ORIGINAL RESEARCH PAPER

Volume - 9 | Issue - 6 | June - 2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

THE INCIDENCE OF CLABSI (CENTRAL LINE ASSOCIATED BLOOD STREAM INFECTIONS)IN A TERTIARY CARE CENTRE- ITS ETIOLOGICAL PROFILE, ANTIBIOTIC SENSITIVITY AND RESISTANCE PATTERN.

Microbiology

Dr. Gowri Veligandla* Associate Professor, Department of Microbiology, Government Vellore Medical College, Vellore. *Corresponding Author

Rahul II MBBS student,Government Vellore Medical College, Vellore.

ABSTRACT

Central Line Associated Blood Stream Infections -CLABSI are a leading cause of Hospital Acquired Infections and are associated with significant morbidity, mortality and healthcare expenditure. The objectives of this study were to determine the incidence of CLABSI, the etiological spectrum of microorganisms causing these infections and their antibiotic susceptibility patterns. This study included a total of 18 patients on Central lines. These patients were monitored daily for the development of HAI. The blood and catheter tip samples were collected from them after removal of Central line, which was done either on completion of treatment or after the development of sepsis. The samples were cultured to isolate the pathogens. Maki's Roll Plate method was used for Catheter tip culture. The pathogens isolated from both the cultures of each case were tested against antibiotics using Kirby-Bauer disk diffusion method (CLSI guidelines, 2018) to determine their antibiotic susceptibility patterns.A diagnosis of CLABSI was made,when both catheter tip culture and blood culture yielded the same microorganism. If a case of CLABSI was identified, then antibiograms were compared to check whether it was Laboratory confirmed CLABSI or Probable CLABSI. The incidence of CLABSI was measured per 1000 central line days. In this prospective observational study, 3 cases of CLABSI (%CLABSI= 16.66%) were identified and all were Laboratory confirmed cases of CLABSI. This gave a significant CLABSI rate of 2.23 per 1000 central line days. The CLABSI causing pathogens identified in this study were *Pseudomonasaeruginosa* and *Klebsiellapneumoniae.* There were 2 cases (11.11%) of Blood Stream Infections (BSI) with no evidence of catheter colonization. These BSI cases were caused by pathogens like *Escherichiacoli* and *Klebsiellapneumoniae.* There were 11 cases (61.11%) of asymptomatic catheter colonization caused by Coagulase-negative *Staphylococci,* where there were no evidences of BSI. The antibiotic susceptibility patterns of the isolates revealed a high incidence of resistance against conventional antibiotics likeAmpicillin, Amoxicillin-clavulanate and Penicillin G. Hence, this study highlights the need for regular surveillance, periodic auditing of Infection Control Practices, and an effective antibiotic policy to tackle the problem of CLABSI .

KEYWORDS

INTRODUCTION:

Central lines (Central Venous Catheters- CVC) are used to access the vascular system of the body for delivery of medications, parenteral nutrition, collection of blood samples, hemodialysis and hemodynamic monitoring. In today's world Central Venous Catheters have become an indispensable part in the management of critically ill patients in the ICUs (Novikov et al 2012).Central Line Associated Blood Stream Infections (CLABSI) also known as Catheter Related Blood Stream Infections (CRBSI)is a major contributing factor to in-hospital Morbidity and Mortality, which increases in-patient stay and patient expenditure (Rello et al 2000)andremain a leading cause of HAIs (Hospital Acquired Infections). Though the central lines provide secure access to the central circulation, they have higher chances of risk for infection than other lines of vascular access.CLABSI are common among patients on chronic hemodialysis, they have a 2- to 3-fold increased risk of infection and death compared to patients witharteriovenous fistula or graft (Dhinghra et al 2001).

The incidence of CLABSI in the developed countries varies from 1.12 to 4.2 per1000 catheter days. Whereas in developing countries the incidence is high. The rate reported from India is 7.9 per1000 catheter days(Mehta et al 2007). This rate is too high when compared to the developed countries. In the Indian set up only a few reports of CLABSI have been made and they show that over the last decade the incidence in India has been varying from 0.2% to 27%.

Due to the paucity of data about the Central Line Associated Blood Stream Infections(CLABSI) in the Indian scenario, especially from the Government Hospitals, the present study was designed to determine the base line data about the incidence of CLABSI in the ICUs and wards in order to understand the actual burden of CLABSI in our tertiary care centre.

In India, the extravagant use of antibiotics and increased prevalence of antibiotic resistant microorganisms warrant the use of high-end antibiotics, this adds to mortality and health-care expenditure due to CLABSI(Ganguly et al 2011).Hence, this study also aims to understand the antibiotic sensitivity and resistance patterns of the microorganisms involved in the causation of CLABSI. This will help in developing an effective antibiotic policy, needed for treating CLABSI and reducing its associated morbidity and mortality.

AIMS AND OBJECTIVES:

1. To determine the incidence of CLABSI among patients on central lines in our tertiary care government hospital.
2. To identify and studyantibiotic sensitivity and resistance patterns of the microorganisms involved in the causation of Central-Line Associated Blood Stream Infections (CLABSI).

MATERIALS AND METHODS:

The study was a prospective observational study conducted in the ICUs and critical care wards of our 500 bedded tertiary care government teaching hospitalafter obtaining Institutional Ethics Committee (IEC) approval and Informed Consent from patients and/or attendersfor a period of 4 months duration A convenient sampling which enrolled patients with a Central Line (CVC) in our Tertiary care centre during the study period.A total of 18 patients were included with the

INCLUSION CRITERIA:

1. Patients of age 18years and above.
2. Patients with Central line (CVC) inserted for first time in ICUs/wards of Medicine, Surgery,Obstetrics-Gynecology, Nephrology and Emergency departments.
3. ICU stay with an indwelling Central line(CVC) for more than 48 hours.

The patients fulfilling the above-mentioned criteria were included for this study.

EXCLUSION CRITERIA:

All patients below the age of 18 years were excluded from this study.

METHODOLOGY:

Work up of the patients:

All the patients enrolled in the study were monitored daily for the development of new-onset sepsis using standard criteria after 48 hours of central line (CVC) placement. These patients were followed up from admission to the ICU or ward after placement of a central line (CVC) till the removal of the catheter or discharge or death, whichever was earlier.

New-onset sepsis was suspected when two or more of the following conditions were observed with suspicion of infection:

- Fever (body temperature >38˚C) or hypothermia (body temperature <36˚C)
- Tachycardia (>90 beats/minute)
- Tachypnea (>24 breaths/minute)
- Leukocytosis(>12,000/cu.mm) or leukopenia(<4,000/cu.mm)

Sample collection and processing:

In case of onset of new sepsis, an attempt was made to exclude other sources of infection by focused physical examination and laboratory examination. Blood samples and catheter tip samples were collected from all the patients during the removal of Central line (CVC), which was done either on completion of the treatment or after the development of sepsis.

Blood samples- collection and processing:

Three blood samples were drawn under aseptic precautions, 2 percutaneously and 1 through the Central line (CVC) over a span of 24 hours in Brain-Heart Infusion broth for qualitative culture and were incubated at 37˚C. Sub-cultures were made on MacConkey's agar plates and Blood agar plates after 24, 48 and 72 hours and incubated at 37˚C.

Catheter Tip samples- collection and processing:

The skin was cleaned with 70% alcohol prior to catheter removal. The catheter was removed carefully from the patient with a sterile instrument, taking care to avoid contact with skin. The distal 10cm segment of the catheter was cut into 2 equal pieces with a sterile blade. One piece was placed in sterile transport tube and was culturedby Maki's Roll Plate Method (semi-quantitative method) In this method, the catheter tip was rolled back and forth using slight pressure at least 4 times. It was made sure that it was having good contact with the surface of the plate. The plate was incubated for at least 72 hours at 35˚C in $C.O_2$ incubator. Other piece was used for fungal culture.The method followed herewas Catheter Tip Culture, as described by Maki *etal(1977)*. All samples were checked for colonization by pathogens.

Identification and Interpretation:

Bloodculture: The agar plates were examined at 24, 48 and 72 hours.

Cathetertipculture: The agar plates were examined at 24, 48 and 72 hours.Colonization of the catheter is defined as the growth of more than 15 Colony Forming Units (CFUs) from a 5 cm segment of the catheter tip by Maki's Roll Plate (semi-quantitative) Method.

The causative microorganisms were identified by colony morphology, gram staining and biochemical tests performed indiagnostic microbiology laboratory.

A definitive diagnosis of CLABSI was made when the same microorganism grows from at least one peripheral blood culture and a catheter tip culture.

Antibiogram- for antibiotic sensitivity and resistance pattern

The Antibiotic Susceptibility Pattern of the causative bacteria was checked by Kirby-Bauer Disk Diffusion Method. This method was done according to Central Laboratory Standards Institute guidelines (CLSI guidelines 2018).

3POSSIBLEOUTCOMES:

A. Blood Culture and Catheter Tip Culture yielding the same microorganism with same antibiogram was labelled as Laboratory-Confirmed CLABSI.

B. Blood Culture and Catheter Tip Culture yielding the same microorganism but with different antibiograms was labelled as Probable CLABSI.

C. When Blood Culture is positive but with a negative Catheter Tip Culture then it was labelled as Blood Stream Infection (BSI).

Data Collection:

For each patient included in the study, detailed history was taken regarding name, age, sex, ICU/ward, current diagnosis, co-morbidities, purpose of catheterization, duration of catheterization, site of Central line (CVC) insertion and any history of systemic antibiotic administration.

Statistical methods:

The incidence of CLABSI was measured per 1000 central line days.

OBSERVATIONS AND RESULTS:

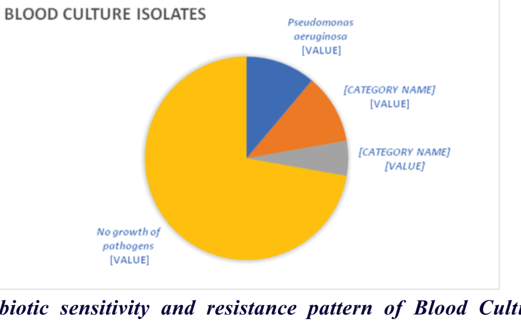
During the study period, samples (Catheter tip samples and blood samples) were collected from 18 patients on a Central line (CVC). Majority of the patients were from the in-patient Hemodialysis unit of Nephrology department followed by the ICUs and wards of other departments. The total duration central lines were in place was 1344 days as many patients on central lines required long term management. Out of the 18 patients, 13 (72.22%) were male and the remaining 5 (27.77%) were female. The male to female ratio was 2.6:1. The mean age of the patients was 50.05 years and majority of them were above 50 years of age. Catheterization of Internal Jugular vein was most common.

Microorganisms isolated from Blood culture.*(Figure:1)*

Blood culture was done using the blood samples received from all 18 patients to check for BSI (Blood Stream Infection- sepsis HAI).

The microorganisms isolated from the blood cultures of the 18 cases included Gram-negative isolates like *Pseudomonas aeruginosa (11.11%), Klebsiella pneumoniae (11.11%)*and *Escherichia coli(5.5%).*

Figure:1



Antibiotic sensitivity and resistance pattern of Blood Culture isolates:

The bacterial isolates were tested against antibiotics using Kirby-Bauer disk diffusion method (CLSI guidelines,2018)

*Pseudomonasaeruginosa*and*Klebsiellapneumoniae* were isolated in 2 cases each.*Escherichia coli* was isolated in 1 case. Their respective antibiotic susceptibility patterns are given in *Table:2.*The antibiotic susceptibility patterns of the cases were obtained on analysis of their respective antibiograms.

Table:2

Pseudomonasaeruginosa	**Sensitive to:**	**Resistant to:**
Pseudomonasaeruginosa Case-1	Ofloxacin and Gentamicin	Ampicillin, Doxycycline, Ceftazidime and Cefotaxime
Pseudomonasaeruginosa Case-2	Ofloxacin, Cefotaxime and Gentamicin	Ampicillin, Amoxicillin-clavulanate and Ceftazidime.
Klebsiellapneumoniae Case-1	Ofloxacin Gentamicin, Ceftazidime and Cefotaxime	Ampicillin and Amoxicillin-clavulanate.
Klebsiellapneumoniae Case-2	Ofloxacin	Ampicillin, Amoxicillin-clavulanate, Doxycycline, Cefotaxime and Gentamicin.
Escherichia coli Case-1	Gentamicin, Cefotaxime and Ofloxacin	Doxycycline, Amoxicillin-clavulanate and Ciprofloxacin.

Microorganisms isolated from Catheter tip culture *(Table:3 and Figure:2)*

- The microorganisms isolated from catheter tip cultures of 18 cases included Gram-positive isolates like Coagulase negative *Staphylococci* (CoNS) and Gram-negative isolates like

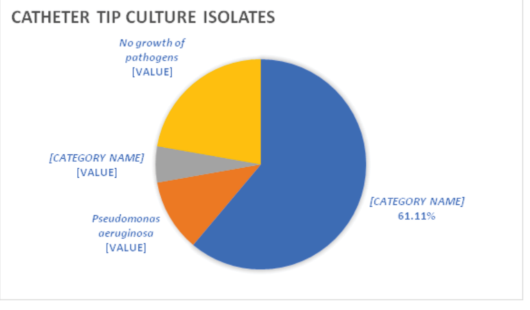
 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

*Pseudomonas aeruginosa*and*Klebsiella pneumoniae.* The number of cases in which each of the following pathogens were isolated is given in *Table:3.*

Table:3

Pathogens isolated:	Number of cases: (Total number of cases N=18)	Percentage of isolation:
Coagulase negative *Staphylococci* (CoNS)	11	61.11%
Pseudomonas aeruginosa	2	11.11%
Klebsiella pneumoniae	1	5.55%
No growth of pathogens	4	22.22%

Figure:2



Antibiotic sensitivity and resistance pattern of Catheter tip culture isolates:

The bacterial isolates were tested against antibiotics using Kirby-Bauer disk diffusion method (CLSI guidelines,2018)

Coagulase negative *staphylococci*was isolated in 11 cases. Each case was tested against antibiotics like Erythromycin,Cephalexin, Teicoplanin and Penicillin G. The antibiotic susceptibility among the 11 cases after the analysis of their antibiograms are given in *Table:4*

***Table:4*(Total number of cases of Coagulase negative *staphylococci:* 11)**

Antibiotic used:	Number of cases sensitive:	Number of cases resistant:
Erythromycin	7 (63.33%)	4 (36.36%)
Cephalexin	6 (54.54%)	5 (45.45%)
Teicoplanin	11 (100%)	0 (0%)
Penicillin G	0 (0%)	11 (100%)

It was observed that all 11 cases were sensitive to Teicoplanin and resistant to Penicillin G (100%).

The blood cultures of the corresponding cases were negative for growth of pathogens indicating colonization of catheters by Coagulase negative *Staphylococci*with no evidence of Blood Stream Infection (BSI).

*Pseudomonas aeruginosa*was isolated in 2 cases and *Klebsiellapneumoniae*was isolated in 1 case. Their antibiotic susceptibility patterns are given in *Table:5.*The antibiotic susceptibility patterns of the cases were obtained on analysis of their respective antibiograms.

Table:5.

Pathogen	Sensitive to:	Resistant to:
Pseudomonasaeruginosa Case -1	Ofloxacin and Gentamicin	Ampicillin, Doxycycline, Ceftazidime and Cefotaxime
Pseudomonasaeruginosa Case -2	Ofloxacin, Cefotaxime and Gentamicin	Ampicillin, Amoxicillin-clavulanate and Ceftazidime.
Klebsiellapneumoniae Case -1	Ampicillin, Ofloxacin, Gentamicin, Ceftazidime and Cefotaxime	Amoxicillin-clavulanate

*Pseudomonasaeruginosa*wasalsoisolated from the blood cultures of the above 2 cases and yielded the same antibiograms. *Klebsiellapneumoniae*was also isolated fromblood cultureof the case and yielded the same antibiogram.No fungal isolates were detected.

For all 18 patients, the blood culture and catheter tip culture results were compared. The antibiograms of the microorganisms isolated from both the cultures of each case were also compared.

In 3 (of 18) cases, both blood cultures and catheter tip cultures yielded the same microorganism. They were diagnosed as CLABSI. In all 3 cases signs of new-onset sepsis were observed. Of the 3 cases of CLABSI, *Pseudomonasaeruginosa* was isolated in 2 cases and *Klebsiellapneumoniae*was isolated in 1 case from both the cultures. In all 3 cases, the antibiograms of both the cultures were the same, so all the 3 were labelled as Laboratory confirmed CLABSI.No case of probable CLABSI was observed.

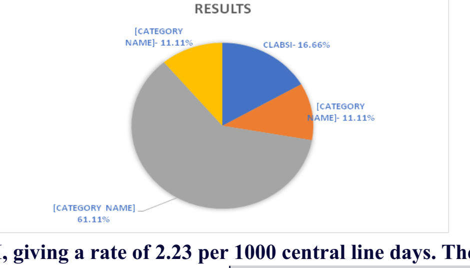
In 2 cases, blood culture was positive for *Escherichiacoli* and *Klebsiellapneumoniae*respectively but their corresponding catheter tip cultures showed no growth of pathogens (No evidence of catheter colonization). These cases were diagnosed as BSI (Blood Stream Infections) due to another source of infection.

In 11 cases, catheter tip cultures were positive for Coagulase negative *Staphylococci* but their corresponding blood cultures were negative for growth of pathogens indicating absence of Blood Stream Infection-BSI. These were considered as cases of Catheter tip colonization which did not lead to the developmentof BSI. (Asymptomatic colonization)

Table:6

Blood Culture	Catheter tip culture	Antibiograms	Diagnosis	Number of cases (Total no 18)	Causative pathogens
Positive	Positive	Same	Laboratory confirmed CLABSI	3	2-*Pseudomonas aeruginosa,* 1-*Klebsiella pneumoniae*
Positive	Positive	Different	Probable CLABSI	0	---
Positive	Negative	---	BSI (caused by another source of infection)	2	1-*Klebsiella pneumoniae,* 1-*Escherichia coli*
Negative	Positive	---	Catheter tip colonization (Asymptomatic colonization)	11	Coagulase negative *Staphylococci*
Negative	Negative	---	No growth of pathogens	2	---

Figure: 3.



Of 18 patients, 3 patients developed CLABSI, giving a rate of 2.23 per 1000 central line days. The %CLABSI was 16.66%.

DISCUSSION:

Central lines, being an indispensable part in the treatment of critically ill patients, remains a serious and most common cause of HAI (Hospital Acquired Infections). These infections have a direct bearing on morbidity, mortality and healthcare expenditure worldwide.

In this study, the CLABSI rate was observed to be 2.23 per 1000 central line days. This was higher compared to CLABSI rates in the hospitals of United States, where the rates ranged from 0.8 to 1.1 per 1000 central line days- as reported by CDC-NHSN (Centers of Disease Control and prevention –National Healthcare Safety Network) (Dudeck et al 2013). In various studies conducted in our country, the rate of incidence of CLABSI reported were(Kaur *etal 2012)* 2.79 per 1000 central line days, (Pawar*etal*2004) 4.01 per 1000 central line days,Bhavana *etal*(2018)8.26 per 1000 central line days,Parameshwaran*etal*(2011) 8.75 per 1000 central line days and Chopdekar*etal*(2011) 9.26 per 1000 central line days. This showed that the burden of CLABSI in India is more when compared to developed countries like United States.

In this study, CLABSI cases were observed to be caused by Gram-negative bacteria like *Pseudomonasaeruginosa* and *Klebsiellapneumoniae*. These microorganisms were also reported to be isolated in other CLABSI studies in our country like Datta*etal(2010)*, Chopdekar*etal(2011)*and Parameshwaran*etal (2011)* However,the percentage of the isolates varied .Some studies also reported Gram-positive isolates like *StaphylococcusAureus*, MRSA- Methicillin Resistant *Staphylococcusaureus*, MSSA- Methicillin Sensitive *Staphylococcusaureus*, Coagulase negative *staphylococci* and Enterococcus; Gram-negative isolates like *Escherichiacoli* and *Acinetobacter*; and fungal isolates like *Candida* species (Bhavana *etal* 2018 ,Chopdekar*etal 2011)*

In this study, though Coagulase negative Staphylococci (CoNS) were isolated in the catheter tip cultures of 11 cases (61.11%), the corresponding blood cultures were negative for the growth of pathogens. These were labelled as cases of asymptomatic catheter tip colonization with no evidence of Blood Stream Infection (BSI). This indicated that catheter colonization did not appear to have a direct bearing on the development of Blood Stream Infection (BSI). Similar picture was also observed in the CLABSI studies of Bhavana *etal(2018)*and Chopdekar*etal(2011)*.

These differences in the microorganisms causing CLABSI and their percentages of isolation in various studies conducted in India and across the worldcould be attributable to the differences in the prevalence of microorganisms in different geographical areas.In this study, no cases of fungal and polymicrobial infections were observed.

In this study, the most effective antibiotics against Gram-negative isolates like *Pseudomonasaeruginosa* and *Klebsiellapneumoniae*were Ofloxacin and Gentamicin. They were least sensitive to Ampicillin and Amoxicillin-clavulanate. The most effective antibiotics against Gram-positive isolates like Coagulase-negative *Staphylococci*were Teicoplanin and Erythromycin. They were least sensitive to Penicillin G. This showed the incidence of resistance against conventional antibiotics like Ampicillin, Amoxicillin-clavulanate and Penicillin G. Bhavana *etal(2018)*also observed the incidence of resistance to conventional antibiotics like Amoxicillin-clavulanate among CLABSI causing pathogens like*Pseudomonasaeruginosa* and *Klebsiellapneumoniae*.

The rate of incidence of CLABSI determined in this study could be affected bythe multitude of antibiotics received by some patients before the development of sepsis and also bythe limited sample size of this study owing to itsshort duration.

This study highlights the need for further research on CLABSI and other HAI, especially in the government hospitals of urban and rural India, in order to improve its surveillance, prevention and treatment. This study also implies the need for periodic auditing of the Infection Control Practices in our centre, this will help us in planning for regular training programs for our healthcare personnel in order to improve their compliance. These steps will help us in reducing the incidence of CLABSI. This study also underlines the need for an effective antibiotic policy to tackle CLABSI.There is also a need to conduct studies on the incidence of CLABSI and other HAI among high-risk groups like immunocompromised patients, children, elderly and pregnant women in our country.

CONCLUSION:

This study documents a significant rate of incidence of CLABSI of 2.23 per 1000 central line daysin our tertiary care centre. It also gives us a first-hand information about the bacterial spectrum of pathogens causing CLABSI. It also reports the increasing drug resistance among the common pathogens causing CLABSI in the catheterized patients. This study also highlights the importance of further research needed in the domain of Hospital acquired infections-HAI, especially in tertiary care government hospitals which cater to the poor people living in the rural areas of our country, from where there is limited HAI data. This is important for us to understand the actual burden of Hospital Acquired Infections (HAI) in our country.

REFERENCES:

1. Bhavana, C., T. Nagarathnamma and Ambica, R. 2018. Study of Central-Line Associated Blood Stream Infections (CLABSIs) and Central-Line Related Blood Stream Infections (CRBSIs) in a Tertiary Hospital, Bangalore, India. Int.J.Curr.Microbiol.App.Sci. 7(05): 697-707. doi: https://doi.org/10.20546/ijcmas.2018.705.084
2. Chopdekar K, Chande C, Chavan S, et al. Central venous catheter-related blood stream infection rate in critical care units in a tertiary care, teaching hospital in Mumbai. Indian J Med Microbiol. 2011;29(2):169–171. doi:10.4103/0255-0857.81796
3. Datta P, Rani H, Chauhan R, Gombar S, Chander J. Device-associated nosocomial infection in the intensive care units of a tertiary care hospital in northern India. J Hosp Infect. 2010;76(2):184–185. doi:10.1016/j.jhin.2010.06.013
4. Dhingra RK, Young EW, Hulbert-Shearon TE, Leavey SF, Port FK. Type of vascular access and mortality in U.S. hemodialysis patients. Kidney Int. 2001;60(4):1443–1451. doi:10.1046/j.1523-1755.2001.00947.x
5. Dudeck MA, Edwards JR, Allen-Bridson K, et al. National Healthcare Safety Network report, data summary for 2013, Device-associated Module. Am J Infect Control. 2015;43(3):206–221. doi:10.1016/j.ajic.2014.11.014
6. Ganguly NK, Arora NK, Chandy SJ, et al. Rationalizing antibiotic use to limit antibiotic resistance in India. Indian J Med Res. 2011;134(3):281–294.
7. Kaur R, Mathai AS, Abraham J. Mechanical and infectious complications of central venous catheterizations in a tertiary-level intensive care unit in northern India. Indian J Anaesth. 2012;56(4):376–381. doi:10.4103/0019-5049.100823
8. Maki DG, Weise CE, Sarafin HW. A semiquantitative culture method for identifying intravenous-catheter-related infection. N Engl J Med. 1977;296(23):1305–1309. doi:10.1056/NEJM197706092962301
9. Mehta A, Rosenthal VD, Mehta Y, et al. Device-associated nosocomial infection rates in intensive care units of seven Indian cities. Findings of the International Nosocomial Infection Control Consortium (INICC). J Hosp Infect. 2007;67(2):168–174. doi:10.1016/j.jhin.2007.07.008
10. Novikov A, Lam MY, Mermel LA, Casey AL, Elliott TS, Nightingale P. Impact of catheter antimicrobial coating on species-specific risk of catheter colonization: a meta-analysis. Antimicrob Resist Infect Control. 2012;1(1):40. Published 2012 Dec 3. doi:10.1186/2047-2994-1-40.
11. Parameswaran R, Sherchan JB, Varma D M, Mukhopadhyay C, Vidyasagar S. Intravascular catheter-related infections in an Indian tertiary care hospital. J Infect DevCtries. 2011;5(6):452–458. Published 2011 Jul 4.
12. Pawar M, Mehta Y, Kapoor P, Sharma J, Gupta A, Trehan N. Central venous catheter-related blood stream infections: incidence, risk factors, outcome, and associated pathogens. J CardiothoracVascAnesth. 2004;18(3):304–308. doi:10.1053/j.jvca.2004.03.009
13. Rello J, Ochagavia A, Sabanes E, et al. Evaluation of outcome of intravenous catheter-related infections in critically ill patients. Am J RespirCrit Care Med. 2000;162(3 Pt 1):1027–1030. doi:10.1164/ajrccm.162.3.99110936