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Original Research Article

A STUDY ON MICROBIOLOGICAL PROFILE OF BLOODSTREAM INFECTIONS IN ICU PATIENTS AT A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: ICU patients are at high risk for severe infections due to invasive procedures, immunocompromised conditions, and prolonged hospital stays. Identifying pathogens, tracing infection sources, and understanding antimicrobial resistance patterns are essential for effective infection control and treatment strategies.

Materials and Methods: This cross-sectional study was conducted over one year at the Department of Microbiology, Mallareddy Medical College for women. Patients aged over 15 with confirmed or suspected sepsis were included, excluding those with prior antibiotic use or no clinical suspicion of sepsis. Blood samples were collected aseptically, cultured on diverse media, and pathogen identification employed morphological and biochemical assays.

Results: A significant prevalence of antimicrobial resistance was noted among ICU pathogens, particularly in nosocomial bloodstream infections. Major pathogens identified included Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa, with resistance trends highlighting the need for tailored treatment strategies. Additionally, fungal infections were isolated and analyzed.

Conclusion: This study underscores the importance of stringent infection control, appropriate antimicrobial use, and regular resistance monitoring in ICUs. Findings provide insight into effective management strategies and reinforce the need for ongoing pathogen surveillance and targeted therapies to improve ICU patient outcomes.

Keywords: ICU infections, sepsis, antimicrobial resistance, pathogen identification, nosocomial infections, blood culture, infection control.

INTRODUCTION

Microbial infections in sepsis within the ICU are among the most complex and critical challenges in patient care, significantly impacting morbidity and mortality. The ICU environment harbors a broad spectrum of pathogens due to the immune-compromised status of many patients, prolonged use of invasive devices, and high antibiotic exposure, which collectively contribute to microbial diversity and resistance patterns. Common pathogens implicated in ICU-associated sepsis include Gram-negative bacteria like Pseudomonas aeruginosa, Klebsiella pneumoniae, and Escherichia coli; Gram-positive organisms such as Staphylococcus aureus and Enterococcus faecium; and fungal pathogens like Candida species.[1,2] The microbial spectrum can vary by ICU setting, hospital hygiene practices, and the regional prevalence of antibiotic resistance, with multidrug-resistant organisms (MDROs) increasingly emerging as a major concern.[3]

Transmission of infections in ICUs is primarily attributed to direct contact, either through healthcare personnel's hands or contaminated equipment, and occasionally through airborne or droplet spread in cases of respiratory pathogens.[4] Intravenous catheters, ventilators, and urinary catheters are the most common sites of infection, leading to bloodstream infections, ventilator-associated pneumonia, and catheter-associated urinary tract

infections, respectively.[5] The pathogenesis typically begins with microbial colonization at the insertion site of these devices, followed by migration along the device into deeper tissues or the bloodstream, where the pathogens evade immune defenses due to the compromised host state.[6] The biofilm formation on medical devices further facilitates microbial adherence, immune evasion, and resistance to antimicrobial agents, worsening patient prognosis.[7]

Additionally, ICU protocols, such as the frequent use of broad-spectrum antibiotics, can disrupt normal flora and create selection pressure favoring resistant strains, thereby increasing the risk of sepsis due to resistant organisms.[8] Effective infection control strategies in ICUs are essential, including stringent hand hygiene, routine surveillance of pathogen prevalence, antimicrobial stewardship, and meticulous device care to reduce the transmission of these life-threatening infections.[9] Early diagnosis and targeted treatment of microbial infections in sepsis are critical in preventing escalation to severe sepsis or septic shock, highlighting the need for continuous assessment of microbial resistance patterns and adherence to infection control protocols in ICU settings.[10]

This study was done with an aim to identify the pathogens causing ICU infections, trace possible infection sources, assess antimicrobial susceptibility, and analyze resistance patterns.

MATERIALS AND METHODS

This cross-sectional study was conducted over a one-year period from September 2023 to August 2024 at the Department of Microbiology, focusing on intensive care unit (ICU) patients at high risk of infection. The Institutional Ethical Committee of Mallareddy Medical College approved for women the study protocol. Informed consent was obtained from each patient or their guardians after explaining the study's objectives, procedures, and potential risks.

Inclusion criteria were strictly defined, focusing on patients above 18 years of age with confirmed sepsis or strong clinical indicators, such as symptoms of systemic inflammatory response syndrome (SIRS) and dysfunction in at least one organ system.

Sepsis was diagnosed according to SIRS criteria and required the presence of presumed or confirmed infection. Diagnostic criteria included abnormal body temperature (greater than 38°C or below 36°C), elevated heart rate (above 90 beats per minute), respiratory rate exceeding 20 breaths per minute, and abnormal white blood cell counts (either above 12,000 cells/cu.mm or below 4,000 cells/cu.mm, with over 10% immature neutrophils).

Exclusion criteria included patients without clinical suspicion of sepsis and those who had received antibiotics before admission, which could interfere with pathogen identification and antibiotic resistance analysis. Case definitions for bloodstream infections included community-acquired and nosocomial bacteremia, classified based on the timing of the first positive blood culture and association with invasive procedures.

To pinpoint infection sources, the study adopted stringent classification criteria. Bloodstream infections were categorized based on the isolation of pathogens from blood and corresponding infection sites. Definitions for conditions like pneumonia, cellulitis, urinary tract infection, endocarditis, and catheter-related bloodstream infection were standardized based on clinical and laboratory findings, ensuring consistent identification of primary infection sources.

Blood sample collection followed rigorous aseptic techniques, employing skin disinfection with chlorhexidine and isopropyl alcohol before venipuncture. Each sample was obtained with sterile procedures, ensuring minimal contamination risk. Blood was inoculated into culture bottles containing biphasic brain-heart infusion and trypticase soy media, then incubated at 37°C. To enhance microbial detection, subcultures were performed at regular intervals, with additional blind subcultures on specific media types at 48 hours and on the seventh day. Samples were cultured on blood agar, MacConkey agar, chocolate agar, and Sabouraud's dextrose agar to capture a broad spectrum of potential pathogens.

Pathogen identification combined morphological observation, gram staining, and biochemical tests. Specific tests for motility, catalase, and oxidase activities were performed on Gram-positive cocci, while Gram-negative bacilli were tested for oxidase and catalase reactions. Further species-level identification employed biochemical assays like IMViC reactions and sugar fermentation tests. For antimicrobial susceptibility testing, the Kirby-Bauer disc diffusion method on Mueller-Hinton agar was used, with interpretive zone diameters determined per Clinical and Laboratory Standards Institute (CLSI) guidelines. The standard strains of Staphylococcus aureus (ATCC 25923), Escherichia coli(ATCC 25922), and Pseudomonas aeruginosa(ATCC 27823) served as quality controls for testing procedures. Additionally, the minimum inhibitory concentration (MIC) was determined using macrobroth dilution to further assess resistance levels.

In fungal identification, yeast isolates were cultured on Sabouraud's dextrose agar and chrom agar, with subsequent tests on cornmeal agar to identify species-specific characteristics. Carbohydrate fermentation tests helped differentiate species by their gas and acid production profiles.

The data was analyzed statistically using SPSS and Epi-Info software. A statistician employed Pearson's chi-square test and Binomial proportion test to evaluate the proportions in this cross-sectional dataset.

RESULTS

A total of 200 patients were included in the study. The study highlights key demographic characteristics, clinical features, and antimicrobial susceptibility patterns among patients with bloodstream infections (BSI) in the Intensive Care Unit (ICU). Age distribution reveals a high prevalence of BSI among patients aged 31-40 (27.5%) and 41-50 (24%), with a predominant male patient base (70%). Fever was a universal symptom (100%), with other common symptoms including headache (75%) and anemia (40%). Diabetes (75%) and hypertension (56%) were the most frequent comorbidities, followed by renal failure (27.5%), indicating a significant overlap between metabolic and cardiovascular conditions and BSI susceptibility.

Blood cultures were positive in 43% of cases, with Gram-positive bacteria such as Staphylococcus epidermidis (15 isolates) and Staphylococcus aureus (16 isolates) being prevalent. Among Gram-negative bacteria, Pseudomonas aeruginosa (17 isolates) was the most frequently isolated pathogen. Notably, antibiotic sensitivity analysis reveals varied susceptibility, with vancomycin showing high efficacy against Gram-positive isolates, while imipenem demonstrated broad effectiveness against Gram-negative bacteria, including Pseudomonas aeruginosa and Escherichia coli. [Table 1]

Amongst the sources of infection, central venous line catheters (20%) and Foley catheters (18%) were the leading sources, emphasizing the need for stringent infection control protocols in catheter management. This demographic and microbiological data underscores the importance of targeted antimicrobial therapy based on sensitivity patterns to manage BSI effectively, especially given the high prevalence of resistant organisms. Additionally, the findings suggest that infection prevention strategies should be prioritized for patients with metabolic comorbidities and catheter use to reduce BSI incidence. [Table 4]

Table 1: Demographic characteristics

Characteristic		No. of patients
Age	<21 years	4 (20%)
	21-30 years	30 (15%)
	31-40 years	55 (27.5%)
	41-50 years	48 (24%)
	51-60 years	43 (21.5%)
	>60 years	20 (10%)
Gender	Males	140 (70%)
	Females	60 (30%)
Clinical features	Fever	**200 (100%)**
	RespiratoryDistress	**10 (5%)**
	Icterus	**32 (16%)**
	Anemia	**80 (40%)**
	Lymphadenopathy	**75 (37.5%)**
	Headache	**150 (75%)**
	Urinary symptoms	**50 (25%)**
	SkinLesions/ rashes	**18 (9%)**
	Altered sensoirum	**20 (10%)**
	Meningism	**24 (12%)**
Comorbidities	Diabetes mellitus	**150 (75%)**
	Hypertension	**112 (56%)**
	Asthma / COPD	**47 (23.5%)**
	Cirrhosis/ alcoholic liver disease	**8 (4%)**
	Renal failure	**55 (27.5%)**
	History of cardiac condition	**14 (7%)**
	Previous history of tuberculosis	**15 (7.5%)**

Table 2

Positivity of culture sensitivity		frequency
Blood cultures	Positive	86 (43%)
	negative	114 (57%)
GRAMPOSITIVECOCCI	Staphylococcusepidermidis	15
	Staphylococcusaureus	16
	Enterococcusfecalis	5
	Pseudomonasaeruginosa	17
GRAMNEGATIVEBACTERIA	Klebsiellapneumonia	12
	Escherichiacoli	11
	Acinetobacterspp	1
	Proteusmirabilis	2
FUNGI	Citrobacterkoseri	2
	Candidaalbicans	3
	Candidatropicalis	2

Table 3: Antibiotic sensitivity

Antibiotic	Staphylococcusepidermidis (n)	Staphylococcusaureus(n)	Enterococcusfecalis(n)	Pseudomonasaeruginosa(n)	Klebsiellapneumonia(n)	Escherichiacoli(n)	Acinetobactersp(n)	Proteusmirabilis(n)	Citrobacter(n)
Amoxycillin and Clavulanic acid	6	7	2	-	-	-	-	-	-
Amikacin	10	9	4	-	-	-	-	-	-
Clindamycin	3	5	-	-	-	-	-	-	-
Cotrimoxazole	5	2	2	-	-	-	-	-	-
Ciprofloxacin	8	3	2	-	-	-	-	-	-
Erythromycin	5	7	3	-	-	-	-	-	-
Cefoxitin	4	4	1	-	-	-	-	-	-
Penicillin	8	5	2	-	-	-	-	-	-
Vancomycin (MIC)	10	9	3	-	-	-	-	-	-
Linezolid	10	9	3	-	-	-	-	-	-
Ciprofloxacin	-	-	-	7	7	6	1	1	0
Cefotaxime	-	-	-	-	2	3	-	0	1
Ceftriaxone	-	-	-	5	2	3	-	-	-
Amoxy clavulanic acid	-	-	-	6	4	5	0	1	0
Amikacin	-	-	-	6	8	9	1	1	0
Gentamycin	-	-	-	5	5	9	1	1	0
Cefoperazone- sulbactum	-	-	-	6	4	6	1	0	0
Piperacillin – Tazobactum	-	-	-	6	4	6	1	1	1
Imipenam	-	-	-	9	10	10	2	1	1
Meropenem	-	-	-	9	10	10	2	1	1
Tobramycin	-	-	-	9	10	10	2	1	1

Table 4: Source of infection

source	Frequency
Central venous line catheter	20
Foley's catheter	18
Endotracheal tube	15
Peritoneal/ hemo dialysis	9
Skin	8
Biliarytract	2
Others	8
Unknown	4

DISCUSSION

The findings of this study provide a comprehensive overview of bloodstream infections (BSIs) in intensive care unit (ICU) patients, aligning with trends observed in other studies on similar patient groups. The predominance of Gram-positive organisms, specifically Staphylococcus aureus and Staphylococcus epidermidis, parallels results from studies by Singh et al,[11] and Banerjee et al,[12] who also reported these pathogens as leading causes of BSIs in critical care settings. Similar to our findings, Singh et al,[11]observed that Gram-positive cocci were prominent among catheter-associated infections, with central venous lines identified as common infection sources, emphasizing the role of device-associated infections in BSI pathogenesis.

The study's demographic data highlights a significant proportion of BSIs in patients with underlying comorbidities, particularly diabetes and hypertension. In concordance, Sharma et al,[13] documented that metabolic and cardiovascular conditions substantially elevate BSI risks, attributing this to impaired immune responses in diabetic and hypertensive patients. The present study also identified fever and headache as primary clinical features, which aligns with findings from Rajesh et al,[14] who described these symptoms as typical presentations among BSI patients. This similarity in clinical characteristics underscores the necessity of early diagnosis and intervention in symptomatic patients to prevent complications.

Antibiotic susceptibility profiles from this study show high efficacy of vancomycin against Gram-positive isolates and imipenem against Gram-negative organisms. These results are consistent with the findings of Patel et al,[15] who documented comparable sensitivity patterns in BSIs. Patel et al,[15] emphasized that vancomycin remains a reliable treatment for Gram-positive infections, while imipenem offers broad-spectrum coverage, particularly for Pseudomonas aeruginosa, as observed in our study. However, the varying sensitivities of Gram-negative pathogens to other antibiotics, such as cefotaxime and amikacin, reveal an emerging trend of resistance that is also noted in studies by Chawla et al,[16] who advocated for

regular susceptibility testing to optimize treatment strategies and curb resistance.

Sources of infection in our study were primarily catheter-related, aligning with the findings of Das et al,[17] who reported that central venous and Foley catheters were primary infection routes in ICU patients. This correlation reinforces the need for stringent infection control practices, including meticulous handling of invasive devices and regular monitoring for early signs of infection.

CONCLUSION

This study emphasizes the importance of pathogen identification, source tracing, and antimicrobial susceptibility testing in managing ICU infections. Rigorous methods and standardized diagnostic criteria revealed a high incidence of resistant ICU pathogens, highlighting the need for strict infection control, careful antibiotic use, and continuous resistance monitoring. Key findings show that nosocomial infections require targeted therapies and robust prevention measures. Statistical validation of infection prevalence and resistance patterns provides valuable insights for enhancing ICU patient care. This study underscores the critical need for ongoing surveillance and tailored interventions to reduce infection rates and improve outcomes in critical care settings.

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Conflicts Of Interest: Nil.

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