pharyngeal pouch are embedded in the tympanic cavity and normally appear during the first half of fetal life. The first two (malleus and incus) derive from the first pharyngeal pouch and the stapes from the second. Eventually

cells from the tissue surrounding the ossicles will suffer apoptosis and a new layer of endodermal epithelial will constitute the formation of the tympanic cavity wall. The mastoid process will appear as the tympanic cavity continues to grow. **(UNSW Embryology,2013)**

## External Ear

Unlike structures of the inner and middle ear, which develop from pharyngeal pouches, the external auditory meatus originates from the dorsal portion of the first pharyngeal cleft. It is fully expanded by the end of the 18th week of development. The tympanic membrane or eardrum is made up of three layers (ectoderm, endoderm and connective tissue) all of which form the outer layer of the articular capsule (fibrous stratum). The auricule originates as a fusion of six proliferations or auricular hillocks form the first and second pharyngeal pouches. The external ears are firstly situated in the lower neck region. As the mandible forms they move towards their final position leveled with the eyes. Once it is fully developed, the external ear functions both to capture sound from the outside and to conduct it through the external auditory meatus towards the tympanic membrane. .**( Moore, Keith L.,2008)**

# ANATOMY OF THE EAR

The human hearing system consists of two ears, located on the left and right sides of the head, the vestibulocochlear nerve, and the central auditory nervous system (CANS) – consisting of auditory centers in the brain and the connecting pathways in the brainstem. Each ear is additionally divided into three functional parts:

the outer (external) ear, the middle ear and the inner (internal) ear.

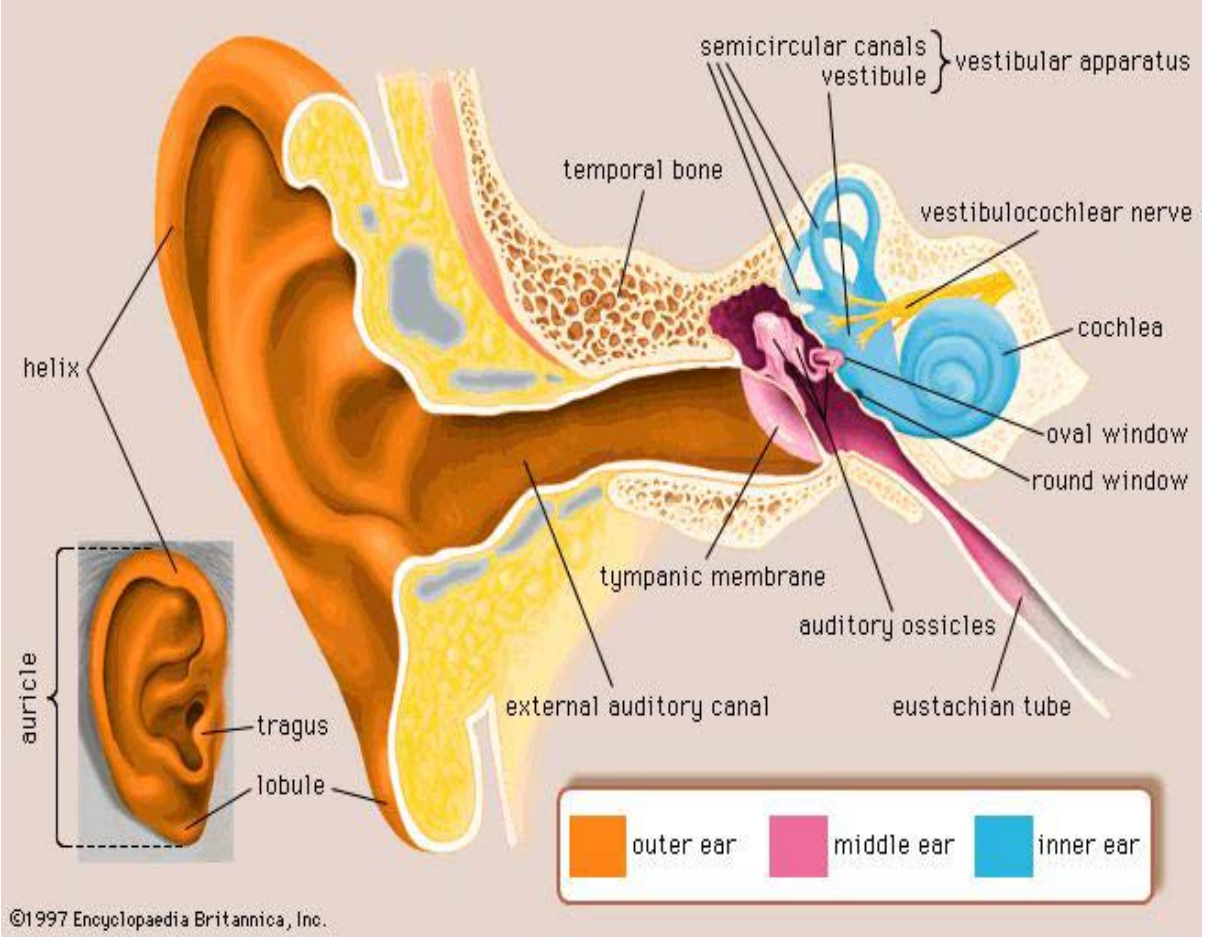


**Figure (3) : anatomy of the ear**

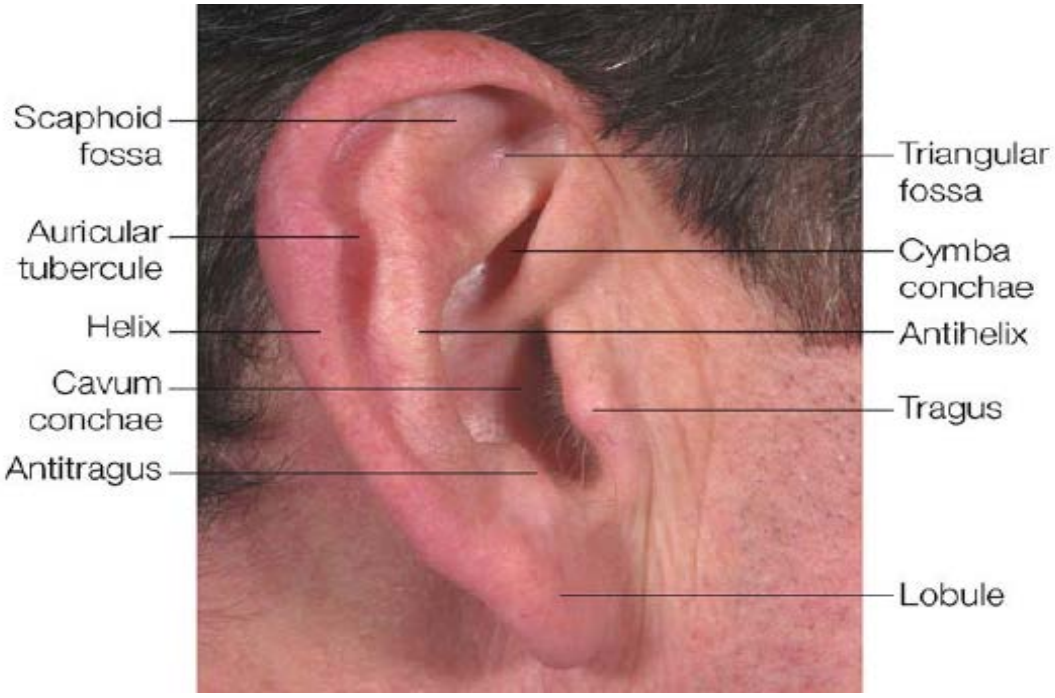


**Fig.(4) The external ear.**

## Outer Ear:-

The outer ear consists of two major elements: the external **flange of the ear** (called the pinna) and the ear canal. The ear canal is terminated by the tympanic membrane (eardrum), which separates the outer ear from the middle ear. The entrance to the ear canal is located within the pinna, in front of the pinna flap. **(Henry, P, et al 2007)**

## Pinna:

The pinna (auricle) is an ovoid-shaped structure with an uneven surface filled with numerous grooves and depressions. Humans have two pinnae, one on each side of the head. The pinna is innervated by nerve fibers

from the great auricular nerve and the auriculotemporal nerve. The pinna is connected to the head by ligaments and small muscles. Many species use these muscles to direct the pinna towards incoming sound, but humans lost this ability (although some humans have maintained rudimentary pinna motion ability). The average length of the pinna is approximately 65 millimeters (mm) (2.6 inches) and the average width is approximately 35 mm (1.4 in).

The center of the major pinna depression called the concha. The cavum concha surrounds the inlet to the ear canal. In the front of the entrance to the ear canal, there is a small cartilaginous flap called the tragus. **The tragus** partially covers the opening of the ear. The intertragal notch is used as a reference point for inserting a probe microphone into the ear canal in real-ear measurements **(Henry and Letowski, 2007).** At the very Basic Anatomy of the Hearing System 283 bottom of the pinna, below the intertragal notch, there is a large soft flap called the lobule (ear lobe).

**Ear canal** : The ear canal (auditory canal; external meatus) is an "S" shaped duct providing an access route for acoustic waves to travel to the tympanic membrane. The outer one third of the ear canal is surrounded by cartilage, whereas the remaining inner two thirds of the canal are surrounded by bone, as the canal enters the temporal bone. **( Ballachanda, B.B, 1995)**

The two respective parts of the canal are called the cartilaginous part and the osseous part of the canal. The cartilaginous part of the ear canal produces cerumen **(ear wax)**, which is comprised of secretions from sebaceous and apocrine glands **(Lucente, 1995; Ballachanda, 1995)**.

Cerumen acts to moisturize the skin and, together with hairs, trap dust, debris and other small objects entering the ear canal The osseous part of the ear canal is covered with relatively thin skin (approximately 0.2 mm [0.01 in thick) that is continuous with the outer layer of the tympanic membrane. There are no hairs or secretion producing glands located in this part of the ear canal. **(Muller, 2003)**

**The skin of the ear canal** is innervated by the branches of three cranial nerves: the auriculotemporal (mandibular) nerve, the facial nerve, and the vagus nerve. The outer layer of the skin lining the ear canal and tympanic membrane has lateral migratory properties. The surface cells of the skin move laterally from the tympanic membrane toward the ear canal opening. The average length of an adult ear canal is approximately 25 mm (1.0 in) with a standard deviation of approximately 2 mm (0.2 in) and is approximately 5% longer in males than in females **(Alvord and Farmer, 1997; Zemlin, 1997)**. The effective acoustic length of the ear canal is approximately 25% larger than its geometrical length due to the “end effect” of the concha and the manner in which the concha is coupled to the ear canal. The canal is oval in shape with an average diameter of 7.0 to 8.0 mm (0.28 to 0.31 in) **(Alvord and Farmer, 1997; Zemlin, 1997;)**.

The shape and cross sectional dimensions of the ear canal change along its length. The oval opening of the canal has average dimensions of 9 mm (0.4 in) by 6.5 mm (0.3 in), and the canal becomes narrower along its length (Shaw, 1974). The final 8 to 10 mm (0.3 to 0.4 in) of the ear canal is slightly tapered and reaches its narrowest point at the isthmus which is located just past the second bend of the ear canal and approximately 4 mm

(0.2 in) from the tympanic membrane **(Seikel, King, and Drumright, 2000).**

**The tympanic membrane** terminates the ear canal at an oblique angle of 45° to 60° in reference to the floor of the canal. This oblique position of the tympanic membrane causes the length of the ear canal to be approximately 6 mm (0.24 in) shorter at its posterior/superior (back/top) portion compared to its anterior/inferior (front/bottom) portion. The cross sectional area of the ear canal in male adults is approximately 10% larger than in female adults **(King and Drumright, 2000; Sundberg, 2008).**

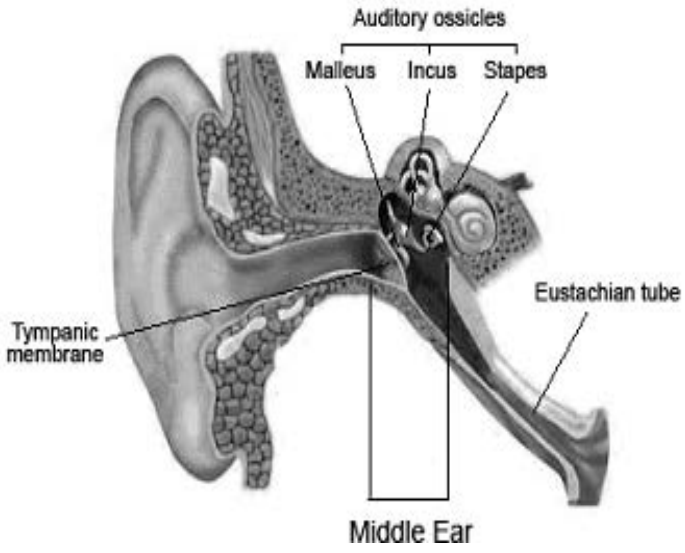


**Fig.(5)Cut section showing different parts of the ear.**

## Middle Ear

The middle ear is an air-filled cavity called the tympanic cavity (tympanum). The walls of the cavity are formed from the temporal bone and the cavity is lined with mucous membrane tissue. The lateral wall of the middle ear contains the tympanic membrane, and the medial wall is formed by a bony wall that separates the middle ear from the inner ear. This wall contains two membranous windows, called the oval and round windows, which act anatomically and physiologicallyto connect the middle ear with the inner ear. The air in the middle ear cavity remains just below atmospheric pressure due to the connection between the tympanic cavity and the upper part of throat (nasopharynx) by a narrow duct called the ***Eustachian tube*** (auditory tube). Within the middle ear cavity are three small bones called the ***malleus*** (hammer), ***incus*** (anvil), and ***stapes*** (stirrup). These bones are collectively called the ***ossicles*** and form a chain called ossicular chain that connects the tympanic membrane with the oval window. The chain is suspended inside the cavity by middle ear ligaments and two middle ear muscles: the ***tensor tympani*** and the ***stapedius***. **( Yost, W, et al 2011)**

The largest dimension of the tympanic cavity does not exceed 10 mm (0.4 in). The ossicular chain and middle ear muscles take up most of the space within the cavity. The superior wall (ceiling) of the tympanic cavity is formed by a thin bone called the ***tegmen tympani***, which separates the middle ear from the brain cavity. A small narrow aperture, called the *aditus ad* ***antrum***, located at the top of the posterior (back) wall, connects the middle ear cavity to another small chamber called the mastoid antrum

(tympanic antrum) that is surrounded by the mastoid air cells. The entrance to the Eustachian tube is located in the anterior (front) wall of the middle ear cavity. **The oval and round windows** of the inner ear form the medial wall of the cavity. The windows are separated by a ridge of bone called the promontory. The tympanic cavity also contains two middle ear muscles: **the tensor tympani muscle and the stapedius muscle.** The tendon of the second middle ear muscle, the tensor tympani, emerges from the anterior wall of the middle ear and attaches to the malleus bone. A thin plate of anterior bone separates the middle ear from the internal carotid artery **(Zemlin, 1997).**