Effect of the size of tympanic membrane perforation on hearing

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Received 3/5/2012 Accepted 1/7/2012

Abstract

Tympanic membrane (TM) perforation is one of the most common causes of hearing impairment. Apart from conduction of sound waves across the middle ear, the tympanic membrane, also sub-serves a protective function to the middle ear cleft and round window niche. It has been established that the larger the perforation on the tympanic membrane, the greater the decibel loss. The aim of this study is to determine the effect of the size of the tympanic membrane perforation on hearing. The study was conducted at Al-Jumhoori teaching hospital during march 2011 to march 2012. Seventy-eight patients with perforated tympanic membranes were included in the study.They all have TM perforation due to recurrent or chronic otitis media. Patients with traumatic TM perforation were excluded from the study. There were 47 males (46.5%) and 54 females (53.5%). Twenty patients had left ear perforation, 35 patients had right ear perforation, and 23 patients had bilateral perforations. Each ear was taken as a case, so the total number of the perforated ear drums were 101. The age ranged from 13- 56 with the mean of (31.64 ± 13.249) years.

The TM perforation was examined and photo image was taken with the aid of the endoscope, and the percentage of the perforation was measured from the whole area by using a special Microsoft (infomap). Controls were 55 patients with a mean age 30.73 ±12.09(range 14-53) years. Male controls were 34 (61.8%), and 21 female controls(38.2%). There was a highly significant correlation between size of TM perforation with the hearing level, air bone gap, high frequency hearing loss and low frequency hearing loss. As a conclusion, there is strong relationship between the size of TM perforation and the hearing level, air-bone gap and both the low frequency and the high frequency hearing level and air-bone gaps.

Key words: Tympanic membrane(TM) perforation, hearing level, air-bone gap, low frequency, high frequency.

تأثير حجم تثقب الطبلة على حدة السمع

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الملخص

ان ثقب غشاء الطبلة هو احد اهم الاسباب شيوعا لضعف السمع . وكلما زادت مساحة الثقب ، زاد ايضا نسبة فقدان السمع بالوحدات السمعية. ان الهدف من هذه الدراسة هو تقييم تأثير مساحة الثقب على السمع. تم اجراء الدراسة في مستشفى الجمهوري التعليمي في مدينة الموصل للفترة من أذار 2011 الى أذار 2012 على

المرضى المراجعين للعيادة الاستشارية جراحة الاذن و الانف و الحنجرة . تضمنت الدراسة بثمانية وسبعين مريضا ، وكانو مصابين بثقب غشاء الطبلة نتيجة الالتهاب المكرر او المزمن في الاذن الوسطى. وقد تم استبعاد المرضى المصابين بثقب الطبلة الرَضْحِيّ . شملت الدراسة 47 مريضا (46%)من الذكور ، و 56 مريضا (53%) من الاناث. عشرون مريضا كان لديهم ثقب في غشاء الطبلة في الاذن اليسرى، و 35 مريضا كان لديهم ثقب الطبلة اليمنى ، و 23 مريضا لديهم ثقب في كلتا الاذنين . كل اذن تم دراستها كحالة مستقلة وبذلك يصبح المجموع الكلي 101 حالة. العمر تراوح بين 13-56 سنة مع متوسط العمر (31,64 سنة). تم فحص وتصوير غشاء الطبة باستخدام الناظور ، وتم قياس نسبة الثقب من المس احة الكلية باستخدام برنامج خاص اسمه (انفو ماب). كانت المجموعة الضابطة تتكون من 55 مريضا مع متوسط العمر (30,73 سنة)، حيث تراوح العمر من 14-53 سنة. شكل الذكور 34 مريضا(61%)، والاناث شكلوا 21 مريضا(38%). و لوحظ أن هناك علاقة قوية بين مساحة الثقب ومستوى السمع ،ومع الَغْرَةٌ العَظْمِيَّةٌ الهَوائِيَّة.

مفاتيح الكلمات:
ثقب غشاء الطبلة، مستوى السمع، الَغْرَةٌ العَظْمِيَّةٌ هَوائِيَّة، الترددات الواطئة ، الترددات العالية.

Introduction

Tympanic membrane(TM) perforation is one of the most common causes of hearing impairment. Infection is the principle cause of TM perforation. It may be acute or chronic. A perforation due to acute infections usually heals if treated timely. Perforation of TM is frequent manifestation of injury and may be due to 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 etc. may cause inner ear injury and sensorineural hearing loss (SNHL)(1). Apart from conduction of sound waves across the middle ear, the tympanic membrane, also sub-serves a protective function to the middle ear cleft and round window niche. Intact tympanic membrane protects the middle ear cleft from infections and shields the round window from direct sound waves which is referred to as (round window baffle)(2). This shield is necessary to create a phase differential so that the sound wave does not impact on the oval and round windows simultaneously. This would dampen the flow of sound energy being transmitted in a unilateral direction from the oval window through the perilymph. It has been found that the effect of the enhanced ratio of the surface area of the tympanic membrane to that of the oval window increases the sound pressure by about 27 decibel (dB) whereas the lever action of ossicles contributes about 3 decibel (dB)(3,4). A perforation on the tympanic membrane reduces the surface area of the membrane available for sound pressure transmission and allows sound to pass directly into the middle ear. As a result, the pressure gradient between the inner and outer surfaces of the membrane virtually becomes insignificant(5). It has been established that the larger the perforation on the tympanic membrane, the greater the decibel loss in sound perception. A total absence of the tympanic membrane would lead to a loss in the transformer action of the middle ear(6,7). Previously, Bordley and Hardy [1937], Payne and Githler [1951] and Mcintire and Benitez [1979] have studied the effect of experimentally. Mcintire and Benitez also demonstrated a correlation between perforation size and auditory threshold. Total removal of the membrane produced a flat hearing loss of about 32 dB HL[8]. Ahmad and Ramani [1979] studied tympanic perforations in young, otherwise healthy adult males who had been referred for closure of perforations which had resulted from trauma or infection. These authors examined affected ears under the operating microscope, noted the location of the perforation and measured its area with techniques more sophisticated than those that had been used hitherto (if they considered it necessary, Ahmad and Ramani used photography and planimetry)[6,9]. In this study, we used the Hopkins rod endoscope to have a video capture of the TM. Then these pictures were dealt with by a special software program ((infomap) to have the precise areas of both the perforation and the whole surface area of the TM. By a simple equation we calculate the percentage of the perforation of the whole TM.

Patients and Methods

It is a prospective case control study, which was conducted between March 2011 and march 2012 with a target patient seen in the Ear Nose and Throat (ENT) clinic of the AL- Jumhoori Teaching Hospital. Seventy-eight patients with perforated tympanic membranes were included in the study. There were 47 males (46.5%) and 54 females (53.5%). Twenty patients had left ear perforation, 35 patients had right ear perforation, and 23 patients had bilateral perforations. Each ear was taken as a case, so total number of 101 perforated ear drums examined. The age ranged from 13- 56 with the mean of (31.64 ± 13.249) years. Each patient was interviewed with a pre tested structured questionnaire and examined clinically to assess the features of the tympanic membrane perforation. Video endoscopy of the perforated TM was done in each patient using a Hopkins rod endoscope attached to a camera and a tuner ((Easycap, model BA0362 ZI-8-A02)) to the laptop. Programmed capture of the TM picture was taken and saved. Then using a special software ((infomap)), the size of the TM perforation, and later the total area of the TM were calculated. Finding the percentage of the perforation from the total area was then simply calculated. Patients with traumatic perforation of the TM were excluded from the study to avoid the possible sensorineural element from the trauma. All patients had tuning fork (Rinne'S and Weber'S) 512 Hz forks in most instances which gives Rinne'S negative in conductive deafness if more than ,14% had positive Rinne'S and 86 %were negative .Weber'S give lateralization to the affected site ,10% central ,51% shift to the right and 39% shift to the left . Similarly Pure Tone Audiometry (PTA) was carried out in each case to confirm that the hearing loss was of conductive type and to determine its extent. PTA was done using audiometer. Patients with sensorineural element of hearing loss were excluded from the study. Controls were 55 patients with a mean age 30.73 ±12.09(range 14-53) years. Male controls were 34 (61.8%), and 21 female controls(38.2%).

Statistical analysis

These were carried out with computer software Statistical Package for Social Sciences (version 17; SPSS). The sites and sizes of the tympanic membrane perforations were separately correlated with the magnitude of hearing losses through Pearson's correlation test. The t-test was applied were appropriate ,to compare between patient and control group.

Results

The results of the data analysis are presented as follows:
1-By using Pearson's correlation test, the findings were:

a-There was a highly significant positive correlation (P ≤ o.ooo1) between size of TM perforation with the hearing level , air bone gap, high frequency hearing loss and low frequency hearing loss .table (1)

Table (1):-

Parameters	R	P-value ≤
Hearing level	0.643	0.0001
Air bone gap	0.452	0.0001
Low frequency hearing l	0.456	0.0001
High frequency hearing l	0.434	0.0001

b-There was a highly significant positive correlation (P ≤ o.ooo1) between hearing level with size of TM perforation , air bone gap, high frequency hearing loss and low frequency hearing loss .table (2)

Table (2):-

Parameters	**r**	**P- value ≤**
Size of TM perforation	0.643	0.0001
Air bone gap	0.666	0.0001
Low frequency hearing l	0.701	0.0001
High frequency hearing l	0.551	0.0001

c-There was a highly significant positive correlation (P ≤ o.ooo1) between air bone gap with the size of TM perforation ,hearing level, high frequency hearing loss and low frequency hearing loss .table (3).

Table (3):-

Parameters	**r**	**P- value ≤**
Size of TM perforation	0.452	0.0001
Hearing level	0.666	0.0001
Low frequency hearing l	0.605	0.0001
High frequency hearing l	0.672	0.0001

d- There was a highly significant positive correlation (P ≤ o.ooo1) between low frequency hearing loss with the size of TM perforation, hearing level, air bone gap and high frequency hearing level .table (4).

Table (4):-

Parameters	**r**	**P- value ≤**
Size of TM perforation	0.456	0.0001
Hearing level	0.701	0.0001
Air bone gap	0.605	0.0001
High frequency hearing l	0.576	0.0001

e-There was a highly significant positive correlation (P ≤ o.ooo1) between high frequency hearing loss with the size of TM perforation , hearing level , air bone gap and low frequency hearing loss .table (5).

Table (5):-

Parameters	**r**	**P-value ≤**
Size of TM perforation	0.343	0.0001
Hearing level	0.551	0.0001
Air bone gap	0.672	0.0001
Low frequency hearing loss	0.576	0.0001

2- To compare between patients and control group, by using t – test it is found that there is statistical significant difference between patients and control group regarding hearing level ,air bone gap ,low frequency and high frequency hearing loss (p≤ 0.0001).table (6).

Table (6):-

PARAMETERS	**Patients**		**Control**		
	No.	X±SD	No	X±SD	P-value≤
Hearing level	101	39.77±13.736	55	19.55±7.628	0.0001
Air bone gap	101	31.61±9.184	55	12.4±2.780	0.0001
Low frequency	101	44.31±10.771	55	20.45±6.256	0.0001
High frequency	101	35.79±13.743	55	14.96±7.219	0.0001

Discussion

Tympanic membrane perforation descriptors can conceivably correlate with hearing level as a result of four basic dysfunctions, directly by impairing the impedance matching mechanism due to reduction in membrane area, secondly due to impaired matching due to reduction of the 'baffle' effect on the fenestra rotunda, and thirdly indirectly as indicants of underlying middle ear pathology, which also affect the functioning of the tympano-ossicular mechanism(8). Perforation-induced changes in transmission result primarily from changes in driving pressure across the TM and that perforation-induced change in the structure of the TM and its coupling to the ossicles contributes a substantially smaller component(10). In our study we find a statistically significant correlation between the size of the TM perforation and the degree of hearing loss manifested by increase in hearing level and increase in air-bone gap. Although tympanic membrane perforations are common, there have been few systematic studies of the structural features determining the magnitude of the resulting conductive hearing loss. Air-bone gaps were largest at the lower frequencies and decreased as frequency increased. Air-bone gaps increased with perforation size at each frequency. The conductive hearing loss resulting from a tympanic membrane perforation is frequency-dependent, with the largest losses occurring at the lowest sound frequencies(11). This agrees with our study that shows a correlation between the size of the TM and the hearing level, air-bone gap, low frequency hearing level and high frequency. In our study, we found that the losses are more in the lower frequencies, which can be attributed to a systematic loss in low-frequency velocity as perforation size increased. These observations were consistent with clinical reports of low-frequency hearing loss in the perforated human TM(12). Conductive hearing loss is frequency dependent; with the greatest loss occurring at the lowest sound frequencies.)(13,14). Another study showed that the hearing loss was found to be more at lower frequencies and less as the frequencies increased. Hearing loss is more marked at lower frequencies as compared to higher frequencies, irrespective any size or location of perforation of pars tensa.

Conclusion

There is strong relationship between the size of TM perforation and the hearing level, air-bone gap and both the low frequency and the high frequency hearing level and air-bone gaps.

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