Introduction

Hearing impairment is a pervasive disability affecting nearly 250 million people in the world and 75 % of sufferers live in developing countries. Hearing loss has become a common problem in industrialized societies due to the combined effects of noise, aging and heredity. Infection is an added factor contributing to hearing loss in developing countries. In other words the problem is global ***(Deafness and hearing impairment, WHO, 2006).***

A national household survey was conducted at 2005 to estimate the prevalence and causes of hearing impairment in Egypt. From 6 randomly governorates, 4000 individuals were screened for hearing loss. The prevalence of hearing loss was 16% with no significant sex differentiation. Otitis media was the commonest causes of hearing loss (30.8 %) ***(Department of otolaryngology, Ain Shams University et al., 2006).***

The impact of hearing loss on the individual and society is significant. Development of hearing loss leads to severe handicap that affects the sufferer's job, home and life with subsequent social and economic burden on the society. In children the problem is compounded since normal hearing is the primary source for acquisition of language, speech and cognitive skills ***(Robson, 2006)***.

Hearing impairment may be conductive, sensory-neural, or mixed. Conductive hearing impairment is a common type that occurs when sound is not conducted through the outer ear or middle ear. It may be also due to inner ear abnormalities as superior canal dehiscence syndrome. It is of mild to moderate severity and most of its causes are curable so that early and accurate diagnosis help greatly in management ***(MacLean et al., 2003).***

Multislice CT plays a critical role in evaluation and management of conductive hearing loss. In general, most causes of conductive hearing impairment including the external auditory canal, middle ear space including the ossicles, the mastoid and the petrous air cell system, and the otic capsule are best visualized with multislice CT scan of the temporal bone using bone algorithm and windowing techniques ***(Michele and Barry, 2008).***

The temporal bone is a region of difficult anatomy includes many small structures within a very compact region, some measuring less than 1 mm rendering the understand and description of CT images of that part is very difficult and requires expert radiologists ***(Remley et al., 2002).***

Things started to change with the worldwide use of multislice CT scanners in imaging of the temporal bone which provide better imaging of that complex part. The 3D multiplanar reformatted images from conventional cross sectional CT data has been increasingly used to better demonstrate the anatomy and pathology of the temporal bone.3D volume rendered CT images can aid in understanding the temporal bone. These images can be rotated in space and dissected in any plane allowing assessment of morphologic features of individual structures including the small ossicles of the middle ear and intricate components of the inner ear ***(Girish et al., 2005).***

Aim of the Work

The main purpose of this study is to focus more light on the diagnostic value and the role of Multislice Computed Tomography in evaluation of patients with conductive hearing loss.

Chapter (1)
Anatomy of the Temporal Bone

I-Osseous components

The temporal bones are situated at the side and base of the skull. Classical descriptions of the temporal bone are based on its five embryologically distinct osseous components: the mastoid, tympanic, squamous, styloid and petrous portions **(Fig 1),** ***(Curtin et al., 2000).***

- ***Mastoid portion***

The mastoid portion composes the bulbous postero-lateral portion of the temporal bone and includes the inferiorly projecting mastoid process. The medial margin of the mastoid is intracranial and forms part of the border of transverse sinus. The mastoid contains multiple aerated cells, which communicate with the middle ear.

- ***Tympanic portion***

The tympanic portion is a U-shaped bony plate that forms the bulk of the bony external auditory canal and the posterior (non-articular) part of the mandibular fossa.

- ***Squamous portion***

The squamous portion is composed of flat bony plate that forms the lateral wall of the middle cranial fossa and medial wall of the high masticator space. This portion contributes the posterior segment of the zygomatic arch and also forms the anterior articular part of the mandibular fossa.

- ***Styloid portion***

The Styloid portion is a thin fingerlike bony projection that extends inferiorly from the posterolateral aspect of the inferior surface of the petrous bone. The base of the styloid process is located at the anterior margin of the stylomastoid foramen.

- ***Petrous portion***

The petrous portion is a pyramid-shaped wedge of bone that forms the medial aspect of the temporal bone. The apex of the pyramid points medially and rests adjacent to the clivus, which relationship defines the petrooccipital fissure. The "sides" of the pyramid are made up of three surfaces: an anterior surface, a posterior surface, and an inferior surface. The dense bone of the otic capsule lies within the center of the petrous bone and contains the structures of the inner ear. The tympanic cavity is a complex space that lies laterally within the petrous bone and constitutes the middle ear ***(Curtin et al., 2000).***

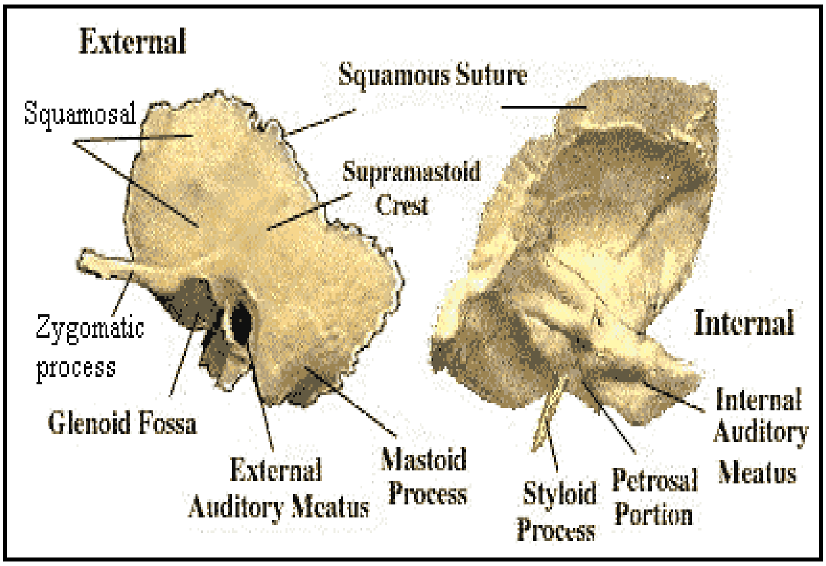

Figure (1): Temporal bone ***(from Gray's Anatomy; 2000).***

II-Functional anatomic classification

The anatomic classification defines five functional regions of the temporal bone, The External ear, Middle ear and mastoid, Inner ear (labyrinth), internal auditory canal, intratemporal facial nerve and petrous bone ***(Davidson, 2004).***

- ***External ear***

The external ear **(Fig 2)**, is the most external portion of the ear; it is comprised of the pinna (the auricle) and the external auditory canal. The pinna functions to collect and focus sound waves. It is composed of a thin plate of yellow fibro cartilage, covered with integument, and connected to the surrounding parts by ligaments and muscles; and to the commencement of the external acoustic meatus by fibrous tissue ***(Remley et al., 2002).***

The external auditory canal extends from the concha to the tympanic membrane. Its length is about 2.5 cm from the floor of the concha. It has two structurally different parts; the lateral third is cartilaginous and the medial two-thirds are osseous. The osseous part is about 16 mm long, and is narrower than the cartilaginous part. It forms an S-shaped curve, directed at first medially, anteriorly and slightly up (pars externa), then posteromedially and up (pars media) and lastly anteromedially and slightly down (pars interna). The lateral, cartilaginous part is about 8 mm long. It is continuous with the auricular cartilage and attached by fibrous tissue to the circumference of the osseous part. Earwax (cerumen) is produced by glands in the skin of the outer portion of the ear canal ***(Remley et al., 2002).***

The tympanic membrane, which closes its medial end, is obliquely set and consequently the floor and the anterior wall of the meatus are longer than its roof and posterior wall. The tympanic membrane is attached to the tympanic annulus.the anterior and superior part of this annulus is called the scutum, ***(Remley et al., 2002).***

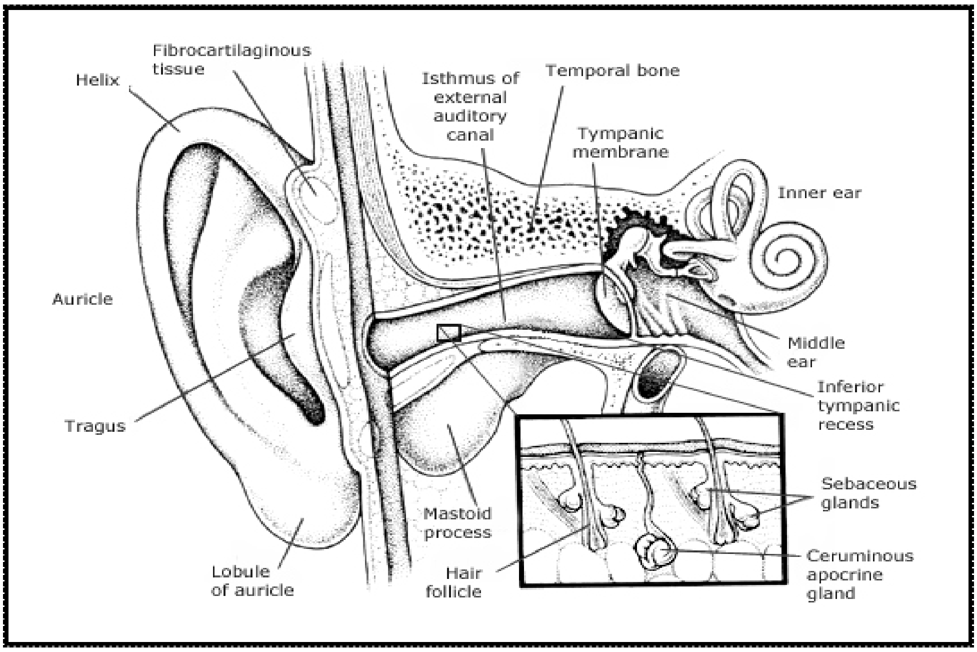

Figure (2): The external ear ***(From Davidson, 2004).***

- ***Middle ear and mastoid***

The middle ear, or tympanic cavity **(Fig 3 and 4),** is a complex space with six walls formed from the surrounding petrous bone. The medial wall of the middle ear is formed by the bony labyrinth. The prominence of the lateral semicircular canal forms an overhang at the upper aspect of the medial wall, below which is found the prominence of the tympanic facial canal. The oval window niche is located just below the facial canal prominence and contains the oval window, which is covered by the footplate of the stapes. Just below the oval window is the cochlear promontory, which is the portion of the otic capsule that covers the lateral aspect of the basal turn of the cochlea. The round window niche is located at the posteroinferior margin of the cochlear promontory and contains the round window, which is covered by the secondary tympanic membrane ***(Davidson, 2004).***

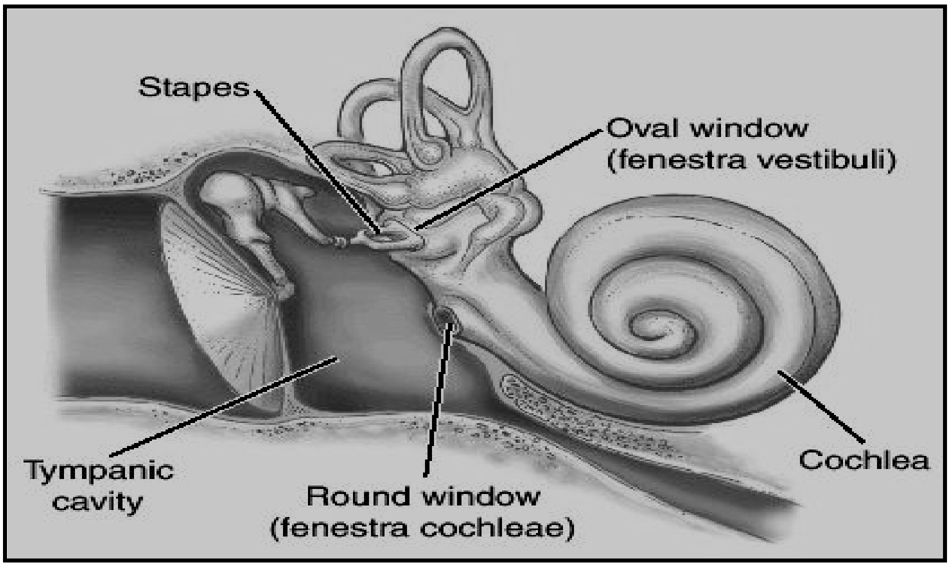

Figure (3): Oval and round windows ***(From Timothy; 2008).***

The posterior wall of the tympanic cavity is formed by the mastoid bone and has three important landmarks: the sinus tympani, the pyramidal eminence, and the facial nerve recess. The upper part of the posterior wall of the mesotympanum communicates with the mastoid via the additus ad antrum. The lateral wall of the middle ear is formed by the tympanic membrane and the squamous bone above the level of the tympanic membrane. The inferior margin of the squamous bone is a pointed bony spicule called the scutum. The tympanic membrane is attached superiorly at the tip of the scutum and inferiorly at the tympanic annulus. The superior wall, or roof, of the middle ear is the tegmen tympani, which forms part of the superior surface of the petrous bone. The inferior wall, or floor, is formed by the bony covering of the petrous carotid canal anteriorly and the roof of the jugular bulb posteriorly, ***(Davidson, 2004).***

The middle ear is subdivided into three sub regions: the epitympanum, the mesotympanum, and the hypotympanum. The epitympanum, or attic, is that portion of the middle ear that extends above a line drawn from the top of the tympanic membrane to the horizontal facial canal. The lateral space between the scutum and the ossicles is known as Prussak's space. The mesotympanum, or middle ear proper, is that portion of the tympanic cavity between the levels of the upper and lower margins of the tympanic membrane. The hypotympanum is that portion of the middle ear below the level of the tympanic membrane ***(Davidson, 2004).***

The anterior epitympanic recess, also called the supratubal recess, is the small space in the epitympanum anterior to the malleus. It is partitioned from the epitympanum proper (attic) by a coronally oriented bony septum, the anterior attic bony plate or "cog," which is suspended from the anterior petrosal tegmen. The anterior epitympanic recess has received scant attention in the radiologic literature. Recent advances in surgical techniques of the middle ear cleft have spawned renewed interest in the microanatomy of the middle ear. The anterior epitympanic recess has also attracted the attention of ear surgeons because of its relationship to important surrounding structures and to its frequent involvement by cholesteatoma ***(Petrus and Lo, 2000).***

The ossicular chain is comprised of three bones: the malleus, the incus, and the stapes. The manubrium of the malleus is attached to the tympanic membrane. The head of the malleus articulates with the body of the incus in the epitympanum. The long process of the incus articulates with the head of the stapes in the mesotympanum. The footplate of the stapes covers the oval window. The ossicular ligaments, the tensor tympani tendon, and the stapedius tendon contribute to the normal conduction of sound across the middle ear. The anterior, lateral, and superior malleal ligaments and the posterior incudal ligament are suspensory ligaments that connect the malleus and incus to the tympanic wall.The anterior malleal ligament, the incus short process, and the posterior incudal ligament are classically described as the axis around which the ossicles rotate. However, a recent study suggests that this motion is only sustained in low frequencies, while at mid and high frequencies, additional or even predominantly translational motion occurs. Abnormal calcification or absence of these suspensory structures has been associated with conductive hearing loss ***(Marc Lemmerling et al., 2000).***

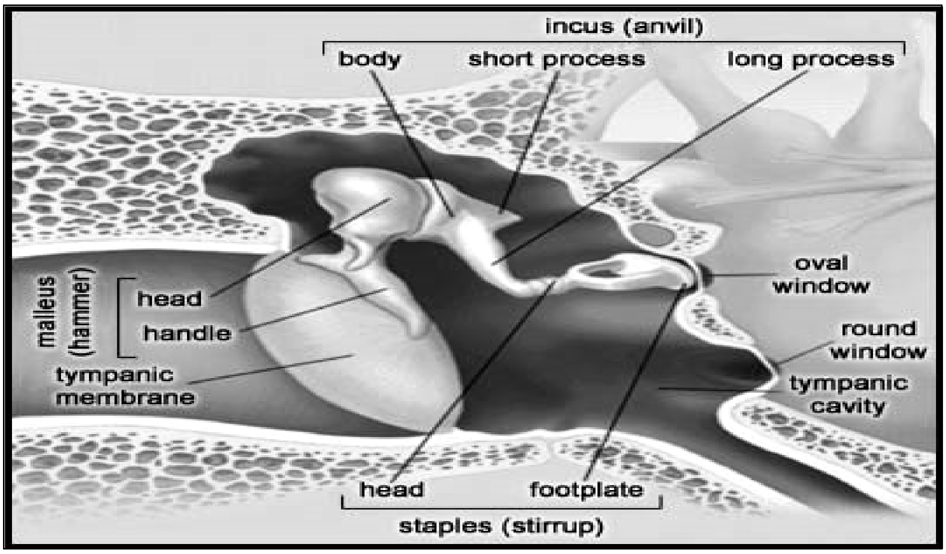

Figure (4): The middle ear ***(From Timothy, 2008)***

The mastoid bone contains multiple pneumatized spaces, the largest of which is the mastoid antrum. The antrum communicates with the mesotympanum through a channel that opens into the upper posterior wall of the middle ear, known as the additus ad antrum. The descending or mastoid segment of the facial nerve traverses the mastoid bone in a vertical trajectory, located just deep to the facial recess in the posterior wall of the middle ear ***(Koike et al., 2002)***.

- ***Inner ear(Labyrinth)***

The inner ear **(Fig 5)**, consists of the components of the membranous and bony labyrinth. The cochlea is a gently tapered tubular structure in a spiral with 2.5 turns, located anteroinferiorly in the otic capsule. The membranous cochlea is divided along its length into two approximately equal perilymphatic chambers, the scala vestibuli (anterior) and scala tympani (posterior), which are separated by the osseous spiral lamina. The cochlear duct is a small endolymphatic chamber located anterior to the spiral lamina that contains the organ or Corti. The round window is a small opening at the posterolateral aspect of the basal turn of the cochlea and is covered by a membrane that separates the cochlea from the middle ear. The cochlear aqueduct is a small bony channel that extends from the basal turn of the cochlea to the lateral margin of the jugular foramen. The vestibule is an ovoid chamber located posterosuperiorly relative to the cochlea. The membranous vestibule contains two endolymphatic subunits, the saccule and utricle, which are surrounded by perilymph. Both subunits are in contiguity with each other, with the endolymphatic duct, and with the cochlear duct ***(Barton and Branstetter, 2008).***

The three semicircular canals **(SCCs)** arise from the vestibule, each with an arc of approximately two thirds of a full circle, oriented at right angles to each other. The superior SCC is in an oblique sagittal plane, approximately perpendicular to the long axis of the petrous bone. The bony roof of the superior SCC forms the arcuate eminence, a landmark on the superior surface of the petrous bone. The posterior SCC is in an oblique coronal plane, approximately parallel to the long axis of the petrous bone. The lateral SCC is in a near-transverse plane that slopes downward anteriorly, perpendicular to the other two SCCs ***(Barton and Branstetter, 2008).***

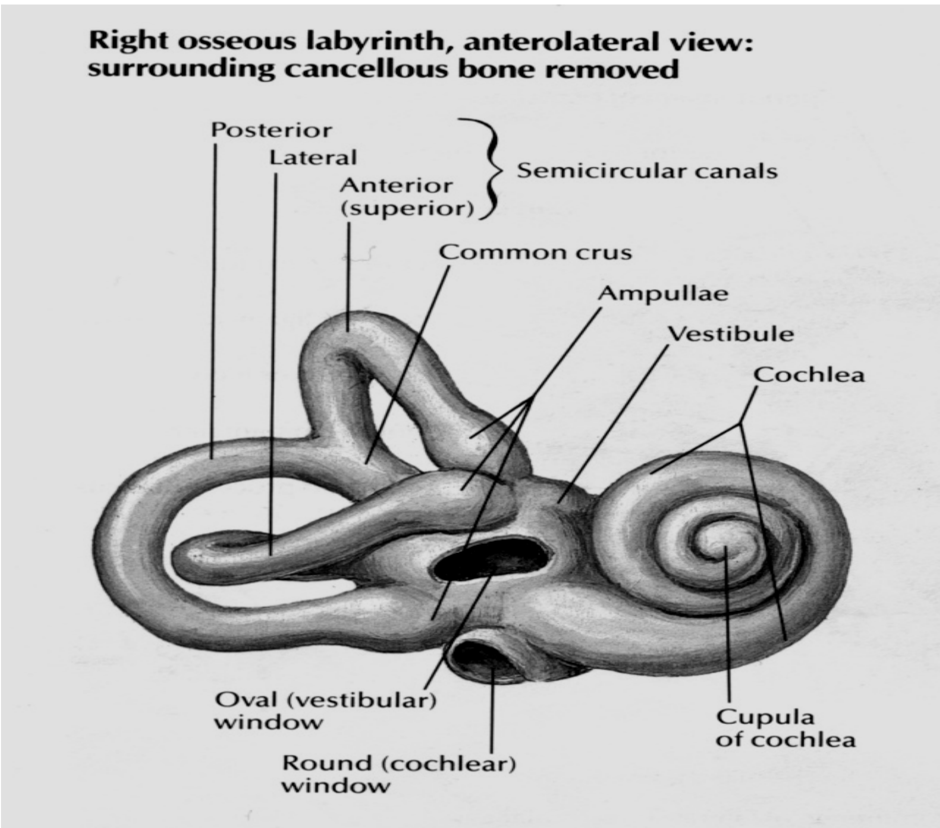

Figure (5): The inner ear ***(from Gray's Anatomy; 2000).***

- ***Internal auditory canal***

The internal auditory canal **(Fig 6),** traverses the petrous bone in a horizontal plane extending anterolaterally from the porus acusticus to the fundus. The facial nerve (CN VII) travels in the anterosuperior aspect of the canal. The cochlear branch of the vestibulocochlear nerve (CN VIII) travels in the antero-inferior aspect of the canal, and the superior and inferior vestibular branches travel in the posterior half of the canal. Vascular structures found in the IAC include the intracanalicular loop of the anterior inferior cerebellar artery (AICA) and internal auditory artery. At the fundus of the IAC, the nerves pass two bony septa before entering the labyrinth through thin perforate bone ***(Davidson, 2004).***

The crista falciformis is a horizontal septum that separates the facial nerve and superior vestibular above from the cochlear nerve and inferior vestibular nerve below. Bill's bar is a vertical bony septum in the upper half of the fundus that separates the facial nerve in front from the superior vestibular nerve behind. The cochlear nerve traverses the cochlear aperture-giving rise to spiral ganglia in the modiolus. The vestibular nerves traverse the macula cribrosa at the medial wall of the vestibule and gives rise to ganglia that serve the vestibular sense organs. Lesions of the IAC typically result in seventh and eighth cranial nerve dysfunction, particularly hearing loss ***(Davidson, 2004).***

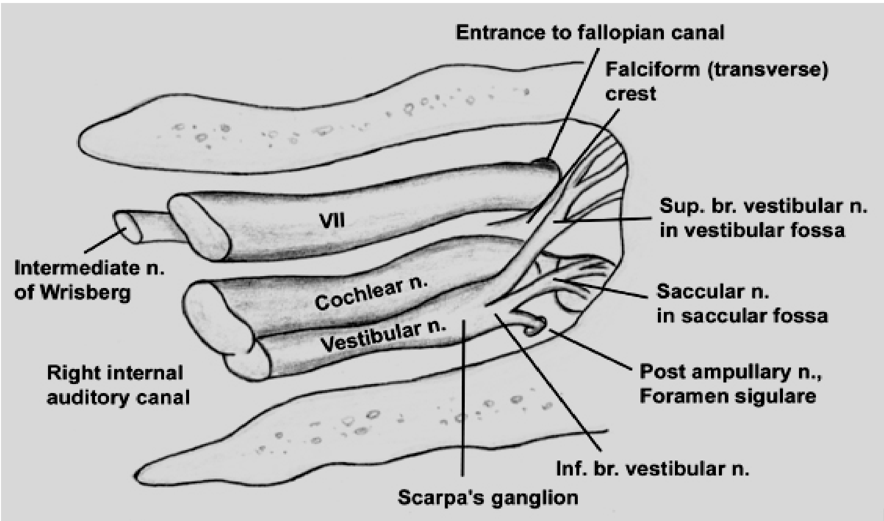

Figure (6): This drawing shows the contents of the right internal auditory canal. Note the relationship between the nervus intermedius (i.e., nerve of Wrisberg) and the facial nerve. Also, note the superior location of the facial nerve relative to the vestibulocochlear nerve ***(from May and Schaitkin, 2000).***