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Original Research Article

An Observational Study to Detect Antibiotic Resistance in the Isolates from Middle Ear Infections with Special Reference to MRSA, ESBL and MBL Producing Organismsin North Karnataka

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Abstract

Aim: To detect antibiotic resistance in the isolates from middle ear infections with special reference to MRSA, ESBL and MBL producing Organisms.

Materials and Methods: A total of 140 ear swab samples meeting the inclusion criteria were processed in the Department of Microbiology, KMCRI, Hubballi. Pus samples were collected from the external auditory canal using sterile cotton swabs and cultured on appropriate microbiological media following standard laboratory procedures. The bacterial isolates were identified using standard microbiological techniques. Antibiotic susceptibility testing was performed and interpreted according to 36th edition CLSI guidelines.

Results: Out of 140 ear swab samples, Staphylococcus aureus (52.1%, n = 73) was the most common isolate, followed by Pseudomonas spp. (23.6%, n = 33), Klebsiella spp. (10.7%, n = 15) and Escherichia coli (7.1%, n = 10), while other organisms constituted 6.4% (n = 9). Among the Staphylococcus aureus isolates, MRSA accounted for 38.3% (n = 28) while MSSA accounted for 61.7% (n = 45).

Among the Gram-negative isolates, ESBL production was detected in 27.5% (n = 18) isolates, while no isolates showed MBL production (0%).

Conclusion: Staphylococcus aureus was the predominant pathogen isolated from middle ear infections, followed by Pseudomonas spp., Klebsiella spp., and Escherichia coli. A considerable proportion of Staphylococcus aureus isolates were identified as MRSA, and ESBL production was observed among Gram-negative isolates, while no MBL producers were detected. Continuous surveillance of bacterial pathogens and their antibiotic resistance patterns is essential for guiding appropriate empirical therapy, improving treatment outcomes, and preventing the emergence of antimicrobial resistance.

Keywords: MRSA, ESBL, MBL.

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Introduction

The World Health Organization defines Chronic Otitis Media (COM) as ear discharge through a perforated tympanic membrane persisting for more than 12 weeks, associated with chronic inflammation of the middle ear and mastoid cavity. Otitis media refers to inflammation of the middle ear cleft irrespective of aetiology or pathogenesis. The Eustachian tube plays a crucial role in maintaining middle ear health by equalizing pressure, facilitating drainage of secretions, and protecting against infections. Dysfunction or obstruction of this tube predisposes to the development of otitis media.[1]Children are particularly susceptible due to anatomical and functional differences in the Eustachian tube, which is shorter, wider, and more horizontal, favoring stasis of nasopharyngeal secretions and facilitating microbial colonization. Acute suppurative otitis media commonly follows upper respiratory tract infections, whereas persistent or recurrent infection leads to Chronic Suppurative Otitis Media (CSOM), characterized by chronic inflammation of the middle ear and mastoid cavity with recurrent otorrhoea through a perforated tympanic membrane.[2] CSOM is clinically classified into two types: tubotympanic (mucosal)

and squamosal (atticoantral). The tubotympanic type involves the pars tensa and presents with central perforation and is considered the "safe" type due to its lower risk of complications. In contrast, the squamosal type involves the pars flaccida with attic or marginal perforation and is termed the "unsafe" type because of its association with bone erosion and potentially serious complications.[3]

Among South-East Asian countries, India has a high prevalence of CSOM, estimated at approximately 7.8%. More than half of the cases are caused by bacterial pathogens. Common aerobic organisms include Pseudomonas spp., Staphylococcus aureus, Escherichia coli, Streptococcus pyogenes, Proteus mirabilis, and Klebsiella spp., while anaerobes such as Bacteroides, Peptostreptococcus, and Peptococcus also contribute. Fungal agents, particularly Aspergillus and Candida species, are also implicated, with microbial distribution varying across geographical regions.[4]

The persistence and severity of infection are influenced by various virulence factors, including biofilm formation, beta-lactamase production, lipopolysaccharides, metalloproteases, capsule formation, and swarming motility. Furthermore, the indiscriminate use of antibiotics, poor compliance, and inadequate follow-up have contributed to the emergence of multidrug-resistant organisms.[5]

In this context, the present study aims to detect antibiotic resistance patterns in isolates from middle ear infections, with special reference to MRSA, ESBL, and MBL-producing organisms.

Methods and Methodology

Study Design: This is a prospective cross-sectional laboratory-based study.

Inclusion Criteria

1. Patient with clinical diagnosis of otitis media presenting with active middle-ear discharge.
2. Age: Both children and adults.

Exclusion Criteria: Contaminated or improperly collected samples, duplicate samples from same site and patient within a short timeframe, unless clinically indicated.

We conducted a prospective cross-sectional study in the Department of Microbiology at KMCRI, Hubballi. Karnataka, India**.** The study adhered to STROBE reporting guidelines for observational research and followed all relevant precautions. Ethical committee approval was obtained before starting the study.

A total of 140 ear swab samples from patients clinically diagnosed with middle ear infections and meeting the inclusion criteria were included in the study. Detailed clinical history regarding name, age, sex, duration of discharge, other associated symptoms and antibiotic therapy were noted down. History was taken from patients.

Sample Collection and Transportation: The ear discharge was collected with two sterile swabs with all aseptic precautions to avoid contamination and were immediately transported to the Department of Microbiology, Karnataka Institute of Medical Sciences, Hubballi for culture and antibiotic sensitivity testing. Swabs were inoculated onto Chocolate agar and MacConkey agar and incubated at 37°C for 18–24 hours. The isolate will be identified as per standard protocol.

Colony Characters: After 18–24 hours incubation at 37°C, the colony characteristics were observed.

Gram's Staining: Smear was prepared from the part of colony and stained with Gram's stain method to study the morphology and staining characteristics of the isolates.

Motility: Motility of bacteria was demonstrated by hanging drop preparation.

Biochemical Tests: For Staphylococcal isolates, Coagulase test was used to differentiate Staphylococcus aureus and CONS.

For Gram negative isolates, following relevant biochemical tests as per standard protocol were used to identify the isolates:

a) Catalase test
b) Oxidase test
c) Triple sugar iron agar
d) Indole test
e) Citrate test
f) Urease test
g) Mannitol motility test
h) Nitrate reduction
i) Methyl red test
j) Voges–Proskauer test

Antibiotic Susceptibility Testing: The isolates were tested by Kirby-Bauer disk diffusion method on Mueller-Hinton agar, according to guidelines of Clinical and Laboratory Standards Institute (CLSI), 2018. The plate of Mueller-Hinton agar was inoculated, using a suspension of the test organism whose turbidity corresponding to 0.5 McFarland standard (1.5×10^8 organism/ml). Inoculation was done by using a sterile cotton swab, which was dipped into the suspension and the surplus solution removed by rotation of the swab against the side of the tube above the fluid level. A lawn culture was made on Mueller-Hinton agar as per 36^{TH} CLSI guidelines.

Methicillin-resistant Staphylococcus aureus (MRSA) was detected using the cefoxitin (30 µg)

disc diffusion method, and interpretation was done according to CLSI 36TH guidelines.

Extended-spectrum beta-lactamase (ESBL) production among Gram-negative isolates was screened using ceftazidime and cefotaxime discs and confirmed by the combination disc method (ceftazidime ± clavulanic acid).

Metallo-beta-lactamase (MBL) production was detected using the imipenem-EDTA combined disc method. A significant increase in zone size in the presence of EDTA was considered indicative of MBL production.

Result

The study analyzed 140 ear swab samples from patients with middle ear infections to identify bacterial isolates and their antibiotic resistance patterns, focusing on MRSA, ESBL, and MBL producers. Staphylococcus aureus was the predominant isolate, constituting 52.1% (n = 73) of the total isolates, followed by Pseudomonas spp. (23.6%, n = 33), Klebsiella spp. (10.7%, n = 15), Escherichia coli (7.1%, n = 10), and other organisms (6.4%, n = 9).

Among the Staphylococcus aureus isolates, 38.3% (n = 28) were methicillin-resistant Staphylococcus aureus (MRSA), while 61.7% (n = 45) were methicillin-sensitive Staphylococcus aureus (MSSA). Gram-negative isolates showed a 27.5% (n = 18) prevalence of extended-spectrum beta-lactamase (ESBL) production, with no metallo-beta-lactamase (MBL) producers detected.

Antibiotic susceptibility testing revealed that Gram-positive isolates had the highest sensitivity to linezolid, vancomycin, and clindamycin. Among Staphylococcus aureus isolates, linezolid exhibited 100% sensitivity, followed by amikacin and cotrimoxazole (95% each), levofloxacin (90%), and ciprofloxacin (89%). Gentamicin showed moderate sensitivity (70%), while erythromycin (55%) and clindamycin (57%) demonstrated comparatively lower sensitivity. Beta-lactam antibiotics such as amoxicillin-clavulanate and ampicillin had high resistance rates (60% and 70%, respectively), indicating limited efficacy.

For Gram-negative isolates, carbapenems (meropenem and imipenem) and tigecycline exhibited 100% sensitivity across all tested organisms. ESBL-producing E. coli and Klebsiella pneumoniae showed complete resistance (100%) to amoxicillin-clavulanate, piperacillin-tazobactam, and all cephalosporins, consistent with CLSI guidelines that classify ESBL producers as resistant to these antibiotics regardless of in vitro susceptibility. Pseudomonas aeruginosa demonstrated near-complete resistance to these agents but retained some susceptibility to β-lactam/β-lactamase inhibitor combinations.

Among aminoglycosides, amikacin and gentamicin showed high sensitivity, particularly in Klebsiella pneumoniae and Pseudomonas aeruginosa, while E. coli exhibited lower sensitivity to amikacin. Fluoroquinolones, including ciprofloxacin and levofloxacin, showed variable and generally reduced susceptibility, especially in E. coli and Pseudomonas aeruginosa, likely due to widespread empirical use. Cotrimoxazole maintained moderate to good sensitivity across Gram-negative organisms.

Demographically, the majority of patients were aged 11–20 years (38.6%, n = 54), followed by those aged 21–30 years (31.4%, n = 44). Male patients were more frequently affected (60%, n = 84) than females (40%, n = 56). Clinically, unilateral ear involvement was observed in 59.3% (n = 83) of patients, with bilateral involvement in 40.7% (n = 57). All infections were monobacterial (100%, n = 140). These findings highlight the predominance of Staphylococcus aureus, including a significant proportion of MRSA, in middle ear infections, alongside a notable presence of ESBL-producing Gram-negative bacteria. The absence of MBL producers suggests limited carbapenem resistance in this cohort. The antibiotic susceptibility patterns emphasize the continued efficacy of linezolid, vancomycin, clindamycin, carbapenems, and tigecycline, while underscoring resistance challenges with beta-lactams and certain fluoroquinolones. Continuous surveillance and antimicrobial stewardship are essential to guide empirical therapy and limit the spread of resistant pathogens.

Table 1: Distribution of Bacterial Isolates from Ear Swab Samples (n = 140)

Organism	Number of Isolates (n)	Percentage (%)
Staphylococcus aureus	73	52.1
Pseudomonas spp.	33	23.6
Klebsiella spp.	15	10.7
Escherichia coli	10	7.1
Other organisms	9	6.4

Distribution of bacterial isolates from 140 ear swab samples collected from patients with middle ear infections. Percentages represent the proportion of each organism among total isolates.

Table 2: Distribution of MRSA and MSSA among Staphylococcus aureus Isolates (n = 73)

Isolate Type	Number (n)	Percentage (%)
MRSA	28	38.3
MSSA	45	61.7

Distribution of methicillin-resistant Staphylococcus aureus (MRSA) and methicillin-sensitive Staphylococcus aureus (MSSA) among 73 Staphylococcus aureus isolates obtained from middle ear infection samples.

Table 3: ESBL and MBL Production among Gram-negative Isolates

Resistance Mechanism	Number (n)	Percentage (%)
ESBL Producers	18	27.5
MBL Producers	0	0

Distribution of extended-spectrum beta-lactamase (ESBL) and metallo-beta-lactamase (MBL) production among Gram-negative bacterial isolates from middle ear infection samples. Percentages represent the proportion of isolates exhibiting each resistance mechanism.

Table 4: Demographic and Clinical Characteristics of Patients (n = 140)

Variable	Category	Number (n)	Percentage (%)
Age Group	11–20 years	54	38.6
	21–30 years	44	31.4
Gender	Male	84	60.0
	Female	56	40.0
Laterality of Infection	Unilateral	83	59.3
	Bilateral	57	40.7
Type of Infection	Monobacterial	140	100
	Polymicrobial	0	0

Demographic and clinical characteristics of 140 patients with middle ear infections, including age distribution, gender, laterality of infection, and type of infection.

Table 5: Antimicrobial Susceptibility Pattern for Gram negative bacilli (n = 18)

Antibiotic	E. coli R (%)	E. coli S (%)	K. pneumoniae R (%)	K. pneumoniae S (%)	P. aeruginosa R (%)	P. aeruginosa S (%)
Amoxicillin-clavulanate	100	0	100	0	99	1
Piperacillin-tazobactam	100	0	100	0	97	3
Cefotaxime	100	0	100	0	100	0
Ceftazidime	100	0	100	0	100	0
Cefepime	100	0	100	0	100	0
Meropenem	0	100	0	100	0	100
Imipenem	0	100	0	100	0	100
Amikacin	29.6	70.4	0	100	20	80
Gentamicin	2	98	1	99	12	88
Ciprofloxacin	66.7	33.3	50	50	61	39
Levofloxacin	100	0	100	0	100	0
Cotrimoxazole	12	88	15	85	8	92
Tigecycline	0	100	0	100	0	100
Aztreonam	100	0	100	0	100	0

ESBL production: 27.5% (n = 18)

Note: ESBL-producing isolates are reported resistant to all penicillin's and cephalosporins and monobactams except cephamycin's as per CLSI guidelines.(R- Resistant,S-Sensitive). For ESBL-producing isolates, E. coli and Klebsiella pneumoniae, Pseudomonas aeruginosa showed 100% resistance to amoxicillin-clavulanate, piperacillin-tazobactam, and all cephalosporins. Carbapenems (meropenem and imipenem) and tigecycline showed 100% sensitivity across all organisms. Amikacin and gentamicin demonstrated high sensitivity, especially in K. pneumoniae and P. aeruginosa, while E. coli showed comparatively lower sensitivity to amikacin. Fluoroquinolones showed variable resistance, and cotrimoxazole retained good sensitivity in all three organisms.

Table 6: Antimicrobial Susceptibility of Staphylococcus Isolates (n = 73)

Antibiotics	Sensitive	%	Resistant	%
CIP	65	89.0	8	11.0
GEN	51	70.0	22	30.0
AK	69	95.0	4	5.0
AMC	29	40.0	44	60.0
AMP	22	30.0	51	70.0
LE	66	90.0	7	10.0
LZ	73	100.0	0	0.0
COT	69	95.0	4	5.0
E	40	55.0	33	45.0
CD	42	57.0	31	43.0
CX	45	61.7	28	38.3

Among the Staphylococcus aureus isolates (n = 73), methicillin-resistant Staphylococcus aureus (MRSA) accounted for 38.3% (n = 28), while methicillin-sensitive Staphylococcus aureus (MSSA) constituted 61.7% (n = 45).” Among the antibiotics tested, linezolid showed 100% sensitivity, followed by amikacin and cotrimoxazole (95% each), and levofloxacin (90%). Ciprofloxacin also demonstrated high sensitivity (89%), while gentamicin showed moderate sensitivity (70%). Erythromycin (55%) and clindamycin (57%) exhibited comparatively lower sensitivity. Beta-lactam antibiotics such as amoxicillin-clavulanate (40%) and ampicillin (30%) showed high resistance rates, indicating limited effectiveness against the isolates.”

Discussion

The present study revealed an ESBL prevalence of 27.5% among Gram-negative isolates, reflecting a considerable burden of β-lactam resistance in the clinical setting. This finding aligns with the increasing global trend of ESBL-producing organisms, particularly among Escherichia coli and Klebsiella pneumoniae, which are well-recognized reservoirs of plasmid-mediated resistance genes. The high prevalence underscores the clinical significance of routine ESBL screening in microbiology laboratories.[6]

A striking observation in this study was the 100% resistance of E. coli and K. pneumoniae to penicillin’s and cephalosporins, including third- and fourth-generation agents. This is expected, as ESBL enzymes efficiently hydrolyse these antibiotics, rendering them ineffective. According to CLSI recommendations, ESBL-producing isolates are to be reported as resistant to all penicillin’s and cephalosporins regardless of in vitro susceptibility, which justifies the uniform resistance pattern observed.[7] In contrast, Pseudomonas aeruginosa demonstrated relatively better susceptibility to β-lactam/β-lactamase inhibitor combinations such as amoxicillin-clavulanate and piperacillin-tazobactam. This difference may be attributed to the distinct resistance mechanisms in Pseudomonas, including efflux pumps and porin channel alterations, rather than classical ESBL production alone. However, the organism still exhibited complete resistance to cephalosporins, highlighting the limited utility of these agents.[8]

Carbapenems (meropenem and imipenem) showed 100% sensitivity across all isolates, reaffirming their status as the most reliable therapeutic agents for ESBL-producing infections. Their stability against ESBL-mediated hydrolysis makes them the cornerstone of treatment, especially in severe infections. However, the increasing reliance on carbapenems raises concerns about the potential emergence of carbapenem-resistant organisms, emphasizing the need for cautious and judicious use.[9]

Tigecycline also demonstrated excellent in vitro activity against all isolates, suggesting its role as a valuable alternative, particularly in multidrug-resistant infections where carbapenem-sparing strategies are desired. Among aminoglycosides, amikacin and gentamicin retained good efficacy, with particularly high sensitivity in K. pneumoniae and P. aeruginosa. The relatively lower sensitivity of amikacin in E. coli may indicate evolving resistance patterns and highlights the importance of local antibiograms in guiding therapy.[10]

Fluoroquinolones, including ciprofloxacin and levofloxacin, showed variable and generally reduced susceptibility, especially in E. coli and P. aeruginosa. This could be attributed to widespread empirical use, leading to selective pressure and the emergence of resistant strains. Similarly, cotrimoxazole demonstrated moderate to good sensitivity across organisms, indicating that it may still be useful in selected, uncomplicated infections based on susceptibility results.[11]

Limitations

The present study has several limitations that should be acknowledged. First, the sample size of 140 ear swab samples, while adequate for preliminary analysis, may limit the generalizability

of the findings across broader populations or diverse geographical regions. Second, the study design was cross-sectional and laboratory-based, which restricts the ability to assess longitudinal trends in antibiotic resistance or clinical outcomes over time.

Third, the study focused solely on aerobic bacterial isolates and did not include anaerobic bacteria or fungal pathogens, which may also contribute to middle ear infections. Fourth, molecular characterization of resistance genes, particularly for MRSA, ESBL, and MBL producers, was not performed, limiting the understanding of the genetic mechanisms underlying resistance.

Fifth, clinical data on prior antibiotic use and treatment outcomes were not extensively analyzed, which could influence resistance patterns. Lastly, the absence of metallo-beta-lactamase (MBL) producers in this cohort may reflect a limitation in detection sensitivity or regional prevalence rather than true absence. Addressing these limitations in future research would provide a more comprehensive understanding of antimicrobial resistance in middle ear infections.

Recommendations

The present study recommends the implementation of continuous and systematic surveillance of bacterial pathogens isolated from middle ear infections to monitor evolving antibiotic resistance patterns, particularly focusing on MRSA and ESBL-producing organisms. Empirical therapy should be guided by local antibiograms to ensure effective treatment, emphasizing the use of antibiotics such as linezolid, vancomycin, carbapenems, and tigecycline, which demonstrated high sensitivity.

Antimicrobial stewardship programs must be strengthened to minimize the indiscriminate use of beta-lactam antibiotics and fluoroquinolones, reducing selective pressure for resistance. Routine screening for resistance mechanisms like MRSA and ESBL production should be incorporated into diagnostic workflows to inform targeted therapy. Additionally, infection control measures should be reinforced to prevent the spread of multidrug-resistant organisms within healthcare settings. Future research should expand to include molecular characterization of resistance genes and assess clinical outcomes to optimize management strategies for middle ear infections. Overall, the findings of this study highlight the growing challenge posed by ESBL-producing organisms in clinical practice. The high resistance to commonly used β-lactam antibiotics limits therapeutic options and necessitates reliance on higher-end drugs such as carbapenems and tigecycline. This situation underscores the urgent need for robust antimicrobial stewardship programs, regular surveillance of resistance patterns, and strict infection control measures to curb the spread of resistant pathogens.

Conclusion

The present study identified Staphylococcus aureus as the predominant pathogen in middle ear infections, with 52.1% of isolates, and highlighted a significant proportion (38.3%) as methicillin-resistant Staphylococcus aureus (MRSA). Among Gram-negative bacteria, 27.5% produced extended-spectrum beta-lactamase (ESBL), while no metallo-beta-lactamase (MBL) producers were detected. Antibiotic susceptibility testing demonstrated that carbapenems (meropenem and imipenem) and tigecycline exhibited 100% sensitivity across all tested Gram-negative organisms. Aminoglycosides such as amikacin and gentamicin showed high efficacy, particularly against Klebsiella pneumoniae and Pseudomonas aeruginosa, whereas fluoroquinolones displayed variable resistance.

The study underscores the clinical relevance of MRSA and ESBL-producing organisms in middle ear infections and emphasizes the limited effectiveness of commonly used beta-lactam antibiotics. These findings highlight the necessity for continuous surveillance and antimicrobial stewardship to guide empirical therapy and mitigate the spread of resistant pathogens, ultimately improving patient outcomes and addressing the challenge of antimicrobial resistance in this clinical context.

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