



Article/Artigo

Reduction of catheter-associated bloodstream infections through procedures in newborn babies admitted in a university hospital intensive care unit in Brazil

Redução de infecções de corrente sanguínea associadas ao cateter, após procedimentos em neonatos admitidos em uma unidade de terapia intensiva de um hospital universitário no Brasil

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ABSTRACT

Introduction: Catheter-associated bloodstream infection (CA-BSI) is the most common nosocomial infection in neonatal intensive care units. There is evidence that care bundles to reduce CA-BSI are effective in the adult literature. The aim of this study was to reduce CA-BSI in a Brazilian neonatal intensive care unit by means of a care bundle including few strategies or procedures of prevention and control of these infections. **Methods:** An intervention designed to reduce CA-BSI with five evidence-based procedures was conducted. **Results:** A total of sixty-seven (26.7%) CA-BSIs were observed. There were 46 (32%) episodes of culture-proven sepsis in group preintervention (24.1 per 1,000 catheter days [CVC days]). Neonates in the group after implementation of the intervention had 21 (19.6%) episodes of CA-BSI (14.9 per 1,000 CVC days). The incidence of CA-BSI decreased significantly after the intervention from the group preintervention and postintervention (32% to 19.6%, 24.1 per 1,000 CVC days to 14.9 per 1,000 CVC days, $p=0.04$). In the multiple logistic regression analysis, the use of more than 3 antibiotics and length of stay ≥ 8 days were independent risk factors for BSI. **Conclusions:** A stepwise introduction of evidence-based intervention and intensive and continuous education of all healthcare workers are effective in reducing CA-BSI.

Keywords: Neonates. Bloodstream infection. Reduction. Central venous catheter.

RESUMO

Introdução: As infecções de corrente sanguínea associadas ao cateter (ICS-AC) são as infecções hospitalares mais frequentes em unidades de terapia intensiva neonatais. O objetivo do nosso estudo foi reduzir as ICS-AC através de um pacote de medidas de cuidados incluindo algumas estratégias de controle e prevenção destas infecções. **Métodos:** Foi realizada uma intervenção desenhada para reduzir as infecções de corrente sanguínea associadas ao cateter com cinco procedimentos de base. **Resultados:** Um total de 67 (26,7%) ICS-AC foi observado. Houve 46 (32%) episódios de sepse com critério microbiológico (24,1 por 1.000 cateter dias (CVC-dias)). Os neonatos do grupo, após a implementação da intervenção, tiveram 21 (19,6%) episódios de ICS-AC (14,9 por 1.000 CVC-dias). A incidência de ICS-AC reduziu significativamente entre os grupos pré-intervenção e pós-intervenção após a implementação das medidas (32% para 19,6%, 24,1 por 1.000 CVC-dias para 14,9 por 1.000 CVC-dias, $p=0,04$). Na análise de regressão logística múltipla, o uso de ≥ 3 antibióticos e tempo de hospitalização ≥ 8 dias foram fatores de risco independentes para ICS. **Conclusões:** A introdução de uma intervenção baseada em evidências e a educação intensiva e continuada de todos os profissionais de saúde são efetivas para a redução de ICS-AC.

Palavras-chaves: Neonatos. Infecção de corrente sanguínea. Redução. Cateter venoso central.

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INTRODUCTION

Hospital-acquired infection is a significant cause of morbidity and mortality in neonatal intensive care units (NICUs)¹ and leads to an increase in the length of stay and hospital costs². Bloodstream infections (BSIs) are the most common healthcare-associated infection in neonates³⁻⁴. Very limited information is available from developing countries on infection rates per hospital-days or device-days including Brazilian units⁵. Incidence density rates per healthcare-associated infection in few studies⁶⁻⁷ were higher than those observed in most studies in the United States or Europe⁸.

Risk factors associated to BSI include prematurity, low birth weight, poor skin integrity, low gestational age, use of parenteral nutrition (PN), central venous catheter (CVC), prolonged duration of NICU stay, and exposure to broad-spectrum antibiotics^{3,8}.

To reduce these infections, guidelines and, recently, bundles of practices have been shown effective in preventing a large proportion of catheter-associated BSI (CA-BSI)^{2,9-10}. These bundles include ongoing surveillance, healthcare workers' education, a trained team of caregivers for catheter insertion and care, and strategies designed to prevent intraluminally and extraluminally acquired BSIs¹¹⁻¹².

The aim of this study was to reduce CA-BSIs in a Brazilian NICU by means of a bundle, including few evidence-based strategies or procedures recommended by the Centers for Disease Control and Prevention (CDC) to reduce risks of CA-BSIs.

METHODS

Design of the study

The study was conducted in the NICU of the University Hospital of Uberlândia. All neonates admitted between August 2008 and September

2009 who required at least one CVC were included in this trial. An epidemiological surveillance for evaluation of nosocomial infection occurrence in the NICU was performed by a team trained by a physician according to the National Healthcare Safety Network, with daily visits to the unit to search BSI and possible risk factors and to the hospital laboratory to recover positive cultures isolated from infections in neonates hospitalized in the period of the trial. Patients were followed from their entry into the study to their discharge or death. An intervention to reduce BSI was followed up from April 2009 to May 2009. Standard definitions for healthcare-associated infections were used¹³. The ethical approval was obtained from the ethics committee of the Federal University of Uberlândia according to the Health Ministry demands.

Intervention

Before implementing any of the components of the study intervention, one physician was designated as the leader. This leader was supposed to train the colleagues about intervention measures. Literature was assessed for methodological quality and applicability and based primarily on categories IA and IB, and guidelines were drafted for CVC insertion and maintenance.

The intervention focused on group sessions and feedback on pathogenesis and data of CA-BSI per 1,000 CVC days in the unit before intervention. Emphasis was placed in five evidence-based procedures (bundle) recommended by the CDC and identified as having the greatest effect on the rate of CA-BSI and the lowest barriers to implementation^{9,14}. The recommended procedures are hand hygiene, using full-barrier precautions during the insertion of CVCs, cleaning the skin with chlorhexidine 0.2%, avoiding the femoral site if possible, and removing unnecessary catheters besides better knowledge about prevention of CA-BSI in neonates. At the first meeting, the pathogenesis and rates of BSI in the unit before intervention (August 2008 to March 2008) were discussed. In the second meeting, the procedures to prevent BSI were addressed. Emphasis was placed on identifying solutions to overcome difficulties to comply with the bundle. Otherwise, visual displays with A3-size

color posters that emphasized care with CVC were distributed at strategic points of the unit.

Post-intervention

Epidemiological surveillance was also performed in the post-intervention period (June 2009 to September 2009). Rates of BSI on this period were calculated per 1,000 CVC days and then presented to healthcare workers as a feedback on the epidemiological indicators of CA-BSI in the unit. Differences in proportions of BSI between the two periods were compared by conducting a statistical analysis.

Microbiological techniques

Hemocultures: blood cultures were collected based on clinical criteria, including apnea, bradycardia, temperature instability, feed intolerance, increased oxygen requirement, fever, and lethargy. To avoid contamination of blood cultures, a specialized nurse drew blood after meticulous skin cleaning. Blood was processed using the BACTEC 9240 (Becton Dickinson Diagnostic Instrument Systems, Sparks, MD, USA) method. Positive cultures were further subcultured in blood agar plates.

Microorganism identification

The identification of samples was performed through traditional phenotype tests¹⁵.

Statistical analysis

Two periods were compared to evaluate the impact of the intervention: the period before the start of intervention (Group 1) and the period after initiation of the intervention (Group 2). Categorical variables were compared using the Chi-square test or the Mann-Whitney U test when appropriate. Univariate analysis of risk factors for BSI was performed by applying the Chi-square test. Statistical significance level was set at $p \leq 0.05$. The variables with $p \leq 0.05$ in the univariate analyses were included in the multivariate logistic regression model to identify independent risk factors for BSI. Software BioStat version 5.0 (Brazil) was used for multiple logistic regression, and GraphPad Prism (Version 5.0, San Diego, USA) was used for other analyses.

TABLE 1 - Characteristics, device utilization, and bloodstream infection rates of neonates with central venous catheter in the neonatal intensive care unit.

Characteristics	Group 1 (n=144)	Group 2 (n=107)	p
Gender, n			
female	64	58	>0.05*
male	80	49	>0.05*
Gestational age, median (range), week	34 (21-41)	33 (24-41)	>0.05**
Birth weight, median (range), g	1,555 (560-4,250)	1,650 (590-4,075)	>0.05**
≤1,500g (LBW), n	67	46	>0.05*
>1,500g, n	77	61	>0.05*
Patient days	2,327	1,717	>0.05*
CVC days, median	13.2 (1-68)	13.2 (1-74)	>0.05**
CVC use, median	1.4 (1-2)	1.5 (1-3)	>0.05**
Length of stay, median	16.2 (1-68)	16.2 (3-77)	>0.05**
BSI (%)	32.0	19.6	<0.05*
BSI (n)	46	21	<0.05*
CA-BSI/1,000 CVC days	24.1	14.9	<0.05*
CA-BSI/1,000 patient days	21.9	12.5	<0.05*
Central line days	13.2	13.2	>0.05**

BSI: bloodstream infection; CA-BSI: catheter-associated-bloodstream infection; CVC: central venous catheter; LBW: low birth weight ≤1,500g, *Chi-square test; **Mann-Whitney U test.

RESULTS

A total of 251 neonates submitted to CVC use were included in this study. One hundred forty-four neonates were admitted before the intervention (Group 1), and 107 neonates were admitted after the implementation of the five evidence-based procedures (bundle) in the NICU (Group 2). No significant differences were observed between the patients' characteristics in both groups (Table 1).

A total of sixty-seven (26.7%) CA-BSIs were observed in the unit. Microbiological criteria were possible for most (91.7%) clinical sepsis. There were 46 (32%) episodes of culture-proven sepsis in Group 1. The most common organisms were coagulase negative *Staphylococcus* (CNS) (50%), mainly *Staphylococcus epidermidis* (46.2%), followed by *Staphylococcus aureus* (15.4%), Gram-negative bacilli (15.3%), *Candida* spp. (7.8%), and *Enterococcus faecalis* (5.8%). The incidence densities of CA-BSI on the preintervention period were 24.1 per 1,000 CVC days and 21.9 per 1,000 patients days, and the median of central line days

was 13.2 (Table 2). Group 2 neonates had 21 (19.6%) episodes of BSI, seven due to CNS (35%), mainly *S. epidermidis* (30%); eight were attributable to *S. aureus* (40%), and three were due to Gram-negative bacilli (15%). The incidence densities of CA-BSI were 14.9 per 1,000 CVC days and 12.5 per 1,000 patient days, with a median of central line days of 13.2 (Table 1).

Figure 1 shows that incidence of BSI decreased significantly after the intervention measures from Group 1 to Group 2, 32% to 19.6% ($p=0.04$). The incidence rate of CA-BSI per 1,000 CVC days also decreased significantly between the groups from 24.1 per 1,000 CVC days to 14.9 per 1,000 CVC days, and that of CA-BSI per 1,000 neonate days decreased from 21.9 per 1,000 neonate days to 12.5 per 1,000 neonate days; however, the average central line length was the same (13.2) in both groups (Table 1).

Overall, the use of PN ($p=0.04$) and mechanical ventilation ($p=0.02$), exposure to ≥ 3 antibiotics ($p<0.001$), and length of stay ≥ 8 days ($p<0.001$) were risk factors for BSI as determined by univariate analysis. The use of more than 3 antibiotics (OR=5.25, $p<0.001$, 95% CI=2.68-1,030) and length of stay ≥ 8 days (OR=2.57, $p=0.01$, 95% CI=1.18-5.61) were found to be independent risk factors for BSI by the multiple logistic regression analysis.

Analyses were repeated for a subgroup of low-birth-weight infants ($<1,500$ g). A total of 113 low-birth-weight infants were included, 67 in Group 1 and 46 in Group 2. There were 25 episodes of culture-proven sepsis in Group 1 and 7 episodes in Group 2. The rate of BSI decreased significantly from Group 1 to Group 2 (37.3% to 15.2%, respectively, $p<0.01$). Central line use was similar in both groups. The incidence density rate of CA-BSI per 1,000 CVC days decreased between groups (26.2 per 1,000 CVC days to 10.2 per 1,000 CVC days), and CA-BSI per 1,000 neonate days decreased from 23.6 per 1,000 neonate days to 9.3 per 1,000 neonate days (Table 2).

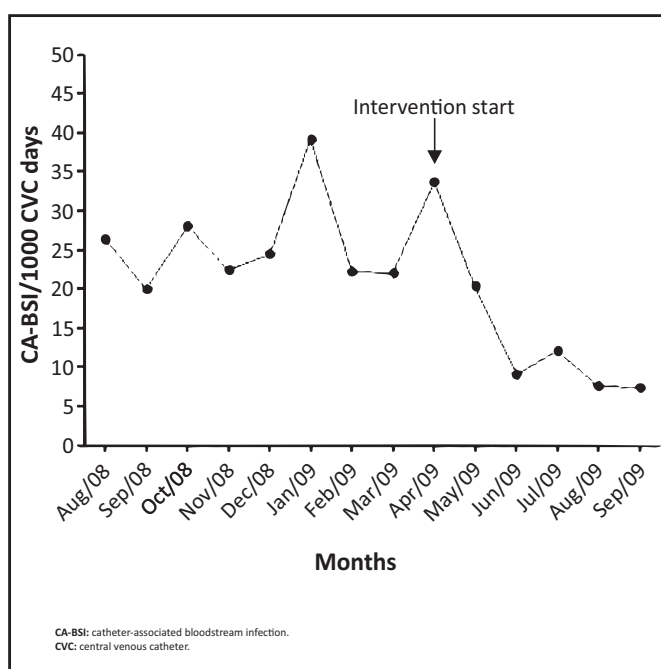


FIGURE 1 - Graph on rates of catheter-associated bloodstream infection in the neonatal intensive care unit in the preintervention and postintervention period.

TABLE 2 - Data on central lines and bloodstream infections among low-birth-weight neonates (subgroup).

	Group 1 (n=67)	Group 2 (n=46)	p
BSI (%)	37.3	15.2	<0.05*
BSI (n)	25	7	<0.05*
CA-BSI/1,000 CVC days	26.2	10.1	<0.05*
CA-BSI/1,000 patient days	23.6	9.3	<0.05*
Central line days	14.2	15.1	>0.05**

CA-BSI: catheter-associated bloodstream infection; BSI: bloodstream infection; CVC: central venous catheter; *Chi-square test; **Mann-Whitney U test.

DISCUSSION

In this report, we affirm the effectiveness of evidence-based prevention bundles in reducing the rate of CA-BSI in our NICU patients. To our knowledge, this is the first study to evaluate the impact of an intervention aimed to decrease CA-BSI among neonates in a Brazilian NICU.

Neonatal BSI is a commonly encountered hospital infection among neonates, mainly premature infants, particularly those who require a CVC¹. Unfortunately, the use of these devices is associated with a considerable risk of infection¹⁶. Of note in both adult and neonatal ICUs, in developing countries, such as Brazil, device-associated infection rates are reported to be several-fold higher than those detected by The National Nosocomial Infection Surveillance in the United States, 16.1 for five developing countries against 6.6 for the US¹⁷. For example, CA-BSIs per 1,000 CVC days occur at rates of 3.1-6.4 in NICUS according to The National Healthcare Safety Network and 22.7 in seven units located in the Brazilian cities³. Our preintervention rate of CA-BSI was similar (24.1) and much higher than those from developed countries¹⁷.

CA-BSIs are largely preventable, and many studies have been published documenting the effectiveness of interventions; reports of several studies have revealed a reduction in CA-BSI rates. Most available data from these interventions are related to adult units^{14,18} and some in pediatrics units^{10,19}. In settings with limited resources, in infants, few data have been published^{2,20}.

In our NICU, we used simple and inexpensive intervention to increase compliance with evidence-based infection control practices and decrease CA-BSI rates. After implementation of the bundle, CA-BSI rate, CA-BSI per 1,000 CVC days, and CA-BSI per 1,000 neonate days had decreased from 32% to 19.6%, 24.1 to 14.9, and 21.9 to 12.5, respectively. The rate of BSI also decreased significantly from Group 1 to Group 2. In low-birth-weight neonates, the rates decreased from 37.3% and 15.2%. We observed a reduction of CA-BSI per 1,000 CVC days and CA-BSI per 1,000 neonate days, observed in association with the new practices, from 26.2 to 10.2 and 23.6 to 9.3, respectively. We have shown that specific education and recommended procedures of CVC insertion and care and feedback to healthcare workers (HCWs) can result in significant reduction on rates of CA-BSI. The overall compliance to the catheter care policy improved significantly in the post-intervention period. Leadership came from within the NICU, which, we think, increased our ability to achieve cooperation from the healthcare workers and to create a change in culture regarding CA-BSI prevention and might explain the success of our intervention.

Coagulase-negative *Staphylococcus* is the most common cause of late-onset BSI in our NICU, accounting for 45.8%, similar to the observations in developed countries, where CNS is the most important microorganism causing CA-BSI^{8,12}. Other studies have shown previously that CNSes were the most frequent agents of BSI as in our NICU⁷. In contrast, Gram-negative bacilli, mainly *Klebsiella* spp., *Escherichia coli*, and *Enterobacter* spp., were most frequent in developing countries⁵⁻⁶.

In this report, the multivariate analysis identified just two independent risk factors for BSI: exposure to ≥ 3 antibiotics and length of stay ≥ 8 days. Risk factors found in previous studies include these, as well as parenteral nutrition and very low birth weight in infants²¹. Parenteral nutrition and mechanic ventilation may be stronger predictors of BSI than CVC use only²² but were not used in a minority of our infants (24.3) and was significant only in the univariate analysis.

There are some limitations in our study. First, we did not collect data of factors that could influence CA-BSI rates such as the line type that was placed and the healthcare worker who placed the line or its duration of use. We are not aware of any market changes, and the procedures have been shown not to change substantially over time; it is likely that the groups remained similar. The postintervention period was only four months, so it was unlikely that there were significant changes.

Second, we did not collect data on preintervention process to measure compliance, and this lack of data decreased our ability to measure the full impact of the bundles, although it is unlikely that the precollaborative performances were markedly different from those in the initial months of the project.

In conclusion, education can significantly improve infection control practices. We implement a simple intervention to reduce these infections in a university NICU. Coinciding with the intervention, the median rate decreased from 24.1 to 14.9 per 1,000 CVC days. We think that it is feasible to sustain this intervention over a long term. The challenge is to continue this reduction, considering the rate of CA-BSI in a university hospital, with more pronounced mobility of students, chiefs, and professionals in the unit.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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