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The influence of tympanic membrane perforation site on the hearing level of conductive hearing loss in chronic suppurative otitis media

Adhika Banu Wicaksono, Edhie Samodra, Melysa Fitriana, Feri Trihandoko, Anisa Haqul Khoiria, Dyah Ayu Kartika Dewanti*

Department of Otorhinolaryngology Head and Neck Surgery, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada/ Dr. Sardjito General Hospital, Yogyakarta, Indonesia

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ABSTRACT

Chronic suppurative otitis media (CSOM) is an infection of the middle ear cavity both partially and totally. It is characterized by ear discharge through a tympanic membrane perforation for over a period of 2 to 6 weeks. Hearing loss is the most common complication of CSOM. One of the degrees of hearing loss in tympanic membrane perforation is depending on the site of perforation, but this premise is still debatable because of pros and contras by some researchers. This study aimed to assess the degree of hearing loss in relation to the site of tympanic membrane perforation. A cross-sectional prospective study design was performed involving 43 patients of safe type CSOM who came to the Department of Otolaryngology Head and Neck Surgery from the period January 2016 to November 2018. All subjects were divided into 4 groups based on the site of perforation. There was a perforation in the posteroinferior, the posterosuperior, the anteroinferior, and the anterosuperior. A statistical analysis using Anova along with multivariate analysis was conducted. Our result showed that the most common site of tympanic membrane perforation was at the anteroinferior (30 samples, 59.8%). The highest hearing threshold was seen at posteroinferior with a mean hearing level of 37.7±2.0 dB, anteroinferior with a mean hearing level of 31.7±0.7 dB, anterosuperior with a mean hearing level 30.7±1.4 dB, and posterosuperior mean hearing level 28.9±1.5 dB. The difference was found significant with p=0.004. Posteroinferior tympanic membrane perforation had a higher number of hearing loss compared to the other sites. In conclusion, the tympanic membrane perforation site has an important role in the hearing level of conductive hearing loss in CSOM.

ABSTRAK

Otitis media supuratif kronis (OMSK) adalah infeksi pada rongga telinga tengah baik sebagian maupun seluruhnya. OMSK ditandai dengan keluarnya cairan dari telinga melalui perforasi membran timpani selama lebih dari 2 sampai 6 minggu. Gangguan pendengaran adalah komplikasi OMSK yang paling umum. Derajat gangguan pendengaran tergantung pada lokasi perforasi membran timpani, tetapi dugaan ini masih diperdebatkan karena adanya pro dan kontra dari para peneliti. Penelitian ini bertujuan menilai derajat gangguan pendengaran dalam kaitannya dengan lokasi perforasi membran timpani. Rancangan penelitian prospektif potong lintang terhadap 43 pasien OMSK tipe aman yang datang ke poli THT-KL rawat jalan periode Januari 2016 sampai November 2018. Subjek penelitian dibagi menjadi empat kelompok berdasarkan letak perforasi yaitu posteroinferior, posterosuperior, anteroinferior, dan anterosuperior. Analisis statistik dilakukan menggunakan Anava disertai analisis perbedaan multivariat. Hasil penelitian menunjukkan bahwa tempat perforasi membran timpani yang paling umum adalah di anteroinferior (30 sampel, 59,8%). Ambang pendengaran tertinggi terlihat pada posteroinferior dengan tingkat pendengaran rata-rata 37,7±2,0 dB, anteroinferior dengan tingkat pendengaran rata-rata 31,7±0,7 dB, anterosuperior dengan tingkat pendengaran rata-rata 30,7±1,4 dB, dan tingkat pendengaran rata-rata posterosuperior 28,9±1,5 dB. Perbedaan ditemukan signifikan dengan p=0,004. Perforasi membran timpani posteroinferior memiliki jumlah gangguan pendengaran yang lebih tinggi dibandingkan dengan tempat lain. Dapat disimpulkan letak perforasi membran timpani memiliki peran penting terhadap derajat pendengaran tuli konduktif pada OMSK.

Keywords:
chronic suppurative otitis media;
tympanic membrane perforation;
site of perforation;
hearing threshold level;
hearing loss

*corresponding author: dyahayukd@gmail.com

INTRODUCTION

Chronic suppurative otitis media (CSOM) is an infection of the middle ear cavity (eustachian tube, tympanic cavity, and mastoid air cell) characterized by ear discharge through a tympanic membrane perforation for over a period of two to six weeks.[1] It is classified into safe type (benign) and unsafe type (malignant) depending on the likelihood of coexisting cholesteatoma.[2]

In Yemen, Muftah *et al*.[3] reported that the prevalence of CSOM in school children from April 2011 to June 2011 was 51 cases with a total of 686 children. This CSOM is significantly related to hearing loss. Anggaraini *et al*.[4] investigated children whose age is 6 to 15 years old suffering CSOM in Indonesia. There are 116 children of the 7005 children studied who suffered CSOM, 30 children sustained acute otitis media, and 26 children sustained otitis media with effusion. In this study, the prevalence of CSOM was 26.4 per 1000 children in the rustic area, and in an urban area, the prevalence was 7 per 1000 children. Data from medical records at Otolaryngology Head and Neck Surgery Department Dr. Sardjito General Hospital, Yogyakarta, Indonesia between 1998-1999, there were 40 patients with CSOM malignant type, and 62.5% of them underwent a mastoidectomy procedure.[5] Another study in the Chikhwawa District in Southern Malawi, CSOM was diagnosed in 15 of 281 (5.3%) cases in children between 4 to 6 years old.[6]

Hearing loss is the most common complication of CSOM. The effect on hearing is variable. It is often mild even though both ears can be affected.[7,8] The degree of hearing loss depends on the site of perforation, however, the mechanism of sound wave transmission through tympanic membrane perforation has not yet been understood. The hearing level can be defined as a degree of hearing status measured by an audiometer that is described in decibels and is expressed by dB HL. The hearing level can be classified into seven degrees. There is normal hearing as -10 to 15 dB HL, slight hearing loss as 16 to 25 dB HL, mild hearing loss as 26 to 40 dB HL, moderate hearing loss 41 to 55 dB HL, moderately severe hearing loss as 56 to 70 dB HL, severe hearing loss as 71 to 90 dB HL, and Profound hearing loss as >90 dB HL.[9,10]

Studies on the effect of the site perforation on the hearing loss had been undertaken several times. Most authors had generally stated that the hearing loss depended on the site of perforation, but the results were found to be conflicting and inconclusive.[11] It was observed that the site of tympanic membrane perforation was influencing the degree of hearing loss. The worst hearing loss of the tympanic membrane perforation sites was at the posteroinferior quadrant site, but another study found that the degree of hearing loss did not relate to the site of perforation.[12-14]

The study of the effects of tympanic membrane perforation on the sound transmission of middle ears was required for an audiologist to determine the frequency and level of hearing loss.[15] Information obtained from the audiometry test could estimate the difference in hearing threshold values with the site of the tympanic membrane perforation, especially in CSOM patients. This study aimed to assess the degree of hearing loss in relation to the site of tympanic membrane perforation.

MATERIALS AND METHODS

Design and subjects

A cross-sectional study was conducted and the data were gathered by investigation of medical records at the medical record installation of Dr. Sardjito General Hospital, Yogyakarta, Indonesia from January 2016 to November 2018. During the period of study 43 patients (43 ears) were selected according to the inclusion criteria. The inclusion

criteria include 1) Safe type CSOM, 2) Tympanic membrane perforation was not exceeding one quadrant, and 3) audiometric examination revealed conductive hearing loss <45 dB. The exclusion criteria were 1) traumatic tympanic membrane perforation, 2) previous history of ear surgery, and 3) sensorineural hearing loss and mixed hearing loss. All patients who visited the Otolaryngology Head and Neck Surgery Department were assessed by collecting the detailed history and general ENT examination. The previous hearing condition was assumed as a normal hearing level if the patient did not feel deafness beforehand.

Procedure

The tympanic membrane was examined using rigid endoscopy with 4 mm in diameter, 4.5 cm in length, and 0^{o} angle. The patient's hearing level in decibel were determined using pure tone audiometry (Interacoustic AD226) at frequencies of 500 Hz, 1000 Hz, 2000 Hz respectively. All subjects were divided into 4 groups based on the site of perforation. The site of perforation was classified according the quadrant involved, anterosuperior (AS), anteroinferior (AI), posteroinferior (PI), and posterosuperior (PS).

Statistical analysis

Statistical analysis was performed using Anova. The results were considered to be statistically significant if the p value < 0.05. After the Anova test was carried out and the results were significant, the Post Hoc Tukey test was enforced to determine which groups had significant or insignificant differences. Ethical committee approval from the Medical and Health Research Committee (MHREC) Faculty of Medicine, Public Health, and Nursing Universitas Gadjah Mada/Dr. Sardjito General Hospital, Yogyakarta was obtained with reference number: KE/FK/297/EC/2018.

RESULTS

This study involved 43 patients (43 ears) consisting 24 females (55.8%) and 19 males (44.2%). The age group of patients in this study ranged from 10 to 52 years old with a mean age of 33 years old. Unilateral involvement was more common than bilateral. Hearing loss was the most common presenting complaint. TABLE 1 describes the demographic profile of the patients.

TABLE 1. Demographic profile of the subjects.

Variable	Mean (min-max)	n (%)
Age (years)	33 (10-52)	43 (100)
Gender		
• Male		24 (55.8)
• Female		19 (44.2)
Ear perforation		
• Right side		18 (40.5)
• Left Side		24 (57.1)
• Bilateral		1 (2.4)
Presenting complaint		
• Hearing loss and tinnitus		11 (25.6)
• Hearing loss		30 (69.8)
• Tinnitus		2 (4.6)

In our study, there were 30 ears (69.8%) in the AI quadrant, 5 ears (11.6%) in the AS quadrant, 5 ears (11.6%) in the PI quadrant, and 3 ears (10%) in the PS quadrant. The distribution of the site perforation was shown in TABLE 2. It showed that the hearing loss found in the PI quadrant was more severe than in the other quadrants. Mean hearing loss in the PI group is 37.7±2.0 dB followed by the AI quadrant is 31.7±0.7 dB, AS quadrant is 30.7±1.4 dB, and PS quadrant is 28.9±1.5 dB. In the patient with bilateral tympanic membrane perforation, we just measured the right side because the hearing level of the conductive hearing loss on the contralateral side was more than 45 dB.

TABLE3 showed the significant difference between the PI quadrant versus the AI quadrant, PI quadrant, and also AS quadrant (p = 0.004) with the Post Hoc Tukey test. It was found that there was a statistically significant difference in the hearing threshold value in the PI quadrant compared to the AI quadrant (p = 0.007). The PI quadrant compared with the PS quadrant was statistically significant (p = 0.009). The PI quadrant compared with the AS quadrant was statistically significant (p = 0.019) as well. Then it was a significant difference (p = 0.004) in the degree of hearing loss comparison in each quadrant with the Anova.

TABLE 2. The site of tympanic membrane perforation and hearing loss in relation to the site of perforation

Sites of perforation	n (%)	Hearing loss level (dB)
AS	5 (11.6)	30.7 ± 1.4
PS	3 (10.0)	28.9 ± 1.5
AI	30 (69.8)	31.7 ± 0.7
PI	5 (11.6)	37.7 ± 2.0
Total	43 (100)	

TABLE 3. Hearing loss related with the site in Post Hoc Tukey test and hearing loss related with the site in Anova.

Comparison of the site of perforation	p	95% CI	
		Lower bound	Upper bound
PI – AI	0.007[a,c]	0.91	13.1
PI – PS	0.009[a,c]	1.70	15.8
PI – AS	0.019[a,c]	1.30	10.7
PI – AI – PS-AS	0.004[b,c]		

[a]: Post Hoc Tuckey test; [b]: Anova; [c]: significant difference

DISCUSSION

Based on TABLE 2, there were 30 ears (69.8%) in the AI quadrant, 5 ears (11.6%) in the AS quadrant, 5 ears (11.6%) in the PI quadrant, and 3 ears (10%) in the PS quadrant. Similar to the study conducted by Patel-Chudasama,[16] it was reported that the most common site of tympanic membrane perforation (81.4%) was the pars tensa (including AI quadrant and PI quadrant). The average hearing loss level in the PI group is 37.7±2.0 dB followed by the AI quadrant is 31.7±0.7 dB, AS quadrant is 30.7±1.4 dB, and the PS quadrant is 28.9±1.5 dB. It means that the PS perforation group has the worst hearing level. This result is also similar to other studies. Pannu *et al.*[17] reported that hearing loss of posterior perforation was worse than anterior perforation at 250 Hz. In another study conducted by Nepal *et al.*[13] also found that PI was the worst hearing loss level among AI, AS, and PS at a frequency less than 2000 Hz and 2000- 6000 Hz. In contrast with study conducted by Virk *el al.*[18] that found the average air-bone gap of PI, AI, and AS were resemblant, that was 13 dB. The average intensity of the PS group was the lowest hearing loss that was 11 dB. This study is in line with the clinical study conducted by Voss *et al.*[11] who showed no difference between perforation locations in the degree of hearing loss.

TABLE 3 showes a significant difference in hearing loss in every quadrant (p = 0,004). There was a statistically significant difference between the PI quadrant versus AI quadrant, PI quadrant, and AS quadrant ($p < 0.05$) with Post Hoc Tukey test. Patel-Chudasama *et al.*[16] reported that there was significantly difference (p=0.0001) in the mean reduction level between the PI quadrant (44.3 dB) and the anterior quadrant (26 dB). A study conducted by Alsarhan *et al.*[19] reported a statistically significant difference between the PI and AI quadrants (p = 0.039), between the PI and AS quadrants (p = 0.031) and between PI to PS quadrants (p = 0.043). It is suitable with our study that it proved the theory of the disappearance of the round window baffle effect.

The function of the tympanic membrane is not only as a conductor of sound waves from the outer ear to the middle ear but also functions as a protector, scilicet protecting the middle ear from infection and the round window from direct sound waves. This function is needed to create a phase difference so that sound waves do not hit oval and round windows at the same time. This will mitigate the flow of sound energy that is transmitted in a unilateral direction from the oval window through the perilymph. The effect of increasing the surface area ratio of the tympanic membrane to the oval window increases sound pressure by about 27 decibels while the movement of the ossicle lever contributes about 3 dB.[14]

Ali *et al.*[20] reported that a conductive hearing impairment in the tympanic membrane perforation could be resulted from two processes. There is ossicular coping that caused a pressure difference between the tympanic membrane surfaces on the inside and outside which would cause a decrease in phase between oval and round windows, and the surface of the tympanic membrane was subjected to interference with the transmission of sound waves from the external auditory canal-ossicles-cochlea. This premise is supported by Ibekwe *et al.*[14] that reported the tympanic membrane perforation would cause the formation of a surface area of the tympanic membrane to transmit sound pressure and cause the disturbance of the sound wave transmissions to the middle ear.

Mehta *et al.*[21] reported that there were several factors that influenced the hearing threshold value of the tympanic membrane perforation, that was the location of the quadrant of the

perforation, the size of the perforation and the mastoid cavity. The impact of the location of the perforation on the hearing threshold by comparing the location of the quadrant of the perforation with almost the same size of the perforation was found that the perforation in the anterior quadrant had a lower air-bone gap (1.8 dB) than the posterior quadrant, although it was not statistically significant.

A perforation in PI had more severe hearing loss than perforation in the anterior central. It is because the position of the round window is parallel to a PI quadrant of the tympanic membrane. When it happens, the sound waves that enter the middle ear will bother the rarefaction effect of the round window by their pressure, and then the hearing loss effect will be present even worse than in other sites. The location of the tympanic membrane perforation also influenced decreasing the hearing threshold. The greater the tympanic membrane perforation the smaller the effect of ocular coupling, so that the sound pressure on the oval window and round window were almost the same. This caused a decrease in the different phases between the two windows also influenced decreasing the hearing threshold.[22,23] Perforation of the tympanic membrane will cause an increase of acoustic coupling from 0-20 dB causing to loss of protective function. The increased acoustic coupling will cause conductive hearing loss of 40-50 dB.[24]

Ravi *et al.*[24] reported that in addition to the location and size of the tympanic membrane perforation, decreased hearing was also influenced by the air resonance of the mastoid bones. The smaller the volume results, the larger the air-bone gap. The sound pressure produced in the ear cavity is inversely proportional to the volume of the middle ear. In the tympanic perforation membrane with a smaller volume of the middle ear air cavity, it will produce a greater hearing threshold value. A study conducted by Voss *et al.*[11] reported that perforations of the same size in two different ears could have different conductive hearing loss thresholds of 20-30 dB when the volume of the middle ear air cavity was different. In normal ears, the volume of the air cavity of the middle ear can vary from 2 cm^3 to 20 cm^3.

CONCLUSION

The tympanic membrane perforation site has an important role in the hearing level of conductive hearing loss in CSOM.

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