Original Article

Bacteriological Profile of Bloodstream Infections Among Adults in a Tertiary Care Hospital From Central India: An Analytical Cross-Sectional Study

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Abstract

Background: Bloodstream infections (BSIs) represent a significant cause of morbidity and mortality in hospital settings. The increasing emergence of antimicrobial resistance among the causative pathogens has further complicated patient management and is a pressing public health concern. This study aimed to identify the etiological agents responsible for BSIs and to provide their antibiotic susceptibility patterns.

Methods: An analytical cross-sectional study was conducted from 1 June 2021 to 30 May 2023 in a tertiary care hospital. Blood samples were collected from adult patients with a clinical diagnosis of septicemia. Isolation and identification of organisms were performed according to standard microbiological guidelines. Antimicrobial susceptibility testing was carried out using the Kirby-Bauer disc diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines.

Results: Out of 430 clinically suspected adult bacteraemia cases, blood cultures were positive in 196 cases (45.58%). Gram-negative bacteria were the most common causative agents, accounting for 71.42% of isolates, among which Klebsiella pneumoniae (21.93%) was predominant, followed by Escherichia coli (13.26%), Acinetobacter baumannii (9.69%). Extended-spectrum beta-lactamase (ESBL) production was observed in 38.55% of Gram-negative isolates, with the highest rates among Klebsiella pneumoniae (54.76%). Gram-positive cocci comprised 26.02%, while Candida albicans was detected in 2.55% of cases. Methicillin resistance was detected in 33.33% of Staphylococcus aureus isolates.

Conclusions: BSIs remain a major concern in tertiary care hospitals, with Gram-negative organisms being the predominant pathogens. Prompt diagnosis and timely reporting of antibiotic susceptibility results are crucial for guiding early and appropriate therapy.

Keywords: bloodstream infections; bacteriological profile; antibiotic susceptibility pattern; adults; tertiary care

Introduction

Bloodstream infections (BSIs) represent a significant cause of morbidity and mortality globally and are among the most frequent healthcare-associated infections [1]. BSIs are broadly classified into intravascular infections, originating within the cardiovascular system (such as infective endocarditis, mycotic aneurysm, and catheter-associated bacteremia), and extravascular infections, where pathogens enter the bloodstream via the lymphatic system from other infection sites. While fungi can also cause these infections, bacteria remain the predominant pathogens responsible for serious vascular infections

[2]. The emergence of multidrug-resistant (MDR) bacterial strains, including Klebsiella, Pseudomonas, Acinetobacter, and Citrobacter species, has exacerbated the challenge of managing BSIs, particularly in intensive care units (ICUs). These resistant organisms contribute to prolonged hospital stays and increased mortality rates [3]. Gram-negative bacilli, especially Klebsiella pneumoniae, are frequently isolated as causative agents in BSIs, with a notable prevalence of antimicrobial resistance, including methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococci, and carbapenem-resistant Enterobacterales. The high prevalence of resistant strains complicates empirical antibiotic therapy, making the selection of appropriate initial treatment critical to improving patient outcomes [4].

Methods

Adults aged over 18 years who were clinically diagnosed with septicemia were enrolled in this study and was carried out in the tertiary care hospital from June 2021 to May 2023 as approved by Ethical Committee. Detailed patient histories were recorded, including demographic data (age and sex), presenting symptoms, existing comorbidities, and any invasive procedures undergone. Blood samples were processed using conventional microbiological methods for culture.

Blood culture

Venous blood (approximately 10 mL) was collected aseptically using a disposable 18–20-gauge needle and a 10–20 mL syringe, taking care to avoid contamination of the venepuncture site. The blood was immediately inoculated into conventional blood culture bottles containing either Tryptic Soy Broth or Brain Heart Infusion broth (50 mL). A blood culture set consisted of two bottles, each containing approximately 80 mL of broth; 10 mL of blood was inoculated into each bottle, one for aerobic and one for anaerobic culture, for a total maximum blood draw of 20 mL per set. The blood-to-broth ratio was maintained at approximately 1:10 to dilute any circulating antimicrobial agents below inhibitory levels [5].

Patients were identified and their blood samples were collected in BHI broth. Then the BHI broth was incubated overnight aerobically at 37°C. The sample was inoculated onto Blood Agar, MacConkey Agar and Sabouraud's Dextrose Agar. Isolates were identified on the basis of colony morphology and standard biochemical tests. If there is no growth then the sample is sub-cultured on alternate days for 7 days before reporting it as sterile.

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was performed using commercially available antibiotic discs of appropriate content and potency (HiMedia Laboratories Pvt. Ltd., Mumbai, India) on Mueller–Hinton agar. Zone diameters were determined by the modified Kirby–Bauer disk diffusion method and Resistance profiles were categorized as sensitive, intermediate, or resistant based on CLSI Guidelines 2020.

Quality control

Escherichia coli ATCC® 25922, Escherichia coli ATCC® 35218 (Escherichia coli ATCC® (for β-lactam/ β-lactamase inhibitor combination), Pseudomonas aeruginosa ATCC® 27853 Staphylococcus aureus ATCC® 25923 (disk diffusion)

ESBL was tested by applying the disks of Ceftazidime (30µg) and Ceftazidime + Clavulanic acid (30µg + 10µg) to the lawn culture of the test organism. If the zone of inhibition around Ceftazidime-Clavulanic acid is $>$5mm than the zone of inhibition around the Ceftazidime disk, then the test organism is said to be ESBL producer (CLSI 2020) [6].

Inclusion criteria- Bacterial and fungal isolates in the laboratory from blood culture from clinically diagnosed patients of septicemia.

Exclusion criteria - Patients on antibiotics

Results

In the present study, blood culture samples from a total of 430 patients with the clinical diagnosis of septicemia were processed. All the blood culture samples were processed by the conventional blood culture method. Out of the total 430 blood samples received, 253 (58.83%) were from males and 177 (41.16%) were from females. Maximum numbers of samples were from patients in the age group of 46-60 years followed by 31-45 years. Among culture-positive samples, males contributed to 65.30% (128/196) of the cases and females to 34.69% (68/196).

In present study, Gram-negative bacilli were found to be the commonest cause of adult septicemia (71.42%). Gram-positive cocci were found in 26.02% of cases, while Candida albicans were isolated in 2.55% of cases as given in (Figure 1).

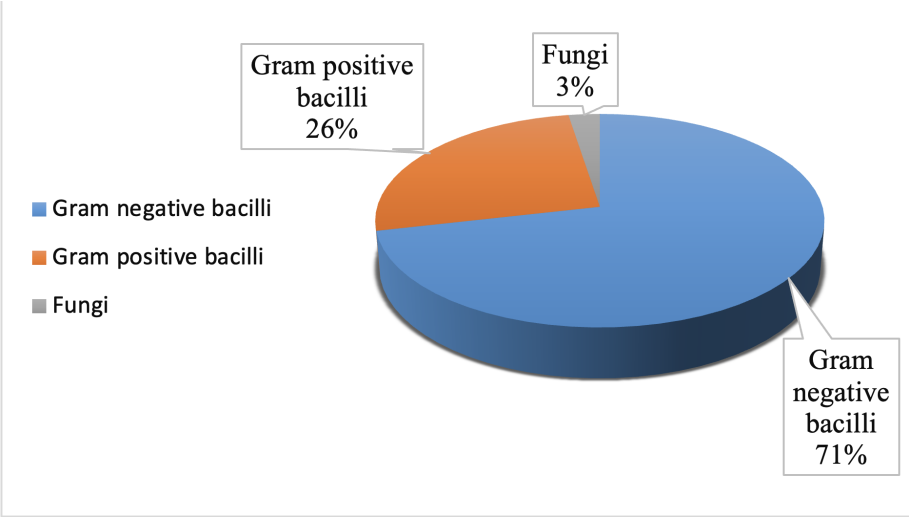

Figure 1: Positive cases of septicemia (%).

Klebsiella pneumoniae (21.93%) being predominant followed by Staphylococcus aureus (18.36%), Acinetobacter spp. (17.85%), E. coli (13.26%) were the commonest isolates from blood culture throughout the study as given in (Figure 2).

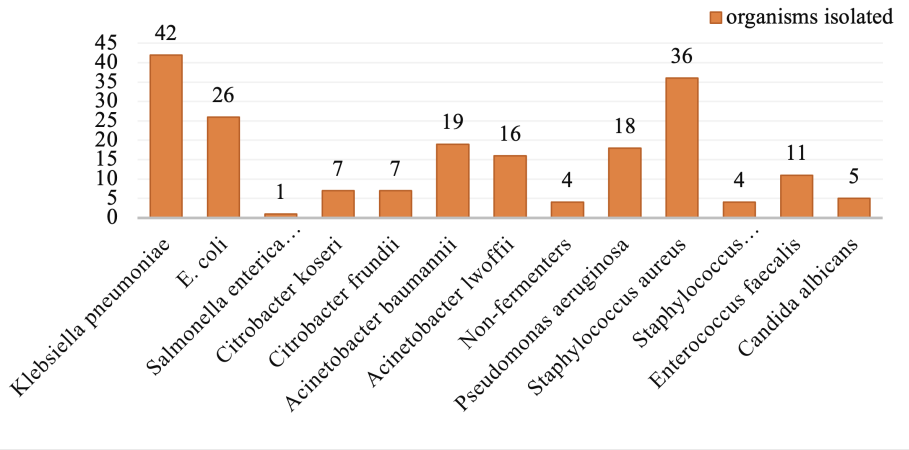

Figure 2: Distribution of microbial isolates from blood culture.

Genito-urinary infections (20.69%) followed by respiratory infection (16.97%) and skin and soft tissue infection (11.86%), undetermined source including primary bacteremia accounted for 36.74% of the clinically suspected cases of Bloodstream infections in our study (Figure 3).

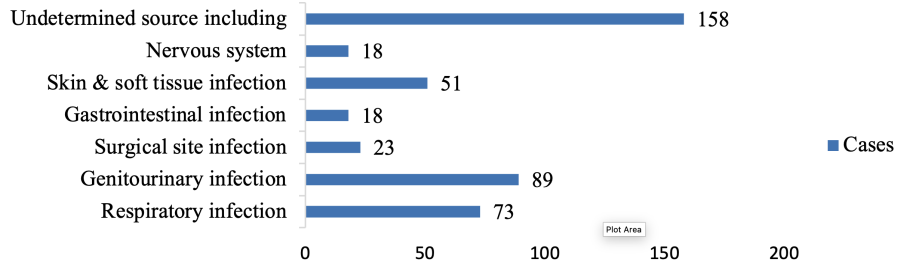

Figure 3: Distribution of cases based on clinical diagnosis.

The antimicrobial sensitivity of Gram-positive bacteria isolates from the blood cultures of adult septicemia cases. All Gram-positive isolates were sensitive to vancomycin and linezolid. All the isolates of Staphylococcus aureus were resistant to penicillin (Table 1).

Table 1: Antibiotics sensitivity pattern for Gram positive bacteria.

Organisms	Antibiotics (%)									
	P	Cx	G	Levo	E	CD	Lz	TEI	VA	HLG
Staphylococcus aureus (n=36)	0	66.66	33.33	77.77	66.66	66.66	100	-	100	-
CoNS (n=4)	50	100	100	50	75	75	100	-	100	-
Enterococcus faecalis (n=11)	0	-	-	72.72	63.63	-	100	72.72	81.81	54.54

Klebsiella isolates in our study showed complete resistance to cefazolin, cefoperazone. Among 26 isolates of E. coli, maximum sensitivity was seen to Amikacin (76.92%), Tobramycin (73.07%), and piperacillin-tazobactam (69.23%). Most of the isolates were resistant to ampicillin, 1st and 2nd Generation Cephalosporins. All the isolates of Citrobacter spp. were resistant to ampicillin, cefazolin, and cefoxitin but sensitive to cefotaxime, piperacillin tazobactam, and aminoglycosides (Table 2).

Table 2: Antibiotics sensitivity pattern for Gram negative bacteria.

Organisms	Antibiotics (%)													
	AMP	CZ	GEN	TOB	CXM	CX	CTX	CPM	PIT	MRP	AK	C	Pf	CIP
Klebsiella pneumoniae (n=42)	-	0	52.38	83.33	35.71	26.08	73.80	50	92.85	90.47	47.61	-	-	-
E. coli (n=26)	0	23.07	80.76	73.07	50	46.15	69.23	61.53	69.23	69.23	76.92	-	-	-
Citrobacter freundii (n=7)	0	0	100	71.42	-	0	71.42	57.14	71.42	71.42	71.42	-	-	-
Citrobacter koserii (n=7)	0	0	71.42	71.42	-	0	57.14	57.14	71.42	71.42	71.42	-	-	-
Salmonella enterica serovar Typhi (n=1)	100	-	-	-	-	-	100	-	-	-	-	100	100	100

In the present study, 38.55% Gram-negative isolates were ESBL producers. ESBL production among Gram-negative bacilli was predominantly shown by Klebsiella pneumoniae (54.76%) followed by E. coli (34.61 %) (Table 3).

Table 3: ESBL production among Enterobacterales isolates (n=83).

Method of detection of ESBL	K. pneumoniae n (%)	E. coli n (%)	Citrobacter spp. n (%)	Total Enterobacterales
Phenotypic confirmatory disk diffusion method	54.76	34.61	-	38.55

The antimicrobial sensitivity of Pseudomonas aeruginosa, Acinetobacter baumannii, Acinetobacter lwoffi. It shows that 16 out of 18 isolates of Pseudomonas aeruginosa and most of the isolates of Acinetobacter baumannii were sensitive to meropenem. For Pseudomonas aeruginosa strains next effective antibiotics were amikacin (83.33%), and piperacillin-tazobactam (83.33%). Most of the isolates of Pseudomonas aeruginosa showed resistance to ceftazidime. Most of the isolates of Acinetobacter baumannii, and Acinetobacter lwoffii were sensitive to amikacin and piperacillin-tazobactam (Table 4).

Table 4: Antibiotics sensitivity pattern for Non-fermenters.

Organisms	Antibiotics (%)									
	CAZ	GEN	TOB	CPM	PIT	AT	MRP	AK	COT	NET
Pseudomonas aeruginosa (n=18)	33.33	77.77	66.66	72.22	83.33	66.66	88.88	83.33	77.77	77.77
Acinetobacter baumannii (n=19)	52.63	63.15	57.89	78.94	68.42	-	78.94	84.21	52.63	-
Acinetobacter lwoffii (n=16)	50	62.50	56.25	87.50	68.75	-	68.75	87.50	75	-

Discussion

Bloodstream infections (BSIs) represent a significant clinical challenge. The extensive use of advanced medical technologies, including the widespread implementation of indwelling devices, has the potential to alter both the epidemiology and clinical outcomes of BSIs. Consequently, prompt detection, accurate identification, and antimicrobial susceptibility testing of pathogens isolated from blood are critical responsibilities of the diagnostic microbiology laboratory.

A total of 430 blood samples were analyzed, with 253 (58.83%) from male and 177 (41.16%) from female patients. The majority of samples were from individuals aged 46–60 years, followed by those aged 31–45 years. These findings are consistent with previous studies, such as Mehta et al. [7], who reported 65% male and 35% female samples out of 567 cases.

In our study of 430 clinically suspected adult septicemia cases, blood cultures were positive in 196 (45.58%) cases, while 234 (54.42%) were negative. This positivity rate aligns closely with previous reports by Khanal et al. [9] (44%) and Sultana et al. [10] (49.28%). It is well established that prior antibiotic administration can reduce pathogen detection in blood cultures. Prior antibiotic intake can reduce the likelihood of detecting pathogens in blood cultures. Collecting multiple blood culture sets and ensuring adequate blood volume per bottle increase the chances of identifying bloodstream infections. Clinical factors such as patient age, fever intensity, and source of infection also affect positivity rates. Consistent with other studies, Gram-negative bacteria predominated as causative agents in adult septicemia, accounting for 71.42% of isolates, followed by Gram-positive cocci at 26.02%, and Candida albicans at 2.55%. This predominance of Gram-negative pathogens concurs with findings reported by Latif et al. [11] (72.1%), Garg et al. [12] (65.5%), and Prashanth et al. [13] (70.47%).

Among the Gram-negative isolates in our study, Klebsiella pneumoniae was the predominant pathogen, accounting for 21.93% of cases, followed by Escherichia coli (13.26%), Acinetobacter baumannii (9.69%), and Pseudomonas aeruginosa (9.18%). These findings are consistent with Mehdinejad et al. [14], who observed Klebsiella pneumoniae (33.5%) and E. coli (20.6%) as the leading Gram-negative pathogens. This pattern underscores the significant role of Klebsiella pneumoniae in bloodstream infections and highlights the need for targeted antimicrobial strategies against these prevalent organisms. In our study, Pseudomonas aeruginosa was 9.8%, similar findings were also reported by Arora et al. [15] (7.63%) and Qureshi M et al. [16] (10.7%). A high percentage of Pseudomonas aeruginosa isolates were reported by Garg et al. [12] (16%), Mehta et al. [7] (19.75%).

Among Gram-negative isolates, one case of Salmonella enterica serovar Typhi was isolated. Similarly, Anbumani et al. [17] reported the isolates of Salmonella Typhi 3.5%, and 14.6% by Garg et al. [12].

In our study, Acinetobacter baumannii (9.69%), and Acinetobacter lwoffii (8.16%) were isolated in positive blood culture samples. In contrast, a very high percentage (32%) of Acinetobacter spp. (mainly Acinetobacter lwoffii followed by Acinetobacter baumannii) were reported by Barati M et al. [18], Malini A et al. [19] Acinetobacter baumannii (73.3%), Acinetobacter lwoffii (5.8%), Samanta et al. [20] who also found Acinetobacter spp. (66%).

Among Gram-positive isolates, Staphylococcus aureus (18.36%) was the commonest followed by Enterococcus faecalis (5.61%), and Staphylococcus epidermidis (CoNS) (2.04%). This was in accordance with other studies carried out by Mehta et al. [7], and Ayobola et al. [21] who reported Staphylococcus aureus as 13.66% and 14.6% respectively. The results of the cefoxitin disk diffusion test, Methicillin resistance was seen in 33.33% of isolates of Staphylococcus aureus.

In our study, Enterococcus faecalis was isolated in 5.61% of blood culture positive samples which were similar to Anbumani et al. [17] (4.16%) and Alam M. S et al. [22] (6.8%). Apart from Gram-positive and Gram-negative organisms, Candida albicans were isolated in 2.55% positive blood culture samples. Similar, findings were found by Qursheed Sultana et al. [10] (1.19%), and Jena et al. [23] found (3.1%).

In the present study, maximum isolates of Enterobacterales were sensitive to Meropenem followed by Amikacin, Tobramycin, and Piperacillin-tazobactam. High resistance showed to Ampicillin, 1st, 2nd generation cephalosporins. Arora et al. [15], Barati M et al. [18] and Kumar S et al. [24] also reported the same antibiotic resistance pattern in Gram-negative isolates from BSIs.

In the present study, 38.55% (32/83) of Gram-negative isolates were ESBL producers, among these ESBL production was highest among Klebsiella pneumoniae (54.76%) followed by E. coli (34.61 %), which is similar to the ESBL production reported by Arora et al. [15] 34.35% and Anathan et al. [25] 144 25.4% respectively among Klebsiella pneumoniae.

In our study, Gram-positive cocci were 100% sensitive to Vancomycin and Linezolid. A similar sensitivity pattern to Vancomycin and Linezolid was reported by 36.4% by Mehdinejad M et al. [14], and Chinna D et al. [26]. In the present study, Enterococcus faecalis (2 cases) show resistance to Vancomycin. Sadar et al. [27] reported 2.4% resistance to Vancomycin. A high degree of Vancomycin resistance was reported by Pavani et al. [28] (33.3%). In the present study, four isolates of Candida albicans were sensitive to Fluconazole and Amphotericin B, one isolate was resistant to Itraconazole, which was comparable with the findings of Pal et al. [29] showed the use of long-term antibiotics and intravascular catheter use directly correlated with a high incidence of Candida infection.

This study from a single tertiary care hospital limits generalizability to other settings with varying patient profiles and antibiotic practices. Prior antibiotic use likely reduced blood culture positivity, underestimating true infection rates, while the sample size restricted capturing broader pathogen diversity.

Conclusion

The present study conclusively demonstrates that Gram-negative bacilli, with Klebsiella pneumoniae as the predominant pathogen, are the leading cause of adult septicemia, particularly affecting male patients in the 46–60 years age group. The principal sources of bloodstream infections were identified as genito-urinary, respiratory, and skin/soft tissue infections. The significant resistance observed in Gram-negative isolates to multiple commonly used antibiotics, including the widespread presence of extended-spectrum beta-lactamase (ESBL) producers, underscores an urgent need for continuous antimicrobial resistance surveillance and tailored antibiotic stewardship. Gram-positive pathogens remain largely susceptible to vancomycin and linezolid, although penicillin resistance is widespread among Staphylococcus aureus isolates. These findings advocate for the prudent use of carbapenems, aminoglycosides, and beta-lactam/beta-lactamase inhibitor combinations like piperacillin-tazobactam to optimize treatment outcomes. Overall, the study emphasizes the critical importance of evidence-based antimicrobial therapy and robust infection control strategies to reduce septicemia-associated morbidity and mortality effectively.

Abbreviations: P: Penicillin G; Cx: Cefoxitin; G: Gentamycin; Levo: Levofloxacin; E: Erythromycin; CD: Clindamycin; Do: Doxycycline; LZ: Linezolid; TEI: Teicoplanin; VA: Vancomycin; HLG: High-level gentamycin; AMP: Ampicillin; CZ: Cefazolin; GEN: Gentamicin; TOB: Tobramycin; CXM: Cefuroxime; CX: Cefoxitin; CTX: Cefotaxime; CPM: Cefepime; PIT: Piperacillin-tazobactum; MRP: Meropenem; AK: Amikacin; CAZ: Ceftazidime; AT: Aztreonam; COT: Co-Trimoxasole; NET: Netilmicin.

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