CORRELATION BETWEEN AIR BONE GAP AND OSSICULAR CHAIN STATUS IN PATIENTS WITH MUCOSAL TYPE CHRONIC SUPPURATIVE OTITIS MEDIA UNDERGOING CANAL WALL UP TYMPANOPLASTY SURGERY

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KEYWORDS
Air-bone gap, ossicular chain status, mucosal-type CSOM

ABSTRACT
Background: Destruction of the ossicular chain is a common complication of chronic suppurative otitis media (CSOM) and is a major cause of conductive hearing loss. Preoperative pure-tone audiometry results and air-bone gap in CSOM patients serve as useful methods for predicting ossicular chain status and have implications for patient planning, prognosis, and overall management. **Objective:** This study aims to analyze the correlation between air-bone gap and ossicular chain status in patients with mucosal-type CSOM undergoing CWU tympanoplasty. **Method:** An observational analytical study with a retrospective cross-sectional design was conducted using secondary data from patient medical records. Sampling was performed using a total sampling technique. Ordinal data were statistically analyzed using the Spearman rank correlation test. **Results:** A total of 65 patients were included. The average air-bone gap at frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz was 57.31 dB, 49.92 dB, 33 dB, and 36 dB, respectively. Ossicular chain status type O (58.46%) was the most frequently found, followed by type C (18.47%), type B (9.23%), type A (7.70%), and types D and E (3.07% each). Statistical analysis using the Spearman rank correlation test at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz yielded p-values of 0.311, 0.163, 0.037, and 0.079, respectively. **Conclusion:** There is a correlation between air-bone gap and ossicular chain status in mucosal-type CSOM patients at a frequency of 2000 Hz, but no correlation was found at frequencies of 500 Hz, 1000 Hz, and 4000 Hz.
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INTRODUCTION

Chronic suppurative otitis media (CSOM) is a global health problem that has a high prevalence, especially in developing countries. According to the World Health Organization (WHO), approximately 330 million cases of otitis media occur each year, with 60% of these cases leading to permanent hearing loss (WHO, 2020). CSOM is one of the main causes of conductive hearing loss that can reduce the quality of life of sufferers, including communication skills and daily productivity. Indonesia, as a high-prevalence country, reports that 18.5% of its population experiences hearing problems associated with CSOM (MOH RI, 2018). This problem not only impacts individual health, but also carries considerable social and economic consequences.

One of the serious complications of CSOM is the destruction of the ossicle chain which causes conduction type hearing loss. This destruction occurs due to a chronic inflammatory process that induces bone resorption of the ossicle through excessive osteoclastic mechanisms (Haidar et al., 2015). In addition, the presence of granulation, scarring, and cholesteatoma are also factors that exacerbate the destruction of the ossicular chain (Gurumani, 2013). This destruction leads to disruption of sound transmission from the tympanic membrane to the cochlea, which directly increases the air bone gap (ABG) on pure tone audiometry examination (Bayat et al., 2019). Previous studies have shown that the larger the ABG, the greater the likelihood of discontinuity or destruction of the ossicular chain (Feng et al., 2005).

Factors that influence the onset of CSOM include recurrent upper respiratory tract infections, allergies, unhygienic environment, and low socioeconomic status (Mittal et al., 2015). In addition, genetic factors and ear anatomy also play a role in increasing the risk of CSOM. The impact of these factors leads to chronic infections in the middle ear that can trigger perforation of the tympanic membrane, accumulation of purulent secretions, and ultimately lead to the destruction of the ossicular chain (Dhingra & Dhingra, 2014). The accumulation of infection and inflammation that is not properly managed will enlarge the ABG and affect the patient's hearing quality.

Air bone gap (ABG) is an important indicator in evaluating hearing function and predicting the status of the ossicular chain. ABG is defined as the difference between air conduction and bone conduction measured through pure tone audiometry (Sheikh et al., 2016). A high ABG value indicates a disturbance in sound transmission through the middle ear, indicating damage or discontinuity of the ossicular chain. In cases of CSOM, ABG is often used as a parameter to determine the type and severity of hearing loss and as a predictor in the planning of tympanoplasty surgical procedures (Bayat et al., 2019).

There are several studies that have examined the relationship between ABG and ossicular chain status. The study by Feng et al. (2005) found that patients with ABG greater than 30 dB had a higher risk of ossicular destruction. Another study by Dudda et al. (2018) reported that there was a positive correlation between increased ABG and the degree of ossicular chain destruction in CSOM patients. However, there are not many studies that specifically examine the relationship between ABG and ossicular chain status in mucosal type CSOM patients undergoing canal wall up (CWU) tympanoplasty surgery. Therefore, this study has novelty value in analyzing the correlation using data from patients who have undergone CWU tympanoplasty surgery at Dr. Soetomo General Hospital Surabaya.

The urgency of this study lies in the importance of predicting the status of the ossicle chain preoperatively to determine the appropriate surgical strategy and improve the prognosis of CSOM patients. By predicting the status of the ossicular chain through ABG analysis, clinicians can determine whether it is necessary to perform complete or partial ossicular reconstruction during the tympanoplasty procedure. This will affect the surgical success rate and hearing quality of the patient postoperatively (Dudda et al., 2018).

This study aims to analyze the correlation between air-bone gap and ossicular chain status in mucosal type CSOM patients undergoing canal wall-up tympanoplasty surgery. It is expected to contribute to the development of a more accurate diagnostic method for predicting pre-operative ossicular chain status.

Practically, this study's results are expected to guide ORL-HNS specialists in planning more effective surgical procedures and improving the quality of health services for CSOM patients. In addition, this study is also expected to enrich the scientific treasures in otology, especially regarding the relationship between ABG and the status of the ossicular chain in mucosal-type CSOM patients.

METHODS

Research Type and Design

This type of research is analytic observational with a retrospective cross-sectional research design using secondary data.

Place and Time of Research

Place

The study was conducted in the Otology division of the Department of ORL-HNS Dr. Soetomo General Hospital Surabaya.

Time

The study was conducted from September 2024 to October 2024 and has obtained Ethical Clearance from the Health Research Ethics Committee of Dr. Soetomo General Hospital Surabaya with number 1738/LOE/301.4.2/VIII/2024.

Research Materials

Population

The study population was mucosal type CSOM patients who had undergone canal wall up tympanoplasty surgery in the Otology division of ORL-HNS Dr. Soetomo General Hospital Surabaya from January 01, 2021 to December 31, 2023.

Sample

The study sample was all the affordable population who met the inclusion and exclusion criteria and total sampling was carried out.

Inclusion criteria were mucosal type CSOM patients who underwent canal wall up tympanoplasty surgery with complete medical record data (identity, history, physical examination), there were preoperative pure tone audiometry results, and there was an operation report assessing the status of the ossicle chain. Exclusion criteria were squamous type CSOM patients, cholesteatoma, tympanosclerosis, middle ear polyps, history of use of ototoxic drugs (aminoglycosides, cisplatin, furosemide), patients with a history of canal wall down surgery (CWD), and a history of previous revision tympanomastoidectomy.

Sample size

The sample size formula is determined based on the Sudigdo & Ismail formula (2011) by setting a 95% confidence level and a 90% power test of the sample size formula to test the correlation coefficient:

$$n = \left[\frac{Z\alpha + Z\beta}{0,5\ ln\left[\frac{1+r}{1-r}\right]} \right]^2 + 3$$

Formula Description:

n : sample size

Z_α withα at 5% then the Z value$_\alpha$ = 1.96

Z_β : withβ at 10%, the Z value of$_\beta$ = 1.28

r : correlation coefficient 0.6 (Rizandiny, et al., 2021)

From the formula above, the sample size in this study was 65 patients.

Sampling technique

Sampling was done with total sampling technique with a large sample size met, namely 65 samples.

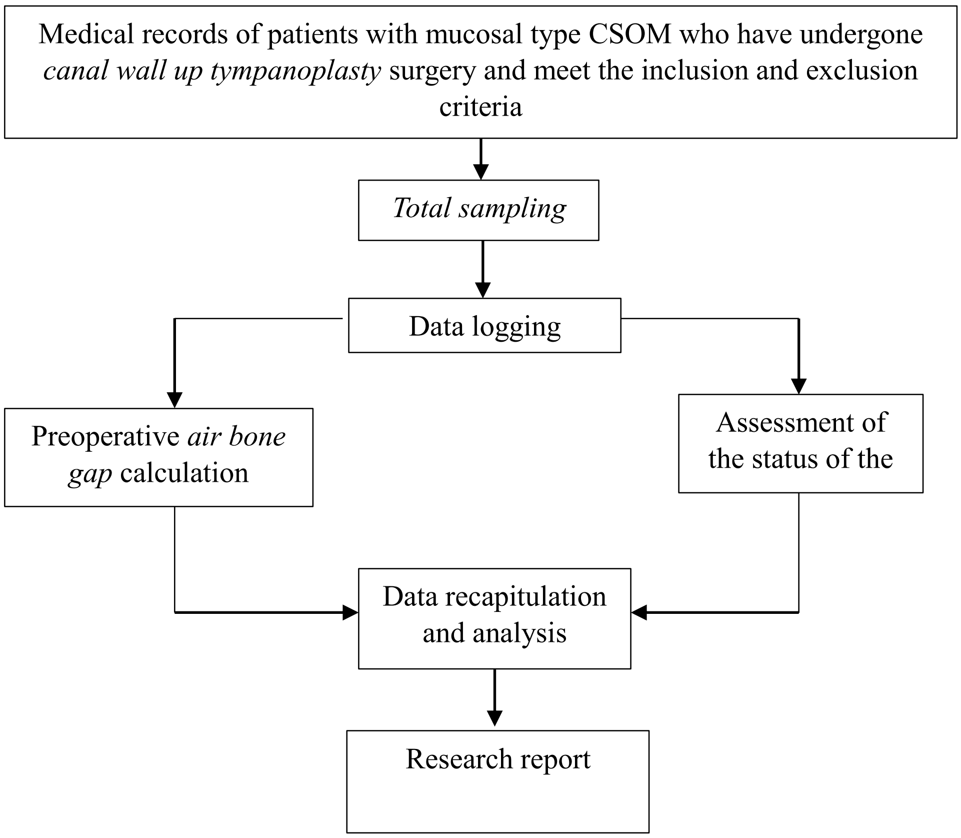
Research Tools

The tools used in the study included medical record data, pure tone audiometry results, operation reports, data collection sheets, stationery, calculators, and computers.

Research variables

The independent variable was the status of the ossicular chain. The dependent variable was air bone gap.

Research Operational Framework



RESULTS AND DISCUSSION

This study was conducted in the Otology division of the Department of ORL-HNS at Dr. Soetomo General Hospital Surabaya from September 01, 2024 to October 31, 2024. Data were collected from the medical records of patients with chronic suppurative otitis media (CSOM) mucosal type, who had undergone canal wall up (CWU) tympanoplasty from January 01, 2021 to December 31, 2023. Selection of medical record data according to the inclusion and exclusion criteria of the study, then the research sample was determined using the total sampling method so that 65 research samples were collected.

Baseline data recorded in this study included patient age and patient gender. The audiogram data recorded included the type and degree of hearing loss, as well as the air bone gap (ABG) at frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. The recorded data on the status of the ossicular chain included the status of the malleus, the status of the incus, the status of the stapes and the type of status of the ossicular chain.

Calculation of the air bone gap value was obtained from the difference between air conduction and bone conduction from audiograms at frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. The status of the ossicle was assessed based on Austin and Kartush's classification from the canal wall up tympanoplasty operation report. Statistical testing used the Spearman rank correlation test with $p < 0.05$ to determine the correlation between air bone gap and ossicular chain status in mucosal type CSOM patients who had undergone canal wall up tympanoplasty surgery.

Basic Data

Of the total 65 study samples, when broken down by gender, there were more men than women. The sample consisted of 36 male patients (55.39%) and 29 female patients (44.61%). The male to female ratio was 1.24: 1.

From the results of this study, based on the age group according to the classification of the Indonesian Ministry of Health (2023), the youngest sample age was nine years and the oldest was 66 years with an average age score of 29.35 ± 14.19 years. The largest age group was the adult age group (19-59 years) with 48 patients (73.85%) , followed by the adolescent age group (10-18 years) with 14 patients (21.54%), the elderly age group (>60 years) with two patients (3.07%), and the pediatric age group (6-9 years) with one patient (1.54%). There were no patients in the infant and toddler age groups (0-5 years) (Table 5.1).

Table. Error! No text of specified style in document.**1** Basic data distribution

Characteristics	**Variables**	**Total Sample (n = 65)**	
		Number (n)	**Percentage (%)**
Gender	Men	36	55,39
	Women	29	44,61
Age	0-5 years	0	0,00
	6-9 years	1	1,54
	10-18 years	14	21,54
	19-59 years old	48	73,85
	>60 years	2	3,07

Audiogram Data

The audiogram data recorded in this study included the type of hearing loss, degree of hearing loss, and air bone gap at four frequencies: 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. Conduction type hearing loss is the most common. In this study there were 46 patients (70.76%), followed by sensorineural type as many as 14 patients (21.54%), mixed type as many as five patients (7.07%) The lowest hearing threshold value in this study was 26.25 dB and the highest was 117.5 dB with an average hearing threshold of 59.42 dB. The degree of hearing loss according to the classification of the international standard organization (ISO) 1964 (Acceptable audiometric hearing levels) and ANSI 1969 (Standard Reference Threshold Sound-Pressure Levels for Audiometers) was found to be moderate (41-55 dB) in 18 patients (27.69%), followed by moderate to severe (56-70 dB) in 16 patients (24.62%), mild (26-40 dB) in 14 patients (21.54%), very severe (> 90 dB) in nine patients (13 patients), and very severe (13 patients).90 dB) as many as nine patients (13.85%) and severe degree (71-90 dB) as many as eight patients (12.30%) (Table 5.2).

Table. Error! No text of specified style in document.**2** Distribution of types and degrees of hearing loss.

Characteristics	**Variables**	**Total Sample (n = 65)**	
		Number (n)	**Percentage (%)**
Types of hearing loss	Conduction	46	70,76
	Sensorineural	14	21,54
	Mixed	5	7,70
Degree of hearing loss	Lightweight	14	21,54
	Medium	18	27,69
	Medium-Heavy	16	24,62
	Weight	9	13,85
	Very Heavy	8	12,30

The largest distribution of air bone gap at four frequencies was the group with air bone gap greater than 50 dB as many as 36 patients (55.38%) at a frequency of 500 Hz and a group of 11 to 20 dB as many as 22 patients (33.84%) at a frequency of 2000 Hz. This study did not find air bone gap values below 10 dB at frequencies of 500 Hz and 1000 Hz (Table 5.3).

Table . Error! No text of specified style in document.**3** Distribution of air bone gap at four frequencies.

Air bone gap (dB)	**Frequency (Hz)**			
	500	**1000**	**2000**	**4000**
0-10	0	0	11 (16,93%)	10 (15,38%)
11-20	2 (3,07%)	7 (10,77%)	22 (33,84%)	15 (23,09%)
21-30	9 (13,85%)	13 (20,00%)	7 (10,77%)	10(15,38%)
31-40	6 (9,23%)	11 (16,93%)	6 (9,23%)	8(12,30%)
41-50	12 (18,47%)	8 (12,30%)	6 (9,23%)	6 (9,23%)
>50	36 (55,38%)	26 (40,00%)	13 (20,00%)	16 (24,62%)

Ossicle Chain Status

The most common malleus status was intact malleus in 26 cases (40%), followed by malleus entangled with granulation tissue in 23 cases (35.39%), and malleus destruction in 14 cases (21.54%). Fixed malleus was found in two cases (3.07%) . The most common incus status was incus destruction in 25 cases (38.46%), intact incus in 21 cases (32.31%), and intact incus entangled with granulation tissue in 19 cases (29.23%). The most common stapes status was intact stapes in 29 cases (44.61%), followed by intact stapes entangled with granulation tissue in 28 cases (43.09%), and stapes destruction in eight cases (12.30%). No incus and stapes fixation was found in this study (Table 5.4).

Table . Error! No text of specified style in document.**4** Distribution of ossicle chain status

Ossicle chain status	**Maleus**	**Inkus**	**Stapes**
Intak	26 (40%)	21 (32,31%)	29 (44,61%)
Intact entangled granulation	23 (35,39%)	19 (29,23%)	28 (43,09%)
Deconstruction	14 (21,54%)	25 (38,46%)	8 (12,30%)
Fixation	2 (3,07%)	0	0

The status of the ossicular chain based on Austin and Kartush's classification was mostly type O with 38 cases (58.46%), followed by type C with 12 cases (18.47%), type B with six cases (9.23%), type A with five cases (7.70%), type D and type E with two cases each (3.07%). Type F was not found in this study (Table 5.5).

Table . Error! No text of specified style in document.**5** Distribution of ossicular chain status based on Austin and Kartush classification.

Ossicle chain status	**Number (n)**	**Percentage (%)**
O (M+, I+, S+)	38	58,46
A (M+, I-, S+)	5	7,70
B (M+, I-, S-)	6	9,23
C (M-, I-, S+)	12	18,47
D (M-, I-, S-)	2	3,07
E (Maleus caput fixation)	2	3,07
F (Stapes fixation)	0	0

Relationship between Air Bone Gap and Ossicular Chain Status

From the characteristics of the air bone gap at four frequencies (500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz), the largest average value obtained at a frequency of 500 Hz is 57.31 dB and the smallest value obtained at a frequency of 2000 Hz is 33 dB (Table 5.6).

Table. Error! No text of specified style in document.**6** Characteristics of bone gap water at four frequencies

Frequency (Hz)	**Mean**	**Median**	**SD**	**Min.**	**Max.**
500	57,31	50	22,10	15	105

1000	49,92	40	25,93	15	110
2000	33	20	23,06	10	100
4000	36	30	23,39	10	110

The characteristics of the relationship between the air bone gap and the status of the ossicle chain at a frequency of 500 Hz obtained the largest average value in the status of the type A (M+, I-, S+) ossicle chain is 70 dB and the smallest average value in the status of the type D (M-, I-, S-) ossicle chain is 47.5 dB. At a frequency of 1000 Hz, the largest average value of air bone gap is obtained in the status of type B (M+, I-, S-) cycula chain which is 67.5 dB and the smallest average value in the status of type D (M-, I-, S-) cycula chain is 22.5 dB. At a frequency of 2000 Hz, the largest average value of air bone gap in the status of type B (M+, I-, S-) cycula chain is 45 dB and the smallest average value in the status of type D (M-, I-, S-) cycula chain is 15 dB. At a frequency of 4000 Hz, the largest average value of air bone gap in the status of type A (M+, I-, S+) ossicular chain is 59 dB and the smallest average value in the status of type D (M-, I-, S-) ossicular chain is 15 dB (Table 5.7).

Table. Error! No text of specified style in document.**7** Characteristics of the relationship between air bone gap and ossicular chain status

Frequency (Hz)	Ossicle chain status							P value
	O	**A**	**B**	**C**	**D**	**E**	**F**	
500	53,02	70	67,50	60,83	47,50	52,50	0	0,311
1000	43,81	59	67,50	60,83	22,50	52,50	0	0,163
2000	27,24	46	45	44,58	15	22,50	0	0,037
4000	30,66	59	45	44,17	15	30	0	0,079

Statistical testing using the Spearman rank correlation test at frequencies of 500 Hz, 1000 Hz and 4000 Hz resulted in p values of 0.311; 0.163; 0.079. This shows that the relationship between the air bone gap and the status of the ossicular chain at frequencies of 500 Hz, 1000 Hz and 4000 Hz is not meaningful ($p > 0.05$). Statistical testing at a frequency of 2000 Hz using the Spearman rank correlation test resulted in a value of $p = 0.037$. This indicates that the relationship between the air bone gap and the status of the ossicular chain at a frequency of 2000 Hz is significant ($p < 0.05$)

Discussion

Chronic suppurative otitis media (CSOM) remains a major health problem, especially in developing countries including Indonesia. CSOM is associated with a high level of morbidity, one of which is hearing loss. As many as 80% of patients with CSOM experience hearing loss and the most common type of hearing loss is conduction (Rizandiny, et al., 2021). Conduction hearing loss is a manifestation of impaired sound wave transmission due to disruption of the integrity and mobility of the sound delivery system due to perforation and damage to the auditory bones. Auditory bone discontinuity is common in one third of CSOM cases. Pure tone audiometry is a routine examination performed before surgery to evaluate the hearing function of patients with preoperative CSOM. Preoperative assessment is a method to ascertain the status of the ossicular chain and would be helpful if it could be predicted before surgery (Browning, et al., 2018).

This study is an analytical observational study of air bone gap and ossicular chain status in patients with chronic suppurative otitis media (CSOM) who have undergone canal wall up tympanoplasty surgery. This study only observed the research subjects without intervening or manipulating. This research is analytic because the research hypothesis will be tested using statistics. The design used in this study is cross sectional, where the measurement of variables is only done once during the examination and no follow-up is done. Data collection through medical record data was carried out at the same time.

The affordable population in this study were mucosal type CSOM patients who had undergone canal wall up tympanoplasty surgery in the Otology division of the Department / KSM of

ORL-HNS at Dr. Soetomo General Hospital Surabaya for three years, from January 01, 2021 to December 31, 2023. The affordable population is part of the target population that can be reached by researchers. Samples were selected from 86 research populations that met the research criteria, namely 65 patients. This research sample was obtained using total sampling. The sample size of this study was 65 patients, adjusted to the formula calculation based on previous research.

This research is analytical because it aims to find a causal relationship between two variables by analyzing the data that has been collected. The hypothesis of this study is that there is a correlation between air bone gap and ossicular chain status in patients with mucosal type chronic suppurative otitis media who undergo canal wall up tympanoplasty surgery. The hypothesis in this study is association hypothesis because it assumes a relationship between variables in the population, through data on the relationship between variables in the sample (Sudigdo & Ismail, 2011).

Hypothesis testing in this study used the Spearman rank correlation statistical test with a significance level (α) of 0.05. The Spearman rank correlation test is a hypothesis test to determine the relationship between two variables where both variables have ordinal data or one variable has ordinal data and the other variable is nominal or ratio. The independent variable in this study uses an ordinal data scale and the dependent variable uses a quantitative ratio scale.

Characteristics of the Research Sample

In this study, 65 patients who met the inclusion criteria were used as research subjects. Distribution based on gender, there were 36 male patients (55.39%) and 29 female patients (44.61%). The ratio between men and women was 1.24: 1,00. Rout, et al., (2014) in his study observed that the ratio of men and women was 1.50 : 1,00. Haidar, et al., (2015) also observed in his study that the number of male patients was more than female patients, namely 2.00 : 1,00. This is consistent with Anglitou, et al., (2011) in his study that the ratio of men and women is 1.14 : 1,00. The dominance of men is due to the fact that they work more outdoors and are more sensitive to atmospheric and climate changes. In this study, the small difference in numbers suggests that gender is not a risk factor for CSOM.

The age distribution of mucosal type CSOM patients in this study showed that the majority were in the adult age group (19-59 years), namely 48 patients (73.85%). Jayakumar, et al., (2016) reported that the age of patients ranged from 15 to 56 years, with a median age of 29 years. This is due to increased awareness of health problems and the presence of hearing loss that can affect performance, thus requiring patients to get medical intervention early (Gupta, et al., 2021). In developing countries, most of the population is young. The second and third decades are the age of development in academics and work potential, therefore patients come for treatment optimally in this age group. This is also because hearing loss due to CSOM will severely hamper these activities. As age increases, the incidence of CSOM decreases to 1.7% at the age of >50 years (Rizandiny, et al., 2021).

Characteristics of Audiogram Findings

The most common type of hearing loss is conductive type as many as 46 patients (70.76%), sensorineural type as many as 14 patients (21.54%) and mixed type as many as five patients (7.07%). Consistent with research conducted by Kadambott, et al., (2023), 109 patients (95.5%) had conductive type hearing loss and five patients had mixed type hearing loss. Conductive hearing loss also occurred in a study conducted by Chao and Wu (1994), where 49% of patients had conductive hearing loss and 29.2% had mixed hearing loss. Patil, et al., (2015) and Gulati, et al., (2002) also found that conduction is the dominant hearing loss in CSOM patients (Kadambott, et al., 2023). The audiometry results in a study conducted by Ekorini & Rahmawati (2021), showed conductive hearing loss in 12 participants (54.54%). This is caused by perforation of the tympanic membrane and damage to the ossicular chain (Ekorini & Rahmawati, 2021). In this study, sensorineural type hearing loss was also found. The study by Rajput, et al. (2020), reported sensorineural hearing loss (SNHL) was found in 30 (19.5%) patients with mucosal type CSOM. In line with Thakur's research, et al. (2019) found SNHL in 23% of mucosal type CSOM cases. The relationship between CSOM and sensorineural type hearing loss is still a controversial topic. This is due to inflammation in the middle ear for a long period of time, which can change the permeability of the round window membrane, so that bacterial debris such as endotoxins can pass through and cause inner ear dysfunction, especially at high frequencies which are anatomically located close to the round window (Rajput, et al., 2020). Nanda, et al., (2015) suggested that higher bone conduction (BC) thresholds were found at high frequencies, this is because infection-related toxins might cause direct damage to hair cells, especially at the base of the cochlea where hair cells are sensitive to high frequency sounds (Nanda, et al., 2015).

The highest degree of hearing loss was moderate as many as 18 patients (27.69%), followed by moderate to severe as many as 16 patients (24.62%), mild as many as 14 patients (21.54%), very severe degree as many as nine patients (13.85%) and severe degree in eight patients (12.30%). This study is in line with the results of research by Mishra, et al., (2020) which states that auditory bone integrity is more often impaired in patients with moderate to moderately severe degrees of conductive hearing loss as measured by pure tone audiometry. This is also in line with research conducted by Jani, et al., (2023) which states that 16 patients (64%) of 25 patients with moderate hearing loss had auditory bone necrosis before surgery. Saha, et al., (2020) reported in their study that 24 patients with moderate hearing loss had auditory bone discontinuity (46.7%). Mucosal type CSOM cases with moderate and severe degrees of hearing loss have a significant chance of hearing bone discontinuity (Saha, et al., 2020). Sharma, et al., (2016) in his research showed that when the incus undergoes necrosis, the hearing loss is mostly of moderate degree, and if the stapes undergoes necrosis, severe or very severe hearing loss occurs.

Air bone gap is the difference between AC and BC on the audiogram. Normal ABG ranges from 0 to 15 dB. In addition to indicating conductive hearing loss, ABG can also predict the presence of ossicular chain abnormalities (Carillo, Yang & Abes, 2006). In this study, the average air bone gap at a frequency of 500 Hz was 57.31 dB, where the largest distribution was the air bone gap group above 50 dB as many as 36 patients (55.38%). The frequency of 1000 Hz has an average air bone gap of 49.92 dB, the highest in the group with air bone gap above 50 dB as many as 26 patients (40%). The average air bone gap at 2000 Hz is 33 dB, with the largest distribution in the 11-20 dB air bone gap group in 22 patients (33.84%). While at a frequency of 4000 Hz the average air bone gap was 36 dB, the highest in the group with air bone gap above 50 dB as many as 16 patients (24.62%). This is in accordance with the research of Sheikh, et al., (2016) that high ABG at 1000 Hz (>27.5 dB) and 2000 Hz (>17.5 dB) is the most reliable variable associated with the destruction of the ossicular chain. Saha, et al. (2020), reported that most auditory bone discontinuities (60%) occurred when the air bone gap was >40 dB and was considered highly statistically significant (Saha, et al., 2020).

Feng, et al., (2005) evaluated the correlation between ossicular chain status and pure tone audiometry in 251 CSOM patients, finding that the air conductance threshold and ABG in patients with ossicular destruction were higher than in patients who did not have ossicular chain destruction (Feng, Chen & Ding, 2005). Ghosh, et al., (2019) in their study stated that a wide ABG especially at high frequencies indicates discontinuity of the ossicular chain. Air bone gap values ≥ 40 dB were found in 60% of CSOM cases with discontinuity of the ossicular chain (Ghosh, et al., 2019). A study conducted by Harkare, et al., 2020, reported that ABG ≥ 40 dB was an indicator for statistically significant preoperative auditory bone necrosis.

Characterization of the Status of the Osikula Chain

In this study, the incus experienced the most destruction at 38.46%, followed by the malleus 21.54%, and the stapes 12.30%. This is in accordance with research conducted by Jayakumar, et al., (2016) reporting auditory bone destruction in 23.1% of cases, with the incus being the most common, followed by the malleus and stapes. Tripathi, et al. (2017) in their study noted that incus destruction was observed in 22.38% of cases out of a total of 67 cases of mucosal type CSOM. Bayat, et al. (2019) in their study reported incus necrosis in 55 cases (51.41%). The study by Kumar, et al. (2015) reported that 50 CSOM patients who underwent mastoidectomy experienced the most ossicular chain destruction in the incus. The processus longus of the incus is the component that is most often destroyed (Varshney, et al., 2010). Auditory bone necrosis usually occurs in the fine-textured part of the chain, especially in the processus longus incus and stapes suprastructure, where osteoclastic activity is greater compared to low osteoblastic activity (Jani, et al., 2023). Activation of osteoclasts by these cytokines will continue the process of bone resorption (Artono, et al., 2020). According to Austin (1997), the processus longus of the incus often undergoes necrosis due to thrombotic pathology in the mucosal blood vessels that supply blood to the incus, but when secondary squamous epithelium grows, the stapes arch and manubrium of the malleus can be destroyed by the formation of osteolytic enzymes or collagenase in the subepithelial connective tissue (Gurumani, 2013).

The status of the ossicular chain according to the classification of Austin and Kartush in this study was determined, namely the status of the ossicular chain type O (all three ossicles intact) as much as 58.46%, 38.47% ossicular deconstruction and type E (fixation of the malleus) as much as 3.07%. The most significant ossicle chain destruction was found in type C (maleus and incus destruction) with 18.47%, followed by type B (incus and stapes destruction) with 9.23%, type A (incus destruction) with 7.70%, and type D (all three ossicles destruction) with 3.07%. Fixation of the ossicular chain was also found in this study, namely type E (maleus caput fixation) at 3.07%. There was no type F status of the ossicle chain in this study.

Relationship between Air Bone Gap and Ossicular Chain Status

The characteristics of the air bone gap at a frequency of 500 Hz obtained the largest average value in the status of the type A (M+, I-, S+) ossicular chain, namely 70 dB and the smallest average value in the status of the type D (M-, I-, S-) ossicular chain, namely 47.5 dB. Statistical testing using Spearman rank resulted in a p value = 0.311. This indicates that the relationship between air bone gap and ossicular chain status at a frequency of 500 Hz is not significant ($p > 0.05$). At a frequency of 1000 Hz, the largest mean value of air bone gap was obtained in type B (M+, I-, S-) ossicular chain status, which was 67.5 dB and the smallest mean value was found in type D (M-, I-, S-), which was 22.5 dB. Statistical testing using the Spearman rank correlation test resulted in a p value = 0.163. This shows that the relationship between the air bone gap and the status of the ossicular chain at a frequency of 1000 Hz is not significant ($p> 0.05$). The average air bone gap at a frequency of 2000 Hz obtained the largest value in the status of the ossicular chain type A (M+, I-, S+) which is 46 dB and the smallest average value in type D (M-, I-, S-) which is 15 dB. Statistical testing using the Spearman rank correlation test resulted in a p value = 0.037. This indicates that the relationship between air bone gap and ossicular chain status at a frequency of 2000 Hz is significant ($p < 0.05$). The average air bone gap at a frequency of 4000 Hz obtained the largest value in the status of the ossicular chain type A (M+, I-, S+) which is 59 dB and the smallest average value in type D (M-, I-, S-) which is 15 dB. Statistical testing using the Spearman rank correlation test resulted in a p value = 0.079. This shows that the relationship between the air bone gap and the status of the ossicular chain at a frequency of 4000 Hz is not significant ($p> 0.05$). From the overall results of the study, in each frequency, it shows that the relationship between the air bone gap and the status of the ossicular chain at frequencies of 500 Hz, 1000 Hz and 4000 Hz is not significant ($p> 0.05$), except at a frequency of 2000 Hz a significant association was found ($p < 0.05$). Based on these statistical tests, the hypothesis of this study was rejected.

The results of this study are in accordance with the study by Jeng, et al., (2003), which reported that the air bone gap was greater in CSOM with and without cholesteatoma accompanied by ossicular discontinuity than without ossicular discontinuity, but was not significantly related ($p = 0.133$). The study by Patil, et al. (2015) concluded that neither AC nor air bone gap threshold values are good parameters to predict preoperative ossicular chain status. Functional integrity of the ossicular chain in ossicular destruction showed the same hearing function as in the presence of cholesteatoma without accompanying ossicular destruction (Patil, et al., 2015).

This study contradicts the research of Carillo, et al., (2007) which reported that an increase in air bone gap can predict the destruction of the ossicular chain, while a decrease in air bone gap indicates the integrity of the ossicular chain so that the hearing threshold and air bone gap can be used as parameters to predict the status of the preoperative ossicular chain (Carillo, Yang, Abes 2007). Other studies have shown that AC and air bone gap values in ossicular defects are higher than those without ossicular defects. The study by Albera, et al., (2012) showed that AC and BC values increased depending on the degree of ossicular destruction, but the air bone gap was relatively stable. This study suggests that audiometry and air bone gap cannot reflect the status of the ossicular chain. Damage to the stapes and the entire ossicular chain can decrease AC and BC hearing thresholds, but only slightly affect changes in air bone gap (Albera, et al., 2012).

Research Limitations

Researchers collected research data through the medical records of mucosal type CSOM patients who underwent CWU tympanoplasty surgery both audiograms and operation reports. Calculation of air bone gap using audiogram and evaluation of ossicular chain status based on Austin and Kartush classification through data from operation report. Researchers cannot directly confirm the measured variables. One type of ossicular chain status that was not found in this study sample was type F (Stapes Fixation). We could not calculate the volume of the middle ear or the area of granulation tissue in this study because CT scan data was not available in the study sample

CONCLUSIONS AND SUGGESTIONS

Conclusion

There was a relationship between the air bone gap at a frequency of 2000 Hz and the status of the ossicular chain in mucosal type CSOM patients, but no relationship was found at frequencies of 500 Hz, 1000 Hz and 4000 Hz.

Suggestions

1. Further research is expected to be conducted on the study population with a longer period of time in order to obtain the overall status of the ossicle chain.
2. Further prospective studies may be considered to assess the relationship and influence of the type and location of tympanic membrane perforation on the status of the intraoperative ossicular chain.

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