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Antimicrobial Resistance in Chronic Suppurative Otitis Media: Current Challenges and Future Perspectives

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Abstract

Chronic suppurative otitis media (CSOM) is a chronic inflammatory disease of the middle ear characterized by persistent or recurrent ear discharge through a perforated tympanic membrane. It remains a major public health problem, particularly in developing countries, and is associated with significant morbidity including hearing loss, speech impairment, poor scholastic performance, and intracranial complications. The emergence of antimicrobial resistance among bacterial pathogens causing CSOM has become an important therapeutic challenge worldwide. Common causative organisms such as Pseudomonas aeruginosa and Staphylococcus aureus increasingly demonstrate multidrug resistance due to irrational antibiotic use, incomplete treatment, biofilm formation, and widespread empirical therapy. Biofilm-associated infections contribute significantly to chronicity and treatment failure. Increasing resistance to fluoroquinolones, cephalosporins, and aminoglycosides has limited the effectiveness of conventional therapies. Culture-guided antimicrobial therapy and antimicrobial stewardship are therefore essential for effective management. Recent advances including anti-biofilm agents, bacteriophage therapy, and nanotechnology-based drug delivery systems show promising future potential. This review discusses the epidemiology, microbiology, mechanisms of antimicrobial resistance, diagnostic approaches, current treatment modalities, and emerging therapeutic strategies for antimicrobial-resistant CSOM.

Keywords: *Chronic suppurative otitis media, antimicrobial resistance, Pseudomonas aeruginosa, multidrug resistance, biofilm, otorrhea*

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Introduction

Chronic suppurative otitis media (CSOM) is a chronic inflammation of the middle ear characterized by persistent or recurrent ear discharge through a perforated tympanic membrane for more than 6 weeks [1]. It remains one of the most common chronic infectious diseases encountered in otorhinolaryngology practice and is a major cause of preventable hearing loss worldwide [2]. The disease predominantly affects children and individuals from low socioeconomic backgrounds, especially in developing countries where overcrowding, poor hygiene, malnutrition, and limited healthcare access are common [3].

The World Health Organization recognizes CSOM as a significant public health problem because of its association with hearing impairment, delayed speech development, poor academic performance, and serious intracranial complications [4]. Persistent middle ear infection usually develops following unresolved acute otitis media, recurrent upper respiratory tract infections, Eustachian tube dysfunction, or chronic microbial colonization [5].

In recent years, antimicrobial resistance (AMR) among CSOM pathogens has emerged as a major therapeutic challenge. Irrational antibiotic use, over-the-counter availability of antimicrobial agents, incomplete treatment courses, and empirical therapy without culture sensitivity testing have contributed significantly to the emergence of multidrug-resistant organisms [6]. Resistant pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA) and multidrug-resistant *Pseudomonas aeruginosa* are increasingly reported worldwide [7]. Biofilm formation further complicates disease management by protecting microorganisms from host immune responses and limiting antibiotic penetration [8].

Epidemiology

CSOM is highly prevalent in low- and middle-income countries, particularly in South Asia and Sub-Saharan Africa [2]. Children are more susceptible because of immature immunity, recurrent respiratory infections, and anatomical predisposition related to shorter Eustachian tubes [9]. In India, CSOM remains an important cause of hearing impairment among school-aged children [10].

Major risk factors associated with CSOM include low socioeconomic status, overcrowding, poor sanitation, malnutrition, passive smoking, recurrent upper respiratory infections, and inadequate healthcare access [11].

Etiopathogenesis

CSOM commonly develops as a sequela of inadequately treated acute otitis media. Persistent inflammation leads to tympanic membrane perforation and chronic mucosal changes within the middle ear cleft [5]. The disease process involves Eustachian tube dysfunction, chronic bacterial colonization, impaired host immunity, and recurrent infections.

Biofilm formation plays a critical role in chronicity and antimicrobial resistance. Biofilms are structured bacterial communities embedded within an extracellular matrix that protects organisms from antibiotics and immune responses [8].

Microbiological Profile

The microbiological spectrum of CSOM varies geographically and according to local antibiotic practices [12]. The most commonly isolated organisms include: Pseudomonas aeruginosa, Staphylococcus aureus, Proteus mirabilis, Klebsiella pneumoniae, Escherichia coli.

Among these, *Pseudomonas aeruginosa* is the predominant pathogen because of its ability to survive in moist environments and produce biofilms [13]. MRSA has also emerged as an important resistant pathogen associated with poor treatment outcomes [7]. Fungal organisms such as *Candida* and *Aspergillus* species may occasionally be isolated, especially after prolonged topical antibiotic use [14].

Mechanisms of Antimicrobial Resistance

Antimicrobial resistance in CSOM occurs through multiple mechanisms:

Biofilm Formation

Biofilms reduce antibiotic penetration and bacterial metabolic activity, making eradication difficult [8].

Enzymatic Drug Inactivation

Many organisms produce β-lactamases and extended-spectrum β-lactamases (ESBLs), which inactivate β-lactam antibiotics [15].

Efflux Pumps and Genetic Mutations

Efflux pump systems actively expel antibiotics from bacterial cells, while genetic mutations alter antibiotic target sites and contribute to resistance against fluoroquinolones and aminoglycosides [16].

Irrational Antibiotic Usage

Overuse and misuse of antibiotics remain major contributors to antimicrobial resistance in CSOM [6].

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Current Resistance Patterns

Recent studies have demonstrated increasing resistance among CSOM pathogens to commonly prescribed antibiotics [17]. *Pseudomonas aeruginosa* frequently exhibits resistance to ciprofloxacin, gentamicin, and cephalosporins, while MRSA strains show resistance to penicillins and macrolides [18].

Better sensitivity has been observed with piperacillin-tazobactam, carbapenems, vancomycin, and linezolid in resistant infections [19].

Clinical Implications

Persistent resistant infection can result in chronic otorrhea, conductive hearing loss, delayed speech development, mastoiditis, facial nerve palsy, and intracranial complications [20].

Diagnostic Approaches

Diagnosis of resistant CSOM requires detailed clinical and microbiological evaluation. Important investigations include otoscopic examination, pure tone audiometry, culture and sensitivity testing, and imaging studies when complications are suspected [21]. High-resolution computed tomography (HRCT) of the temporal bone is useful in detecting cholesteatoma, ossicular erosion, and intracranial complications [22].

Treatment Strategies

Medical Management

Aural toilet remains an essential component of therapy by removing debris and improving antibiotic penetration [23]. Topical fluoroquinolones such as ciprofloxacin and ofloxacin are commonly used because of their broad-spectrum activity and low ototoxicity [24].

Surgical Management

Surgical intervention is indicated in persistent disease, cholesteatoma, hearing loss, failed medical therapy, or complications [25]. Common procedures include tympanoplasty and mastoidectomy, which aim to eradicate infection and restore hearing function.

Emerging Therapeutic Approaches

Novel anti-biofilm agents and bacteriophage therapy are being investigated as potential treatments for multidrug-resistant infections [26]. Nanotechnology-based drug delivery systems may improve targeted antibiotic delivery within the middle ear [27].

Antimicrobial stewardship programs are essential to reduce irrational antibiotic usage and slow the emergence of resistance [28]. Vaccination against respiratory pathogens may also help reduce recurrent otitis media and progression to CSOM [29].

Conclusion

Antimicrobial resistance in chronic suppurative otitis media has become a major global healthcare challenge. Increasing multidrug resistance among common pathogens such as *Pseudomonas aeruginosa* and *Staphylococcus aureus* complicates treatment and increases disease burden. Biofilm formation, irrational antibiotic use, and poor antimicrobial stewardship significantly contribute to persistent infection and treatment failure. Early microbiological diagnosis, culture-guided therapy, rational antibiotic use, and timely surgical intervention remain essential for effective management. Emerging therapies including anti-biofilm agents, bacteriophage therapy, and nanoparticle-based drug delivery systems may provide promising future solutions.

Author Contribution

All authors contributed equally.

Conflict of Interest

Nil.

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