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Traumatic perforation: determinants of conductive hearing loss

Ravi K. S.*, Ravishankar S. N.

Department of ENT, AIMS, B G Nagar, Karnataka, India

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***Correspondence:**
Dr. Ravi K. S.,
E-mail: drraviksgowda@gmail.com

ABSTRACT

Background: Traumatic perforations of the tympanic membrane are very common in day to day life and it may be due to direct or indirect source. The aim of this study is to evaluate the various factors which determine the degree of hearing loss in patients with traumatic perforation of tympanic membrane.
Methods: A retrospective review was performed in 50 patients seen at the ENT department in our rural tertiary center over a period of two years between January 2015 to December 2016. The patients with history of ear trauma from various causes and with absolutely no previous history of any ear disease were included in our study. The data retrieved included parameters such as age, sex, side, cause of injury and presenting complaints such as hearing loss, earache, tinnitus, and vertigo. A detailed clinical and otoscopic examination was done to determine the size and location of the perforation. Hearing was assessed using pure tone audiometry (PTA) to determine the degree of hearing loss and to correlate with frequency, size and location of perforation.
Results: A total of 50 patients with traumatic perforations of the tympanic membrane were enrolled for the study, comprising of 32 males and 18 females patients. Age of the patients ranged from12 to 65 years of age. The results showed that the most common mode of trauma was RTA (46%). Audiometry shows that the larger the tympanic membrane perforation, the larger the air–bone gap. Hearing loss was highest at the lowest frequencies and generally decreased as the frequency increased. The results also showed that there was no difference in air bone gap with relation to location of perforation (anterior vs. posterior).
Conclusions: The conductive hearing loss resulting from a tympanic membrane perforation is frequency dependent, with the largest losses occurring at the lowest sound frequencies, hearing loss increases as size of the perforation increases and no relation with location of perforation.

Keywords: Conductive hearing loss, Pure-tone audiometery, Traumatic tympanic membrane perforation

INTRODUCTION

The tympanic membrane (TM) serves as a key component of the tympano-ossicular system for sound transmission. Perforations of the TM can result in a conductive hearing loss (CHL) that ranges from negligible to 50 dB. Perforation of the TM is common in otologic practice and can result from various causes. The cause of TM perforation include direct trauma by instrumentation such as cotton swab, pins and sticks, Iatrogenic such as syringing, suctioning, probing of ear and skull fracture. Pressure changes include blast injury and open palm trauma (slapping), diving and flying.[1] As expected the incidence of perforation of TM is on a rise, due to increased violence and accidents seen in the present day life.[2]

A perforated TM results in loss of hearing due to decreased surface area and liability to recurrent infection of the middle-ear mucosa. These problems limit the patient participation in water sports and their recruitment for jobs in military services and as motor vehicle drivers.[3]

TM perforation leads to an increase in acoustic coupling by 10–20 dB, caused by a loss of the shielding effect of an intact TM. The increase in acoustic coupling allows one to predict the maximum conductive hearing loss following a perforation to be about 40–50 dB.[4]

The volume of middle-ear space also affects hearing. A smaller volume results in a larger air–bone gap. For a given sound pressure in the ear canal and a given perforation, the resulting sound pressure within the middle-ear cavity is inversely proportional to the middle ear volume. Thus, the transtympanic sound pressure difference will be smaller with smaller middle-ear volumes. Identical perforations in two different ears have conductive losses that can differ by up to 20–30 dB if the volumes of the middle-ear space differ.[4]

With an incidence estimated at 6.8/1000 persons it is one of the most commonly seen cases in our OPD.[5] There is a relative increase of trauma in our society which in turn can dampen our economic growth. Hearing loss with significant physical and psychosocial problems has become a national health problem. However, most of the studies advocates masterly inactivity as the prime mode of treatment since 90% and above of traumatic perforations heals spontaneously within three months of injury.[6]

The aim of this study is to evaluate the factors which determine the degree of hearing loss in patients with traumatic perforation of tympanic membrane.

METHODS

A retrospective review was performed in 50 patients seen at the ENT department in our rural tertiary center over a period of two years between January 2015 to December 2016.

The patients with history of trauma to ear from various causes like assault, road traffic accidents, pin prick, iatrogenic etc. were included in the study. Patients with history of any ear disease in the study and also subjects underwent any form of ear surgery involving tympanic membrane in the past were not included in our study.

A detailed clinical and otoscopic examination along with tuning fork test was performed on all patients. We studied ears where a TM perforation was the sole cause of a CHL. In each ear, we determined the size and location of the perforation. The location of each perforation was determined to be anterior or posterior with respect to an imaginary line drawn across the TM at the level of the manubrium.

Hearing was assessed using pure tone audiometry (PTA), and associated symptoms such as tinnitus and vertigo were noted. The data retrieved included parameters such as age, sex, side, cause of injury and presenting complaints such as hearing loss, earache, tinnitus, and vertigo. Quantitative or qualitative results will be analysed using Fisher's extract test wherever applicable. Follow up assessment was recorded at least three times for every patient.

RESULTS

In our study, out of 50 patients with traumatic perforation who were enrolled in the study, 32 were males and 18 were females with age ranging from 12 to 65 years of age. Most of the patients were in the age group of 26 to 40 years of age group (Table 1).

Table 1: Age distribution.

Age group (in years)	No of cases (%)
10-25	9 (18%)
26-40	21 (44%)
41-55	15 (30%)
>55	5 (10%)

Etiology

In our study, the most common aetiology of traumatic perforation of TM was injury caused in road traffic accident (46%) followed by physical assault (36%). Iatrogenic i.e. during removal of foreign body and self-cleaning by patients accounted for 8% of cases each. Barotrauma was seen in only one patient (Table 2).

Table 2: Aetiology of traumatic perforation.

Aetiology	Number (%)
Road traffic accident	23 (46%)
Physical assault	18 (36%)
Self-ear cleaning	4 (8%)
Iatrogenic	4 (8%)
Barotrauma	1 (2%)

Hearing loss

In our study, majority of patients (60%) presented with conductive hearing loss in the range of 20–35 dB, 28% of patients with <20 dB, and only 8% of patients presented with >35 dB hearing loss. While 4% of the patients had no air bone gap (Table 3).

Degree of hearing loss with site of perforation

In our study, posteroinferior quadrant of the tympanic membrane was found to be affected most commonly. Out of the 50 cases, posteroinferior quadrant portion involved in 29 cases. In 19 patients, the maximum portion of perforation in anteroinferior quadrant of tympanic membrane (38%). Thus the lower half of the eardrum was found to be involved in 96% of the cases. Only in few cases the superior part of the tympanic membrane involved.

Although there was a trend for the anterior perforations to show a slightly smaller mean AB gap, no statistically significant differences in AB gaps were found between anterior and posterior TM perforations (p=0.9113) (Table 4).

Table 3: Degree of conductive hearing loss.

Air bone gap (dB)	No. of patients (%)
<20	14 (28%)
20-35	30 (60%)
>35	4 (8%)
No AB gap	2 (4%)

Table 4: Degree of hearing loss with site of perforation.

Air bone gap (dB)	Anterior	Posterior	Total	P value*
<20	6	8	14	0.9113
20-35	11	19	30	
>35	1	3	4	
No AB gap	1	1	2	
Total	19	31	50	

Size of perforation

In our study out of the 50 patients with single perforation, 28 patients had small sized perforation (grade 1) involving only one quadrant of the tympanic membrane. 19 patients had medium sized perforation (grade 2) involving two quadrants of the eardrum. 3 patients had large sized perforation (grade 3) involving three quadrants of the tympanic membrane. No patients had subtotal or total perforation (Table 5).

Table 5: Size of perforation.

Size of TM perforation	No of cases (%)
Grade 1	28 (56%)
Grade 2	19 (38%)
Grade 3	3 (6%)
Subtotal or total	0

DISCUSSION

Trauma to the ear could be a simple blunt trauma to the pinna, laceration of the pinna, avulsion of a part of the pinna or the whole pinna, uncomplicated TM peforation, dislocation of the ossicles and longitudinal and transverse fractures of the petrous temporal bone with associated loss of inner ear and facial nerve function.

Trauma to the TM can be caused by overpressure (slap, fight, assault from security personnel and road traffic injury), thermal or caustic burns and blunt or penetrating injuries, such as trauma caused by instruments and barotraumas.[1]

Traumatic TM perforations are seen in all age groups. In our study, middle age group (20–40 years) has the highest incidence similar to studies undertaken by Gacek and Gacek and Berger et al.[6,7] The incidence of traumatic perforation was found to be more in males (64%) compared to females (36%) which was similar to studies reported by Gacek and Gacek and da Lilly- Tariah and Somefun.[6,8] The high prevalence can be explained by the fact that most cases were road traffic accidents involving two wheelers and majority of the drivers were males.

Posteroinferior quadrant of the tympanic membrane was found to be affected in most of our cases. Out of the 50 cases 29 had a posteroinferior quadrant perforation. Posteroinferior quadrant seems to be more vulnerable to the trauma since it is more laterally placed and more easily accessible. Direct trauma is more likely to damage the posteroinferior quadrant. During slap the pressure wave travels along the posterior canal wall and strikes the posteroinferior quadrant first thereby creating a perforation there.[9]

The tympanic membrane (TM) is an important component of sound conduction as its vibratory characteristic is necessary for sound transmission in human beings.[6] In a normal ear, the sound pressure difference across the TM provides the primary drive to motion of the TM and ossicles.[10] Perforation causes hearing loss, which depends on frequency, perforation size and middle-ear space. Mehta et al in their experimental and theoretical work demonstrated that the primary mechanism of hearing loss by a TM perforation is a reduction in middle-ear sound transmission caused by a loss in sound pressure difference across the TM.[10-12] They postulated that a perforation will cause a conductive hearing loss that a) is largest at low frequencies; b) increases as the size of the perforation increases; c) does not depend on location of the perforation; and d) will vary inversely with the middle-ear volume.

Our study showed that perforation-induced hearing losses was generally greatest at the lowest frequencies, and decreased as frequency increased. This is consistent with other studies in the literature and the study by Santhi and Rajan, who in their study found that perforation-induced losses are greatest at the lowest frequencies.[13]

The size of the perforation was also an important determinant of the hearing loss. Larger perforations resulted in greater hearing loss, an effect that was present at all audiometric frequencies. In our study, hearing loss increased with increase in size of perforation at each frequency. It is due to hydraulic action arising from the difference in area of foot plate, the most important factor in impedance matching.[14]

When the surface area is decreased, there is decrease in amplification and hearing loss will be proportional to the size of perforation.[15]

In our study, audiometric results showed no differences or mild variations in the air-bone gaps at any frequency with relation to location of perforation i.e. anterior vs. posterior perforation. This is very contradictory to widely held clinical view that posterior perforations result in larger hearing losses than anterior perforations.

The explanation for this view has been that, perforations over the round window result in a sound pressure acting at the round window that diminishes the cochlear response by a "phase cancellation effect".[16] This explanation of a phase-cancellation effect is not valid on theoretical or experimental grounds as explained by Mehta et al. Because the wavelengths of sound at audiometric frequencies (≤4 kHz) are larger than the middle-ear dimensions, the phase-cancellation effect should theoretically be similar for anterior and posterior perforations.

It is also important to note that the main mechanism of hearing loss at audiometric frequencies from a perforation is a reduction in driving pressure across the TM. Such a mechanism is expected to be independent of location of the perforation.

Most traumatic perforation have a tendency to heal spontaneously, there was 90% healing in our study similar to other studies.[17]

CONCLUSION

In our experience traumatic perforation of the tympanic membrane is still common in our community especially in our institution since it is located in the highway which is more prone to road traffic accidents. It affects all age groups with males affected more than females. Based on our studies main factor which determines the degree of hearing loss is size of perforation i.e. as the size of perforation increases the degree of hearing loss increases with little or not dependent on location of perforation. The hearing loss in traumatic perforation is frequency dependent, with the greatest loss occurring at the lowest sound frequencies.

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