

Research Article

Effect of middle ear and mastoid air space volume on acoustic transmission of sound in tympanic membrane perforation

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ABSTRACT

Background: Loss of hearing is a national health problem with significant social and psychosocial implications. Worldwide there are about 65-330 million people affected with hearing impairment, of which 60% suffers from significant hearing loss. Role of tympanic membrane and ossicular chain in the physiology of hearing is well documented. The emergence of the role played by mastoid air space volume in sound transmission is being critically evaluated these days. The present study is designed to analyze the effect of mastoid air space volume in tympanic membrane perforation with conductive hearing loss.

Methods: 32 subjects both male and female with medium sized tympanic membrane perforation were included in the study. They were grouped into two (those with sclerotic and cellular mastoid). Hearing threshold assessed using pure tone audiometer. Mastoid air space volume evaluated using digital X-ray mastoid schuller's view. Tympanic membrane perforation size assessed using otoscope.

Results: The hearing loss in first group having cellular mastoid and second group with sclerotic mastoid were 22.82 ± 6.28 and 27.82 ± 5.66 respectively. Their p value was 0.026 which was statistically significant.

Conclusions: Mastoid air space volume is inversely proportional to conductive hearing loss. Therefore mastoid air space volume also plays a key role in the sound transmission. The awareness of the pneumatisation status of the mastoid helps clinicians to choose appropriate line of management.

Keywords: Mastoid air space volume, Hearing loss, Tympanic membrane perforation, Pure tone audiometry

INTRODUCTION

Hearing empowers us and enriches our lives. It enables us to socialize, work, interact, communicate and even relax. Loss of hearing is a national health problem with significant physical and psychosocial implications. In India, incidence of chronic otitis media is around 30% with prevalence rate of 60/1000 population in urban and 46/1000 in rural areas.¹

Poor and overcrowded living conditions, poor hygiene and nutrition has been suggested as a basis for the wide spread prevalence of chronic otitis media in developing countries.² Conducting hearing loss occurs when there is a problem in conducting sound waves anywhere along the

route through the outer ear, tympanic membrane and ossicles in middle ear. The role of each of these components in the physiology of hearing is well documented.

In addition to these components, mastoid air cell system is now believed to be an important contributor to the physiology of hearing. It is now argued that mastoid air cell system is a reservoir for the middle ear and plays a role in middle ear pressure regulation and thus modifies the sound transmission.

Tympanic membrane perforation results in conductive hearing loss. Long standing perforation and repeated infection will lead to sclerotic changes in mastoid. In

patients with tympanic membrane perforation having conductive hearing loss, a detailed study on the role of mastoid air space volume is not seen in the available literature.

Two types of mastoid have been described based on the development of air cell system.

- Well pneumatized or cellular – Here mastoid cells are well developed and intervening septa are thin.
- Sclerotic or acellular – There are no air cells or marrow spaces. With any type of mastoid pneumatization, the mastoid antrum is always present. In sclerotic mastoids, antrum is usually small.

Chronic suppurative otitis media can result in changes in the mastoid antrum which can contribute to the hearing loss. The present study was designed to analyze the effect of variations in pneumatization of mastoid and middle ear in the acoustic transmission of sound.

METHODS

A total of 32 patients with chronic otitis media mucosal type who attended the outpatient department of otolaryngology and head and neck surgery at Jubilee Mission Medical College and Research Institute, Thrissur, Kerala, India were studied during the period of December 2013 to July 2015.

Patients were selected based on the inclusion and exclusion criterias. Patients with small and large size perforations, cholesteatoma, previously operated ears, ossicular disruption, Sensorineural hearing loss and patients not willing to enroll in the study were excluded.

After obtaining institutional ethical clearance, informed written consent from those willing to enroll in the study was obtained. A detailed proforma was filled for each patient with regard to history, otological, audiological and radiological evaluation.

Ears examined using an otoscope (Welch Allyn) and subsequently under operating otomicroscope. The size and site of the perforation as well as ossicular chain status assessed.

Only ears with intact ossicular chain were selected. Tympanic membrane is divided into four quadrants by two imaginary lines.

One line drawn horizontally through umbo (centre most region); where the handle of malleus ends. Another line is drawn perpendicular to this along the handle of malleus.

Thus we get four quadrants in intact tympanic membrane. Those perforations involving any two quadrants either lying in front of handle of malleus or behind it are grouped as medium sized perforations.

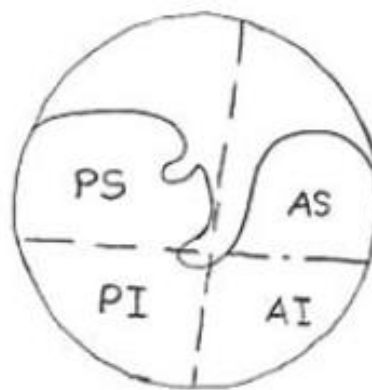


Figure 1: Division of tympanic membrane.



Figure 2: Medium sized perforation – right tympanic membrane.

Hearing assessment was done preoperatively by doing pure tone audiogram using advanced digital audiometer AD 2000 ALPS diagnostic audiometer in a sound proof environment of the auditory physiology lab of the audiology department.

This consists of air conduction (AC) and bone conduction (BC) testing. Pure tone audiogram values are assessed mainly in the frequencies of 250Hz, 500Hz, 1000Hz, 2000Hz and 4000Hz.

Middle ear air space volume assessed by evaluating the cellularity of X- ray mastoid preoperatively and later confirmed intraoperatively by direct visualization using operating otomicroscope.

The digital radiography helps to note the middle ear air space volume by assessing the pneumatization status of mastoid graded as cellular & sclerotic. Size and site of the perforation were also assessed. Variations in air bone gap pattern when mastoid is extremely sclerotic as compared to mastoid which is well pneumatized are evaluated.

At the end of the study master chart was prepared with relevant variables. This data was statistically analyzed with the help of software SPSS version 22. Student t test

has been used to find the significance of study parameters between two groups. A p value of <0.05 was considered to be statistically significant.

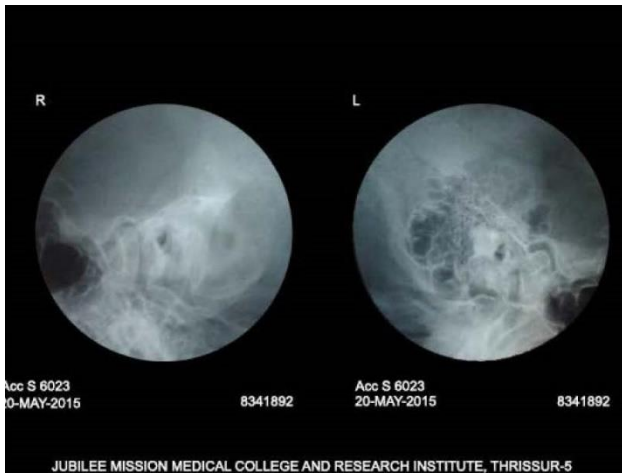


Figure 3: Digital radiography X-ray mastoid.

(X ray of mastoid lateral oblique view showing sclerosis on the right side and well pneumatization on the left mastoid).

RESULTS

In the present study 32 subjects with medium sized tympanic membrane perforations and conductive hearing loss were grouped into those with sclerotic mastoid and cellular mastoid.

Table 1: Demographic profiles of the subjects.

Variable	Subgroup	Percentage
Gender	Females	58.8%
	Males	41.2%
Age distribution	Mean	32.14±14.61

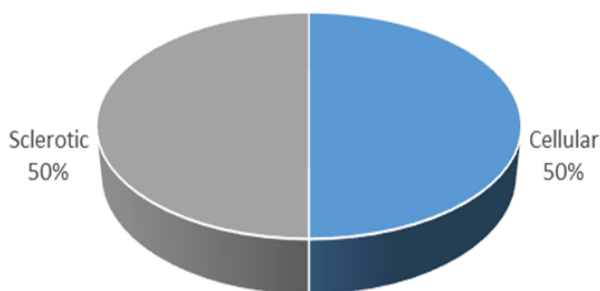


Figure 4: Distribution of mastoid air space volume.

- *Group I:* Medium size perforation with cellular mastoid
- *Group II:* Medium size perforation with sclerotic mastoid

Table 2: Comparison of magnitude of hearing loss with varying mastoid air space volume.

Group	Mastoid status	Size	Mean HL	P-value
Group I	Cellular	Medium	22.82±6.28	0.026*
Group II	Sclerotic	Medium	27.82±5.66	

*P-value statistically significant, HL- Hearing loss.

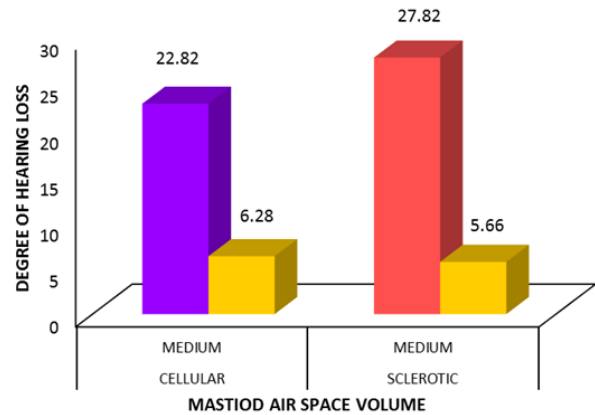


Figure 5: Comparison of medium sized perforations with cellular and sclerotic mastoids to degree of hearing loss.

DISCUSSION

The term mastoid air space volume refers to the volume of air contained within the tympanic cavity (including the epitympanum, hypotympanum and protympanum) and the mastoid collectively. In our study, we had mainly two groups of 16 subjects each. The group I and group II had mean and SD 22.82±6.28 and 27.82±5.66 respectively. Their t value was -2.36 and their degree of freedom was 29.68.

The p value was 0.026 which was <0.005. Subjects having sclerotic mastoid had more hearing loss when compared with cellular mastoid. Well pneumatized mastoids had larger volume which adds to the resonance of hearing whereas sclerotic mastoids had minimal air volume. Therefore magnitude of hearing loss is inversely proportional to the pneumatization status of the mastoid.

This mastoid air space volume is a novel concept and our findings are in agreement with authors Voss SE et al. who did experiments on temporal bones of the cadavers and Mehta et al. who did studies on models.³⁻⁷ The limitation of their study was that they used tympanometry to assess the volume. For small volumes this method is fine.

But for larger volumes that are greater than 7 ml, these methods underestimate the volume in the mastoids. Our study is comparable with the study conducted by above authors. We have assessed the volume by looking at cellularity of the mastoids by lateral oblique view of

digital X-ray mastoid. Absence of pneumatization of the mastoid (sclerotic) may be the causative reason for higher degree of hearing loss than that expected from same size of the perforation of pneumatized mastoid in the absence of other middle ear pathology.

Air cell system is capable of gas exchange by submucosal capillary network. Because gas exchange occurs in cellulat mucosa, total area of mucosal surface affects gas exchange rate. Increased mastoid pneumatization enhances the ability of regulating middle ear pressure.

CONCLUSION

The conclusions drawn from the present study was that the hearing loss varies inversely with mastoid air space volume.

The effect of tympanic membrane and middle ear structures in the sound transmission has been already been substantiated and reviewed in detail. From our study, we conclude that, mastoid air space volume also plays a key role in physiology of hearing apart from other middle ear structures.

This is a novel concept with regard to the effect of transmission of sound in hearing. Clinicians while treating patients with TM perforations should consider not only the size of the perforation but also the mastoid air space volume while evaluating hearing loss.

This will help in predicting hearing improvement and making necessary alteration in the surgical management. Thus appropriate line of management will provide better Quality Of Life for the subject in the society.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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