Original Article

Bloodstream infections in NNICU: Blight on ICU stay

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Abstract

Background: Bloodstream infections (BSIs) are among the serious hospital-acquired infections. Data regarding BSIs in intensive care units (ICUs) are available but there is limited information regarding these infections in neurology and neurosurgery intensive care units (NNICUs). **Objectives:** This study was conducted to find out the occurrence of BSI in NNICU patients of a tertiary care institute in India, along with the microbiological profile and risk factors associated with it. **Materials and Methods:** One hundred patients admitted in the NNICU of a tertiary care hospital for more than 24 h were included in the study. After detailed history, blood samples were collected from catheter hub and peripheral vein of all patients for culture, followed by identification and antibiotic sensitivity testing of the isolates. **Results:** Out of 100 patients, laboratory-confirmed bloodstream infection (LCBI) was detected in 16 patients. Five patients had secondary BSI, while 11 had central venous catheter (CVC)-related primary BSI. Gram-positive organisms constituted 64% of the isolates, especially coagulase-negative *staphylococci* and *Staphylococcus aureus*. Increased duration of CVC was a significant risk factor for catheter-related BSI (CR-BSI). **Conclusion:** BSIs pose a significant burden for NNICU patients, and increased duration of catheter insertion is a significant risk factor for CR-BSI.

Key Words

Bloodstream infections (BSI), central venous catheter (CVC), neurocritical care, neurosurgery ICU

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Ann Indian Acad Neurol 2016;19:327-331

Introduction

Over the past few decades, specific neurological and neurosurgical intensive care has gained importance.[1,2] Patients with neurologic disorders may differ in several fundamental ways from other medically ill patients, possibly requiring distinct metrics to adequately measure quality of care. There are several risk factors responsible for intensive care unit (ICU) outcome and mortality. Health care-associated infection (HAI) is one of the major factors among them.

The Centers for Disease Control and Prevention (CDC) defines a HAI as a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxin(s). There should not be any evidence of an infection being present or incubating at the time of admission to the acute care setting. HAIs or nosocomial infections in ICUs are common and responsible for high mortality, morbidity, and hospital expenditure.[3]

Intravascular catheters are an indispensable part of current medical practice, especially in the ICU. Their use, however, often increases the burden of various complications, including local site infection, catheter-related bloodstream infections (CR-BSI), and other systemic infections. The seriousness of underlying disease, diagnostic as well as therapeutic procedures that breach normal host defense mechanisms, contaminated life-support equipment, and the prevalence of

Access this article online

Quick Response Code:

Website: www.annalsofian.org

DOI: 10.4103/0972-2327.179983

How to cite this article: Mehndiratta MM, Nayak R, Ali S, Sharma A. Bloodstream infections in NNICU: Blight on ICU stay. Ann Indian Acad Neurol 2016;19:327-31.
Received: 18-02-15, **Revised:** 06-03-15, **Accepted:** 08-09-15

resistant microorganisms are critical factors attributing to the high risk of infection in the ICUs.[4] In all nosocomial infections, surveillance of trends in microorganisms and their resistance profile as well as risk factors is necessary.[5]

Patients receiving intensive care are at high risk for acquiring one or more infections. Bloodstream infections (BSIs) are usually serious infections resulting in prolonged hospital stay and increased risk of mortality.[6]

Knowledge of the incidence of BSIs is important for setting health care and research priorities and for evaluating the effectiveness of preventative interventions.

Abundant information is available regarding HAIs in medical and surgical ICUs; however, data cannot be extrapolated to neurology or neurosurgery ICUs. Paucity of data on BSI in the setting of neurological ICUs prompted us to perform this study with the aim to find out the occurrence and causative microorganism(s) in neurology and neurosurgery intensive care units (NNICUs) and to study the risk factors in patients harboring the infection.

Materials and Methods

This study is a prospective observational study conducted in the NNICU and microbiology department of a tertiary care hospital in India over a period of 18 months. A total of 100 patients hospitalized for more than 24 h in the NNICU were included in the study. Patients whose stay was less than 24 h or who died within the first 24 h period of admission were excluded [Figure 1]. The study was conducted after obtaining ethical clearance and the permission of the institutional Ethics Committee. Written informed consent was taken after adequate explanation, from the subjects or their caregivers.

Detailed history was recorded regarding demography, duration of hospital stay, and comorbidities. Data were also recorded regarding neurological diagnosis of the patient and disease severity, type of catheter, insertion sites, presence or absence of HAI, microorganism(s) isolated after culture, and antibiotic sensitivity profile. Bacterial or fungal identification and antibiotic susceptibility tests were performed on all specimens as per Clinical and Laboratory Standards Institute (CLSI) guidelines. Clinical scores for general disease severity [Acute Physiology and Chronic Health Evaluation (APACHE II) index] and impairment of consciousness [Glasgow Coma Scale (GCS) score] were measured on admission and subsequently during the ICU stay.[7,8] Finally, disease outcome was noted. CR-BSI rate was calculated as central line-associated BSIs/1000 central line days and device utilization ratio as number of device days/ number of patient days. Secondary BSI was defined as a BSI that occurred as a result of a microbiologically diagnosed infection from another body site, excluding central venous catheters (CVCs).[9]

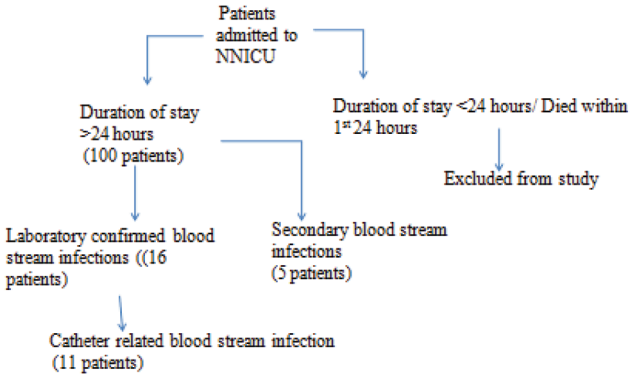

Figure 1: Flowchart of study design

Sample collection

Paired blood samples were collected using aseptic technique. Blood samples from the hub of the catheter and the peripheral vein were collected for quantitative blood culture. Puncture sites were cleaned with 70% alcohol followed by chlorhexidine and allowed to dry. Then 10-20 mL of blood was collected for each blood culture set and divided to inoculate into two blood culture bottles, one for aerobes and another for anaerobes. Diagnosis of CR-BSI was made when blood cultures from both catheter and venipuncture were positive for the same organism and antibiotic sensitivity profile, along with clinical signs and symptoms of BSI with no other apparent source of BSI (except catheter).

Statistical analysis

Values were expressed as mean ± standard deviation (SD). Pearson's chi-square test, Fisher's exact test, and Student's *t*-test were used in univariate analysis. All variables found to be statistically significant in the univariate analysis were entered into the multiple regression analysis. All statistical analysis was conducted using SPSS 20.0 software developed by IBM (International Business Machines) corporation to ascertain statistical significance. In all the tests, values of $P < 0.05$ were considered statistically significant.

Results

Out of 100 subjects, 70 patients were recruited from the neurology ICU and 30 from the neurosurgery ICU. Fifty-eight patients were males and 42 were females (M:F ratio 1.38:1). The mean age was 43.65 ± 20.8 years. Stroke was the most common diagnosis (29%) in studied subjects. The mean length of ICU stay of patients was 19.67 ± 17 days.

Bloodstream infection (BSI)

Thirty-two out of 100 patients had CVC insertion with a mean duration of 16.2 ± 10 days. Laboratory-confirmed bloodstream infection (LCBI) was detected in 16 patients (16%). Five patients had secondary BSIs, while 11 had CVC-related primary BSIs. The central line utilization ratio was 0.27. The CR-BSI rate was 20.7. BSIs in the studied subjects in the NNICU based on individual primary diagnosis are shown in Table 1.

Catheter-related blood stream infection (CR-BSI)

Eleven pathological organisms were isolated in 11 patients with CR-BSI. Infection was found to be monomicrobial in all cases. Gram-positive organisms formed the predominant isolates (64%), which included coagulase-negative staphylococci

and *Staphylococcus aureus* [Table 2]. Both the isolates of *Staphylococcus aureus* and 50% of the coagulase-negative staphylococci were found to be methicillin-resistant. The Gram-positive agents of CR-BSIs were mostly sensitive to linezolid (100%), tigecycline (100%), netilmicin (86%), and teicoplanin (71%), while all the Gram-negative organisms were susceptible to imipenem and meropenem. Most of the cephalosporins were found to be resistant against Gram-positive and Gram-negative organisms.

Risk factors for CR-BSI

Increased duration of CVC was significantly associated with increased incidence of CR-BSI on univariate analysis (P = 0.0072). Other variables, including age, sex, comorbid illnesses, and severity of underlying illness as scored by GCS and APACHE II, were not significantly associated (P > 0.05) with occurrence of CR-BSI [Table 3].

Treatment

All LCBSI patients received antimicrobial therapy based on antibiotic sensitivity testing of blood culture isolates, and four patients had their antibiotic regimen adjusted within the first 24 h. Glycopeptide antibiotics were incorporated to cover Gram-positive organisms. Third-generation cephalosporins and carbapenems were used in case of Gram-negative isolates. Fluconazole was administered for *Candida* infection.

The overall mortality in the NNICU in the studied patients was 37% (37/100). Mortality in patients with BSI was found to be 56.3% (9/16).

Discussion

Over the past few decades, specific neurological intensive care has been widely expanded to benefit neurocritical patients.[10] The overall clinical outcome of patients under neurologic intensive care is greatly affected by the occurrence of medical complications and infections during the course of disease.[11] Studies have been conducted regarding BSI in community hospitals and ICUs[6] or pediatric critical care,[12] but information regarding the occurrence of BSIs in neurological ICUs is sparse. The reported incidence of ICU infections varies according to the hospital or ICU type, and by the population of patients and the precise definition used.[13] This study was done in great detail regarding the occurrence and pattern of BSIs acquired in NNICUs.

LCBIs were detected in 16% patients, while 11% had CVC-related primary BSI. The primary BSI rate in our study is comparable with that of other neurology-ICU — specific studies (1.4-15.5%).[14,15] CR-BSI rate/1000 days in our study was 20.7. Similar results were found in a study conducted on nosocomial infection surveillance in ICUs (medical-surgical-neurosurgical), where the overall rate of CR-BSIs was 23.1 per 1000 device days,[16] although other neurology-specific ICU studies have revealed lower CR-BSI densities.[14] The rate of CR-BSIs in limited-resource countries ranged from 1.6 to 44.6 cases per 1000 central line days in nonneurological adult and pediatric ICUs.[17]

The central line utilization ratio in our study was 0.27, which is less in comparison to studies conducted by Dettenkofer *et al.*[14] (0.75) and Zolldann *et al.*[15] (0.69). The relatively high CR-BSI rate despite the low central line utilization ratio could be due to inadequate catheter care practice in our NNICUs.

Table 1: BSI in studied subjects in NNICU

Primary diagnosis	Total number of patient (*N* = 100)	No. of patients with secondary BSI (*n* = 05)	No. of patients with CR-BSI (*N* = 11)
Stroke	29	01	03
Ischemia	17	0	01
Hemorrhage	12	0	02
Cerebral venous thrombosis	02	0	0
Central nervous system infection	14	01	0
Guillain-Barré syndrome	09	01	01
Intracranial tumors	18	01	03
Seizures	10	0	0
Subarachnoid hemorrhage	05	01	01
Dementia	02	0	0
Myasthenic crisis	01	0	0
Diverse neurological diseases	10	0	0

Table 2: Pathogens isolated in CR-BSI

Microorganism	Frequency (*N* = 11)
Methicillin-resistant *Staphylococcus aureus*	02
Methicillin-resistant coagulase-negative staphylococci	02
Methicillin-sensitive coagulase-negative staphylococci	02
Acinetobacter baumannii	02
E. coli	01
Enterococcus	01
Candida	01

Table 3: Univariate analysis of risk factors for CR-BSI

Variable (*n*)	CR-BSI	No CR-BSI	*P* value
Age			
<50 years (20)	06	14	0.5
>50 years (12)	05	07	
Sex			
Male (18)	06	12	0.89
Female (14)	05	09	
Comorbidities			
Yes (06)	04	02	0.06
No (26)	07	19	
GCS on admission			
<8 (09)	04	05	0.68
>8 (23)	07	16	
APACHE II score on admission			
<10	04	13	0.28
>10	07	07	
Duration of ICU stay (mean and SD)	35±29.3	25.9±17.9	0.3
CVC days* (mean and SD)	24.7±16.7	11.8±7.9	0.0072

*Increased duration of CVC was significantly associated with increased incidence of CR-BSI

Increased duration of CVC was the only variable found to be significantly associated with increased incidence of CR-BSIs on univariate analysis ($P = 0.0072$). Duration of catheterization has been suggested as an important risk factor in the development of CR-BSI in other studies.[18,19]

Gram-positive cocci were the most common causative organism. Coagulase-negative staphylococci were the predominant isolates from patients with BSI. The results were consistent with results in other published studies.[20]

In this study, we performed cultures of the blood from the CVC port and the peripheral vein. A study conducted by Kumar *et al*.[21] demonstrated that cultures of the blood from the CVC port and periphery had negative predictive values of 86.67% and 84.38%, respectively, for the catheter origin of BSI. The classic reference method to confirm CR-BSI consists of concomitant isolation of the same microorganism from blood samples and the catheter tip. However, this requires catheter removal and culture of the catheter tip, which is usually premature and unnecessary.

In the current study, the mean length of NNICU stay was 19.67 ± 17 days. Comparison of the length of ICU stay in our study in the NNICU revealed that the mean duration (mean ± SD) was 19.6 ± 17 days and the range was 3-123 days, while a study conducted on CVC-related BSIs in medical ICU patients in a tertiary referral center in India revealed the mean duration (mean ± SD) to be 11.19 ± 7.84 with the range of 3-46 days.[22]

Overall mortality in patients in our study group was 37%, while mortality in patients with BSI was found to be 56.3%. Studies conducted in nonneurology ICUs by Prowle *et al*.[23] in two hospitals showed overall mortality of 23.5% and 41.2% in patients with BSI. Higuera *et al*.,[24] studying patients with and without BSI, found that the mean extra length of stay of cases was 6.1 days and the attributable extra mortality was 20%.

The limitation of our study was that the criteria for admission in the neurology and the neurosurgery ICUs were different, which could have led to selection bias. The majority of patients in the neurology ICU were admitted from neurology emergency or the outpatient department, while patients in the neurosurgery ICU were principally admitted as postoperative cases.

Conclusion

It can be concluded from the current study that BSIs are among the serious complications in the setting of neurological ICUs. LCBIs were detected in 16 patients, 5 had secondary BSI, and 11 had CVC-related primary BSI. Increased duration of CVC was found to be a statistically significant risk factor for CR-BSI. Limited data are available regarding BSI in neurological ICUs, hence this study is an initiative in that direction — to provide clinicians with baseline knowledge so that adequate preventative measures can be taken.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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