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PREVALENCE OF CATHETER RELATED BLOODSTREAM INFECTION IN ADULT ICU PATIENTS : A CROSS SECTIONAL STUDY WITH COMPARISON BETWEEN AUTOMATED & CONVENTIONAL BLOOD CULTURE METHODS FOR DETECTION.

DR. MANASWINI RATHOR[1] , DR.DINESH VERMA [2], DR. ANITA SHARMA[3], DR. SAURABH SHARMA[4]*

1- PG RESIDENT DEPARTMENT OF MICROBIOLOGY, GOVERNMENT MEDICAL COLLEGE, KOTA
2- PROFESSOR AND HEAD, DEPARTMENT OF MICROBIOLOGY, GOVERNMENT MEDICAL COLLEGE, KOTA
3- ASSISTANT PROFESSOR, DEPARTMENT OF MICROBIOLOGY, GOVERNMENT MEDICAL COLLEGE, KOTA
4- ASSOCIATE PROFESSOR, DEPARTMENT OF MICROBIOLOGY, GOVERNMENT MEDICAL COLLEGE, KOTA
* CORRESPONDING AUTHOR- DR. SAURABH SHARMA, H. NO-107, DADABARI EXTENSION, KOTA-324009, RAJASTHAN, INDIA.
E-MAIL: drsaurabhsharma09@gmail.com MOB.NO. 8696339220

ABSTRACT

Introduction CVC catheterization is often associated with serious infectious complications, mostly catheter related bloodstream infections (CRBSI), resulting in significant morbidity, increased duration of hospitalization and additional medical costs. Patients with CVCs are at risk of developing local as well as systemic infectious complications like local insertion-site infection, CRBSI, septic thrombophlebitis, endocarditis and other metastatic infections. This study aims to determine the prevalence, microbial profile, associated risk factors, AST pattern with comparison of automated & conventional blood culture methods for detection of central venous catheter related blood stream infection in adult ICU patients.

Material & methods The present cross-sectional study was conducted on 150 adult ICU patients. The specimens collected were processed by standard microbiological methods. Antimicrobial sensitivity testing (AST): As per CLSI 2022 guidelines, AST was performed on Mueller-Hinton Agar using Kirby-Bauer disk diffusion method.

Results

CRBSI rate was found 17.78/1000 central-line days by automated method and 9.63/1000 central-line days by conventional method. The risk factors identified were Male gender, higher age group of 41 years and above, patient admitted in nephrology department with indication of haemodialysis, increased duration of catheterisation, femoral site insertion, emergency catheterisation , multiple attempts with inexperienced venipuncturist. Coagulase

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Negative Staphylococcus was the most common organism isolated, followed by Escherichia coli by both methods. .Ampicillin, Clindamycin, Trimethoprim-Sulfamethoxazole found to be more effective against gram positive isolates while Amikacin, Ciprofloxacin, Ceftriaxone, Gentamicin, Imipenem were found most effective against gram negative isolates. . By automated culture method, positivity in blood culture, rate of CRBSI and frequency of detectation of pathogens by day of detectation were more reported as compared to conventional blood culture methods (CBCM). automated system showed 16% positivity of CRBSI as compared to 8.67% by conventional blood culture system.

Conclusion

The CRBSI prevalence was high with significant association of prolonged duration of catheterization, elderly age group,femoral site insertion, emergency catheterisation , multiple attempts with inexperienced venipuncturist with CRBSI. The automated blood culture systems acts as an appropriate means for the initial identification and detection of blood pathogens and improved provision of antimicrobial therapeutic options for septic patients especially in Critical Care and Intensive Care Units .Thus, enhancing infection control measures, setting up surveillance systems, applying evidence-based prevention strategies and use of strict and rational antibiotic policy are essential to prevent and manage bloodstream infections related to central venous catheters

Key words

Automated & conventional blood culture methods, CRBSI, Antibiotic Susceptibility testing (AST)

BACKGROUND

Catheter-related bloodstream infections are a major cause of poor patient prognosis and mortality. CRBSIs significantly affect the length of hospital stays and quality of patients' lives. The most common causes of CRBSIs are contamination of the catheter hub and entry of skin flora into the patient's bloodstream during/after CVC insertion.[1] Diagnosis of CRBSI is based on the following:

- The presence of a CVC
- Signs of catheter insertion site infection
- Clinical symptoms and signs of bacteraemia
- Resolution of the symptoms and signs of bacteraemia after removal of the suspect CVCpositive blood culture;
- Growth of the same organism from the catheter tip culture

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In practice, a presumptive diagnosis of CRBSI is often made on the basis of one or two of these criteria. The 'gold standard' is the combination of a positive blood culture with the same organism isolated from the catheter tip culture.[2]

Central venous catheter (CVC) colonization is defined as the significant growth of a micro-organism (> 15 colony forming units) from the catheter tip by semi-quantitative culture. The rate of CRBSI is expressed in number of CVC days and was calculated by the following formula:

Rate of CRBSI = Number of catheter related Infections/ Total number of Catheter Days during the Time period x 1000.[3]

Hence, the present study aimed to;

- To calculate CRBSI rate per 1000 catheter days of Central Venous Catheter in ICU.
- To study the microbial profile ofCentral Venous Catheter related Bloodstream Infections in ICU.
- To determine its Antibiotic Susceptibility Profile of isolated organisms.
- To determine the associated risk factors.
- To compare automated and conventional blood culture methods of Central Venous Catheter related Bloodstream Infections in ICU.

MATERIAL AND METHODS

Study population &Design

The present cross-sectional study was conducted on patients, admitted in ICU with the age more than 18 years, who's CVC Tips & Blood for culture samples were received at Department of Microbiology, Government Medical College, Kota, from the duration of 1-1.5 years, after getting approval from the ethical committee of the institution.

Sample size

A total of 150 patients satisfying the inclusion and exclusion criteria, admitted in ICU with CVC were examined in this study.

Inclusion Criteria

- ICU Patients > 18yr. of age
- All patients admitted in ICU and inserted with CVC.
- Signs and symptoms of septicaemia after 48 hours of CVC insertion.
- Those patients who are willing to give consent

Exclusion Criteria

- CVC tips from NICU, PICU patients.
- All patients whose CVC inserted outside NMCH & MBS Hospital, Kota.

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- Those patients who are not willing to give consent

Methods

All specimens were collected under sterile aseptic conditions were further processed by standard microbiological methods and Antimicrobial sensitivity testing was performed on Mueller-Hinton Agar using Kirby-Bauer disk diffusion method, as per CLSI 2022 guidelines,

Collection of Sample

Collection of central line catheter tip:

- Skin preparation with 70% alcohol or tincture iodine prior to catheter removal.
- By holding the proximal end of the catheter with sterile forceps and removed it carefully avoiding contact with skin
- 4-5cm of catheter tip was cut with sterile blade and dropped it into a sterile container.
- Add sterile normal saline to avoid drying of tip.
- Transported to laboratory as soon as possible.

Collection of peripheral blood:

Blood for culture was collected from a peripheral vein, preferably antecubital vein, simultaneously with the catheter tip. Prepare the skin with 70% alcohol or tincture iodine and allowed to dry and Collected the blood upto 10 ml from the adults.

- Inoculated into adult BACTEC and conventional blood culture bottles.
- Incubated in BACTEC automated and conventional blood culture system.

Sample Processing

Catheter tip endoluminal flush culture:

The tip was rolled back and forth across the entire surface of blood agar plate using sterile forceps. Plates were examined at 24 hours, 48 hours and 72 hrs. Significant growth to was defined as $\geq$15 CFU.

Blood Culture:

Peripheral blood collected from the patients was inoculated into the blood culture bottles kept in the Bactec, was taken out when the Bactec flagged positive.They were sub-cultured on Blood agar and MacConkey agar and incubated and examined at 24,48,72 hours of incubation.Growth obtained by catheter tip culture and sub cultured positive blood culture was followed by standard microbiological methods.

Antimicrobial sensitivity testing (AST):

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As per CLSI guideline, AST was performed on Mueller-Hinton Agar using Modified Kirby-Bauer disk diffusion method.

RESULTS

In our study the rate/ incidence density (ID) of CRBSI was 9.63 and 17.78 per 1000 catheter days by conventional and automated methods respectively.

Among 150 cases studied, age ranging from 18 to >80 years, majority of the subjects belonged to 41-60 years and 94 (62.66%) were male and 56 (37.33%) were female. Male predominance was observed with the ratio of 1.68:1.(table 1)

Table 2 shows catheter related risk factors aassociated with CRBSI. As the reference value of P is 0.050 , on applying chi square test the longer duration of catheterisation (>6 days, site of catheterizationie femoral vein, emergency catheterisation, more no. of attempts and lesser experience of venipuncturist were found to be significantly associated risk factors. (P< 0.05) in prevalence of CRBSI.The local site of infection of catheter was found not significant as the p value was observed > 0.05.

On comparison of blood culture by automated and conventional methods 24 (16%) cases were reported with CRBSI by automated method whereas 13 (8.67%) cases reported positive by conventional method. On comparison of both the difference was found statistically significant. (p=0.05)(table 3)

Table 4 shows the comparative distribution pattern of microorganism by automated and conventional blood culture methods.

When sensitivity pattern of Gram positive isolates was studied, Staphylococcus aureus showed 87.89% sensitivity to Linezolid, 76.9% sensitivity to Vancomycin and Tetracycline, followed by Clindamycin (65.43%), Erythromycin (43.5%), and 34.5% to Oxacillin.

Coagulase Negative staphylococci showed 100% sensitivity to Vancomycin, Linezolid and Tetracycline followed by Trimethoprim-Sulfamethoxazole (84.33%), Clindamycin (57.29%), Oxacillin (50%), and Erythromycin (25%). Enterococcus showed 100% sensitivity to Ampicillin, Linezolid and Vancomycin. (figure 1)

Amongst Gram Negative isolates, Escherichia coli showed 100% sensitivity to Amikacin, Ceftriaxone, Meropenem and Imipenem followed by, Piperacillin-Tazobactam (91%) and Gentamycin (82%), then Ciprofloxacin (37.78%) and Trimethoprim-Sulfamethoxazole (37%).

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Acinetobacter showed 100% sensitivity to Amikacin, 75% to Ciprofloxacin, Gentamycin and Trimethoprim-Sulfamethoxazole followed by Amoxyclav (63%) then Piperacillin-Tazobactam (50%) & Levofloxacin (50%), Ceftriaxone (34%) and Cefepime (25%).

Burkholderia-its strains showed 100% sensitivity to Ceftriaxone, Levofloxacin and Trimethoprim-Sulfamethoxazole. Enterobacter showed 100% sensitivity to Amikacin, Ciprofloxacin, Ceftriaxone and Meropenem.

Proteus showed 100% sensitivity to Amikacin, Cefepime, Gentamicin, Imipenem, Meropenem, Amoxyclav, Piperacillin-Tazobactam and Trimethoprim-Sulfamethoxazole and 61% sensitive to Ceftriaxone.

Pseudomonas showed 100% sensitivity to Amikacin, Gentamycin and Meropenem. 50% sensitivity to Piperacillin-Tazobactam. 34% sensitivity to Aztreonam , Ciprofloxacin, Cefepime and Levofloxacin. Klebsiella showed 76% sensitivity to Ceftriaxone, 75% sensitivity to Amikacin, Ciprofloxacin, Gentamicin, Trimethoprim-Sulfamethoxazole, 63% sensitivity to Amoxyclav, 50% sensitivity to Levofloxacin and Piperacillin-Tazobactam, and 25% sensitivity to Cefepime. (figure 2)

By conventional method maximum positivity (38.5%) was recorded on day 2 with the rate of 9.63 per 1000 central line daysfollowed by the day 3 (23.09%) with the cumulative percentage of 76.95%. On day 1 and 4 same positivity was recorded (15.36%) with cumulative percentage (92.31%). Least positivity was recorded on day 5 (7.69%) with cumulative percentage of 100%.

By automated method maximum positivity (75%) was recorded on same day i.e. on day 0 followed by the day 1 (20.83%) with the cumulative percentage of 95.83%. On day 2 least positivity was recorded (4.17%) with cumulative percentage of 100% with the rate of 17.78 per 1000 central line days.

TABLE 1

AGE GROUPS (YEARS)	GENDER		TOTAL (%)	X^2	P Value
	Male (%)	Female (%)			
18-20	11 (73.33%)	4 (26.66%)	15 (10%)	3.74	0.44*
21-40	22 (61.11%)	14 (38.88%)	36 (24%)		

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41-60	28 (63.63%)	16 (36.36%)	44 (29.33%)		
61-80	24 (54.54%)	20 (45.45%)	44 (29.33%)		
>80	9 (81.81%)	2 (18.18%)	11 (7.33%)		
TOTAL	94 (62.66%)	56 (37.33%)	150 (100%)		

AGE/GENDER WISE DISTRIBUTION OF THE STUDY GROUP

TABLE 2 CATHETER RELATED RISK FACTORS AMONG THE STUDY GROUP

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VARIABLES	NO.(%)	P-VALUE
Duration of catheterization: < 6 days >/= 6 days	 48 (32%) 102 (68%)	 <0.05 Significant
Length of catheter: < 20 cm	150 (100%)	-
Type of procedure: Emergency Elective	 67(44.67%) 83 (55.33%)	 <0.05 Significant
No. of attempts: 1 2	 107 (71.33%) 43 (28.67%)	 <0.05 Significant
Local site infection of catheter: Present	13(8.67%)	>0.05 Insignificant
Absent	137(94%)	
Experience of venipuncturist: Inexperienced (<25 venipunctures in 3 months) Experienced (>25 venipunctures in 3 months)	 37 (24.67%) 113 (75.33%)	 <0.05 Significant
Site of catheterization: Internal jugular vein Femoral vein Subclavian vein Umbilical vein External jugular vein	 123 (82%) 21 (14%) 2 (1.33%) 3 (2%) 1 (0.67%)	 <0.05 Significant

TABLE 3COMPARATIVE BLOOD CULTURE RESULTS BY AUTOMATED/CONVENTIONAL BLOOD CULTURE METHODS

BLOOD CULTURE	AUTOMATED (%)	CONVENTIONAL (%)	X^2	P Value
CRBSI	24 (16.0%)	13 (8.67%)	3.71	0.05*
Sterile	126 (84.0%)	137 (91.33%)		
Total	150 (100%)	150 (100%)		

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***statistically significant**

TABLE 4

COMPARATIVE DISTRIBUTION PATTERN OF MICROORGANISM BY AUTOMATED/CONVENTIONAL BLOOD CULTURE METHODS

SN	ORGANISMS	ABCM	CBCM
1.	CONS	05	03
2.	Escherichia coli	04	02
3.	Staphylococcus aureus	03	02
4.	Klebsiella	02	01
5.	Pseudomonas aeruginosa	02	01
6.	Streptococcus	01	-
7.	Proteus vulgaris	01	01
8.	Enterococcus	01	02
9.	Morganella	01	-
10.	Proteus mirabilis	01	01
11.	Acinetobacter	01	-
12.	Burkholderia	01	-
13.	Enterobacter	01	-
	TOTAL	24	13

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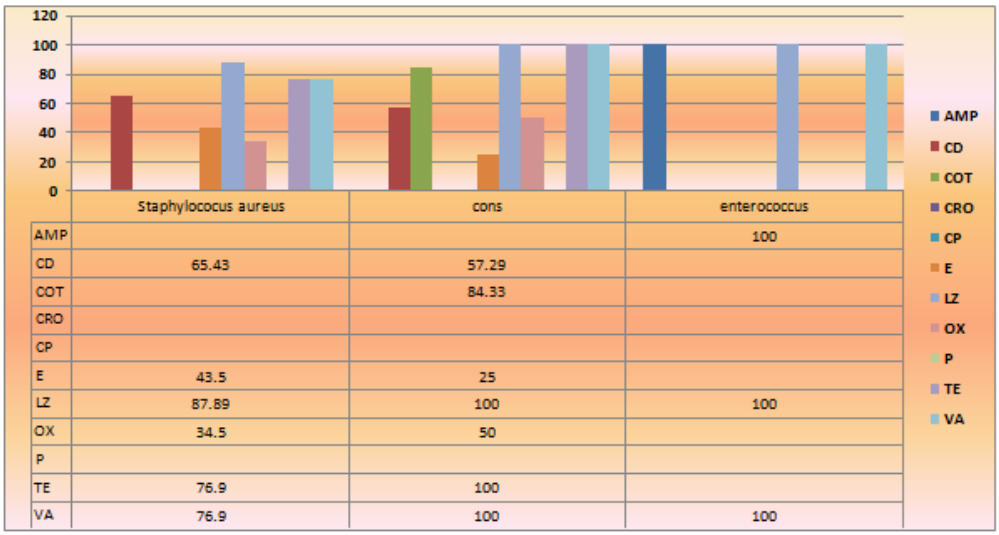
FIGURE 1

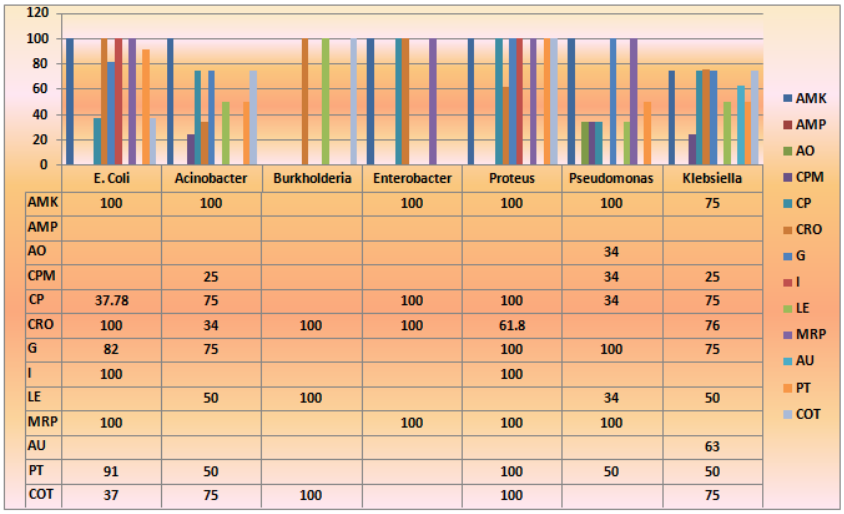
SENSITIVITY PATTERN OF GRAM POSITIVE ISOLATES



	Staphylococus aureus	cons	enterococcus
AMP			100
CD	65.43	57.29	
COT		84.33	
CRO			
CP			
E	43.5	25	
LZ	87.89	100	100
OX	34.5	50	
P			
TE	76.9	100	
VA	76.9	100	100

FIGURE 2

SENSITIVITY PATTERN OF GRAM NEGATIVE ISOLATES



	E. Coli	Acinobacter	Burkholderia	Enterobacter	Proteus	Pseudomonas	Klebsiella
AMK	100	100		100	100	100	75
AMP							
AO						34	
CPM		25				34	25
CP	37.78	75		100	100	34	75
CRO	100	34	100	100	61.8		76
G	82	75			100	100	75
I	100				100		
LE		50	100			34	50
MRP	100			100	100	100	
AU							63
PT	91	50			100	50	50
COT	37	75	100		100		75

TABLE 5

COMPARISION OF RATE AND DAY OF DETECTION OF PATHOGENS BY AUTOMATED & CONVENTIONAL METHOD BY DAY OF DETECTATION

	AUTOMATED METHOD				CONVENTIONAL METHOD			
DAY	**Positive**	**%**	**Cumulative %**	**Rate**	**Positive**	**%**	**Cumulative %**	**Rate**
0	18	75	75	17.78	00	00	00	9.63
1	5	20.83	95.83		02	15.36	15.36	
2	1	4.17	100		05	38.5	54.86	
3	-	-	-		03	23.09	76.95	
4	-	-	-		02	15.36	92.31	
5	-	-	-		01	7.69	100	

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Total	24	100	-		13	100	-	

DISCUSSION

In our study the rate/ incidence density (ID) of CRBSI was 9.63 and 17.78 per 1000 catheter days by conventional and automated methods respectively. Over the years, various workers have reported an incidence of CRBSI ranging from 5-49%. In the present study, the rate of CRBSI was similar to that of a study done by Peng et al (2013)[4], and study by Chopedkar K et al(2011)[5] .This study also showed 57.6% of catheter tips to be colonized and 7.05% of the tips accounting for CRBSI. This difference in rates in various studies is because of various factors like duration of catheterisation, mean age of study group, compliance to hand hygiene, and other infection control measures followed in the institute, nurse patient staffing ratio and extent of financial and administrative support.

In the present study, males (62.66%) were more commonly affected than females (37.33%). This correlates with the study of Khanna V et al (2013)[6] (72.7%), and other studies such as Apostolopoulou E et al (2009)[7], Bicudo D et al (2011)[8] and Dutta P et al (2014)[9] where the incidence of bloodstream infections were more in males than females. The male gender has been stated as risk factor for the development of CRBSI in the study done by Rajan et al (2017)[10]. However, in our study the reason for this high rate in males might be due to the greater number of male patients attending at our hospital.

In the present study, CRBSI was common in the age groups 41-60 years and 61-80 years, which is in comparison with the studies like Brito et al [11], Apostolopoulou E et al [7] and Datta P et al.[9] This can be explained by the gradual decline in efficiency of immune response with the advancing age.

As per the risk factors associated, We observed an increase of two fold in CRBSI RATES with duration of catheterisation of 6 days or more. Emergency procedures with more number of attempts in instrumentation is also observed as Other Potential risk factors for BSI

It has been observed that the location of insertion may be an important risk factor for the development of BSI .Catheters inserted in the ie femoral vein are more prone to colonization than those inserted at other sites.. This may be related to factors thatfavor colonization of the skin next to femoral vein, e.g.,Pelvic/perinial flora, increased temperature, difficulties in catheter immobilization and dressing. Patient admitted in nephrology department with indication of haemodialysis, increased duration of catheterisation, femoral site insertion, multiple attempts with inexperienced venipuncturist are other observed potential risk factors.

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On comparison of blood culture CRBSI, by automated and conventional methods the difference was found statistically significant. (p=0.05). These findings show that the automated system has a good isolation performance and is a reliable and better alternative to the conventional system in our settings. This can be attributed to automated system's continuous monitoring of culture, higher sensitivity, standardized conditions for incubation, faster detection and reduced contamination as there is minimal manual handling.

The most common pathogen identified by both methods was Coagulase negative Staphylococcus, followed by Escherichia coli. This study correlated with the study conducted by Sarangi et al in (2016)[14] and with the study done by Sultana Q et al in (2016)[15] ,where a predominance of Gram positive isolates like Staphylococcus aureus & Coagulase negative Staphylococci were observed. The reason behind CONS being the most common pathogen detected can be attributed to colonisation of CONS as a part of skin microbiota of heath care personal & are readily available to cause BSI..

Our findings related to day of detection by conventional method and automated methods are in concordance with the study done by Rajan LL et al in (2017) [10] in which, the conventional method detected 34 percent, 75.5 percent and 88.7 percent of the cases within 48, 72 and 96 hours of incubation respectively and 17.4 percent of the positive cases within 12 hours of incubation and 72.5 percent of the cases within 24 hours of incubation by automated method.

This early detection of positive blood cultures by automated system is attributed to its continuous monitoring, advanced sensors, optimal growth conditions and ability to support a wide variety of organisms. Its media contains anticoagulant like Sodium polyanethol sulfonate and resins or adsorbents which neutralize antibiotics and other inhibitors that might be present in blood and enhance recovery of microorganisms.

CONCLUSION

The CRBSI prevalence was high with significant association of prolonged duration of catheterization,elderly age group,femoral site insertion, emergency catheterisation , multiple attempts with inexperienced venipuncturist with CRBSI. The automated blood culture systems acts as an appropriate means for the initial identification and detection of blood pathogens and improved provision of antimicrobial therapeutic options for septic patients especially in Critical Care and Intensive Care Units where positive culture reporting is crucial.The pattern of pathogens causing bloodstream infections and their resistance profiles differ from those reported in other studies, likely due to geographic variation. Thus, enhancing infection control measures, setting up surveillance systems, applying evidence-based prevention strategies and use of strict and rational antibiotic policy are essential to prevent and manage bloodstream infections related to central venous catheters

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Coagulase Negative Staphylococcus was the commonest bacteria isolated by both culture methods. Most of the isolates were found to be multidrug resistance, leaving the physician with only limited options.

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Conflicts of interest There are no conflicts of interest

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