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OTOLOGY

Evaluation of middle ear risk index in patients undergoing tympanoplasty

Mahmood Shishegar[1] · Mohammad Faramarzi[1] · Mohsen Rashidi Ravari[2]

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Abstract

Introduction Tympanoplasty is a standard surgical procedure for the treatment of chronic otitis media. In this study, we aimed to determine the effect of the predictive factors of middle ear risk index (MERI) in patients undergoing tympanoplasty.

Materials and methods A total of 200 patients who underwent tympanoplasty surgery from 2008 to 2018 at Khalili hospital in Shiraz were evaluated. In this study, variables such as age, sex, systemic diseases (diabetes mellitus, hypertension), location and size of tympanic membrane perforation (TMP), health of the opposite ear, dryness duration of the ear, presence or absence of myringosclerosis during surgery, type of operation and the risk of MERI were evaluated.

Results The success rate for a 6-month follow-up of patients was 88%. Results showed that there was a significant difference between the MERI scores and the three types of operation of intact canal wall (ICW), canal wall down (CWD) and non mastoidectomy ($P < 0.001$). The longer the dryness duration of the ear, the MERI score was lower. When MERI score is low, the patient doesn't need mastoidectomy. Also, the worse the opposite ear, the higher the MERI score was. The highest MERI score was in patients undergoing CWD, and the lowest MERI score was in patients undergoing simple tympanoplasty.

Conclusion MERI score is a useful tool for predicting the success rate of tympanoplasty and helps the surgeon planning the type of tympanoplasty.

Keywords Tympanoplasty · Chronic otitis media · MERI

Introduction

Tympanoplasty is a surgical procedure for the removal of infection and restoring the function of the middle ear. For chronic otitis media (COM), tympanoplasty is performed after mastoidectomy [1, 2].

Otitis media is the most common disease in childhood after upper respiratory tract viral infections. Infectious and non-infectious complications of otitis media during childhood may lead to serious morbidity. After childhood, infectious complications such as acute and chronic mastoiditis, petrositis, and intracranial infections occur despite extensive use of antibiotics for this disease. In many cases of otitis media that begin in adulthood, certain causes such as paranasal sinus disease, carcinoma, and nasopharyngeal tumors can be identified. COM is often emerged as mastoid infection with otitis media. COM occurs when the infectious process remain stable for more than 1–3 months [1].

Due to the destructive nature, cholesteatoma is responsible for many of the complications associated with COM. Diagnosis of ear cholesteatoma is based on the otoscopic examination, endoscopic and microscopic evaluation, or surgical examination [1]. Some cholesteatomas are asymptomatic, while the rest are infected and quickly cause ossicular destruction. Cholesteatoma expansion can erode ear ossicles, otic capsule, facial nerve canal, tegmen tympanic, and mastoid tegmen. Then, these complications may cause craniocerebral complications. Congenital or acquired cholesteatoma can only be removed from the temporal bone by surgical removal. The purpose of the surgery is firstly to root out the disease and treat the complications and secondly, to reconstruct the middle ear [1]. Surgical procedures include atticotomy, simple mastoidectomy, operation with intact canal wall (ICW) or canal wall down (CWD), radical

✉ Mahmood Shishegar
shishehgar@sums.ac.ir

[1] Otolaryngology Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

[2] Zahedan University of Medical Sciences, Zahedan, Iran

mastoidectomy, modified radical mastoidectomy, and Bondy procedure [1].

A categorization of the patients based on preoperative conditions such as Kartush's MERI index can help to predict hearing results and risks for complication [3]. The middle ear risk index (MERI, Table 1) is one of the most reliable indices to assess the reconstruction of ear bones [4]. Given the high prevalence of otitis media and the need for tympanoplasty for its treatment, using an index such as MERI can be effective for surgeons in order to determine the type of operation and the correct choice of the patients for the operation type. The MERI score varies from zero to 15 and is categorized as follows: normal (0), mild (1–3), moderate (4–7), and severe (8–15).

Pinar et al. [5] evaluated the prognostic factors such as age, sex, systemic disease, type of surgery, and MERI indices in tympanoplasty on 231 patients. Finally, the success rate was about 74.4% and after analyzing the different factors, they concluded that size of tympanic membrane perforation (TMP) (> 50%), health status of the opposite ear, lack of myringosclerosis, more than 3 months of the dryness of the ear, and low MERI were among the prognostic factors that should be improved in order to affect the result of tympanoplasty.

Table 1 Middle ear risk index 2001

Risk factor	Risk value
Otorrhea (Bellucci)	
Dry	0
Occasionally wet	1
Persistently wet	2
Wet, cleft palate	3
Perforation	
None	0
Present	1
Cholesteatoma	
None	0
Present	1
Ossicular status (Austin/Kartush)	
M + I + S +	0
M + S +	1
M + S –	2
M-S +	3
M – S –	4
Ossicular head fixation	2
Stapes fixation	3
Middle ear: granulation or effusion	
No	0
Yes	2
Previous surgery	
None	0
Staged	1
Revision	2
Smoker	
No	0
Yes	2

M malleus, *I* incus, *S* stapes

Kumar et al. [6] evaluated the use of MERI and eustachian tube function as predictive factors for the evaluation of the result of tympanoplasty. In that study, 50 patients with unilateral and bilateral TMP were evaluated for 2 years. Graft was successful in 80% of patients and failed in 20% of them because 6 patients showed inappropriate eustachian tube function, 2 patients had a MERI score from 7 to 12 and 2 patients had upper respiratory tract infection after surgery. Almazrou et al. [7] conducted a study on 44 children and assessed MERI as a prognostic factor in ossicular chain reconstruction in children. This was a retrospective study that lasted for about 10 years. The results showed that MERI was not a reliable mean for predicting the auditory outcome in ossicular chain reconstruction in children. Fleck et al. [8] used MERI as a predictor factor in restructuring the type of two ear bones. In this study, patients in the first stage of surgery were classified in the medium-risk group, and those who were undergoing multi-stage surgery or re-surgical procedures were categorized in the high-risk group. After 26-month post-operative follow up study, they concluded that MERI is a good tool that helps surgeons in choosing a patient and evaluating the chance of success before surgery. In the present study, we aimed to determine the effect of MERI predictive factors in patients undergoing tympanoplasty.

Methodology

A total of 200 patients who underwent tympanoplasty from 2008 to 2018 at Khalili Hospital in Shiraz, southern Iran, were evaluated. Indications for tympanoplasty were persistent TMP and COM with pathologies, such as mucosal hypertrophy, granulation tissue and polyp. Meanwhile, when the tympanic cavity and mastoid portion were involved with polyp, granulation tissue and cholesteatoma, with regard to extension of pathology, we did canal wall up or canal wall down mastoidectomy. This study was approved by Institutional Review Board.

The age range of the patients were from 7 to 75 years. Patients aged less than 16 years were classified in the pediatric group, and patients aged 17–75 years were classified in the adult group. The patients were evaluated in 3-month and 6-month follow-up visits and underwent clinical examination and audiometry. An intact graft in the right place, well-aerated middle ear, and restored middle ear function at the

end of the third month of follow-up indicated the success of the tympanoplasty.

In this study, variables such as age, sex, systemic diseases (diabetes mellitus, hypertension), location and size of TMP, the health status of the opposite ear, the dryness duration of the ear, presence or absence of myringosclerosis during surgery, a deviated septum and hypertrophy of the inferior turbinate, the type of operation (CWD, ICW, without mastoidectomy), and MERI were evaluated. MERI 2001 was used in the present study [9].

Patients with severe septal deviation, severe otorrhea, severe hypertrophy of the inferior turbinate, and the patients who died were excluded from the study.

In all patients, underlay surgical technique was used for tympanoplasty and temporal fascia was used as graft material in all patients. All patients underwent general anesthesia and then, tympanoplasty. Performing a type of operation including ICW, CWD and without mastoidectomy was dependent on the findings before and during surgery. Postural auricular procedure was used for all patients.

Statistical analysis

After collecting the data, they were sorted by SPSS software version 16 and analyzed by using descriptive-inferential method. In the descriptive analysis, the frequency, percentage of frequency, mean and standard deviation were reported. Chi-square, Fisher's exact and Mann–Whitney non-parametric tests and Kruskal–Wallis test were used for inferential statistics. Finally, the binary logistic regression model was employed.

Results

In this study, 200 patients were classified in the medium- and low-risk group ($n = 100$, MERI: 1–7) and high-risk group ($n = 100$, MERI: 8–15). There was no zero or normal score. The age range of the participants in this study was 7 to 75 years with a mean age ± SD of 37.8 ± 14.3 years. Of the participants, 88 (44%) were men and 112 (56%) were women. Of all, 175 (87.5%) had no systemic disease and 17 patients (8.5%) had hypertension (HTN), 5 (2.5%) had diabetes mellitus (DM) and 3 (1.5%) had both DM and HTN. The demographic and clinical data of the patients and the relationship between these variables and the success rate of tympanoplasty in 3 and 6 months follows-ups are shown in Table 2.

In studying the status of patients in the 3-month follow-up, 183 (91.5%) patients had a good tympanoplasty condition, and graft was also satisfactory. 17 (8%) patients had unsatisfactory graft and the result was not good.

In studying the status of patients in the 6-month follow-up, 176 (88%) patients had a good graft and the operation was satisfactory. 24 (12%) patients had unsatisfactory graft and the result was not good.

Mean ± SD of MERI was 5.69 ± 3.71. The MERI score was mild for 80 (40%) patients, moderate for 20 (10%) patients, and was severe for 100 (50%) patients. No patient had normal state or zero score.

The comparison of the mean MERI scores between two CWD and ICW procedures showed that there was no significant difference between the mean MERI scores between these two types of surgery (Table 3). There was a significant difference between MERI scores of the two types of surgery with and without mastoidectomy (Table 4). Likewise, there was a significant difference between the MERI scores in these three types of surgery (Table 5), so that the lower the MERI score, the patient did not need to perform mastoidectomy and vice versa.

Fisher's and Chi-square tests were used to investigate the relationship between the variables and success of surgery in the 3-month and 6-month follow-ups. The results showed that there was no significant relationship between the variables and success of surgery in the 3-month and 6-month follow-up visits. Nevertheless, there was only a significant relationship between the sex variable and successful tympanoplasty in 6th month, so that female patients showed more satisfactory results of tympanoplasty in the 6-month follow-up compared with the male patients. In the logistic model, only the sex variable was included. The results indicated that, the chance of success of tympanoplasty after 6 months follow-up for women was 3.6 times more than that of men [Odds ratio (OR) = 3.6; 95% confidence interval (CI): 1.41–9.1].

Spearman correlation coefficient was used to investigate the correlation between the factors affecting the success of tympanoplasty and MERI score. Finally, the health status of opposite ear, duration of dryness, and operation type had a significant correlation with MERI score, so that the worse the condition of the opposite ear, the higher MERI score was, and the longer the duration of dryness, the lower MERI score was and vice versa. There was a direct correlation between MERI and type of surgery, so that the highest MERI score was for those who underwent CWD surgery and the lowest MERI score was for those who performed simple tympanoplasty without mastoidectomy.

Discussion

Age is one of the prognostic factors for the success of tympanoplasty. The rate of success in pediatric patients undergoing tympanoplasty was less than that of adults due to the dysfunction of the eustachian tube [10, 11]. In the present

Table 2 The relationship between the effective variables on the success rate of tympanoplasty in 3 and 6 months follow-up visits

Variables	Patients ($n=200$)	Successful (n%)		P value	
		3 months	6 months	3 months	6 months
Age[a]					
< 16 year	7	7 (100%)	6 (85.7%)	1	0.597
≥16 year	193	176 (91.2%)	170 (88.1%)		
Sex[a]					
Male	88	78 (88.6%)	71 (80.7%)	0.213	0.005
Female	112	105 (93.8%)	105 (93.8%)		
Location of perforation[a]					
Retraction	11	11 (100%)	10 (90.9%)	0.215	0.496
Anterior perforation	24	19 (79.2%)	19 (79.2%)		
Posterior perforation	40	36 (90%)	34 (85%)		
Central perforation	43	40 (93%)	38 (88.4%)		
Subtotal perforation	82	77 (93.9%)	75 (91.5%)		
Size of perforation[b]					
< 50%	92	84 (91.3%)	84 (91.3%)	0.927	0.184
> 50%	108	99 (91.7%)	92 (85.2%)		
Status of the opposite ear[b]					
Healthy	121	113 (93.4%)	110 (90.9%)	0.236	0.117
Abnormal	79	70 (88.6%)	66 (88.2%)		
Duration of dryness[b]					
< 3 months	47	42 (89.4%)	41 (87.2%)	0.548	0.853
> 3 months	153	141 (92.2%)	135 (88.2%)		
Myringosclerosis[b]					
Yes	27	25 (92.6%)	24 (88.9%)	0.827	1
No	173	158 (91.3%)	152 (87.9%)		
Septal deviation[b]					
Yes	23	20 (87%)	19 (82.6%)	0.406	0.491
No	177	163 (92.1%)	157 (88.7%)		
Inf. turbinate hypertrophy[b]					
Yes	46	42 (91.3%)	40 (87%)	0.957	0.804
No	154	141 (91.6%)	136 (88.3%)		
Operation type[b]					
ICW	86	77 (89.5%)	73 (84.9%)	0.39	0.479
CWD	36	32 (88.9%)	33 (91.7%)		
No-mastoidectomy	78	74 (94.9%)	70 (89.7%)		
Risk of MERI[b]					
Low + moderate	100	93 (93%)	90 (90%)	0.447	0.384
High	100	90 (90%)	86 (86%)		

[a]Fisher's test

[b]Chi-square test

Table 3 Comparison of the mean MERI scores between the two CWD and ICW procedures

Surgery type	N	MERI scores (mean ± SD)	P value
ICW	86	7.37 ± 3.25	0.09
CWD	36	8.28 ± 2.46	

ICW intact canal wall, *CWD* canal wall down

Table 4 Comparison of the mean MERI scores between the two types of surgery with and without mastoidectomy

Surgery type	N	MERI scores (mean ± SD)	P value
Mastoidectomy	122	7.64 ± 3.06	0.0001
No mastoidectomy	78	2.63 ± 2.32	

Mann–Whitney test

Table 5 Comparison of the mean MERI scores between the three types of surgery

Surgery type	*N*	MERI scores (mean ± SD)	*P* value
ICW	86	7.37 ± 3.25	0.0005
CWD	36	8.28 ± 2.46	
No mastoidectomy	78	2.63 ± 2.32	

ICW intact canal wall, *CWD* canal wall down

study, there was no significant relationship between age and the success rate of tympanoplasty. However, given the high number of adult population aged over 16 years compared with those under 16 years (who were only seven patients), no judgement can be provided.

Pinar et al. [5] in 2008 found no relationship between age and tympanoplasty. Kumar et al. [6] and Almazrou [7] did not investigate the relationship between age and tympanoplasty.

Anterior perforation is more difficult to be used for tympanoplasty graft placement than other techniques. In the present study, the success rate of graft placement in the anterior perforation was 79.2% that was less than other perforations, however, there was no significant relationship for the anterior perforation. Pinar et al. [5] concluded that the success rate of tympanoplasty in the central TMP was higher than anterior and posterior perforations. Meranda et al. [12] and Singh et al. [13], showed that perforation site had no effect on surgery and auditory outcome.

Analysis of perforation size showed no statistically significant relationship. Meranda et al. [12] and Denogelle et al. [14] reported that there was no relationship between perforation size and operation success. Pinar et al. [5] showed that there was a significant relationship between the size of the perforation and the success of tympanoplasty. When the size of perforation was less than 50%, tympanoplasty was more successful. Kumar et al. [6] indicated that there was a significant relationship between the size and success of tympanoplasty.

Many otolaryngologists believe that the longer the duration of the ear dryness, the greater the probability of graft success. So, most people prefer to have a dry ear for 3 months and then undergo a tympanoplasty. In the present study, those who had dry ear for more than 3 months had higher success rate with higher frequency in grafting than those who had dry ear less than 3 months, but no significant relationship was found. There was no such a relationship in the studies done by Albera et al. [15] and Onal et al. [16], which is similar to the present study. Pinar et al. [5] showed that there was a significant relationship between ear dryness and the success rate of tympanoplasty, and suggested that tympanoplasty should be conducted after 3 months of ear dryness.

Sustainable condition of the opposite ear is important as a prognostic factor, so that people with healthy ears and proper functioning of the eustachian tube of the opposite ear have a higher success rate of grafting. In the present study, those who had healthy opposite ear had higher successful grafting than those with an unhealthy opposite ear, but this was not significant, which was also found in the study by Singh et al. [13].

Pinar et al. [5] found that when the opposite ear do not have a perforation or atelectasis problem, the probability of successful tympanoplasty is greater. Collins et al. [17] showed the concurrent disease of the opposite ear led to less successful operation.

Myringosclerosis is one of the risk factors that increase the likelihood of tympanoplasty failure. In the present study, there was no significant relationship between the success of tympanoplasty and myringosclerosis. No such a relationship was reported in the studies done by Onal et al. [16] and Pinar et al. [5].

There was a significant difference between the mean scores of ICW, CWD and without mastoidectomy in the analysis and comparison of the mean scores. The mean MERI score in the CWD group was the highest, indicating that individuals who have higher MERI scores, have higher risk factors and require CWD surgery. In the group that had undergone a simple tympanoplasty without mastoidectomy, MERI score was low, suggesting that individuals with lower risk factors undergo simple tympanoplasty with a high success rate. Pinar et al. [5] acknowledged that ICW had a higher success rate in tympanoplasty compare with CWD, but there was no such a significant relationship in other studies.

In examining the relationship between other variables and the success rate of tympanoplasty in the 3-month and 6-month follow-up visits, there was only a significant relationship between sex and the success at 6 months. This means that likelihood of success for women in the logistic model (OR = 3.6) was more than likelihood of success for men. In other studies, there was no analysis in terms of sex and success rate of tympanoplasty.

Analysis of the correlation between age, TMP, perforation size, opposite ear status, dryness period, myringosclerosis, septum deviation, hypertrophy of inferior turbinate, and type of surgery with MERI score showed that the correlation between apposite ear health status, dryness duration, and type of operation with MERI score was significant, which indicates that these three variables are effective in the success of tympanoplasty, and each of them has an effect on the success rate of transplantation. Pinar et al. [5] showed that there was a correlation between the health status of the opposite ear and the type of operation with MERI.

This study showed that patients with a MERI lower than 3 or mild group had higher success rates. The mean MERI score was significantly higher in patients underwent CWD than ICW. The reason for this is that in moderate and severe MERI, cholesteatoma, ossicular chain instability and middle ear pathology are likely to occur. The results of this study were consistent with those of Pinar who showed that the mean MERI score in patients underwent CWD was higher than those underwent ICW.

Conclusion

This study showed that patients with high MERI are more likely to require CWD, but those with low and moderate MERI are less likely to undergo CWD surgery. Accurate MERI, especially high, helps surgeons to some extent to explain to patients about the possibility of failure of tympanoplasty prior to surgery. Also, it helps surgeons to plan the surgery more precisely before operations.

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Compliance with ethical standards

Conflict of Interest The authors declare no conflicts of interest.

Ethics approval The research protocol was approved by Shiraz University of Medical Sciences Ethics Committee (ethics committee reference number: IR.SUMS.MED.REC.1394.s75).

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