Original Article

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Hearing Evaluation Post Canal Wall-Up (CWU) Tympanoplasty on Patients with Safe Type Chronic Suppurative Otitis Media

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Abstract:

Objective: Otitis media is a contagious inflammatory illness of the middle ear that might have a sudden onset and a complete resolution, or it can have a persistent presentation and long-term implications. Surgical treatment is available for all kinds of otitis media. Different types of operations include canal wall-up, canal wall-down, and their variations. The wall-up approach of the two canals with or without posterior tympanotomies, also known as tympanoplasty surgery, preserves the rear wall of the ear canal.

Material and Methods: Hearing evaluation was conducted after canal wall-up tympanoplasty surgery at the outpatient clinic, Department of Otorhinolaryngology, Dr. Soetomo Hospital, Surabaya, Indonesia over a period of two years (2018-2019).

Results: Two hundred and thirty-seven patients underwent from January 1, 2018 to December 31, 2019. However, only 74 (31.2%) of them had complete medical records after surgery. Fifty-nine ears (79.7%) experienced a better hearing threshold, six ears (8.1%) did not improve, and nine ears (12.2%) deteriorated. The hearing threshold improvement was of a magnitude of 10.9 dB; before surgery, it was 56.6 dB, and after surgery, it became 45.6 dB.

Conclusion: A 10.9-dB improvement in hearing threshold mean was observed among patients undergoing canal wall-up tympanoplasty, whereas the bone gap improvement between pre- and post-tympanoplasty was 6.9 dB.

Keywords: audiometry, CWU disease, otitis media, tympanoplasty

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Introduction

Otitis media is a wide spectrum disease involving the inflammation of the middle ear, which may or may not be infectious in nature.[1,2] This disease can have both an acute manifestation with a total resolution and a chronic manifestation with a permanent sequel.[3] In some cases, where patients do not experience a total resolution, the course of the disease can progress into otitis media with effusion or chronic suppurative otitis media (CSOM). CSOM can be divided into two types–CSOM without cholesteatoma (mucosal type/benign type/safe type) and CSOM with cholesteatoma (bone type/dangerous type).[4] It can cause total or partial damage to the tympanic membrane and ossicular chain, thus leading to varied conductive hearing loss.[5] The therapy of otitis media is divided into medical and surgical treatment. Safe-type CSOM is primarily managed via medical therapy followed by routine follow-up. Nevertheless, surgery is a treatment option for all types of otitis media. The kinds of surgeries employed in such cases are canal wall-up (CWU), canal wall-down (CWD), including all its variations, and modified radical mastoidectomy, also called the Bondy procedure.[6]

Canal wall-up tympanoplasty is a procedure, which preserves the posterior wall of the ear canal with or without posterior tympanostomy. CWU tympanoplasty is indicated in CSOM patients with a fine middle ear condition and mastoid pneumatization. Relative contraindications of CWU tympanoplasty are mastoid sclerosis, labyrinth fistula of one functional ear, and poor function of the Eustachian tube.[7] While tympanoplasty can be considered as an intervention for safe type CSOM after medical treatment; surgery is the only choice of treatment for dangerous type CSOM.[8,9] In such cases, surgery aims to repair hearing by restoring air pressure at the oval window via an intact tympanic membrane.[9] Hearing improvement is more commonly found in CWU tympanoplasty than in CWD mastoidectomy.[10]

Our study aimed to evaluate the hearing of patients who had undergone CWU tympanoplasty surgery at the outpatient clinic of the Department of Otorhinolaryngology, Dr. Soetomo Hospital, Surabaya, Indonesia over a period of two years (2018–2019) based on age, sex, and type of hearing improvement.

Material and Methods

The study is descriptive, retrospective research. Approval was obtained from the Ethics Committee of Dr. Soetomo Hospital (0431/117/4/XII/2020). Data from all patients with safe type CSOM, who underwent CWU tympanoplasty between January 2018 and December 2019, were collected from the medical records of the outpatient clinic, Department of Otorhinolaryngology–Head and Neck Surgery, Dr. Soetomo Hospital. The type of surgery involved was CWU, which includes simple mastoidectomy; thus, the term tympanomastoidectomy was used. The type of tympanoplasty performed in this patient cohort was type 1 tympanoplasty since the collected data corresponded only to safe type CSOM; hence, an intact ossicle and no cholesteatoma were found during surgery. The patients' demographic characteristics, type of hearing impairment, and pre- and post-surgery audiometry measurements were recorded. We included patients with safe-type CSOM who had undergone audiometry tests before and after CWU tympanoplasty surgery. Meanwhile, patients with a history of previous ear surgery, a diagnosis of CSOM dangerous type or cholesteatoma found during surgery, tympanosclerosis, and a discontinued ossicular chain were excluded from the study. For patients under 17 years of age, consent for the surgery was given by their parents or legal guardians.

Hearing impairment was measured based on the pure-tone audiometry results. In accordance with the World Health Organization (WHO) criteria, the normal hearing threshold was ≤25 dB. The types of hearing impairment

were characterized as normal hearing, sensorineural hearing loss (SNHL), conductive hearing loss (CHL), and mixed hearing loss (MHL). The hearing impairment could impact unilaterally or bilaterally. The degree of hearing impairment was divided into mild (26–40 dB), moderate (41–55 dB), moderate–severe (56–70 dB), severe (71–90 dB), and profound (>90 dB). The data were collected and processed using Microsoft Excel.

Results

Two hundred and thirty-seven patients were diagnosed with safe type CSOM at the outpatient clinic of the Department of Otorhinolaryngology, Dr. Soetomo Hospital between January 2018 and December 2019. Seventy-four patients met the inclusion criteria and were enrolled into the research. The data belonging to these patients were all complete and contained hearing evaluations both pre- and post-surgery. Meanwhile, the rest of the data, belonging to the other 163 patients, were excluded due to being incomplete.

Demographics

Of the total 74 participants (Table 1), 46 (62.2%) were male patients and 28 (37.8%) were female. The ratio between the two sexes was 1.64:1. In this research, the youngest participant was 11 years old, while the oldest was 68. The mean age of the study population was 48.4±14.6 years. Concerning age distribution, the patients belonged to several age groups; the 21–30-year-olds accounted for the majority of safe-type CWU tympanoplasty patients.

Types and degrees of hearing impairment

The most commonly found type of hearing impairment associated with safe type CSOM before surgery was conductive hearing loss [41 ears (55.4%)], while the second most common was mixed hearing loss [31 ears (41.9%)] (Table 2). There were two patients with normal hearing, whereas SNHL was not found. Moderate–severe was the most common degree of hearing loss found in this study, accounting for 24 samples (32.4%). Table 3 describes the type and degree of hearing loss in our study population. Conductive hearing loss was the most common hearing impairment found by post-operative audiometry; it accounted for 31 ears (41.9%). Meanwhile, mixed hearing loss was the second most hearing impairment, accounting for 30 ears (40.5%), and 13 ears (17.6%) had normal hearing. Moderate hearing loss was the most common postoperative level of hearing impairment in this study, accounting for 21 ears (28.4%). Table 4 displays the patient characteristics based on the type and degree of hearing loss.

Table 1 Demographic data of the patients

	Number	%
Sex		
Male	46	62.2
Female	28	37.8
Age (years)		
0–10	0	0.0
11–20	22	29.7
21–30	26	35.1
31–40	16	21.6
41–50	6	8.1
51–60	3	4.0
61–70	1	1.4
Total	**74**	**100**

Hearing threshold by air conduction and air–bone gap

Audiometry studies were performed on our safe-type CSOM patients before surgery. Pure-tone average testing was formed using air conduction (AC) values at frequencies of 500 Hz, 1,000 Hz, 2,000 Hz and 4,000 Hz. Meanwhile, the post-surgical audiometry test was performed two months after surgery in order to allow for ample time for the inflammatory and wound-healing processes to subside.

The pure-tone averages prior to the surgery are displayed in Table 3. A meaningful air conduction threshold improvement post-surgery compared to pre-surgery, to the magnitude of 10.9 dB, was observed-from 56.6 dB pre-surgery to 45.6 dB post-surgery. The most considerable improvement, 12.3 dB, was associated with the 1,000 Hz frequency. As shown in Table 3, an improvement in the air-bone gap (ABG) mean after surgery compared to before surgery was also detected. The improvement was 6.9 dB-38.0 dB pre- and 31.0 dB post-surgery. The 4,000 Hz frequency showed the most significant improvement (7.0 dB). Moreover, the hearing thresholds of 59 ears improved after tympanoplasty for safe type CWU in this study (Table 4). The thresholds of 39 (52.7%) ears were enhanced by more than 10 dB, while those of 10 (27.0) ears improved by less than 10 dB. Finally, 6 (8.1%) ears did not show any improvement after surgery, and 9 (12.2%) ears deteriorated.

Table 2 Type and degree of hearing loss pre- and post-surgery

Degree of hearing loss	Type of hearing loss pre-surgery					Type of hearing loss post-surgery				
	CHL	MHL	SNHL	NH	N (%)	CHL	MHL	SNHL	NH	N (%)
Normal	0	0	0	2	2 (2.7)	0	0	0	13	13 (17.6)
Mild	15	2	0	0	17 (23.0)	15	2	0	0	17 (23.0)
Moderate	10	6	0	0	16 (21.6)	8	13	0	0	21 (28.4)
Moderate-severe	13	11	0	0	24 (32.4)	7	7	0	0	14 (19.0)
Severe	2	9	0	0	11 (14.9)	1	4	0	0	5 (6.8)
Profound	1	3	0	0	4 (5.4)	0	4	0	0	4 (5.4)
Total	**41 (55.4%)**	**31 (41.9%)**	**0**	**2 (2.70%)**	**74 (100)**	**31 (41.9%)**	**30 (40.5%)**	**0**	**13 (17.6%)**	**(100)**

CHL=conductive hearing loss, MHL=mixed hearing loss, SNHL=sensorineural hearing loss, NH=nomal hearing

Table 3 Hearing threshold improvement by air conduction and air-bone gap

Frequency (Hz)	N	Air conduction			Air-bone gap		
		Pre-surgery Mean±S.D. Intensity (dB)	Post-surgery Mean±S.D. Intensity (dB)	Hearing threshold improvement (Db)	Pre-surgery Mean±S.D. Intensity (dB)	Post-surgery Mean±S.D. Intensity (dB)	Hearing threshold improvement (Db)
500		60.4±20.8	49.4±23.3	11.0	45.6±21.2	38.8±21.9	6.8
1,000		58.0±23.3	45.7±23.9	12.3	43.6±18.9	36.6±21.0	7.0
2,000	74	51.0±21.5	40.8±21.1	10.2	28.4±14.4	21.6±14.6	7.0
4,000		56.8±24.7	46.6±24.9	10.2	34.2±18.1	27.1±16.8	7.1
Mean air conduction		56.6±22.6	45.6±23.3	11.0	38.0±18.2	31.0±18.6	7.0

S.D.=standard deviation

Tabel 4 Hearing threshold differences after canal wall-up (CWU) tympanoplasty

Hearing threshold differences	Magnitude (dB)	Number (%)	Total
Improvement	<10	20 (27.0)	59 (79.7)
	≥10	39 (52.7)	
Stability	0	6 (8.1)	6 (8.1)
Degradation	<10	5 (6.8)	9 (12.2)
	≥10	4 (5.4)	
	Total		**74 (100)**

Discussion

The study results revealed that of the 74 patients included in the analysis, 46 were male (62.2%) and 28 were female (37.8%). This concurred with the findings reported in a study by Muftah et al. where CSOM prevalence was higher among male patients.[11] Another survey by Querat et al. also revealed a predominance of male patients with a female-to-male ratio of 1:1.25.[12] The study of Benson et al. supported the findings of both of these prior studies; in it, the proportion of CSOM male patients (65%) was almost twice as high as that of female ones (35%).[13] However, none of the studies mentioned above have offered any reasonable explanation regarding the link between CSOM and the sex of the patient.

The 21–30-year-olds (35.1%) were the most common group of patients found to have safe type CSOM, whereas the 0–10 years age group was the least common. Similarly, Benson et al. found that adults ranging from 15 to 29 years of age comprised the largest age group of CSOM patients.[14] Moreover, our study found 11–20 years age group to be the second most common (29.7%). In agreement with this study, the survey conducted by Shresta et al. also identified the 11–20-years-olds as the second most common age group.[15] Adult patients are more often found to have this disorder compared to pediatric patients because the latter tend to endure the symptoms associated with this condition and start seeking medical treatment when they grow up. Another reason is ignorance of the subtle signs of CSOM, which means that only when the disease grows do severe, accompanied by pain, headache, and hearing loss, patients seek medical help.[16] Adulthood is also considered the productive age, making it a more likely time for people to get medical treatment.[17]

This study's most common types of hearing loss were conductive hearing loss (41 ears (55.4%)] and mixed hearing loss [31 ears (41.9%)]. In addition, the most common degree of hearing loss was moderate-severe (24 ears (32.4%)], while the normal hearing was the least common finding (2 ears (2.7%)]. Our findings go in the same direction as those reported published literatures, i.e., the most common types are conductive hearing loss and mixed hearing loss.[18] In relation to the pre-surgery degree of hearing loss, our finding of moderate-severe hearing loss differed from that of another study, which reported that the most common degrees of hearing loss were mild and moderate. The survey by Devianti et al. also stated that the most common pre-surgery degree of hearing loss was average. Moderate to-severe hearing loss is found chiefly in dangerous type CSOM.[19]

The degree of hearing loss is determined by the tympanic membrane perforation size, ossicular damage, and the existence of granulation tissue or cholesteatoma.[5] The more extensive the perforation, the smaller the surface area that can act as a sound energy conductor.[20,21] The remnants of the tympanic membrane will only conduct helpful energy. They are mainly located in the posterior quadrant of the tympanic membrane, where the ossicular chain rests. The smaller the remnants, the smaller the degree of ossicular and acoustic coupling. Besides the perforation size, the middle ear condition and the mastoid cavity volume impact the degree of hearing loss. The other contributing factor to the degree of hearing loss is the location of the perforation. A perforation at the posterior side of the tympanic membrane

worsens the degree of hearing loss compared to an anterior perforation since it exposes a round window. This means that nothing can protect the round window from the effect of the sound.[11]

Furthermore, the degree of hearing loss aligns with the duration of CSOM. Two factors contributing to this are the necrosis of the ossicular chain and mastoid air cell sclerosis that led to a shrinkage of the mastoid air cell volume. Due to this fact, it can be assumed that a patient with CSOM would benefit from early surgery not only in terms of achieving an improvement in hearing impairment but also in preventing hearing loss deterioration.[22,23] Effusion in the middle ear prevents sound energy waves from being distributed from the tympanic membrane into the oval window; thus, conductive hearing loss happens. Furthermore, inflammation mediators released during CSOM can penetrate the inner ear through a round window. The consequence is the loss of cochlear hair cells, which leads to SNHL or mixed hearing loss.[24]

Air conduction improvement pre- and post-tympanoplasty at all frequencies can be translated to better hearing after surgery. We observed an increase of 10.9 dB in the mean air conduction from pre- to post-surgery. In a similar fashion, a study conducted by Hayati et al. mentioned that 16 of their 21 patients, who underwent tympanoplasty, experienced a 5 dB improvement in hearing threshold. A significant improvement in the hearing threshold at both air and bone conduction frequencies was found in our investigation. Moreover, the study by Batni et al. claimed an increase of 14.6 dB in air conduction hearing threshold.[3,8]

The air-bone gap between pre- and post-tympanomastoidectomy improved by 6.9 dB. Shresta et al. also reported an 8.0-dB improvement in ABG after surgery.[17] Similarly, Chapparbandi et al. reported that the ABG of female patients improved by 8.3 dB, whereas that of male patients ameliorated by 9.6 dB.[5] The air-bone gap comparison between pre- and post-surgery can be an indicator of improved hearing. Such a comparison could serve as a baseline for any hearing threshold improvement or deterioration after therapy. One contributing factor to improvements in ABG is perforation size, where the smaller the size, the higher likelihood of ABG improvement happening.[14,17]

Fifty-six ears had a hearing threshold improvement after surgery. An earlier study has pointed out that one of the benefits of surgery is improved hearing.[13] Our study found that an improvement of more than 10 dB was the most prevalent [39 ears (52.7%)]. The criteria for a successful CWU tympanoplasty are an intact graft 12 months post-surgery with excellent integrity; post-surgery examination showing a good healing process with no effusion, atelectasis or otorrhea; and stable or improved hearing with a minimum hearing threshold escalation of 10.0 dB.[18,19] In our study, 52.7% of patients experienced a more-than-10.0-dB improvement in hearing threshold. The mean of air conduction threshold improvement over the two years investigated in our study was 10.9 dB. The other two criteria for CWU tympanoplasty success were not explored in this study. The study by Kolo et al. states that, in the majority, surgery resulted in significantly improved hearing.[11] They reported that nine ears deteriorated in their study; during the two months of their evaluation, these patients were found to have either recurrent ear discharge or loss of tympanoplasty integrity.

The factors contributing to ear surgery success are disease severity, ossicular chain condition, tympanic membrane perforation, middle ear condition, the existence of cholesteatoma, surgeon skill, and both post-surgery pathologic and physiologic processes.[18,25] The condition of the middle ear mucosa after surgery plays an essential role in its aeration. Mucosal edema or granulation tissue can alter the regular aeration of the tympanic cavity.[15] Other potential pathologic processes associated with middle ear mucosa are fibrosis, adhesion, and tympanosclerosis. All

three are reactions that arise from the post-surgery healing process, which can alter middle ear aeration.[6]

Conclusion

Two hundred and thirty-seven CSOM patients underwent CWU tympanoplasty from January 1, 2018 to December 31, 2019. Only 74 patients (31.2%) had complete medical records after surgery; the rest, 163 patients (68.8%), were lost to follow-up, leading to incomplete medical records. The possible reasons behind becoming lost to follow-up were ameliorated health condition, distance between domicile and clinic, and inability to leave work. Fifty-nine ears (79.7%) experienced a better hearing threshold mean, six ears (8.1%) did not experience any improvement, and nine ears (12.2%) deteriorated. The hearing threshold improvement observed was 10.9 dB–56.6 dB before surgery vs. 45.6 dB after surgery. The air-bone gap improvement between pre- and post-tympanoplasty was 6.9 dB–from 38.0 dB before surgery, it improved to 31.0 dB after tympanoplasty.

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Conflict of interest

The authors declare no conflict of interest related to this research.

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