The Effect of Tympanic Membrane Perforation on Hearing

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ABSTRACT

Background: Tympanic membrane perforation is a relatively common finding that is caused by various factors, including trauma and infection. Conductive hearing loss of varying degrees can be caused by a perforated eardrum.

Objective: The aim of this study was to evaluate the effect of size and site of tympanic membrane perforation on hearing.

Methods: This is a case-control study involving patients with tympanic membrane perforation at the ENT Department—Al-Jumhori Teaching Hospital, Mosul, Iraq, from September 1st, 2010, to September 1st, 2011. All the data were collected and compared with normal control persons with no tympanic membrane perforation.

Results: The study included 78 patients with tympanic membrane perforation. Fifty-eight patients (74.3%) have unilateral perforation, while the other twenty patients (25.7%) have bilateral perforation. A total of 98 ears with tympanic membrane perforation were included in this study compared with 100 control persons with no perforation. The mean age of patients was 35.3 years, while the control average age was 42.59 years. Hearing level in patients with perforated tympanic membrane was as that, in 16 patients, the hearing level was 0-20 dB (16.3%), 60 patients hearing level 21-40 dB (61.22%), 20 patients hearing level 41-60 dB (20.4%) and two patients hearing level more than 60 dB (2.04%). In comparison, in the control group, 89 patients the hearing level was 0-20 dB (89%), seven patients had a hearing level of 21-40 dB (7%), three patients had a hearing level of 41-60 dB (3%) and one patient's hearing level more than 60 dB (1%). Moreover, posteroinferior perforation was the most common site of perforations.

Conclusion: Our results revealed that the larger the perforation, the greater the hearing impairment. Moreover, posterior perforations of the tympanic membrane were the most common types. They significantly caused more hearing loss, possibly even greater than those due to larger perforations located elsewhere.

Keywords: Tympanic membrane perforation, ear drum perforation, hearing loss.

ثقب غشاء الطبلة وتأثيره على السمع

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الخلاصة

الخلفية: يعتبر ثقب غشاء الطبلة من المشاهدات الشائعة بين المرضى والتي تحدث بسبب الصدمة او التهاب الأذن الوسطى. ضعف السمع التوصيلي بدرجات مختلفة ممكن ان ينتج بسبب ثقب غشاء الطبلة.

الهدف : تقييم تاثير ثقب غشاء طبلة الأذن من حيث الحجم والموقع على السمع.

المرضى وطريقة العمل: اشتملت هذه الدراسة المستقبلية المقارنة التي اجريت في المستشفى الجمهوري التعليمي-الموصل- العراق للفترة من تشرين الاول ٢٠١٠ - تشرين الأول ٢٠١١ على مجموعتين من المرضى. المجموعة الاولى تتكون من ٧٨ مريض يعانون من ثقب في غشاء طبلة الأذن بينما تتكون المجموعة الثانية من ١٠٠شخص سليم وتمت مقارنة نتائج السمع بين المجموعتين.

النتائج: كان من بين المرضى ٤٦ انثى (٥٨.٩%) و ٣٢ ذكر (٤١.١%). ثمان وخمسون مريض منهم يعاني من ثقب في أذن واحدة, بينما يعاني عشرون مريضا من ثقب في كلا الأذنين. بالمحصلة تمت دراسة السمع في ٩٨ اذنا ومقارنة النتائج مع ١٠٠ مريض من الاصحاء. كان معدل العمر في المجموعة الاولى ٣٥.٣ سنة فيما كان معدل العمر ٤٢.٥٩ في المجموعة الثانية الخاصة بالاصحاء. وقد شملت متغيرات الدراسة حجم وموقع ثقب طبلة الاذن .وقد كانت نتائج المجموعة الاولى كألأتي: ١٦ (١٦.٣ %) من المرضى كان معدل السمع لديهم ٢٠-٠وحدة سمعية,٦٠(٦١.٢٢%) من المرضى كان معدل السمع لديهم ٢١-٤٠وحدة سمعيةو٢٠ (٢٠.٤%) من المرضى كان معدل السمع لديهم ٤١-٦٠وحدة سمعية و ٢(٠٤ .٢%) من المرضى كان معدل السمع لديهم اكثر من ٦٠ وحدة سمعية. بالمقارنة كانت نتائج المجموعة الثانية كالأتي:٨٩ مريضا(٨٩)% كان معدل السمع لديهم ٠-٢٠وحدة سمعية, ٧مريضا(٧%) كان معدل السمع لديهم ٢١-٤٠وحدة سمعية, ٣ مريضا (٣%) كان معدل السمع لديهم ٤١-٦٠وحدة سمعيةو١مريضا(١%) كان معدل السمع لديه أكثر من ٦٠ وحدة سمعية. بالاضافة الى ذلك كان الثقب الخلفي السفلي هو الاكثر شيوعا من بين الثقوب الاخرى.

الأستنتاج: وجد من خلال هذه الدراسة انه كلما ازداد حجم ثقب طبلة الاذن , زادت تأثيراته السلبية على السمع. وكذلك وجد ان ثقب الطبلة الخلفي يؤثر بصورة اكبر على حدة السمع من تأثير الثقب الامامي وبالحجم نفسه.

الكلمات المفتاحية: ثقب غشاء الطبلة, ثقب طبلة الاذن, ضعف السمع.

INTRODUCTION

The tympanic membrane is a membranous partition separating the external auditory meatus from the tympanic cavity, measuring 9-10 mm vertically and 8-9 mm horizontally. It plays a significant role in the middle ear transformer mechanism[1]. Tympanic membrane perforation is a very common disease, either due to infection or trauma, and is one of the common causes of hearing loss. It is estimated that at least 2/3rd of the world population of persons with disabling hearing impairment reside in developing countries[2]. Most (up to 80%) of these perforations heal spontaneously. The remaining cases may be addressed with surgery, especially when patients experience significant discomfort due to recurrent otorrhea, conductive hearing loss, or interdiction to water activities[3].

The site and the size of the perforation, whether or not in contact with the manubrium mallei, and the volume of the middle ear and the mastoid are some factors that affect the level of hearing loss. Some articles show that large posteriorly located perforations in contact with the manubrium mallei increase the CHL level, especially at lower frequencies[4].

The aim of this study was to evaluate the effect of size and site of tympanic membrane perforation on hearing.

PATIENTS AND METHODS

This case-control study was conducted to analyze 78 patients with central tympanic membrane perforation at the Otolaryngology Department/ Al-Jamhory Teaching Hospital for the period from September 1st 2010- September 1st 2011.

The Ethical Committee of the College of Medicine, University of Mosul, approved the study with approval code 20-21(5) on 5/10/2020. All studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

To be enrolled in this study, the patients should fulfill the following criteria:

1. Central and dry tympanic membrane perforations without cholesteatoma.
2. No tympanosclerosis in tympanic membrane remnant.
3. No middle ear infection and the middle ear mucosa is not infected by otoscopic and microscopic examination at the time of surgery.
4. The patient must be more than six years old.

Patients with the following features were excluded from the study:

1. Patients using ototoxic drugs.
2. Patients with ear discharge.
3. Patients who have had hearing loss before tympanic membrane perforation.
4. Patients with a history of excessive recreational or occupational noise exposure.
5. Patients with autoimmune disease.
6. Perforation of pars flaccida.
7. Patients with sensorineural hearing loss.

The control group consisted of 100 individuals collected from the relatives and accompanying patients visiting the Outpatient Clinic at Al-Jamhory Teaching Hospital in Mosul who did not have tympanic membrane perforation provided by complete otological examination or any of the exclusion factors mentioned above. Their ages were between 20-60 years. They were willing to cooperate with this study, and their consent was obtained.

The patients were assessed according to the following parameters:-

1. Etiology of perforation
   A. Infection.
   B. Trauma.
   C. Other or unknown.
2. Size of perforation

This analysis measures the size of tympanic membrane perforation using Hopkins rod telescope O degree and digital camera to capture a picture of the tympanic membrane and perforation. The perforation size was calculated as a percentage of the whole tympanic membrane size using the computer and special software (Mapinfo Professional 5.5). At the same time, both site and shape of the perforation were determined.

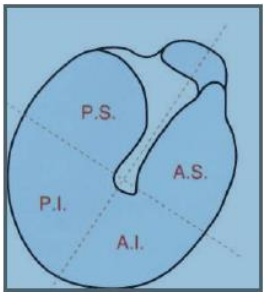
The size of the perforation was graded into six grades

A. From 0 - 9.9%.
B. From 10 – 19.9 %.
C. From 20 – 20.9 %.
D. From 30 – 39.9 %.
E. From 40 – 49.9 %.
F. More than 50%.

3. Site of perforation

The site of perforation was located in relation to the handle of the malleus as follows:

A. Anterosuperior.
B. Anteroinferior.
C. Posterosuperior.
D. Posteroinferior.



4. Hearing assessment

For hearing assessment, we used the following methods:

A. Tuning fork: A set of tuning forks composed of 128, 256, 512, and 1024 Hz are used, depending mainly on 512 Hz. Rinne and Weber tests were done for each patient.
B. Pure tone audiometry (Atmoscreen 20 K) made in Germany: It was done for all patients and controls to measure air and bone conduction thresholds, finding the air-bone gap and using digital- clinical audiometer model AC3 from interacoustics which fulfilled the general requirement for the audiometer (American National Standards Institute, 1959, 1978; International Electro-technical Commission, 645-1959; British Standards 5966-1980). Audiometry was performed for all patients by the same experienced physicist in sound – reduced booth that was carried out in a standardized manner using strict masking rules.

The physicist frequently and objectively calibrated the audiometer to the accepted standards, using the standard Hughson West Lake technique (1944) to find the hearing threshold level using ascending and descending techniques: 5 dB ascending and 10 dB descending (Scherwood, 1987).

All frequencies of pure tone threshold (250, 500, 1000, 2000, 4000, and 8000 Hz) were recorded to calculate each ear's mean air-bone gap.

Conductive hearing impairment was classified into four grades according to the hearing impairment:

a. 0-20 dB.
b. 21- 40 dB.
c. 41-60 dB.
d. More than 60 dB.

Outcome Measure

The odds ratio was calculated as a risk measure in a case-control study as illustrated:

OR=ad/bc

If OR= 1, there is no association between the risk factor and the disease.

If OR>1 +ve association.

If OR<1 –ve association, i.e., the factor may be protective.

	Cases	Control
Risk factor present	A	B
Risk factor absent	C	D

RESULTS

This study included 78 patients with tympanic membrane perforation. Fifty-eight patients (74.3%) have unilateral perforation, whereas the other twenty patients (25.7%) have bilateral perforations. So, 98 ears with tympanic membrane perforation were included in this study, and the number was compared with that of 100 control persons with no perforation.

The age of our patients was 6-70 years, with a mean of 35.3 years. The maximum age of incidence was between 16-30 years. Forty-six patients (58.9%) out of 78 were females and 32 (41.1%) were males.

The control consisted of 100 individuals whose average age was 42.59 years; 65 (65%) of them were males, and 35(35%) were females (Table 1 and 2).

Table 1: Age distribution of the patients and control group.

Age group	Ears (Patients) N=98		(Ears) Controls N=100		0dd's ratio	95% C.I
	No.	%	No.	%		
1-15 years*	14	14.2%	3	3%	….	….
16-30 years	24	24.48%	24	24%	4.67	1.2;18.4
31-45 years	22	22.44%	40	40%	8.5	2.2;32.8
46-60 years	14	14.2%	31	31%	10.4	2.6;41.8
≥61	4	4.08%	2	2%	2.4	0.3;19.2
Total	98	100%	100	100%	….	….

Table 2: Sex distribution of patients and control group.

Sex	Patient N=78		Control N=100		Odd's ratio	95% C.I
	No.	%	No.	%		
Male	40	40.8	65	65	0.37	0.209;0.660
Female	58	59.18	35	35		
Total	98	100	100	100		

Statistical analysis revealed no statistical difference between ages in both groups, but being a male as a risk factor is less prone to develop tympanic membrane perforation than being female (odd artio=0.37, CI =0.209; 0.660).

1.Cause of perforation

Seventy-two perforated tympanic membranes (92.3%) were due to infection, two perforations (2.5%) were due to trauma, and four perforations (5.1%) were of unknown etiology (Table 3).

Table 3: Aetiology of perforation.

Cause	No. of patient	%
Infection	72	92.3
Trauma	2	2.56
Unknown	4	5.12
Total	78	100

2.Size of perforation

The mean hearing level in relation to the size of the perforation is illustrated in Table 4.

Table 4: Relation between perforation size and each group's mean hearing level.

Size of perforation	No.(%)	Mean hearing level	P-Value*
0 – 20%	46(46.94%)	30 dB	0.001
21-40%	40(40.82%)	44.66 dB	
> 41%	12(12.24%)	38.75 dB	
Total	98(100%)		

*ANOVA test.

We can conclude from these statistical data that the larger perforation of the tympanic membrane, the greater the hearing impairment (P< 0.001).

3.Site distribution of perforation

The mean hearing level in relation to the perforation site is described in Table 5.

Table 5: Relation between perforation site and mean hearing level of each group.

Site of perforation	No. of patients (%)	Mean hearing level	P-Value*
Posteroinferior	50(51.02%)	40	0.001
Anterioinferior	42(42.86%)	25	
Posteriosuperior	6(6.12%)	40	
Anteriosuperior	0(0 %)	0	…
Total	98(100%)		

*ANOVA test.

Statistical studies showed that posterior perforations of the tympanic membrane were the commonest types and significantly cause more hearing loss, which may be even greater than that due to larger perforations located elsewhere (P=0.001).

4.Hearing loss

Table 6 shows the difference in hearing levels between the patients and the control group.

Table 6: Hearing level for patients and control group in dB.

Hearing level	Patient		Control		Odds ratio	95% C.I
	No.	%	No.	%		
0-20 dB *	16	16.3%	89	89%	…	…
21-40 dB	60	61.22%	7	7%	47.7	18.5;122.8
41-60 dB	20	20.4%	3	3%	37.0	9.8;139.5
> 60 dB	2	2.04%	1	1%	11.1	1.5;65.0
Total	98	100%	100	100%	…	…

*Reference group (low risk).

Statistically, when we compared the first group as a reference group with a hearing level of 0-20 dB with the other groups, the results showed that perforation of the tympanic membrane could be considered an essential factor in hearing impairment (Odds ratio> 1 in rest groups).

DISCUSSION

Tympanic membrane perforation is an old phenomenon as old as the evolution of human beings[5]. The effects of perforation of tympanic membranes on the transmission of sound and its dynamics are not easy to correlate because of additional pathological changes in the middle ear[6]. It has been a general view that hearing loss increases with the size of the perforation, more so if it is in the postero-inferior quadrant[7].

In our study, the mean age of our patients was 35.3 years, which agrees with that of Ibekwe et al.[8] and Maharjan et al.[9], where the mean age of their patients was 35.4 ± 4 and 34 years, respectively. On the contrary, our result was higher than a study by Afolabi et al.[10], which has a mean age of 29.2 years, and a study of da Lilly-Tariah[11], where the mean age was 27.6 years with the highest incidence among the middle age groups. Moreover, the study by Bhusal et al.[12] had an age range of 15-24 years.

Our study included 46 females (58.9%) out of 78 patients and 32 males (41.1%). These results concord with that of Ibekwe et al.[8] and Maharjan et al.[9] studies. However, Afolabi et al.[10], Bhusal et al.[12], and Nepal et al.[13] found different results: 50%,70%, and 55% were males and 50%,30%,45% were female respectively.

This study found that infection is the most common cause of tympanic membrane perforation (92.3%). Our result agreed with a study done by Anderson and Sheehy[14]. Moreover, Nepal et al.[13] found that 85% of tympanic membrane perforations were due to chronic suppurative otitis media. This was followed by trauma and acute suppurative otitis media in 8.0% and 7.0% of cases, respectively. We believe this difference may reflect the referral pattern to our hospital and the prevalence of chronic otitis media in the general population.

The size of the perforation was measured using our method, described in patient and methods. The commonly used method for describing the perforation size was developed by Griffin, 1979 [15], a grading system based on the percentage of tympanic membrane perforation.

- Grade I: 25% or less of the tympanic membrane involved.
- Grade II: 25% to 50% or multiple perforations in 2 quadrants.
- Grade III: 50%-75% or multiple perforations in three quadrants.
- Grade IV: 75%-100% (fig.8).

We believe this method is not so accurate because if there is a perforation, it may be considered as grade I when occupying one quadrant. In contrast, the same perforation is considered grade II when it partially occupies two quadrants. Our method measures the perforation as a percentage of the total tympanic membrane surface area.

In this study, we found that when the size of perforation was 0-20% of the total tympanic membrane size, the mean hearing level was 30 dB, and 44.66 dB, 38.75 dB when the size of perforation was 21-40% and more than 40% respectively. We can conclude from these data that the larger the tympanic membrane perforation, the greater the hearing impairment.

Similarly, Gupta, Harshvardhan, and Samdani in 2019 [7] reported that the bigger the perforation, the greater the hearing loss, with posterior perforations being associated with much more hearing loss than anterior perforations thus refuting the null hypothesis that site and size of a tympanic membrane perforation do not affect the degree of conductive hearing loss. Austin[16] reported this in 1978 in his study of sound conduction of the diseased ears. In his study, he compared such findings with those of others and with the experimental animals. Moreover, Pannu et al.[1] in 2011 stated that hearing loss in tympanic membrane perforation increased significantly with the increase of perforation size. However, Al-Ghamdi[17], from his 183 patients, found that 122 patients had large perforation with average conductive hearing loss of 25.3 dB, 21 patients had medium-sized perforation with a 19.2 dB hearing loss, and 40 patients were suffering from small perforation with 11.35 dB hearing loss. In his study, interestingly, the number of large perforations was relatively high, and the hearing loss in their observation was reported to be significantly low. However, the hearing loss was proportionate to the size of the perforations.

Moreover, Anderson and Sheehy(1980)[14], in their study of 472 patients with myringoplasty, showed an association between the size of the perforation and the conductive impairment. However, all these studies used the Griffin method to measure the size of the tympanic membrane perforation. Perforation size was found to be the most crucial determinant of hearing loss by Voss et al.[18] in their various series in 2001. They mentioned that the volume of middle ear space, the tympanic cavity, and mastoid air volume are essential parameters that determine the degree of hearing impairment caused by perforation. Thus, the smaller air space in the middle ear results in a more significant air-bone gap. Berger et al.[19] 1997 conducted a prospective study on 120 patients with non-explosive blast injury during six years. They found that the severity of conductive hearing loss was proportional to the perforation size.

We can conclude from our study that hearing loss was directly proportional to the perforation size, which is consistent with all the above studies.

The air-bone gap results were divided into four groups according to the perforation site. In this study, the most common perforation was the inferior one (Posteroinferior 40.8%, followed by anteroinferior perforation 36.7%). This may be explained by the fact that the common cause of perforation is infection. All the anterior perforations have air-bone gaps of less than 40 dB, while the posterior perforations have more than that. This explains the loss of the baffling effect on the round window membrane in posterior perforations.

Similarly, Berger et al.[19], Durko et al.[20], Yung MW[21], Admed and Ramani[22], and Gupta S, Harshvardhan R, Samdani S.[7] found similar results. Moreover, Khurshid N, Khurshied S, Khizer M A, et al.[23] stated that when the site of perforation was compared with the degree of hearing loss, it was found that there was a statistically significant association between the two, with the posterosuperior quadrant perforation producing the essential degree of impairment. Furthermore, Rana AK, Upadhyay D, Yadav A, Prasad S.[6] reported that Perforations involving the posterior half of tympanic membranes showed more significant loss than those involving the anterior or inferior half of the membrane statistically. Maximum loss (51.56 ± 5.1 dB) was seen in perforation involving all four quadrants.

In comparison, Pannu et al. 2011 [1] reported that posterior perforations lead to more hearing loss than anterior, but this was statistically insignificant. On the contrary, in their study, Vose et al. 2001 [18] did not agree with the notion. They stated that the location of perforation should not influence the resulting hearing loss, which is contrary to all previous studies. Moreover, Katz et al. (2015)[24] reported that the larger the perforation, the more loss of sound pressure is transmitted to the inner ear. However, if the perforation is small but over the round window, the loss may be even more significant than that due to a larger perforation located elsewhere. Similarly, Kolluru, Kumar, and Upadhyay 2021 [25] stated that hearing loss in chronic otitis media is directly proportional to the size of the T.M. perforation, and posteriorly based perforations have worse audiometric thresholds at lower frequencies (500 Hz).

CONCLUSION

We can conclude that hearing impairment is directly proportional to the size of tympanic membrane perforation. Moreover, posterior perforations of the tympanic membrane were the most common types. They significantly caused more hearing loss, possibly even greater than those due to larger perforations located elsewhere. We believe that our method to measure the size of tympanic membrane perforation is logical, along with the Griffin method.

Funding Sources

None.

Conflict of Interest

None declared.

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