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ORIGINAL RESEARCH

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Evaluation of the current bacteriological profile and antibiotic sensitivity pattern in chronic suppurative otitis media

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Abstract

Objective: To determine the current microbiological profile of chronic suppurative otitis media (CSOM), their antimicrobial sensitivity, their resistance pattern to locally available antibiotics and the appropriate antibiotic against isolated microorganisms causing CSOM.

Methods: This cross-sectional study involved 91 ear swab specimens obtained from patients clinically diagnosed with active CSOM. Swabs were cultured for microbial identification according to a standard protocol. We performed antibiotic susceptibility testing, using the modified Kirby-Bauer disc diffusion method, and the diameter of the inhibition zone was interpreted based Clinical Laboratory Standards Institute guidelines.

Results: Microbial growth was seen in 85 (93.4%) samples, but 6 (6.6%) samples had no growth. Among the samples with growth, 63 (69.2%) were monomicrobial, 13 (14.3%) were polymicrobial, and 9 (9.9%) were of mixed growth with more than three microorganisms. The most common bacteria isolated was *Pseudomonas aeruginosa* (32.6%) followed by *Staphylococcus aureus* (16.9%) and *Klebsiella* spp. (5.6%). The most sensitive antibiotics against *P aeruginosa* were ceftazidime, meropenem, piperacillin-tazobactam, and cefepime. *S aureus* showed the highest sensitivity toward rifampin, cefoxitin, and fusidic acid.

Conclusions: The bacteriological profile of CSOM showed a high prevalence of *P aeruginosa*, followed by *S aureus* and *Klebsiella* spp. with different distributions in different age groups. We observed a declining pattern of their antibiotic sensitivity. It is important to be aware of the current trend of the bacteriological profiles and to revise the antibiotic regime according to both the sensitivity and age groups.

Level of Evidence: NA.

KEYWORDS
antibiotic sensitivity, bacterial profile, chronic suppurative otitis media

1 | INTRODUCTION

The World Health Organization defines chronic suppurative otitis media (CSOM) as ear discharge through a perforated tympanic membrane present for more than 12 weeks.[1] It is characterized by a chronic inflammation of the middle ear and mastoid cavity, followed by permanent abnormality of the pars tensa or flaccida. Varying degrees of edema; submucosal fibrosis and hypervascularity; and infiltration with lymphocytes, plasma cells, and histiocytes result in the production of pus discharge.[2] A Malaysian study showed that the prevalence of CSOM among school children was approximately 2%.[3]

CSOM is an important cause of preventable hearing loss. Inadequate treatment can result in severe, life-threatening adverse effects, such as intracranial and extracranial complications. Because CSOM can cause significant morbidity, the identification of the microorganisms responsible for CSOM can help in the selection of the most appropriate antibiotic for the treatment regimen. We conducted a study to evaluate the current bacteriological profile of microorganisms resulting in CSOM and to study their antibiotic sensitivity pattern to available antibiotics.

2 | MATERIALS AND METHODS

2.1 | Study design and participants

We conducted a cross-sectional study in a tertiary hospital from June 1, 2018 to March 31, 2019. The participants with CSOM were selected using a convenience sampling method. We excluded patients with otomycosis, acute otitis externa, cholesteatoma, and tympanostomy tube as well as patients receiving either topical or systemic antibiotic or antifungal treatment within the 2 weeks before sampling.

A detailed clinical history, including age, gender, duration of discharge, and previous antibiotic therapy, was obtained. The data were collected during the consultation and from the patients' medical records. Otoscopy and microscopy examination was performed followed by aural toileting. The character of ear discharge, tympanic membrane perforation, including size and area of tympanic membrane perforation, and middle ear status were recorded.

A sample of ear discharge from the middle ear was collected under aseptic precautions from the perforated tympanic membrane area using a sterile aluminum stick with a 1.5-mm-diameter cotton wool-tipped applicator and an otomicroscope. The collected specimen was placed in Amies transport media and sent to the microbiology laboratory for analysis.

The material was inoculated on blood agar, MacConkey's agar, and chocolate agar. The plate was incubated for 24 to 48 hours. Blood agar and MacConkey's agar were incubated in O_2 medium, and chocolate agar was incubated in a CO_2 medium for 24 to 48 hours.

Microscopic examination was performed to identify microorganisms and their antibiotic sensitivity using the modified Kirby-Bauer disc diffusion technique in Mueller-Hinton agar. The inhibition zone diameter was interpreted following the 2017 Clinical Laboratory Standards Institute guideline.[4,5] Data were collected and recorded and then analyzed using the Statistical Package for Social Science (SPSS) version 24.0.

All participants gave informed consent to participate in the research. The Human Research Ethics Committee of our institution (USM/JEPeM/17120683) and the Medical Research and Ethics Committee, Ministry of Health (NMRR-17-3042-39263[IIR]) approved this study.

All relevant information was analyzed using SPSS version 24.0. Numerical independent variables in the normality distribution were measured using the mean and standard deviation. When the normality distribution was skewed, the statistic was reported as the median and interquartile range (IQR).

The statistical analysis used in this study was descriptive and consisted of categorical data analysis. Frequency and percentage were examined for categorical independent variables.

Fisher's exact test was used for the statistical analysis of the association between age and distribution of isolated microorganisms. A *P* value of <.05 indicated statistical significance.

3 | RESULTS

Table 1 shows the sociodemographic data of the 88 patients involved in this study. The patients ranged in age from 1 to 90 years, with a median of 24 years. The peak incidence of CSOM was observed in patients aged 1 to 10 years (33.0%) and over 40 years (35.1%). Female sex was predominant, with a female: male ratio of 1.9:1. Otomicroscopy revealed unilateral disease in 85 (96.6%) patients and bilateral disease in 3 (3.4%) patients, with an almost equal number of sides affected.

Table 2 displays the characteristics of CSOM in our patients. In 44 (48.4%) patients, ear discharge was mucopurulent and had no odor. Eighty-nine (97.8%) patients had central perforation, and otoscopy revealed that 46 (50.5%) patients had a perforation size of less than 25%.

Table 3 summarizes the microbiological profiles. A total of 91 ear swab samples were collected for microbial identification. Of these, microbial growth was seen in 85 (93.4%) samples, whereas 6 (6.6%) samples showed no microbial growth. Gram-negative microorganisms were more commonly identified than gram-positive bacteria. *Pseudomonas aeruginosa* was the most common isolated microorganism, followed by *Staphylococcus aureus*, *Klebsiella* spp., and *Acinobacter* spp. Polymicrobial organisms were identified in 13 (14.2%) samples.

We observed a different pattern of microorganism predominance among the different age groups, as shown in Table 4. There was a statistically significant association between younger patients with isolated microorganisms, with a *P* value less than .05 using the Fisher exact test ($P = .025$), but there was no significant association in adults.

The antibiotic sensitivity patterns of the gram-positive and gram-negative organisms are shown in Tables 5 and 6. The most sensitive antibiotics against *P aeruginosa* were ceftazidime, meropenem, piperacillin-tazobactam, and cefepime. *S aureus* showed the highest

TABLE 1 Sociodemographic profiles of the study participants (n = 88)

Characteristic	Number of patients (%)
Sex	
Male	30 (34.1)
Female	58 (65.9)
Age distribution, years	
1-10	29 (33.0)
11-20	13 (13.6)
21-40	16 (18.2)
>41	31 (35.1)
Median age, years	24.00 (IQR = 41)
Duration of CSOM, months	
<6	20 (22.7)
6-12	23 (26.1)
>12 months	45 (51.1)
Affected side	
Unilateral	85 (96.6)
Right	43 (48.9)
Left	42 (47.7)
Bilateral	3 (3.4)
Precipitating factors	
Upper respiratory tract infection	49 (55.7)
Allergic rhinitis	24 (27.3)
Nil	15 (17.0)
Associated symptoms	
Hearing loss	40 (45.5)
Pain	9 (10.2)
Itchiness	12 (13.6)
Nil	27 (30.7)

Abbreviation: CSOM: chronic suppurative otitis media.

TABLE 2 Characteristics of chronic suppurative otitis media (CSOM) among the study participants (n = 91)

Characteristic of discharge	No. of ear swabs (%)
Type of ear discharge	
Mucoid	9 (9.9)
Mucopurulent	44 (48.4)
Purulent	38 (41.8)
Blood stained	Nil
Odor	
Foul smelling	2 (2.2)
Nonfoul smelling	89 (97.8)
Size of tympanic membrane perforation, %	
<25	46 (50.5)
26-50	35 (38.5)
51-75	7 (7.7)
>75 (subtotal)	3 (3.3)
Location of perforation	
Marginal	2 (2.2)
Central	89 (97.8)
Attic	Nil
Presence of granulation tissue	
Yes	8 (8.8)
No	83 (91.2)

TABLE 3 Microbiological profiles of chronic suppurative otitis media participants (n = 91)

Type of isolated microorganisms		Frequency (%)
Monomicrobial		63 (69.2)
Polymicrobial		13 (14.3)
Mixed growth		9 (9.9)
No growth		6 (6.6)
Name of isolated microorganisms		No. of isolates (%)
Gram-positive bacteria	*Staphylococcus aureus*	15 (16.9)
	Streptococcus spp.	3 (3.4)
	Enterococcus spp.	1 (1.1)
Gram-negative bacteria	*Pseudomonas aeruginosa*	29 (32.6)
	Klebsiella spp.	5 (5.6)
	Acinetobacter spp.	4 (4.5)
	Proteus spp.	4 (4.5)
	Pseudomonas spp.	4 (4.5)
	Enterobacter spp.	3 (3.4)
	Citrobacter spp.	2 (2.2)
	Escherichia coli	3 (3.4)
	Alcaligenes spp.	2 (2.2)
	Haemophilus influenzae	1 (1.1)
	Serratia marcescens	1 (1.1)
Fungal organisms	*Candida* spp.	7 (7.9)
	Aspergillus spp.	4 (4.5)
	Scedosporium spp.	1 (1.1)

sensitivity to rifampin (100%), fusidic acid (93.3%), and cefoxitin (93.3%), with a decreased sensitivity toward ciprofloxacin (66.7%), gentamicin (80%), chloramphenicol (80%), and trimethoprim-sulfamethoxazole (80%).

4 | DISCUSSION

Irrational use of antibiotics and poor patient compliance, resulting in organism resistance to commonly used drugs, has led to treatment

TABLE 4 Distribution of isolated microorganisms among different age groups (n = 64)

Age, years	Gram-positive microorganisms n (%)	Gram-negative microorganisms n (%)	*P* value
0-10	3 (14.3)	18 (85.7)	.025[a]
11-20	6 (54.5)	5 (45.5)	
21-40	4 (33.3)	8 (66.7)	.573[a]
>41	6 (30.0)	14 (70.0)	

[a]Fisher's exact test was applied.

TABLE 5 Antibiotic sensitivity pattern of gram-positive microorganisms (n = 18)

Antibiotic	*Staphylococcus aureus* (n = 15)	*Streptococcus* spp. (n = 3)
Trimethoprim-sulfamethoxazole	12 (80.0)	1 (33.3)
Clindamycin	12 (80.0)	3 (100)
Erythromycin	12 (80.0)	3 (100)
Chloramphenicol	12 (80.0)	3 (100)
Fusidic acid	14 (93.3)	—
Penicillin G	2 (13.3)	3 (100)
Gentamicin	12 (80.0)	—
Rifampin	15 (100)	—
Cefoxitin	14 (93.3)	—
Ciprofloxacin	10 (66.7)	—
Cephalexin	—	3 (100)
Chloramphenicol	—	2 (66.7)
Tetracycline	—	1 (33.3)

failure. The doubt regarding the possibility of the emergence of bacterial resistance following prolonged use of ototopical medications was also raised in persistent otorrhoea. Therefore, there is a need to re-evaluate the sensitivity and resistance of isolated bacteria toward available antibiotics. By determining the sensitivity strength of different antibiotics toward the most common isolated organisms, we can revise our antibiotic regimen for CSOM to ensure the most efficient and cost effective treatment protocol. The revision will prevent recurrent and further complications of CSOM by initiating the most appropriate antibiotic treatment.

In our study, the median patient age was 24.0 (IQR = 41). There were two peaks age of incidence, between 1 and 10 years and over 40 years. Bakari et al and Chirwa et al showed that CSOM occurs mostly within the first 5 years of life.[6,7] The high prevalence of CSOM in children may be attributed to the fact their Eustachian tubes are shorter, narrower, and more horizontal as compared with the adult ear.[2] This anatomical difference makes children more vulnerable to ear infections.[1] This age group is also more prone to upper respiratory tract infections (URTIs), which can progress to ear infections.[8] On the contrary, a study conducted by Loy et al. in Singapore showed a different prevalent age group, whereby the disease was more common among patients aged 31 to 40 years.[9]

Our study found that females were more commonly affected than males, with a male: female ratio of 1:1.9. This result is similar to other studies conducted in Pakistan and Malaysia.[10-12] Female predominance may be attributed to the increase of health awareness among women, whereby they tend to seek earlier treatment. However, several studies have shown a male predominance, which can be attributed to their active lifestyles, such as swimming or diving activities.[6,8,13] Soiling of the middle ear from swimming can lead to intermittent ear discharge and recurrent infection.

In the present study, 55.7% patients developed active CSOM following URTIs. Koch et al. also revealed that URTIs increase the risk of CSOM.[14] Respiratory pathogens, such as *Streptococcus pneumoniae*, *S aureus*, and *Haemophilus influenza*, can be insufflated into the middle ear from the nasopharynx via the Eustachian tube during URTI spells.[1]

Allergic rhinitis may cause inflammation of the nasal mucosa leading to edema of the Eustachian tube opening. Nasal obstruction can increase the negative pressure of the nasopharynx, leading to further blockage of the Eustachian tube. Both effects result in the development of negative middle ear pressure. In a recent study conducted by Md Daud et al,[15] a significant association between CSOM and allergy was reported ($P = .001$). In our study, 27.3% patients developed active CSOM during exacerbation of allergic rhinitis, especially when they had poor control of allergens.

In our study, most of the ear discharge was mucopurulent and did not have an odor. Otoendoscopy revealed that 50.5% patients had a perforation size of less than 25%; the majority were central tympanic membrane perforation. Only 2.2% patients had marginal perforation. Granulation tissue was identified in 8.8% ears. On the contrary, a study conducted in South Africa showed a higher incidence of granulation tissue in CSOM, occurring in about 37.2% of patients.[16]

The most significant sequelae of CSOM is mild to moderate conductive hearing loss, which has been reported in 50% of cases.[1] The present study also showed a similar finding, whereby 45.4% of our patients had associated symptoms of hearing loss. In long-standing and frequent episodes of active CSOM, inflammatory mediators generated during CSOM can penetrate into the inner ear through the round window. This can result in the loss of hair cells in the cochlea, leading to mixed conductive and sensorineural hearing loss.[2,17]

In practice, bacterial cultures may not be required to diagnose CSOM; exhaustive studies have established that 90% to 100% of chronic draining ears yield two or more isolates consisting of both aerobic and anaerobic bacteria.[1,7] Most prescribed treatments might eradicate middle ear bacteria successfully, but this does not guarantee the nonrecurrence of otorrhoea or complete resolution of the CSOM. However, bacterial cultures are recommended, especially in cases of recalcitrant infection or when bacterial resistance is suspected.

The microbiology profile in our study population revealed that 69.2% of the isolated organisms were monomicrobial, 14.3% were polymicrobial, and only 6.6% were mixed growth of more than three microorganisms. In general, gram-negative aerobes were more

TABLE 6 Antibiotic sensitivity patterns of gram-negative microorganisms (n = 48)

Antibiotic	*P. aeruginosa* (n = 29)	*Klebsiella* spp. (n = 5)	*Acinetobacter* spp. (n = 4)	*Proteus* spp. (n = 4)	*E. coli* (n = 3)	*Enterobacter* spp. (n = 3)
Amikacin	23 (79.3)	5 (100)	4 (100)	4 (100)	3 (100)	3 (100)
Ceftriaxone	—	4 (80.0)	—	4 (100)	3 (100)	3 (100)
Cefuroxime	—	4 (80.0)	—	4 (100)	3 (100)	1 (33.3)
Ceftazidime	29 (100)	4 (80.0)	4 (100)	4 (100)	3 (100)	3 (100)
Cefotaxime	—	4 (80.0)	—	4 (100)	3 (100)	3 (100)
Imipenem	28 (96.6)	5 (100)	3 (75.0)	4 (100)	3(100)	3 (100)
Meropenem	29 (100)	—	3 (75.0)	—	—	—
Ciprofloxacin	27 (93.1)	4 (80.0)	3 (75.0)	3 (75.0)	3 (100)	3 (100)
Piperacillin-tazobactam	29 (100)	5 (100)	4 (100)	4 (100)	3 (100)	2 (66.7)
Cefepime	29 (100)	4 (80.0)	—	4 (100)	3 (100)	3 (100)
Gentamicin	25 (86.2)	5 (100)	4 (100)	4 (100)	2 (66.7)	3 (100)
Chloramphenicol	—	5 (100)	—	1 (25.0)	2 (66.7)	2 (66.7)
Amoxillin clavulanate	—	4 (80.0)	—	3 (75.0)	3 (100)	1 (33.3)
Ampicillin	—	0 (0)	4 (100)	1 (25.0)	1 (33.3)	1 (33.3)
Trimethoprim-sulfamethazole	—	4 (80.0)	—	1 (25.0)	2 (66.7)	3 (100)

common than gram-positive aerobes. Our study showed a different distribution of isolated aerobes among patients of different age groups. Patients younger than 10 years had a more predominant growth of gram-negative microorganisms, whereas patients age 10 to 20 years had a predominant growth of gram-positive bacteria ($P = .025$). However, there was no statistically significant difference in the older age group. In contrast, in their study in Malawi, Chirwa et al. showed a nonsignificant association between age and causative pathogen of CSOM.[7]

The most common microorganism isolated in our study was *P aeruginosa* (32.6%), followed by *S aureus* (16.9%). This finding is similar to other bacteriological studies of CSOM conducted in countries such as Ghana, Greece, Singapore, and eastern Nepal.[9,13,18] Our findings were corroborated in studies conducted in Nigeria, Sri Lanka, India, Pakistan, and South Asia.[11,13,19-21]

A higher incidence of *P aeruginosa* is a concern. Although *P aeruginosa* is a common colonizer in the external auditory canal, this organism can cause nosocomial infections and has developed resistance to many potent antibiotics.[9] These bacteria can also cause progressive destruction of the middle ear and mastoid structure by releasing their toxins and enzymes.

However, other studies have reported that *S aureus* was the most commonly detected pathogen, followed by *P aeruginosa*.[22-25] A study conducted by Bakari et al. in Nigeria found that the most prevalent organisms causing CSOM were coliform bacteria.[6] *Klebsiella* spp. was the most common, followed by *Escherichia coli*. In studies performed in Malawi, Kenya, and Ethiopia, *Proteus mirabilis* was the most common isolated bacteria, ranging from 28.6% to 32.7% of samples.[7,26]

This study also revealed fungal growth in 13.3% samples. The most common of these was *Candida* spp. 7.7%, followed by *Aspergillus* spp. 4.5%. This finding is similar to other studies, but different types of fungus were isolated.[7,27] Our local study revealed that the incidence of fungal infection in persistent middle ear discharge was only 5.0%.[12] Because fungi grow well in the moist ear, fungal infection is common in a middle ear infection. Therefore, the superimposed fungal infection should be suspected when antibiotic treatment for CSOM results in poor improvement.

This study revealed that *P aeruginosa* showed 100% sensitivity to ceftazidime, meropenem, piperacillin-tazobactam, and cefepime. However, there was reduced sensitivity to commonly prescribed antipseudomonal agents, such as gentamicin (86.2%) and ciprofloxacin (93.1%).

A study conducted in Pakistan showed that *P aeruginosa* has an increased rate of resistance toward fluoroquinolones (48.7%), followed by antipseudomonal penicillin (41.7%) and carbapenems (29.4%).[11] A study in Korea showed that 46.3% of *P aeruginosa* were susceptible to the entire 10 antibiotics tested, and 53.7% were resistant to >1 antibiotic.[28] Resistance to aminoglycosides and quinolones was higher than that to other antibiotics.

S aureus showed the highest sensitivity to rifampin (100%), fusidic acid (93.3%), and cefoxitin (93.3%), with declined sensitivity toward ciprofloxacin (66.7%), gentamicin (80%), chloramphenicol (80%), and trimethoprim-sulfamethoxazole (80%). This is consistent with a study conducted in South Korea, which revealed the increasing antibiotic resistance pattern of *S aureus* with an increasing MRSA rate.[29] This study suggested that continuous and periodic surveillance of MRSA is necessary to reduce the spread of antibiotic-resistant pathogens and to guide appropriate antibacterial therapy.

In routine practice, patients with draining ears receive topical antibiotic ear drops, and ear swab culture is performed only in recalcitrant cases. Apart from patient negligence, the widespread and indiscriminate use of antibiotics also precipitates the emergence of multiple resistant strains of bacteria, resulting in treatment failure. Infection with multidrug-resistant pathogens is responsible for the increased duration of treatment and follow-up as well as increased cost of management. The present study focuses on causative agent for CSOM which are usually from community, therefore their susceptibility pattern might be different from hospital antibiogram. Even though the bacterial pathogens were already defined but the different distributions in different age groups and the declining pattern of antibiotic sensitivity were something important that may be considered in the management of the patients. An interesting future study would be to see whether the bacteriological profile of microorganisms and their antibiotic sensitivity pattern are affected by the size and chronicity of perforation as well as the character of drainage.

5 | CONCLUSION

The bacteriological profile of CSOM in our study showed a high prevalence of *P aeruginosa*, followed by *S aureus* and *Klebsiella* spp. with different distributions in different age groups. We observed a declining pattern in their sensitivity toward commonly used antibiotics. It is important to be aware of the current trend of the bacteriological profiles and to revise the antibiotic regime according to both the sensitivity and age groups.

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CONFLICT OF INTEREST

The authors declare no conflict of interest regarding this study.

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