Sensorineural damage in chronic suppurative otitis media with and without cholesteatoma: a comparative study

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Background: Chronic suppurative otitis media (CSOM) is a common otolaryngology disease, and cholesteatoma is the most aggressive type of CSOM. CSOM with and without cholesteatoma both result in a certain level of sensorineural damage, which can be categorized as air conduction (AC), bone conduction (BC), or air-bone gap (ABG), and AC, BC, and ABG are affected by many factors. Further analyses and comparisons of factors affecting sensorineural damage in CSOM with and without cholesteatoma were conducted in this study.

Methods: A comparative study was conducted of 79 patients with CSOM (39 with cholesteatoma and 40 without cholesteatoma) whose diagnoses were mainly based on chronic middle ear infections and hearing loss (HL), typical computed tomography (CT) and surgical findings. Audiological evaluation included AC, BC and ABG, and sensorineural damage was defined as mixed and sensorineural HL (SNHL).

Results: In relation to the types of HL, there were no significant differences between both groups. The CSOM with cholesteatoma group had significantly greater AC (P=0.000) and a significantly greater ABG (P>0.05) than the CSOM without cholesteatoma group, but BC did not differ significantly between both groups (P>0.05). The average AC-middle frequency (MF), AC-high frequency (HF), ABG-MF and ABG-HF of CSOM without cholesteatoma were smaller than these of CSOM with cholesteatoma (P<0.05). The degree of HL differed significantly between both groups (P=0.000). The CSOM with cholesteatoma group showed a higher level of HL than the CSOM without cholesteatoma group. The presence of cholesteatoma was presented a protective factor associated with sensorineural damage (P<0.05), while higher degrees of hearing and aging were risk factors (P<0.05), respectively.

Conclusions: Our direct comparisons showed that HL progressed more rapidly in the CSOM with cholesteatoma group, which had higher frequencies in relation to AC, the ABG, and severity. However, in relation to BC, there were no significant differences between both groups, which was in line with the similar proportions of the types of HL in both groups. The logistic regression showed that the presence of cholesteatoma was a protective factor, and the degree of hearing and aging were risk factors associated with sensorineural damage.

Keywords: Audiometric data; cholesteatoma; chronic suppurative otitis media (CSOM); sensorineural damage

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Introduction

Chronic suppurative otitis media (CSOM) is one of the most common otolaryngological diseases with a wide range of prevalence from 0.5% to 33.3% in both developing and developed countries (1-3). CSOM is defined as inflammation of the middle ear cavity, eustachian tube, and mastoid air cell system caused by aerobic and anaerobic bacteria (4), leading to typical irreversible tympanic membrane perforation, which presents with ear discharge (5). Additionally, due to the irreversible inflammatory damage, CSOM can progress from tympanic membrane retraction and middle ear effusion to tympanic membrane perforation, and possibly to the formation of cholesteatoma, which can be defined as the squamous epithelial type of CSOM (6). The entire process can be detected in the contralateral ear (7).

In CSOM, perforation of the tympanic membrane and erosion of the ossicular chain can cause defective middle ear function, which always results in conductive hearing loss (HL) (1). In CSOM with cholesteatoma, where ossicular-chain erosion frequently occurs as a result of chronic inflammation and pressure necrosis induced by the cholesteatoma mass (8), conductive HL is a typical symptom. It has been reported that the prevalence of conductive HL caused by CSOM ranges from 13.8% to 36.2% (9), which shows the progression of CSOM and the damage that CSOM can cause.

In previous studies, the bone conduction (BC) threshold was also shown to be elevated (2,10), which is a sign of sensorineural damage, in CSOM, with and without cholesteatoma, and to have a maximum prevalence of 52.00% (11). In relation to this phenomenon, due to labyrinthitis, toxic materials penetrate the middle ear through the round window membrane into the inner ear (12), which is caused by a part of the inner ear being exposed to the environment of the affected middle ear through the lateral semicircular canal (13).

HL in CSOM with and without cholesteatoma, especially over long disease durations, should be taken seriously regardless of the degree and type because of its negative effects on language, speech, educational progress, and socialization (1,14).

The degree of HL is dependent on injuries to different structures, such as the tympanic membrane, ossicular chain, and inner ear (1). CSOM with cholesteatoma, which is the most aggressive type of CSOM (15), results in approximately 80% partial or total ossicular erosion (15), and its audiological parameters are comparable to those of CSOM without cholesteatoma. A previous study found no significant difference in sensorineural HL (SNHL) between CSOM without and with cholesteatoma (16).

Notably, studies (17-19) have shown that a long disease duration should be seen as a risk factor for sensorineural damage in CSOM with and without cholesteatoma. Additionally, other significant factors associated with sensorineural damage including sex, age, the degree of HL, and the presence or absence of cholesteatoma should be taken into consideration.

This study sought to compare audiological data (of levels and types of HL between CSOM with and without cholesteatoma), to analyze the factors causing sensorineural damage in CSOM with and without cholesteatoma to extend understandings of the audiological differences between CSOM with and without cholesteatoma, and to enable the earlier diagnosis and the implementation of appropriate treatment, including medications, operations, and hearing aids, to improve the quality of life of qualifying patients. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-2606/rc).

Methods

Our clinical research design was firstly to search the medical record system and the audiometry system for CSOM patients either with or without cholesteatoma, who had complete audiological data and medical records, then to summarize the descriptive data and compare audiological data between CSOM without cholesteatoma group and CSOM with cholesteatoma group.

Participants

A total of 79 patients with unilateral and bilateral CSOM (39 with cholesteatoma and 40 without cholesteatoma), who underwent pure-tone audiometry between January 2019 and January 2022 at The First Affiliated Hospital of Jinan University, Jinan University, China, were included in this study. The CSOM diagnoses were based on the history of middle ear infections over 12 weeks, HL, and typical computed tomography (CT) findings of high-density inflammatory and bone-destruction imaging. For the diagnoses of CSOM with cholesteatoma, in addition to the aforementioned criteria, the typical surgical findings and a diagnosis of middle ear cholesteatoma were added.

Patients were excluded from the study if they met any of the following exclusion criteria: (I) were in an acute stage; (II) had previously undergone ear surgeries; (III) had traumatic head or ear injuries; (IV) had a malformation of the ossicular chain or cochlea; (V) had a history of chronic noise exposure; (VI) had sudden HL; and/or (VII) had missing or incomplete medical records.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of The First Affiliated Hospital of Jinan University (No. KY-2022-080). Informed consent was not required because this was a retrospective study, and all data were collected after the patients were discharged.

Audiological measurements

The audiological evaluation was carried out using pure-tone audiometry. Air conduction (AC) could be detected at all 0.125 to 8 kHz frequencies, while BC could only be detected at 0.5 to 8 kHz frequencies, as the sense of vibration caused by the BC vibrator at lower frequencies would have interfered with the accuracy of BC values.

At every frequency, there was a noise threshold, above which a sense of vibration was caused that interfered with the accuracy of AC and BC values, and which was thus marked as undetectable. In AC, these values were 80 dB at 0.125 kHz, 100 dB at 0.250 kHz, 115 dB at 0.5 kHz, 120 dB at 1.0 kHz, 115 dB at 2.0 kHz, 115 dB at 4.0 kHz, and 105 dB at 8.0 kHz. In BC, these values were 70 dB at 0.5 kHz, 75 dB at 1.0 kHz, 80 dB at 2.0 kHz, 70 dB at 4.0 kHz, and 45 dB at 8.0 kHz.

The air-bone gap (ABG) was calculated as AC minus BC. Low frequency (LF) referred to 0.125 and 0.25 kHz; middle frequency (MF) referred to 0.5, 1.0, and 2.0 kHz, and high frequency (HF) referred to 4.0 and 8.0 kHz. The pure-tone average (PTA) referred to 0.5, 1.0, 2.0, and 4.0 kHz.

The degrees of HL were divided into the following six categories: (I) normal (<25 dB); (II) mild (26–40 dB); (III) moderate (41–55 dB); (IV) moderately severe (56–70 dB); (V) severe (71–90 dB); and (VI) profound (>90 dB).

Conductive HL referred to AC >25 dB and BC <25 dB; SNHL referred to AC and BC >25 dB and ABG <10 dB; mixed HL referred to AC and BC >25 dB and ABG >10 dB, which also represented both conductive HL and SNHL.

Medical records

Patients' medical records included their name, sex, age, main complaint, and history of disease. These were also analyzed.

Statistical analyses

The statistical analyses were performed using SPSS v26.0. First, we verified that our audiological data of the two groups were normally distributed using normality test. Then, associations between the hearing outcomes and clinical data were analyzed using independent-sample *t*-tests (for comparisons of the audiological parameters), Mann-Whitney tests, Chi-square tests (for comparisons of the composition of types of HL and the proportions of the degree of hearing) and logistic regression (for the protective and risk factors associated with mixed HL and SNHL). The data are expressed as the mean, standard deviation of the mean, and percentages. A P value ≤0.05 was considered statistically significant, and P<0.05 was two-sided. In addition, an odds ratio ≤1.00 was considered as a protective factor, and an odds ratio >1.00 was considered as a risk factor. Bar charts and logistic regression graphs were generated using SPSS v26.0 and GraphPad v9.0, respectively.

Results

In total, the audiological data of the 79 patients with CSOM were collected and analyzed (see *Table 1*). Incomplete descriptive and audiological data were not collected. A total of 40 patients had CSOM without cholesteatoma, of whom 14 (35.00%) had right ear CSOM, 18 (45.00%) had left ear CSOM, and 8 (20.00%) had bilateral CSOM. Of the 48 affected ears, 22 (45.83%) were right ears, and 26 (54.17%) were left ears. Additionally, 43 (89.58%) of the 48 affected ears had symptoms of ear discharge, 47 (97.92%) had tympanic membrane perforation, and 31 (64.58%) had sensed tinnitus. Female patients accounted for 55.00% [22] of the CSOM without cholesteatoma cohort, and male patients accounted for 45.00% [18]. The mean age of the CSOM without cholesteatoma cohort was 40.58 years.

A total of 39 patients had CSOM with cholesteatoma, of whom 20 (51.28%) had right ear CSOM with cholesteatoma, 18 (46.15%) had left ear CSOM with cholesteatoma, and 1 (2.57%) had bilateral CSOM with cholesteatoma. Of the 40 affected ears, 21 (52.50%) were right ears, and 19 (47.50%) were left ears. Additionally, 30 (75.00%) of the 40 affected ears had symptoms of ear discharge, 34 (85.00%) had tympanic membrane perforation, and 11 (27.50%) had sensed tinnitus. Female patients accounted for 48.72% [19] of the CSOM with cholesteatoma cohort, and male patients accounted for 51.28% [20]. The mean age of the CSOM with

Table 1 Descriptive data of the 79 patients

Types of CSOM	CSOM without cholesteatoma	CSOM with cholesteatoma
Gender, n (%)		
Female	22 (55.00)	19 (48.72)
Male	18 (45.00)	20 (51.28)
Age (years), mean	40.58	43.64
Affected side, n (%)		
Right	14 (35.00)	20 (51.28)
Left	18 (45.00)	18 (46.15)
Bilateral	8 (20.00)	1 (2.57)
Number of ears, n (%)		
Right	22 (45.83)	21 (52.50)
Left	26 (54.17)	19 (47.50)
Total	48	40
Ear discharge, n (%)		
Positive	43 (89.58)	30 (75.00)
Negative	5 (10.42)	10 (25.00)
Perforation, n (%)		
Positive	47 (97.92)	34 (85.00)
Negative	1 (2.08)	6 (15.00)
Tinnitus, n (%)		
Positive	31 (64.58)	11 (27.50)
Negative	17 (35.42)	29 (72.50)

CSOM, chronic suppurative otitis media.

cholesteatoma cohort was 43.64 years.

Figure 1 displays the types of HL in the CSOM without cholesteatoma group and the CSOM with cholesteatoma group. In the CSOM without cholesteatoma group, 19 patients had conductive HL (39.58%), 0 patients had SNHL, and 29 patients had mixed HL (60.42%). In the CSOM with cholesteatoma group, 18 patients had conductive HL (45.00%), 2 patients had SNHL (5.00%), and 20 patients had mixed HL (50.00%). The results of the Chi-square tests showed that there were no significant differences between the groups (χ^2=2.977; P=0.226).

Figure 2 displays the degree of hearing (dB) of the CSOM without cholesteatoma group and the CSOM with cholesteatoma group. In the CSOM without cholesteatoma group, 4 patients had normal hearing (8.33%), 21 patients had mild HL (43.75%), 12 patients had moderate HL (25.00%), 11 patients had moderately severe HL (22.92%), and no patients had severe or profound HL. In the CSOM with cholesteatoma group, 1 patient had normal hearing (2.50%), 4 patients had mild HL (10.00%), 14 patients had moderate HL (35.00%), 10 patients had moderately severe HL (25.00%), 7 patients had severe HL (17.50%), and 4 patients had profound HL (10.00%). The results of the Chi-square tests showed that there were significant differences between the groups (χ^2=24.003; P=0.000).

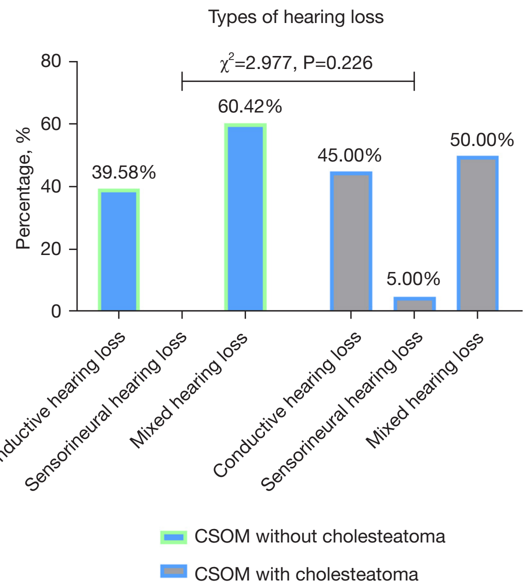

Figure 1 Bar chart of the types of HL in the CSOM without cholesteatoma group and the CSOM with cholesteatoma group. CSOM, chronic suppurative otitis media; HL, hearing loss.

Table 2 displays the averages of PTA audiological parameters and the comparative measures for both types of CSOM. In the CSOM with cholesteatoma group, 2 ears had undetected AC-PTA and BC-PTA parameters. Between the two groups, AC-PTA (CSOM without cholesteatoma: 42.03±13.10 dB; CSOM with cholesteatoma: 57.67±17.65 dB) and ABG-PTA (CSOM without cholesteatoma: 22.45±8.40 dB; CSOM with cholesteatoma: 34.56±11.22 dB) differed significantly (P=0.000); however, there were no significant differences in relation to BC-PTA (P>0.05).

Table 3 displays the averages of the AC parameters of different frequencies and the comparative measures for both types of CSOM. In the CSOM without cholesteatoma group, 1 ear had undetected AC-LF parameters, and in the CSOM with cholesteatoma group, 9 ears had undetected AC-LF, AC-MF, and AC-HF parameters. Between the two groups,

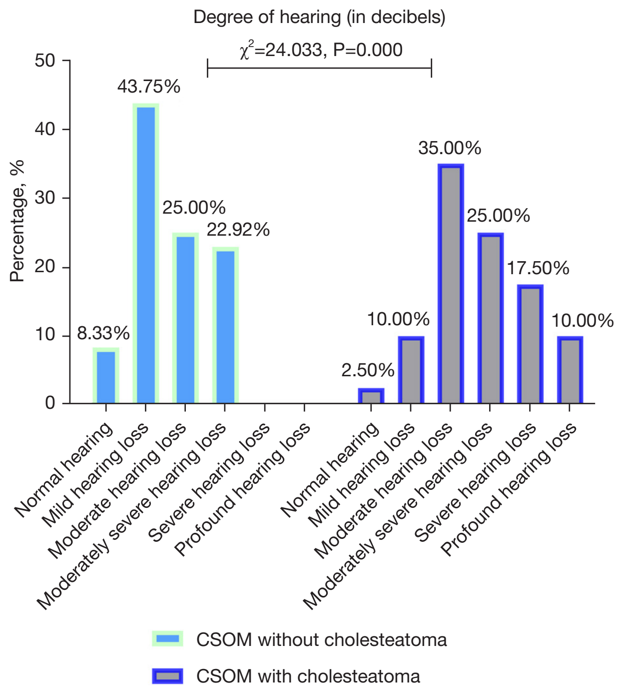

Figure 2 Bar chart of the degree of hearing (dB) of the CSOM without cholesteatoma group and the CSOM with cholesteatoma group. CSOM, chronic suppurative otitis media.

AC-MF (CSOM without cholesteatoma: 41.60±13.80 dB; CSOM with cholesteatoma: 52.63±15.21 dB) and AC-HF (CSOM without cholesteatoma: 43.24±17.85 dB; CSOM with cholesteatoma: 55.81±17.82 dB) differed significantly (P<0.05); however, there were no significant differences in relation to AC-LF (P>0.05).

Table 4 displays the averages of BC and ABG parameters of different frequencies and comparative measures for both types of CSOM. In the CSOM without cholesteatoma group, 6 ears had undetected BC at 8 Hz, and in the CSOM with cholesteatoma group, 13 ears had undetected AC-MF, AC-HF parameters, and BC at 8 Hz. Between the two groups, ABG-MF (CSOM without cholesteatoma: 21.03±10.15 dB; CSOM with cholesteatoma: 31.98±10.74 dB) and ABG-HF (CSOM without cholesteatoma: 23.87±8.80 dB; CSOM with cholesteatoma: 34.17±11.07 dB) differed significantly (P=0.000); however, there were no significant differences in relation to BC-MF and BC-HF (P>0.05).

Figure 3 displays the logistic regression of the prognostic factors for mixed HL and SNHL. To reduce the collective bias, we did not include the data of patients with bilateral CSOM. Of all the factors considered, the presence of cholesteatoma was shown to be a protective factor (P<0.05) with an odds ratio (OR) of 0.230 [95% confidence interval (CI): 0.056–0.937], while higher degrees of hearing and aging (minimum: 13 years; median: 45 years; maximum: 80 years; average: 42.8 years) were shown to be risk factors (P<0.05) with ORs of 2.696 (95% CI: 1.363–5.334) and 2.055 (95% CI: 1.164–3.626), respectively. Other factors, such as sex (P=0.768) (female: 41, male: 38) and the duration of disease (P=0.825) (minimum: 3 months; median: 36 months; maximum: 600 months; average: 104.5 months) were not found to be associated with sensorineural damage.

Discussion

SNHL can be observed in CSOM with and without cholesteatoma, and its prevalence ranges from 2.01% to 52.00% (1,2,11,20), showing different proportions of types of HL in CSOM with and without cholesteatoma. In the present study, the types of HL did not differ significantly between the two groups (P=0.226). In both groups, mixed HL comprised the largest proportion of HL. Notably, while no patients in the CSOM without cholesteatoma group had SNHL, 2 patients in the CSOM with cholesteatoma group had SNHL. Shariff (1) reported 87.5% conductive HL and 12.5% mixed HL in CSOM, which is consistent with the findings of Islam *et al.* (2), who reported 80.8% conductive HL, 17.17% mixed HL, and only 2.01% SNHL. Unlike in our study, in Shariff's (1) and Islam *et al.*'s (2) studies, conductive HL took up the largest proportions, and in Islam *et al.*'s study (2), SNHL took up the smallest proportion.

Notably, a previous study has shown that in CSOM with and without cholesteatoma, in addition to increases in BC, there are also increases in the ABG in SNHL, and patients with CSOM with cholesteatoma have a significantly greater ABG than patients with CSOM without cholesteatoma, and lower frequencies are more compromised than higher frequencies (21).

Our study also showed significantly greater AC and a significantly greater ABG in the CSOM with cholesteatoma group than the CSOM without cholesteatoma group in terms of PTA, MF, and HF, while AC-LF, BC-PTA, BC-MF and BC-HF did not differ significantly between the groups. Additionally, the average of ABG-MF was lower than that of ABG-HF in both groups. Kaur *et al.* (22) reported a mean AC-PTA of 41.16±14.92 dB, a mean BC-PTA of 16.98±8.74 dB, and a mean ABG-PTA of 24.17±10.34 dB in CSOM, while Weiss *et al.* (23) reported a mean AC-PTA of 47.1±22.7 dB, a mean BC-PTA of 24.1±21.0 dB, and a mean ABG-PTA of 23.0±11.7 dB in CSOM with cholesteatoma.

Table 2 Averages of PTA audiological parameters and comparative measures for both types of CSOM

Audiological parameter	CSOM without cholesteatoma (n=48)	CSOM with cholesteatoma (n=37)	t	P
AC-PTA (dB)	42.03±13.10	57.67±17.65	4.69	0.000
BC-PTA (dB)	19.58±7.84	23.11±13.23	1.44	0.156
ABG-PTA (dB)	22.45±8.40	34.56±11.22	5.69	0.000

The results are shown as the mean ± standard deviation. PTA, pure-tone averages; CSOM, chronic suppurative otitis media; AC, air conduction; BC, bone conduction; ABG, air-bone gap; t, t-score.

Table 3 Averages of AC parameters of different frequencies and comparative measures for both types of CSOM

Audiological parameter	CSOM without cholesteatoma (n=47)	CSOM with cholesteatoma (n=31)	t	P
AC-LF (dB)	59.04±11.40	58.48±13.96	0.20	0.843
AC-MF (dB)	41.60±13.80	52.63±15.21	3.32	0.001
AC-HF (dB)	43.24±17.85	55.81±17.82	3.04	0.003

The results are shown as the mean ± standard deviation. AC, air conduction; CSOM, chronic suppurative otitis media; LF, low frequency; MF, middle frequency; HF, high frequency; t, t-score.

Table 4 Averages of BC and ABG parameters of different frequencies and comparative measures for both types of CSOM

Audiological parameter	CSOM without cholesteatoma (n=42)	CSOM with cholesteatoma (n=27)	t	P
BC-MF (dB)	20.32±7.40	17.84±6.52	1.42	0.160
BC-HF (dB)	15.48±9.21	16.02±6.62	0.26	0.792
ABG-MF (dB)	21.03±10.15	31.98±10.74	4.27	0.000
ABG-HF (dB)	23.87±8.80	34.17±11.07	4.28	0.000

The results are shown as the mean ± standard deviation. BC, bone conduction; ABG, air-bone gap; CSOM, chronic suppurative otitis media; MF, middle frequency; HF, high frequency; t, t-score.

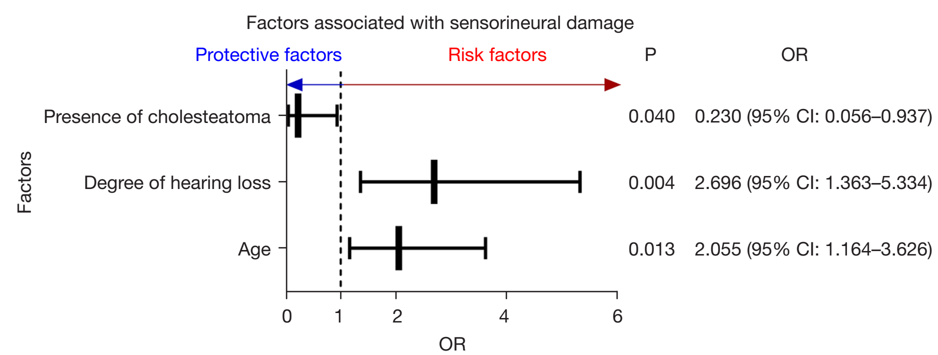

Figure 3 Logistic regression of the prognostic factors for mixed HL and SNHL. OR, odds ratio; HL, hearing loss; SNHL, sensorineural hearing loss.

Our study showed increasing AC across all frequencies, and Weiss *et al.* (23) showed an increasing mean ABG-PTA in CSOM with cholesteatoma; however, it should be noted that while cholesteatoma can cause the erosion of ossicles, leading to a certain level of HL, it can also bridge the ossicular gap and then transmit sound, leading to a reduced

HL threshold (24,25). Thus, consideration must be given to the accuracies of AC and the ABG in CSOM patients with cholesteatoma.

Additionally, the ABG values may not only be a predictor of advanced cholesteatoma (10) but may also be a predictor of the erosion of ossicles. The erosion of each ossicle could lead to an increase in the ABG, and the status of the incus was the most effective factor of ABG gain (26).

A previous research (27) has shown that simple drumhead perforation, ossicular-chain damage, and ossicular-chain discontinuity could cause 15 to 60 dB of conductive HL. More importantly, the incus, especially the long process of the incus, was most commonly necrosed in CSOM patients both with and without cholesteatoma (27). The erosion of the ossicles and the discontinuity of the ossicular chain caused by CSOM with or without cholesteatoma could be a plausible explanation for the wide range of HL levels across different studies (28).

In the present study, the degree of hearing different significantly between the groups (χ^2=24.003; P=0.000). Notably, 4 patients in the CSOM without cholesteatoma group had normal AC-PTA hearing (8.33%), while only 1 (2.50%) in the CSOM with cholesteatoma group had normal AC-PTA hearing. Most patients in the CSOM without cholesteatoma group had mild HL (43.75%). Conversely, most patients in the CSOM had moderate HL (35.00%). None of the patients in the CSOM without cholesteatoma group had severe or profound HL; however, 11 patients (27.50%) in the CSOM with cholesteatoma group had severe or profound HL. Patients in the CSOM with cholesteatoma group had a higher level of HL than those in the CSOM with cholesteatoma group. Shariff (1) found 40.6% moderate HL and 14.1% moderately severe HL in their study of CSOM patients, which is in line with our findings. Additionally, de Azevedo *et al.* (29) observed 21.7% of normal AC threshold and 37.4% of mild HL in CSOM patients.

However, in relation to the BC threshold (the most essential parameter for determining SNHL), our study demonstrated that BC thresholds did not differ significantly between the CSOM with and without cholesteatoma groups (20). Detectable BC thresholds at all three frequencies did not show significant differences between the CSOM with and without cholesteatoma groups in our study; however, there were more patients with undetectable BC thresholds at all 3 frequencies in the CSOM with cholesteatoma group than the CSOM without cholesteatoma group.

In our study, the BC thresholds at every frequency that could be detected remained under 25 dB in both groups. Kaur *et al.* (22) and Weiss *et al.* (23) also had mean BC-PTA thresholds under 25 dB in CSOM with and without cholesteatoma. However, other studies have demonstrated that BC thresholds could be elevated at different frequencies in CSOM with and without cholesteatoma, which might be due to toxic products from the middle ear passing into the inner ear, causing biochemical changes in the perilymph and endolymph and gradually damaging the organ of Corti, and eventually leading to changes in the mechanics of sound transmission (2,10).

In relation to the BC thresholds, it should be noted that other studies have also mentioned that BC thresholds could be elevated without actual cochlear damage, as ossicular-chain fixation caused by functional masses and fluids and semisolid material that can take over the place of normal gas could directly limit the mobility of the oval window and inner ear fluids. Additionally, the skull can resolve the energy of sound waves through its transmission (2,17,30).

In summary, in CSOM with and without cholesteatoma, many factors could alter the BC thresholds that define SNHL. Consistent with our findings, multiple risk factors were mentioned in other studies associated with sensorineural damage, including age (29,31), the presence of cholesteatoma, and the severity of HL (2). Additionally, in our study, sex, and the duration of disease were not found to be significantly associated with sensorineural damage. Jesic *et al.* (15), Samantaray *et al.* (20), de Azavedo *et al.* (29), and Khatri *et al.* (4) also reported that the duration of disease was not a risk factor for sensorineural damage. Conversely, other studies have found that the presence of cholesteatoma (10) and the duration of the disease (17) are risk factors, but that the degree of HL remains questionable (18,32).

In summary, controversy remains as to whether the duration of disease, absence or presence of cholesteatoma, and severity of HL are risk and protective factors associated with sensorineural damage. It is reasonable to assume that the progress of infections could be much more severe due to prolonged exposure of the round window membrane, through which toxic materials and substances can pass into the inner ear, especially with the presence of cholesteatoma (14), and that recurrent infections together with ear discharge could increase the permeability of bacterial toxins of the round window (18,19).

However, others have contended that cholesteatoma could cause middle ear mucosal thickening and make it difficult for bacteria to access the inner ear (29). Naveen *et al.* (6) also noted that CSOM can make the round window membrane 3 to 5 times thicker over time.

The duration of disease was not found to be significantly correlated with sensorineural damage in our study; however, the wide range of our discrete duration data must be noted.

Our study was limited by the small number of samples due to the lack of complete audiological data. To expand the number of research samples and to create a more detailed and statistic plan will be needed for further study.

Conclusions

Our study showed worse HL in CSOM with cholesteatoma, especially at higher frequencies in relation to AC, the ABG, and severity, while BC did not differ significantly between the groups with or without cholesteatoma, which is in line with similar findings on the proportions of types of HL between the two groups. Based on the logistic regression analysis, the presence of cholesteatoma was found to be a protective factor, and the degree of hearing and aging were shown to be risk factors associated with sensorineural damage. Factors such as sex and the duration of disease were not found to be associated with sensorineural damage.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-2606/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-2606/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-2606/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of The First Affiliated Hospital of Jinan University (No. KY-2022-080). Informed consent was not required because this was a retrospective study, and all data were collected after the patients were discharged.

References

1. Shariff MEA. Analysis of hearing loss by pure tone audiometry in patients with chronic suppurative otitis media. Natl J Physiol Pharm Pharmacol 2019;9:515-8.
2. Islam MS, Islam MR, Bhuiyan MAR, et al. Pattern and degree of hearing loss in chronic suppurative otitis media. Bangladesh Journal of Otorhinolaryngology 2010;16:96-105.
3. Handi PS, Patil MN, Prasenkumar KR. Evaluation of hearing loss by pure tone audiometry in chronic suppurative otitis media patients. Int J Otorhinolaryngol Head Neck Surg 2018;4:1173-6.
4. Khatri VK, Siddiqui AH, Rahim DU, et al. Analysis of Sensorineural Hearing Loss by Pure Tone Audiometry in Chronic Suppurative Otitis Media. Annals of Abbasi Shaheed Hospital and Karachi Medical & Dental College 2021;26:245-50.
5. Dawood MR. Otoscopic, radiological, and audiological status of the contralateral ears in patients with unilateral chronic suppurative otitis media. Indian Journal of Otology 2018;24:16.
6. Naveen KAG, Ravikeerthi G. Chronic suppurative otitis media and sensorineural hearing loss. J Evol Med Dent Sci 2015;4:11595-600.
7. Silva MN, Muller Jdos S, Selaimen FA, et al. Tomographic evaluation of the contralateral ear in patients with severe chronic otitis media. Braz J Otorhinolaryngol 2013;79:475-9.
8. Dornelles C, Schmidt Rosito LP, Meurer L, et al. Hystology findings' correlation between the ossicular chain in the transoperative and cholesteatomas. Braz J Otorhinolaryngol 2007;73:738-43.
9. Lasisi AO, Olaniyan FA, Muibi SA, et al. Clinical and demographic risk factors associated with chronic suppurative otitis media. Int J Pediatr Otorhinolaryngol

2007;71:1549-54.
10. Gulustan F, Yazici ZM, Sayin I, et al. Evaluation of the Presence of Sensorineural Hearing Loss and the Relationship With Intraoperative Findings in Cholesteatoma. Ear Nose Throat J 2021;100:249S-52S.
11. Ali Zaidi SS, Pasha HA, Suhail A, et al. Frequency of Sensorineural hearing loss in chronic suppurative otitis media. J Pak Med Assoc 2016;66:S42-4.
12. Cureoglu S, Schachern PA, Paparella MM, et al. Cochlear changes in chronic otitis media. Laryngoscope 2004;114:622-6.
13. de Zinis LO, Campovecchi C, Gadola E. Fistula of the cochlear labyrinth in noncholesteatomatous chronic otitis media. Otol Neurotol 2005;26:830-3.
14. Luntz M, Yehudai N, Haifler M, et al. Risk factors for sensorineural hearing loss in chronic otitis media. Acta Otolaryngol 2013;133:1173-80.
15. Jesic SD, Jotic AD, Babic BB. Predictors for sensorineural hearing loss in patients with tubotympanic otitis, cholesteatoma, and tympanic membrane retractions. Otol Neurotol 2012;33:934-40.
16. Dobrianskyj FM, Dias Gonçalves ÍR, Tamaoki Y, et al. Correlation Between Sensorineural Hearing Loss and Chronic Otorrhea. Ear Nose Throat J 2019;98:482-5.
17. Redaelli de Zinis LO, Campovecchi C, Parrinello G, et al. Predisposing factors for inner ear hearing loss association with chronic otitis media. Int J Audiol 2005;44:593-8.
18. Nagle SK, Jagade MV, Gandhi SR, et al. Comparative study of outcome of type I tympanoplasty in dry and wet ear. Indian J Otolaryngol Head Neck Surg 2009;61:138-40.
19. Sadasivan SS, Viswanatha B, Satish HS, et al. A comparative study of sensorineural hearing loss in mucosal and squamous type of chronic otitis media. Research in Otolaryngology 2015;4:13-7.
20. Samantaray K, Rout K, Biswal RN. Analytical study of sensorineural hearing loss in CSOM with and without cholesteatoma. L Evid Based Med Health 2016;3:3131-4.
21. Durko M. Air-bone gap and hearing impairment level predictive value in preoperative assessment of cholesteatoma localization in the tympanic cavity. Otolaryngol Pol 2004;58:73-7.
22. Kaur R, Singh SP, Singh J. A Study of Determinants of Sensorineural Hearing Loss in Chronic Suppurative Otitis Media with or without Cholesteatoma. International Journal of Otolaryngology and Head & Neck Surgery 2018;7:148.
23. Weiss NM, Bächinger D, Rrahmani A, et al. Mapping the ChOLE classification to hearing outcomes and disease-specific health-related quality of life. Eur Arch Otorhinolaryngol 2020;277:2729-38.
24. Sanna M, Pandya Y, Mancini F, et al. Petrous bone cholesteatoma: classification, management and review of the literature. Audiol Neurootol 2011;16:124-36.
25. Kuo CL, Shiao AS, Yung M, et al. Updates and knowledge gaps in cholesteatoma research. Biomed Res Int 2015;2015:854024.
26. Martins O, Victor J, Selesnick S. The relationship between individual ossicular status and conductive hearing loss in cholesteatoma. Otol Neurotol 2012;33:387-92.
27. Iqbal J, Ahmad MM, Naeem M. Incidence of the Incus Erosion in Chronic Suppurative Otitis Media with Cholesteatoma. Pakistan Journal of Medical & Health Sciences 2017,11:718-20.
28. Sarmento KMA Jr, Sampaio ALL, Santos TGT, et al. High-frequency conductive hearing loss as a diagnostic test for incomplete ossicular discontinuity in non-cholesteatomatous chronic suppurative otitis media. PLoS One 2017;12:e0189997.
29. de Azevedo AF, Pinto DC, de Souza NJ, et al. Sensorineural hearing loss in chronic suppurative otitis media with and without cholesteatoma. Braz J Otorhinolaryngol 2007;73:671-4.
30. Sadé J, Luntz M. Dynamic measurement of gas composition in the middle ear. II: Steady state values. Acta Otolaryngol 1993;113:353-7.
31. Sakagami M, Maeda A, Node M, et al. Long-term observation on hearing change in patients with chronic otitis media. Auris Nasus Larynx 2000;27:117-20.
32. Kaplan DM, Fliss DM, Kraus M, et al. Audiometric findings in children with chronic suppurative otitis media without cholesteatoma. Int J Pediatr Otorhinolaryngol 1996;35:89-96.

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