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Original Research Article

Microbial Profile of Infections in Various Surgical and Non-Surgical Intensive Care Units

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Abstract:

Background : Intensive care units(ICUs) are specialized departments that provide life-sustaining treatment to critically ill patients. ICUs can be broadly categorized into two types: Surgical ICUs(SICUs) and Non-surgical ICUs (NSICUs). Infections with resistant strains in the ICUs leads to increased mortality, morbidity and health care cost. The microbiological profile of ICUs plays a critical role in guiding antimicrobial therapy, infection control measures, and patient outcomes.

Aims and objective : To study the isolates causing infections in various surgical and non-surgical ICUs and their antimicrobial susceptibility pattern.

Materials and Methods : A cross sectional study was conducted in various ICUs (MICU,PICU,NICU,SICU,TICU) . Samples like blood , Endotracheal aspirate, sputum/BAL, CSF, pleural fluid, ascitic fluid, peritoneal fluid, urine, pus were collected from the patients admitted in various ICUs. These samples were transported immediately to Department of Microbiology laboratory .All samples were processed by Standard bacteriological techniques and the Antimicrobial susceptibility testing was done by Kirby-Bauer disk diffusion method and results were interpreted in accordance with CLSI 2023 guidelines.

Results: Respiratory infections were more common in both non-surgical and surgical ICUs(46.07% and 62.92% respectively) , followed by blood stream infection, skin and soft tissue and urinary infections. Gram negative pathogens were predominant which include *Klebsiella pneumoniae(*32.30%),*Acinetobacter baumannii (*15.17%), *Pseudomonas aeruginosa* (14.05%), *Escherichia coli* (10.67%). Among these, 30.16% were ESBL producers, 14% were MBL producers, and 6.44% were Amp C producers. Gram-positive cocci, primarily *Staphylococcus aureus*, constituted 17.13% of isolates, with 60% of *Staphylococcus aureus* isolates being methicillin-resistant.

Conclusion: High prevalence of gram-negative bacterial infections and multi-drug resistant isolates was noted in Indian ICUs.

Keywords: Intensive care units, *Klebsiella pneumoniae, Acinetobacter baumannii*, drug resistance

Introduction

Increased isolation of antibiotic-resistant microorganisms has become one of the most vital threats to the existing healthcare sector.[1] Healthcare associated infection

(HAI) in surgical intensive care units (SICU) and non-surgical intensive care units (NSICU) witness more notorious incidence rate in hospital. The reasons behind this are - prolonged hospital stay, the severity of diseases , excessive use of antimicrobials, exposure to various medical interventions like peripheral intravenous or central venous lines, urinary catheterization, mechanical ventilation etc.[2]

The most important nosocomial infections in ICUs are bloodstream infections (BSIs), ventilator-associated pneumonia (VAP), and urinary tract infections (UTIs).[3] Patients admitted in ICUs with infection might have acquired it in the community level, indoor ward, or from peripheral hospitals. Moreover, infections caused by multidrug resistant bacteria have resulted in increased mortality and morbidity of the patients. Also, profile of microbial agents isolated might be different from different clinical specimen. Therefore monitoring of prevalence rates of different pathogens along with their antimicrobial susceptibility patterns is necessary for proper management of infections in patients, in order to develop or modify the hospital antibiotic policy.[4] Widely available and convenient measurement of an institution's pathogens and susceptibilities is an Antibiogram.[5] There is paucity of published literature on microbial profile and antimicrobial susceptibility pattern of infections in ICU patients in this region.

Therefore, this study was undertaken with the aim to determine the microbial profile and antimicrobial susceptibility of isolates causing infections in patients admitted in SICUs and compare them to isolates from Non SICUs in the same hospital from the same period.

Materials and Methods

Study design and settings

A cross sectional study was conducted in various ICUs of a tertiary care hospital in Central India from December 2023 to November 2024.

All patients admitted in ICU during the study period who gave their assent with informed consent by their guardians or care-givers were included in the study.

Data Collection

Demographic data and clinical information such as age, gender, admission date, clinical diagnosis, and specimen collection date were recorded. The specimen viz. blood culture, urine, and endotracheal aspirate were sent for culture and sensitivity from ICU during the study period. The microbiological culture and susceptibility result of all patients admitted in ICU during the period of study was observed. The total number of positive cultures in different specimens, culture isolates, and their antibiotic susceptibility and resistance pattern was noted.

Bacterial isolation and identification

The clinical specimens were processed and analysed following standard microbiological protocol. Bacterial isolates were identified and speciated using conventional identification method .[6, 7] Antimicrobial susceptibility testing (AST) was performed by modified Kirby Bauer disc diffusion method against antimicrobial discs recommended by Clinical Laboratory Standard Institute (CLSI) , while Vancomycin MIC was tested using E test.[8]

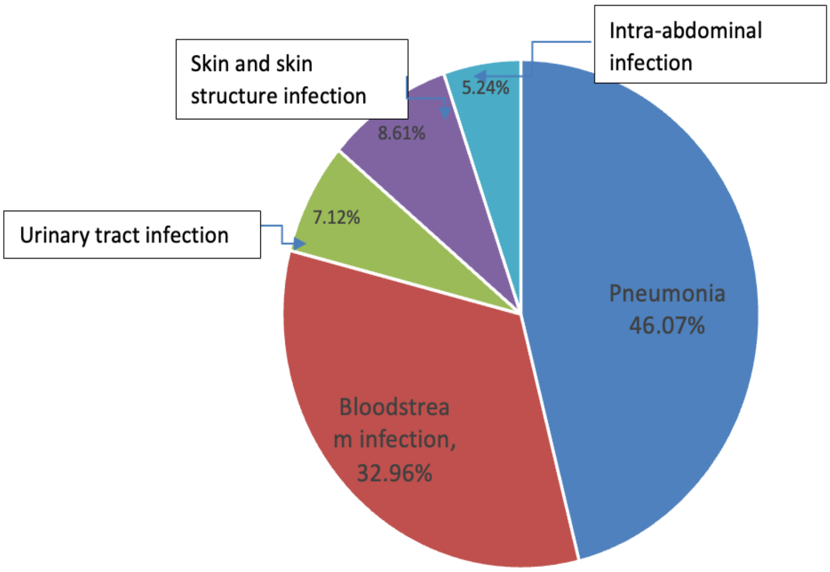
Results

A total of 870 patients admitted in various ICUs whom comprised the study population were analysed. There were 356 (40.92 %) patients who were found culture positive. 75% isolates from Non-surgical ICU and 25% from SICU. (Table 1)

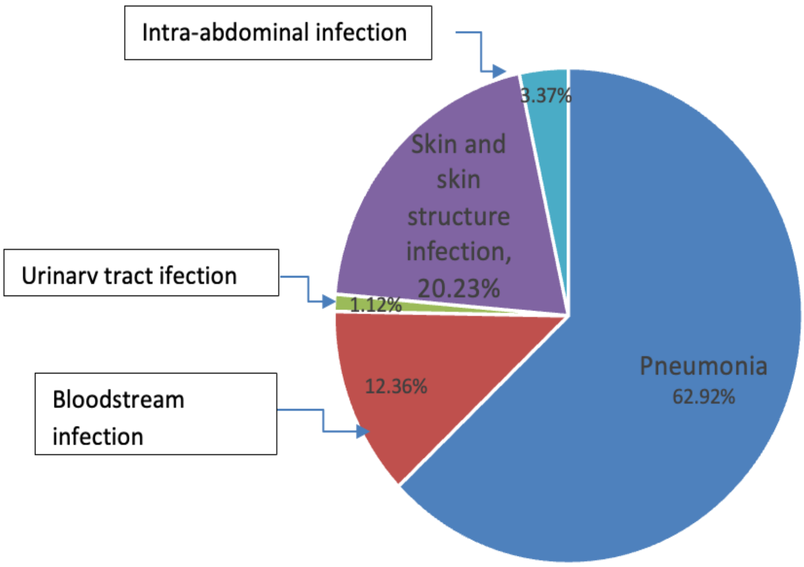
Table 1: Distribution of isolates in various ICUs.

Non SICU			
MICU	PICU	NICU	Total(%)
97	96	74	267(75%)
SICU			
TICU	SICU	Total(%)	
56	33	89(25%)	

Respiratory infections were the most common infection in both Non-surgical(46.07%) and Surgical ICUs(62.92%) followed by blood stream infection ,skin and soft tissue infection, and urinary tract infections .(Chart 1) The isolation rate was very high in tracheal aspirates (177, 49.72%) as compared to blood (85, 23.87%) and pus (22, 6.18%). HAI rates of VAP, CAUTI, and CRBSI were 14.2, 4.8 and 2.5 per 1000 device days.



➤ **A. NON-SICU**



➤ **B. SICU**

Chart 1.Types of infections from non-SICU and SICU.

Gram negative bacilli (GNB) (295 of 356; 82.87%) was the most common pathogen group isolated followed by Gram positive cocci (GPC) (61 of 356; 17.13%). *Staphylococcus aureus* (50.8%) was the most common GPC isolate followed by, Coagulase negative Staphylococci (19.7%),*Enterococcus* species (18%) from non-SICU while 5% *Staphylococcus aureus* and Coagulase negative Staphylococci from SICU. *Klebsiella pneumoniae*, *Acinetobacter* species , and *Pseudomonas aeruginosa* represented the top three gram negative organisms in non-SICU and SICU.(Table 2)

Table 2: Distribution of Gram-positive isolates (n=61) and Gram-negative isolates(n=295)

Isolates	**Non-SICU**				**SICU**		
Gram positive isolates							
Isolates	**MICU**	**PICU**	**NICU**	**Total (%)**	**SICU**	**TICU**	**Total (%)**
S .aureus	4	12	15	31(50.8)	0	3	3(5.0)
CoNS	0	6	6	12(19.7)	3	0	3(5.0)
Enterococcus	4	1	6	11(18.0)	1	0	1(1.5)
Gram negative isolates							
K. pneumoniae	28	36	14	78(26.44)	15	22	37(12.54)
Acinetobacter	26	13	15	54(18.30)	6	20	26(8.81)
P. aeruginosa	19	11	8	38(12.88)	4	8	12(4.08)
E.coli	14	12	10	36(12.20)	2	0	2(0.06)
Citrobacter spp.	2	4	0	6(2.03)	1	3	4(1.35)
Proteus spp.	0	1	0	1(0.03)	1	0	1(0.03)

Respiratory infection caused by *Staphylococcus aureus* from surgical ICUs showed high resistance to erythromycin and levofloxacin while blood stream infection and skin infections were highly susceptible to doxycycline, linezolid ,gentamycin and levofloxacin. In non SICU, respiratory infections showed high resistance to Cephalosporin. CoNS showed high resistance to erythromycin in both surgical and non-surgical ICUs and were highly susceptible to doxycycline, linezolid, gentamycin and levofloxacin. *Enterococcus* in all infections were highly resistant to Erythromycin and susceptible to Teicoplanin, Vancomycin and Nitrofurantoin. (Chart 2)

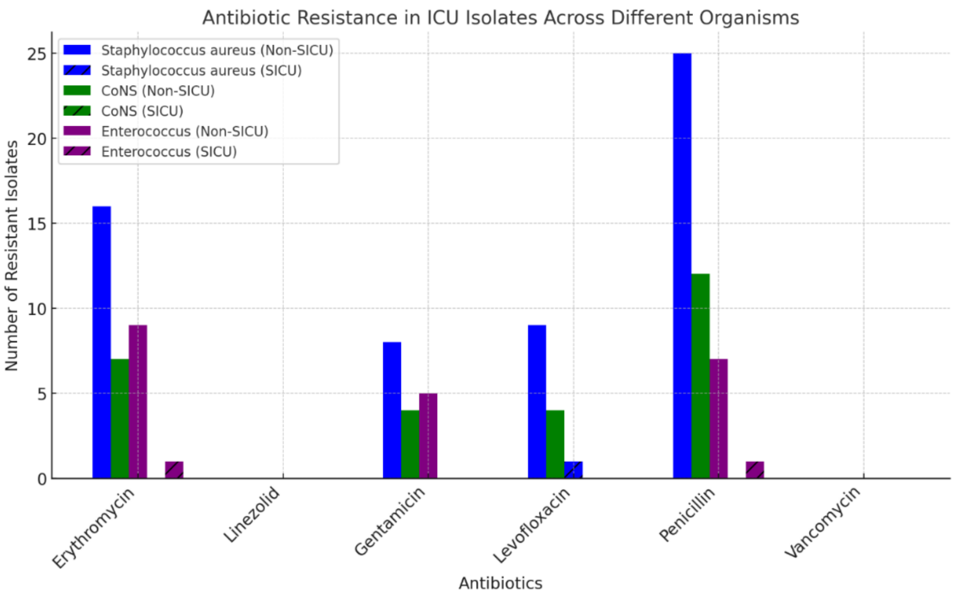


Chart 2: Resistance pattern of gram positive isolates from non-SICU and SICU.

Out of 165 isolates of Enterobacterales , highest resistance observed for Cefazolin, Cefuroxime, and Levofloxacin. Meropenem and Amikacin showed relatively lower resistance, indicating their effectiveness in both SICU and non-SICU settings. *Acinetobacter spp*. showed high resistance to Ampicillin-sulbactam, Ceftazidime, and Gentamicin. Minocycline and Meropenem showed better effectiveness, but resistance patterns varied between SICU and non-SICU.

Among 50 isolates of *Pseudomonas aeruginosa* ,high resistance was shown to Ceftazidime, Piperacillin-tazobactam, and Cefepime. Lower resistance was observed with Amikacin and Meropenem. SICU isolates tend to have higher resistance across most antibiotics compared to non-SICU isolates, suggesting more extensive antibiotic use in SICUs. (Table 3)

Table 3.Antimicrobial resistance patten of Gram negative isolates from non-SICU and SICU

Infections	LRTI (86)		BSI (35)		SSSI (19)		UTI (14)		IAI (11)	
ICUs	NON - SICU	SICU	NON-SICU	SICU	NON-SICU	SICU	NON-SICU	SICU	NONSICU	SICU
Enterobacterales(165)										
Ampicillin	9	4	4	2	7	7	6	0	2	1
Cefazolin	39	19	22	7	7	7	10	1	5	3
Amoxicillin-clavulanate	44	22	24	7	6	7	9	1	4	2
Gentamicin	41	22	20	5	4	5	5	1	5	2
Tobramycin	49	25	23	6	5	7	11	1	5	2
Cefuroxime	48	25	24	8	7	7	12	1	6	3
Cefepime	28	19	19	5	6	7	9	1	0	2
Levofloxacin	47	24	24	8	5	7	11	1	7	2
Meropenem	37	22	21	5	3	7	8	1	7	3
Amikacin	59	25	24	8	4	6	8	1	5	2
Cefoxitin	38	24	23	8	6	7	10	1	5	2
Cefotaxime	38	24	25	8	8	7	12	1	5	2
Piperacillin-tazobactam	33	21	23	5	3	7	9	1	3	2
Nitrofurantoin	-	-	-	-	-	-	6	1	-	-
Norfloxacin	-	-	-	-	-	-	7	1	-	-
Fosfomycin	-	-	-	-	-	-	1	-	-	-
***Acinetobacter* spp (80)**										
Ampicillin-sulbactum	24	18	7	1	1	2	3	-	1	-
Ceftazidime	25	13	8	1	1	2	1	-	1	-
Gentamicin	24	13	7	1	0	2	1	-	1	-
Tobramycin	22	12	6	1	1	2	1	-	3	-
Meropenem	24	13	8	1	1	2	2	-	1	-
Levofloxacin	20	12	7	1	0	2	2	-	1	-
Cefepime	24	13	8	1	1	2	2	-	1	-
Piperacillin-tazobactam	19	12	8	1	1	2	2	-	3	-

Amikacin	23	13	7	1	0	2	2	-	1	-
Cefotaxime	16	5	5	1	1	2	1	-	3	-
Minocycline	21	11	6	1	1	2	0	-	1	-
***P .aeruginosa* (50)**										
Ceftazidime	5	9	2	1	2	1	1	-	1	-
Gentamicin	11	7	0	1	2	0	1	-	0	-
Tobramycin	7	7	0	1	2	0	1	-	0	-
Meropenem	5	8	1	1	2	1	1	-	1	-
Levofloxacin	5	7	1	1	2	0	1	-	0	-
Cefepime	4	9	0	1	2	0	1	-	1	-
Piperacillin-tazobactam	4	9	0	1	2	0	1	-	0	-
Amikacin	7	7	0	1	2	0	1	-	0	-
Aztreonam	7	7	0	0	1	0	1	-	0	-
Netilmicin	6	8	0	1	1	0	0	-	1	-

Gram negative isolates isolated from various ICUs 30.16% were ESBL producers, 6.44% were AmpC producers and 14% were MBL producers. Co-production of ESBL and AmpC were found in 12 (4.4%) isolates; also, co-production of ESBL and MBL were found in 4% isolates. *K.pneumoniae* were found to be the most resistant strain with β lactamase production.(Table 4)

Table 4. Distribution of β-lactamases in ICUs (n=295)

Isolates	**ESBL producer**	**AmpC producer**	**MBL**	**ESBL +MBL**	**ESBL +AmpC**
Klebsiella pneumoniae (115)	60	14	2	12	9
E.coli (38)	24	4	0	0	3
Others (12)	5	1	0	0	1
Acinetobacter spp (80)	0	0	22	0	0
P. aeruginosa (50)	0	0	18	0	0
Total (%)	89(30.16)	19(06.44)	42(14)	12(4)	13(4.4)

Discussion

The study was conducted among 870 ICU patients, reporting a culture positivity rate of 40.92% (356/870), indicating a significant burden of infections. This aligns with previous large-scale Intensive Care Units surveillance studies, such as those by Vincent et al. in 2009 [3] and Magiorakos et al. (2012) [9], which similarly found high infection rates, particularly in critically ill patients requiring prolonged mechanical ventilation. The predominance of Gram-negative bacilli (82.87%) over Gram-positive cocci (17.13%) follows global trends, with *Klebsiella pneumoniae*, *Acinetobacter spp.,* and *Pseudomonas aeruginosa* emerging as the most common pathogens, consistent with findings from international ICU settings (Richter et al., 2019) .[10]

Among ICU infections, respiratory infections were most frequent in both non-surgical ICUs (46.07%) and surgical ICUs (62.92%), emphasizing the significant burden of ventilator-associated pneumonia (VAP). The reported VAP rate (14.2 per 1000 device days) is consistent with global estimates ranging from 10–20 per 1000 device days, as documented in the studies by Kollef et al. (1997) [5] and Klein et al. (2013) . [11] Other major healthcare-associated infections included catheter-associated urinary tract infections (CAUTI) (4.8 per 1000 device days) and central line-associated bloodstream infections (CLABSI) (2.5 per 1000 device days).

These rates are comparable to data from Indian and global ICUs, where mean VAP, CLABSI, and CAUTI rates were reported as 20.69, 2.53, and 2.23 per 1000 device days, respectively (Khan et al., 2022) .[12]

The higher isolation rate from tracheal aspirates (49.72%) compared to blood (23.87%) and pus (6.18%) further underscores the role of mechanical ventilation in ICU infections, as observed in earlier studies by Balkhy et al. (2018) [13] and Rello et al. (2019) .[14]

Antimicrobial resistance remains a critical challenge in ICU settings, with high resistance patterns observed across both Gram-positive and Gram-negative bacteria. Among Gram-positive cocci, *Staphylococcus aureus* from SICU respiratory infections showed high resistance to erythromycin and levofloxacin, whereas bloodstream and skin infections remained susceptible to doxycycline, linezolid, gentamicin, and levofloxacin. This pattern closely mirrors findings from Vincent et al. (2009) .[3]

In non-SICU settings, respiratory infections demonstrated high resistance to cephalosporins, highlighting the limited effectiveness of this antibiotic class in ICU settings, a concern raised by Bassetti et al. (2017).[15] Coagulase-negative Staphylococci (CoNS) exhibited high resistance to erythromycin but remained susceptible to doxycycline, linezolid, gentamicin, and levofloxacin, findings consistent with studies by Arias et al. (2012) .[16] *Enterococcus spp*. displayed resistance to erythromycin, yet retained susceptibility to teicoplanin, vancomycin, and nitrofurantoin, aligning with global resistance trends. [16]

Among Gram-negative isolates, Enterobacterales demonstrated high resistance to cefazolin, cefuroxime, and levofloxacin, while meropenem and amikacin remained effective, similar to resistance trends reported by Gales et al. (2019) . [17] *Acinetobacter spp.* exhibited notable resistance to ampicillin-sulbactam, ceftazidime, and gentamicin, though minocycline and meropenem showed relative effectiveness, findings corroborated by Rodriguez et al. (2018) .[18] *Pseudomonas aeruginosa* presented high resistance to ceftazidime, piperacillin-tazobactam, and cefepime, but remained susceptible to amikacin and meropenem, consistent with findings by Magiorakos et al. (2012) .[9]

A significant concern identified in this study was the high prevalence of β-lactamase-producing strains, with 30.16% ESBL producers, 6.44% AmpC producers, and 14% MBL producers. *Klebsiella pneumoniae* was the most resistant strain, often producing multiple β-lactamases, a trend similarly reported in studies by Nordmann et al. (2011) [19] and Pitout et al. (2008) .[20] The higher resistance rates in SICU isolates highlight the impact of greater antibiotic exposure and selection pressure, necessitating strict antimicrobial stewardship measures, as emphasized by Rodriguez et al. (2018) .[18]

Limitations

There were some limitations to the study like unable to analyse clinical outcome in terms of recovery or mortality. More clinico-epidemiological studies will be needed to validate our findings**.**

Conclusions

Gram negative bacteria were the predominant pathogens in all ICU specimen. *Klebsiella* species and *Acinetobacter* species were the most common pathogens isolated while *Staphylococcus aureus* was the common among Gram positive bacteria. Although isolates showed multiple drug resistance to commonly used antimicrobials but a good susceptibility pattern was observed for Linezolid, and Vancomycin. Due to advent of carbapenem resistant Gram negative bacteria, use of carbapenems in ICU infection may lead to failure of antibiotic therapy. Routine microbial culture and antimicrobial susceptibility testing in ICU specimen and periodic review of hospital antibiotic policy should be mandatorily practised to prevent morbidity and mortality.

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