RESEARCH PAPER

Study of antimicrobial resistance in patients admitted in intensive care unit in tertiary care hospital, Jaipur, Rajasthan

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ABSTRACT

Background: Antimicrobial resistance (AMR) is a major threat in intensive care units (ICUs), where broad-spectrum antibiotic exposure, invasive procedures, prolonged hospitalization, and severe illness promote the emergence and transmission of resistant organisms.

Objective: To determine the microbiological profile and antimicrobial resistance pattern of bacterial isolates recovered from patients admitted to the medical and surgical ICUs of a tertiary care teaching hospital in Jaipur, Rajasthan.

Methods: A cross-sectional observational study was conducted in the Department of Microbiology, NIMS Medical College and Hospital, Jaipur, over six months from December 2019 to May 2020. A total of 248 adult ICU patients with clinically suspected infection contributed 276 clinical specimens. Organisms were identified using standard microbiological methods, and antimicrobial susceptibility testing was performed by the Kirby-Bauer disk diffusion method on Mueller-Hinton agar according to CLSI 2019 criteria.

Results: Of 276 specimens, 214 (77.5%) were culture-positive. Gram-negative organisms accounted for 156 (72.9%) isolates, Gram-positive organisms for 38 (17.8%), and fungi for 20 (9.3%). Escherichia coli was the most common isolate (22.4%), followed by Klebsiella spp. (16.8%), Acinetobacter spp. (15.9%), and Pseudomonas spp. (13.1%). Among 194 bacterial isolates, 152 (78.4%) showed resistance to at least one tested antimicrobial and 98 (50.5%) were multidrug resistant. ESBL production was detected in 52/156 (33.3%) Gram-negative isolates, MRSA in 14/24 (58.3%) Staphylococcus aureus isolates, and carbapenem resistance in 28/156 (17.9%) Gram-negative isolates. Acinetobacter spp. showed the highest carbapenem resistance (14/34, 41.2%). Vancomycin and linezolid retained activity against all tested Gram-positive isolates.

Conclusion: The ICU microbiological profile was dominated by Gram-negative organisms with a substantial burden of multidrug resistance, ESBL production, MRSA, and carbapenem resistance. Regular ICU-specific antibiograms, strengthened antimicrobial stewardship, and rigorous infection-prevention practices are required to support appropriate empirical therapy.

Keywords: Antimicrobial resistance; intensive care unit; multidrug resistance; ESBL; MRSA; carbapenem resistance; Jaipur

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1. INTRODUCTION

Antimicrobial resistance (AMR) refers to the ability of microorganisms to survive or multiply despite exposure to antimicrobial agents that would ordinarily inhibit or kill them. Resistance may be intrinsic or acquired and can arise through enzymatic inactivation of drugs, modification of antimicrobial targets, reduced permeability, active efflux, or acquisition of mobile genetic elements [1,2]. In critically ill patients, delayed administration of an active antimicrobial agent is associated with treatment failure, prolonged hospitalization, and an increased risk of sepsis-related complications. Intensive care units are especially vulnerable to AMR because they concentrate severely ill patients, invasive devices, prolonged hospital stays, and intensive exposure to broad-spectrum antibiotics.

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The EPIC III study, involving more than 1,100 ICUs in 88 countries, demonstrated that infection is common in critical care and that Gram-negative organisms account for a major proportion of ICU pathogens [3]. The burden is particularly important in low- and middle-income countries, where diagnostic capacity, antibiotic regulation, staffing, and infection-control implementation may be inconsistent [4]. Indian tertiary care hospitals have reported high frequencies of extended-spectrum beta-lactamase-producing Enterobacterales, methicillin-resistant Staphylococcus aureus, and carbapenem-resistant non-fermenting Gram-negative bacilli [5,6]. Nevertheless, resistance patterns vary markedly across hospitals because of differences in patient case-mix, prescribing practice, referral patterns, device

utilization, and local infection-control performance [7]. Therefore, empirical treatment should be guided by current institution- and unit-specific susceptibility data rather than by national averages alone. The period of data collection also overlapped with the beginning of the COVID-19 pandemic, during which several institutions reported increased empirical antibiotic use and prolonged mechanical ventilation despite relatively low rates of proven bacterial co-infection [8,9]. Local baseline data are therefore useful for interpreting subsequent changes in resistance epidemiology.

The present study was undertaken to determine the distribution of microorganisms isolated from ICU patients and to describe their antimicrobial resistance patterns at a tertiary care teaching hospital in Jaipur, Rajasthan. The findings were intended to support local empirical treatment, antimicrobial stewardship, and infection-prevention policy.

2. MATERIALS AND METHODS

2.1 Study Design, Setting, and Duration

This cross-sectional observational study was conducted over six months, from December 2019 to May 2020, in the Department of Microbiology, NIMS Medical College and Hospital, Jaipur, Rajasthan. The hospital is a tertiary care teaching institution serving urban and peripheral referral populations. Patients admitted to the medical ICU (MICU) and surgical ICU (SICU) were included.

2.2 Study Population and Eligibility Criteria

A total of 248 adult ICU patients with clinically suspected infection were enrolled. Patients were eligible when they were 18 years of age or older, admitted to the MICU or SICU, clinically suspected of sepsis, ventilator-associated pneumonia, respiratory tract infection, urinary tract infection, postoperative infection, bloodstream infection, or another ICU-associated infection, and had an appropriate clinical specimen collected. Patients without clinical evidence of infection, those with inadequate or contaminated specimens, patients younger than 18 years, and those with infection diagnosed before ICU admission were excluded. Patients with suspected infection at more than one anatomical site could contribute more than one specimen.

2.3 Specimen Collection and Microbiological Processing

The 248 patients contributed 276 specimens, including blood, urine, endotracheal aspirate, wound or pus samples, cerebrospinal fluid, pleural fluid, peritoneal or ascitic fluid, and other clinically indicated specimens. Blood cultures were processed using the BACTEC 9050 automated system. Specimens were inoculated on 5% sheep blood agar and MacConkey agar and incubated aerobically at 37°C for 18-24 hours. Chocolate agar was incubated at 37°C in 5% carbon dioxide. Isolates were identified by colony morphology, Gram staining, and standard biochemical reactions, including catalase, oxidase, citrate, indole, and urease tests.

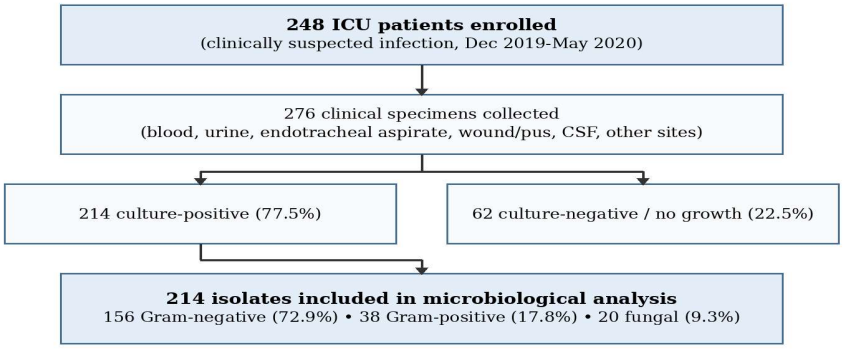
2.4 Antimicrobial Susceptibility Testing and Quality Control

Antimicrobial susceptibility testing was performed by the Kirby-Bauer disk diffusion method on Mueller-Hinton agar and interpreted according to CLSI M100 criteria, 29th edition (2019) [13]. AMR was defined as resistance to at least one tested agent in at least one antimicrobial category. Multidrug resistance was defined as resistance to at least one agent in three or more antimicrobial categories. ESBL production and methicillin resistance in Staphylococcus aureus were identified using standard phenotypic methods. Staphylococcus aureus ATCC 25923, Escherichia coli ATCC 25922, and Pseudomonas aeruginosa ATCC 27853 were used for quality control.

2.5 Statistical Analysis and Ethical Considerations

Data were entered in spreadsheet software and analyzed descriptively. Categorical variables are presented as frequencies and percentages, while age and ICU stay are summarized using mean and standard deviation. Percentages were calculated using the denominator specified in each table. Written informed consent was obtained from participants or their legally authorized representatives. Institutional Ethics Committee approval details should be inserted before journal submission: [approval number and date].

Figure 1. STROBE participant flow diagram.



Note: STROBE is the appropriate reporting framework for this cross-sectional observational study; PRISMA and CONSORT are not applicable.

3. RESULTS

3.1 Demographic and Clinical Characteristics

The mean age of the 248 patients was 52.4 ± 16.8 years (range 18-85 years). The largest age group was 41-60 years (104/248, 41.9%), and 156 patients (62.9%) were male. A total of 142 patients (57.3%) were admitted to the MICU and 106 (42.7%) to the SICU. The mean ICU stay was 9.6 ± 5.2 days, and 118 patients (47.6%) stayed for more than seven days. Mechanical ventilation for more than 48 hours was required in 134 patients (54.0%). Hypertension and diabetes mellitus were the most frequent comorbidities.

Table 1. Baseline demographic and clinical characteristics of ICU patients (n = 248)

Variable	Category	n	%
Age group (years)	18-40	54	21.8
	41-60	104	41.9
	>60	90	36.3
Mean age ± SD	52.4 ± 16.8 years	-	-
Gender	Male	156	62.9
	Female	92	37.1
ICU type	MICU	142	57.3
	SICU	106	42.7
ICU stay duration	≤7 days	130	52.4
	>7 days	118	47.6
Mechanical ventilation (>48 h)	Yes	134	54.0
	No	114	46.0
Comorbidities	Hypertension	104	41.9
	Diabetes mellitus	88	35.5
	COPD	42	16.9
	CKD	29	11.7
	Multiple comorbidities	96	38.7

3.2 Microbiological Profile

Of the 276 specimens, 214 (77.5%) yielded significant bacterial or fungal growth. Endotracheal aspirate was the most frequent positive specimen (68/214, 31.8%), followed by urine (52/214, 24.3%), blood (46/214, 21.5%), and wound or pus samples (30/214, 14.0%). Gram-negative organisms accounted for 156 isolates (72.9%), Gram-positive organisms for 38 (17.8%), and fungi for 20 (9.3%). Escherichia coli was the most frequently isolated organism, followed

by Klebsiella spp., Acinetobacter spp., and Pseudomonas spp. A larger proportion of isolates originated from the MICU than from the SICU.

Table 2. Microbiological profile of ICU isolates (n = 214)

Parameter	Category	n	%
Total culture-positive isolates	-	214	100
Specimen type	Endotracheal aspirate	68	31.8
	Urine	52	24.3
	Blood	46	21.5
	Wound/pus	30	14.0
	Others	18	8.4
Gram-stain distribution	Gram-negative	156	72.9
	Gram-positive	38	17.8
	Fungal	20	9.3
Organism distribution	Escherichia coli	48	22.4
	Klebsiella spp.	36	16.8
	Acinetobacter spp.	34	15.9
	Pseudomonas spp.	28	13.1
	Staphylococcus aureus	24	11.2
	Enterococcus spp.	14	6.5
	Candida species	20	9.3
	Others (Proteus/Providencia spp.)	10	4.7
Distribution by ICU	MICU	124	57.9
	SICU	90	42.1

3.3 Antimicrobial Resistance Pattern

Antibacterial resistance analysis was restricted to the 194 bacterial isolates. Resistance to at least one antimicrobial agent was observed in 152/194 isolates (78.4%). Resistance was more frequent among Gram-negative isolates (128/156, 82.1%) than among Gram-positive isolates (24/38, 63.2%). MDR was identified in 98/194 bacterial isolates (50.5%), of which 82 (83.7%) were Gram-negative. ESBL production was detected in 52/156 (33.3%) Gram-negative isolates. Fourteen of 24 Staphylococcus aureus isolates (58.3%) were methicillin resistant. Carbapenem resistance was detected in 28/156 (17.9%) Gram-negative isolates and was most frequent in Acinetobacter spp. (14/34, 41.2%), followed by Klebsiella spp. (6/36, 16.7%), Pseudomonas spp. (4/28, 14.3%), and Escherichia coli (4/48, 8.3%). Vancomycin and linezolid were active against all tested Gram-positive isolates.

Table 3. Antimicrobial resistance among bacterial ICU isolates

Parameter	n/N	%
Total bacterial isolates analyzed	194	100
Bacterial isolates showing any antimicrobial resistance	152	78.4
Resistant Gram-negative isolates	128/156	82.1
Resistant Gram-positive isolates	24/38	63.2
Multidrug-resistant (MDR) bacterial isolates	98/194	50.5

Parameter	n/N	%
MDR - Gram-negative	82/98	83.7*
MDR - Gram-positive	16/98	16.3*
ESBL-producing Gram-negative isolates	52/156	33.3
MRSA isolates	14/24	58.3**
Carbapenem-resistant Gram-negative isolates	28/156	17.9
Carbapenem-resistant Acinetobacter spp.	14/34	41.2
Carbapenem-resistant Klebsiella spp.	6/36	16.7
Carbapenem-resistant Escherichia coli	4/48	8.3
Carbapenem-resistant Pseudomonas spp.	4/28	14.3

*Percentage of total MDR isolates (n = 98). **Percentage of Staphylococcus aureus isolates (n = 24).

4. DISCUSSION

The present study demonstrates a substantial burden of antimicrobial resistance among bacterial isolates recovered from critically ill patients at a tertiary care hospital in Jaipur. Gram-negative organisms accounted for nearly three-quarters of all culture-positive isolates and were responsible for most MDR, ESBL-producing, and carbapenem-resistant phenotypes. This distribution is consistent with international ICU surveillance and Indian tertiary care studies in which Enterobacterales and non-fermenting Gram-negative bacilli predominate [3,5,6].

Escherichia coli was the single most frequently isolated organism, whereas Acinetobacter spp. exhibited the most concerning carbapenem-resistance profile. Carbapenem resistance in 41.2% of Acinetobacter isolates is clinically important because this organism can persist in the hospital environment, colonize respiratory equipment, and accumulate multiple resistance mechanisms. Comparable studies have identified Acinetobacter and Klebsiella as major contributors to difficult-to-treat Gram-negative infections in critical care [14,15].

ESBL production was detected in one-third of Gram-negative isolates. This finding supports the need for cautious empirical use of third-generation cephalosporins in patients at high risk for ICU-acquired infection and reinforces the value of early culture collection and de-escalation when susceptibility results become available. The MDR prevalence of 50.5% among bacterial isolates further indicates that reliance on broad-spectrum empirical therapy without local antibiogram support may increase ineffective treatment and selection pressure.

MRSA represented 58.3% of Staphylococcus aureus isolates. Although the number of S. aureus isolates was modest, this proportion is within the wide range reported from Indian ICUs [6,16]. The preserved activity of vancomycin and linezolid against tested Gram-positive isolates is reassuring; nevertheless, these agents should remain stewardship-protected because unnecessary use may accelerate the emergence of glycopeptide- or oxazolidinone-resistant organisms.

Endotracheal aspirates were the most common culture-positive specimens, which is compatible with the high frequency of prolonged mechanical ventilation in the study population. Device-associated infection prevention, ventilator-care bundles, hand hygiene, environmental cleaning, and timely removal of invasive devices should therefore accompany antimicrobial stewardship interventions [17,18].

The study supports the development of an ICU-specific cumulative antibiogram that is updated at least annually and stratified, where possible, by specimen type and ICU location. Such local surveillance can improve empirical antibiotic selection and enable monitoring of changes in ESBL, MRSA, and carbapenem resistance over time [7,10].

5. LIMITATIONS

This study was conducted at a single centre over a six-month period, and the findings may not be generalizable to other hospitals or seasons. The descriptive cross-sectional design does not establish causal relationships between clinical exposures and resistance outcomes and does not adjust for potential confounding. Molecular characterization of ESBL and carbapenemase genes was not performed. Patient-level outcome measures, including mortality, antibiotic exposure before culture, appropriateness of empirical therapy, and resistance-attributable length of stay, were not available. Some organism-level susceptibility results were available only as aggregate summaries rather than isolate-level data.

6. CONCLUSION

Gram-negative organisms predominated among culture-positive specimens from ICU patients, and more than three-quarters of bacterial isolates were resistant to at least one antimicrobial agent. MDR, ESBL production, MRSA, and carbapenem resistance were common, with Acinetobacter spp. showing the

highest carbapenem-resistance proportion. These findings emphasize the need for regularly updated ICU-specific antibiograms, culture-guided de-escalation, strict device-associated infection prevention, and coordinated antimicrobial stewardship at the study institution.

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