

Hearing loss and complications in chronic suppurative otitis media: influence of mastoid pneumatization, microbiological profile, and treatment delay

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Abstract: *Background:* Chronic suppurative otitis media (CSOM) remains a major cause of preventable hearing loss and otologic morbidity in developing countries. Delayed presentation, recurrent infections, and associated complications contribute significantly to disease burden. Factors such as mastoid pneumatization, virulence of infecting organisms, and delay in treatment may influence disease severity and outcomes. *Aim and Objectives:* To assess the pattern and severity of hearing loss in CSOM, evaluate the frequency of intratemporal and extratemporal complications, and determine their association with mastoid pneumatization, bacterial infection, and delay in initiation of treatment. *Methods:* A clinical observational study was conducted among 67 patients with CSOM attending the Department of Otorhinolaryngology of a tertiary care hospital. All patients underwent detailed clinical and otoscopic examination, radiological assessment of mastoid pneumatization, microbiological analysis of ear discharge, and pure tone audiometry. Hearing loss was classified according to type and degree, while complications were categorized as intratemporal or extratemporal. The interval between symptom onset and initiation of treatment was recorded and analysed. *Results:* Most patients were young and middle-aged adults, with tubotympanic disease being more common than atticotympanic disease. Conductive hearing loss was the predominant type, and mild-to-moderate hearing impairment was observed in the majority of cases. Complications occurred more frequently in atticotympanic disease, with intratemporal complications being more common than extratemporal complications. Poor mastoid pneumatization was associated with a higher incidence of complications. Gram-negative organisms, particularly *Pseudomonas aeruginosa* and *Klebsiella* species, were more frequently linked to severe disease and complications than Gram-positive organisms. Delayed initiation of treatment was also significantly associated with increased complication rates. *Conclusion:* CSOM continues to be an important cause of hearing impairment, predominantly resulting in conductive hearing loss. Reduced mastoid pneumatization, infection with virulent Gram-negative organisms, and delayed treatment increase the risk of intratemporal and extratemporal complications. Early diagnosis, appropriate antimicrobial therapy, radiological evaluation, and timely intervention are essential to prevent complications and irreversible hearing loss.

Keywords: CSOM, Intratemporal, Extra temporal, Mastoidectomy and Attico-antral disease.

Introduction

Chronic suppurative otitis media (CSOM) is a persistent inflammatory disease of the middle ear cleft characterized by recurrent or continuous otorrhoea through a perforated tympanic membrane. Despite being largely preventable and treatable, CSOM continues to represent a major public health problem, particularly in low and

middle income countries (LMICs). The World Health Organization recognizes CSOM as a neglected condition due to its high prevalence, early onset, prolonged course, and significant impact on hearing, communication, educational attainment, and quality of life [1]. Globally, CSOM affects an estimated 65-330 million individuals, with nearly 60% experiencing clinically significant hearing

impairment [2]. The burden is disproportionately higher in South Asia, Sub-Saharan Africa, and the Western Pacific region, where overcrowding, poor sanitation, recurrent upper respiratory infections, and limited access to healthcare services are common [3].

India contributes substantially to the global burden, with reported prevalence ranging from 2% to 7.8% in community-based studies [4-5]. The disease burden is particularly pronounced in rural and peri-urban populations, where delayed diagnosis and inconsistent treatment remain common [6]. Hearing impairment is the most significant and disabling consequence of CSOM. The WHO estimates that more than half of CSOM-related hearing loss is preventable through early diagnosis and appropriate management [1]. Conductive hearing loss is the predominant type and results from tympanic membrane perforation, ossicular chain erosion, chronic mucosal inflammation, and middle ear effusion. The degree of hearing loss varies according to perforation size and site, disease duration, frequency of infection, and ossicular involvement [7]. In long-standing disease, mixed hearing loss may occur due to secondary cochlear damage caused by inflammatory mediators and bacterial toxins crossing the round window membrane [8]. Such sensorineural involvement is often irreversible and adversely affects long-term auditory outcomes.

The epidemiology of CSOM is closely linked to socioeconomic and environmental determinants. Poverty, overcrowding, malnutrition, poor sanitation, and inadequate healthcare access are consistently associated with increased prevalence and disease severity [9]. Environmental factors such as indoor air pollution, passive smoking, and recurrent respiratory infections contribute to Eustachian tube dysfunction, creating a favourable milieu for chronic middle ear infection [10]. Limitations within primary healthcare systems, including lack of trained personnel and diagnostic equipment, often lead to delayed referral and advanced disease at presentation [11]. CSOM may be complicated by a range of intratemporal and extratemporal complications. Intratemporal complications include mastoiditis, facial nerve paralysis, labyrinthitis, and petrositis, while extratemporal complications include meningitis, brain abscess, lateral sinus

thrombosis, and otitic hydrocephalus [12]. Although their incidence has declined with antibiotic use, complications continue to occur, particularly in patients with atticointral disease and cholesteatoma. Delayed presentation and inadequate treatment remain major contributors [13].

Recent literature highlights the role of mastoid pneumatization, microbiological profile, and treatment delay in determining disease severity and complication risk. Poor mastoid pneumatization has been associated with aggressive disease behaviour, increased complication rates, and poorer surgical outcomes due to limited buffering capacity against infection [14-16]. Gram-negative bacilli, particularly *Pseudomonas aeruginosa* and *Klebsiella* species, predominate in complicated CSOM and are associated with greater virulence, biofilm formation, and antibiotic resistance, leading to chronicity and higher complication rates [17-19]. Delay in initiating appropriate treatment allows sustained inflammation, ossicular erosion, and intracranial spread, and is consistently associated with increased morbidity in LMIC settings [20].

The present study was undertaken to assess hearing loss patterns using pure tone audiometry and to evaluate the frequency and nature of intratemporal and extratemporal complications in CSOM, with specific emphasis on mastoid pneumatization, infecting organisms, and treatment delay, in patients presenting to a tertiary care teaching hospital.

Material and Methods

Study Design and Setting: This hospital-based clinical observational study was conducted in the Department of Otorhinolaryngology of Viswabharathi Medical College and General Hospital, Kurnool, A.P. a tertiary care teaching hospital in India, serving both urban and rural populations and functioning as a referral centre for otological disorders.

Study Period and Population: The study was carried out over ten months January 2025 to December 2025 All patients attending the ENT outpatient department during the study

period and clinically diagnosed with chronic suppurative otitis media (CSOM) were screened for inclusion.

Sample Size and Sampling: A total of 67 consecutive patients fulfilling the eligibility criteria were enrolled using a consecutive sampling method.

Inclusion and Exclusion Criteria: Patients aged ≥ 10 years of either sex with CSOM defined as tympanic membrane perforation with or without otorrhea persisting for more than six weeks who provided informed consent were included. Patients with acute otitis media, otitis externa or otomycosis without middle ear involvement, previously operated middle ear cases, congenital ear anomalies, pre-existing sensorineural hearing loss due to other causes, or incomplete records were excluded.

Definitions and Classification: CSOM was classified into tubotympanic disease (pars tensa involvement without cholesteatoma) and atticotympanic disease (pars flaccida or posterosuperior quadrant involvement with or without cholesteatoma). Hearing loss was categorized as conductive, sensorineural, or mixed, and graded by pure tone average (PTA) into mild, moderate, moderately severe, severe, or profound loss. Complications were categorized as intratemporal (mastoiditis, facial nerve paralysis, labyrinthitis, petrositis) or extratemporal (meningitis, brain abscess, lateral sinus thrombosis, otitic hydrocephalus).

Clinical and Otoloscopic Evaluation: All patients underwent detailed clinical assessment including demographic details, duration and nature of ear discharge, hearing complaints, laterality, and associated symptoms. Otoloscopic examination assessed the site and size of tympanic membrane perforation, presence of discharge, granulation tissue, or cholesteatoma, allowing classification into tubotympanic or atticotympanic disease.

Audiological Assessment: Pure tone audiometry was performed using a calibrated audiometer in a sound-treated room. Air- and bone-conduction thresholds were measured at 500, 1000, 2000, and 4000 Hz, and PTA was calculated. Audiological testing was conducted during periods of minimal or absent discharge whenever possible.

Assessment of Complications and Risk Factors: Patients were evaluated for intratemporal & extratemporal complications through clinical examination and radiological investigations (mastoid radiographs or CT temporal bone) when indicated. Mastoid pneumatization was categorized as well pneumatized or poorly pneumatized/sclerotic. Microbiological data, where available, were grouped into Gram-positive cocci and Gram-negative bacilli. Delay in treatment was defined as symptom duration exceeding six months prior to definitive care.

Data Analysis and Ethics: Data were analysed using statistical software. Categorical variables were expressed as frequencies and percentages. Associations were tested using appropriate statistical tests, with $p < 0.05$ considered statistically significant. Institutional Ethics Committee approval was obtained, informed consent was secured, and confidentiality was maintained in accordance with the Declaration of Helsinki.

Results

Demographic Profile: A total of 67 patients diagnosed with chronic suppurative otitis media (CSOM) were included in the study. Males constituted a slightly higher proportion of the study population than females. The majority of patients belonged to the economically productive age group of 21-40 years. Younger patients aged 10-20 years also represented a substantial proportion of cases, while relatively few patients were older than 50 years. The demographic distribution suggests that CSOM predominantly affects adolescents and young to middle-aged adults attending tertiary care centres.

Table-1: Age and Sex Distribution (n = 67)

Age Group (years)	Male	Female	Total (%)
10-20	08	06	14 (20.9)
21-30	12	09	21 (31.3)
31-40	10	08	18 (26.9)
41-50	06	04	10 (14.9)
>50	02	02	4 (6.0)

Inference: CSOM was most prevalent in the 21-40-year age group (58.2%), with a slight male predominance (56.7%) (Table-1).

Disease Characteristics: CSOM was classified into tubotympanic and atticoantral disease based on clinical and otoscopic findings. Tubotympanic disease represented the majority of cases in the present study. Atticoantral disease constituted approximately one-fourth of the study population. The predominance of tubotympanic disease is consistent with its higher prevalence in routine clinical practice. However, atticoantral disease remains clinically important because of its greater tendency to produce complications.

Table-2: Type of CSOM (n = 67)		
Type	Number	Percentage (%)
Tubotympanic	49	73.1
Atticoantral	18	26.9

Inference: Tubotympanic CSOM was the most common clinical type, accounting for nearly three-fourths of all cases (Table-2).

Hearing Outcomes: Assessment of hearing impairment was performed using pure tone audiometry. Conductive hearing loss was the predominant pattern observed, reflecting the pathology of the middle ear and tympanic membrane. Mixed hearing loss was less common, while pure sensorineural hearing loss was relatively rare. Analysis of hearing thresholds demonstrated that moderate hearing loss was the most frequent degree of impairment. Severe and profound hearing losses were observed in a smaller proportion of patients, indicating advanced disease.

Inference: Conductive hearing loss was the predominant auditory deficit, affecting more than two-thirds of patients (Table-3).

Table-3: Type of Hearing Loss (n = 67)		
Type	Number	Percentage (%)
Conductive	46	68.7
Mixed	15	22.4
Sensorineural	06	8.9

Table-4: Degree of Hearing Loss (n = 67)		
Degree	Number	Percentage (%)
Mild	18	26.9
Moderate	25	37.3
Moderately Severe	14	20.9
Severe	08	11.9
Profound	02	3.0

Inference: Moderate hearing loss was the most common degree of impairment, followed by mild and moderately severe hearing loss (Table-4).

Complications: The occurrence of intratemporal & extratemporal complications was evaluated in relation to disease type and selected risk factors. Overall, complications were observed in 19 patients (28.4%). Intratemporal complications occurred more frequently than extratemporal complications. Atticoantral disease demonstrated a markedly higher rate of complications compared with tubotympanic disease. Poor mastoid pneumatization, Gram-negative bacterial infection, and treatment delay exceeding six months were significantly associated with an increased risk of complications.

Table-5: Distribution of Complications and Association with Disease Type and Risk Factors (n = 67)				
A. Distribution of Complications According to Type of CSOM				
Type of CSOM	No Complication	Intratemporal	Extratemporal	Total
Tubotympanic	42	06	01	49
Atticoantral	06	08	04	18

B. Association of Selected Risk Factors with Complications			
Variable	Complications n (%)	No Complications n (%)	p-value
Poor Mastoid Pneumatization	17 (44.7)	21 (55.3)	0.02
Gram-negative Infection	16 (44.4)	20 (55.6)	0.01
Treatment Delay >6 Months	18 (46.2)	21 (53.8)	<0.001
Some patients experienced more than one complication.			

Inference: Complications were significantly more common in atticotranal disease. Poor mastoid pneumatization, infection with Gram-negative organisms, and delayed initiation of treatment were important risk factors associated with increased occurrence of intratemporal and extratemporal complications (Table-5A & B).

Discussion

This hospital-based observational study highlights the continued burden of hearing morbidity and complications among patients with chronic suppurative otitis media (CSOM) presenting to a tertiary care centre. Despite advances in antimicrobial therapy and surgical techniques, CSOM remains a leading cause of preventable hearing loss and a significant contributor to intratemporal and extratemporal complications, particularly in patients with unfavourable mastoid anatomy, virulent bacterial infection, and delayed initiation of definitive treatment [21-22].

Burden and Pattern of Complications: In the present cohort, intratemporal complications were more frequent than extratemporal complications, a pattern consistent with recent otological literature [23-24]. Facial nerve paralysis, labyrinthitis, and mastoiditis continue to predominate, while intracranial complications, though less common, persist in patients with advanced disease and delayed presentation. The significantly higher complication rate observed in atticotranal disease reinforces the established association between cholesteatoma, bone erosion, and aggressive disease behaviour [25].

Mastoid Pneumatization as an Anatomical Risk Factor: Poor mastoid pneumatization emerged as a significant anatomical determinant of complications. Patients with sclerotic or poorly pneumatized mastoids demonstrated a significantly higher incidence of intratemporal and extratemporal complications compared to those with well-pneumatized mastoids ($p = 0.02$). Reduced mastoid aeration compromises ventilation and drainage, facilitating persistent infection and limiting the buffering capacity of the mastoid air cell system. Radiological studies have consistently linked poor pneumatization with atticotranal disease, cholesteatoma formation, and increased risk of facial nerve and

intracranial complications [26-27]. The present findings support routine radiological assessment of mastoid pneumatization as part of risk stratification in CSOM.

Microbiological Profile and Disease Aggressiveness: The microbiological profile significantly influenced disease severity. Gram-negative bacilli, particularly *Pseudomonas aeruginosa* and *Klebsiella* species, were associated with a significantly higher complication rate compared to Gram-positive organisms ($p = 0.01$). These pathogens are known for biofilm formation, toxin production, and antimicrobial resistance, contributing to chronicity and bone erosion. Recent studies consistently report a predominance of Gram-negative organisms in complicated CSOM, whereas *Staphylococcus aureus* and *Streptococcus* species are more frequently associated with uncomplicated disease [28-30]. These findings underscore the importance of early culture-directed antibiotic therapy in patients with active or refractory disease.

Delay in Initiation of Treatment: Delay in initiating appropriate treatment was identified as the strongest modifiable risk factor for complications. Patients presenting after more than six months of symptom onset had a significantly higher incidence of both intratemporal & extratemporal complications ($p < 0.001$). Prolonged untreated disease allows sustained inflammation, progressive ossicular erosion, cholesteatoma expansion, and eventual spread beyond the middle ear cleft. Studies from India and other low- and middle-income countries consistently demonstrate a strong association between delayed presentation and increased CSOM-related morbidity [31-33]. Addressing barriers such as low health literacy, socioeconomic constraints, and inadequate primary ear care services remains critical.

Hearing Loss Patterns and Clinical Implications: Conductive hearing loss was the predominant auditory deficit, reflecting tympanic membrane perforation, ossicular chain damage, and middle ear mucosal disease. However, the presence of mixed and sensorineural hearing loss in long-standing

cases suggests secondary cochlear involvement, likely due to diffusion of inflammatory mediators and bacterial toxins through the round window membrane [34-37]. These findings emphasise the importance of early disease control and routine audiological assessment to prevent irreversible auditory damage.

Strengths and Limitations: The strengths of this study include its real-world clinical setting and integrated evaluation of anatomical, microbiological, and healthcare-related risk factors. Limitations include the modest sample size, single-centre design, and absence of multivariable analysis, which may limit generalisability. Nonetheless, the findings provide clinically relevant insights into risk stratification and management priorities in CSOM.

Conclusion

This study confirms that chronic suppurative otitis media (CSOM) remains a significant cause of hearing impairment and otologic morbidity in the studied population. Conductive hearing loss was the predominant auditory deficit, affecting 68.7% of patients, while moderate hearing loss was the most common degree of impairment, observed in 37.3% of cases. Complications

occurred in 28.4% of patients, with intratemporal complications (20.9%) being more frequent than extratemporal complications (7.5%). Atticoantral disease demonstrated a substantially higher risk of complications compared to tubotympanic disease. Poor mastoid pneumatization was significantly associated with adverse outcomes and increased complication rates.

Gram-negative bacterial infections, particularly *Pseudomonas aeruginosa* and *Klebsiella* species, were strongly associated with severe disease and complications. Delayed initiation of treatment beyond six months emerged as the most important modifiable risk factor for disease progression and morbidity. The findings emphasize the importance of comprehensive evaluation incorporating audiological, radiological, and microbiological parameters for early risk stratification. Timely diagnosis, culture-directed antimicrobial therapy, and appropriate surgical intervention are essential to prevent irreversible hearing loss and life-threatening complications. Strengthening primary ear care services and promoting early referral can substantially reduce the burden of CSOM and improve patient outcomes.

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