Interdisciplinary task-force reduces catheter-related bloodstream infection in a Pediatric Intensive Care Unit

Equipe interdisciplinar reduz infecção sanguínea relacionada ao cateter venoso central em Unidade de Terapia Intensiva Pediátrica

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ABSTRACT

Objective: To determine the impact of interdisciplinary interventions on central venous catheter-related bloodstream infections rates in a Pediatric Intensive Care Unit (PICU) and on the bloodstream infection organisms.

Methods: Interventional study type before-and-after. An educational program was performed and an interdisciplinary team of interventions was created. This team was formed by nurses and doctors of the PICU and of the Infection Control Committee. The interventions were composed by direct and indirect educational and procedural measures. Task-force interventions were developed from Jun/2003 to May/2004. This pre-intervention period (Phase 1) was compared with two post-intervention periods: Phases 2 (Jun/2004 to May/2005) and 3 (Jun/2005 to May/2006). Central venous catheter-related bloodstream infection rates during the three periods were compared by ANOVA, being significant $p<0.05$.

Results: 1,234 patients were studied from June 1st 2003 to May 31, 2006. The number of central venous catheter-related bloodstream infections was 22.72 per 1,000 catheter-days in Phase 1, and 6.81 and 5.87 in Phases 2 and 3 respectively (Phase 1 vs Phase 2 and 3; $p<0.001$). *Gram*-positive organisms were isolated in 57% of bloodstream infections in Phase 1, and 45 and 58% in Phases 2 and 3, respectively.

Conclusions: The interdisciplinary educational approach and the central venous catheter insertion policies were effective to reduce central venous catheter-related bloodstream infections in the Pediatric Intensive Care Unit.

Key-words: cross infection; catheterization, central venous; child; intensive care.

RESUMO

Objetivo: Avaliar o impacto de intervenções interdisciplinares nos indicadores de infecção de corrente sanguínea relacionada ao cateter venoso central e microrganismos isolados, em uma Unidade de Terapia Intensiva Pediátrica.

Métodos: Estudo de intervenção do tipo antes e depois. Foi criado um programa educativo e constituída uma equipe interdisciplinar de intervenção composta por médicos e enfermeiros da unidade e do Serviço de Controle de Infecção Hospitalar. As intervenções foram compostas por medidas diretas e indiretas educativas e processuais. O período pré-intervenção (Fase 1), de junho de 2003 a maio de 2004, foi comparado ao período pós-intervenção nas Fases 2 (junho de 2004 a maio de 2005) e 3 (junho de 2005 a maio de 2006). As taxas de infecção foram comparadas por ANOVA, sendo significante $p<0,05$.

Resultados: Foram avaliados 1.234 pacientes entre 1º de junho de 2003 e 31 de maio de 2006. A densidade de incidência de infecção de corrente sanguínea relacionada ao cateter venoso central foi de 22,72 por 1.000 dias de cateter na Fase 1; diminuiu para 6,81 e 5,87 nas Fases 2

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e 3, respectivamente (p<0,01) e não houve diferença entre as Fases 2 e 3. Os *Gram*-positivos representaram 57% dos microrganismos isolados no período pré-intervenção e 45 e 58%, respectivamente, nos períodos pós-intervenção.

Conclusões: A abordagem educacional interdisciplinar e o estabelecimento de normas para inserção e intervenção no processo de manutenção de cateteres reduziram as taxas de infecção da corrente sanguínea relacionada ao cateter venoso central em uma Unidade de Terapia Intensiva Pediátrica.

Palavras-chave: infecção hospitalar; cateterismo venoso central; criança; cuidados intensivos.

Introduction

Central venous catheters (CVCs) are used to infuse solutions that are capable of irritating the vascular tunica intima, as is the case with high osmolality parenteral nutrition (greater than 800 to 900mOsm/L) and also with the pharmaceuticals used for cancer chemotherapy, and they also make hemodynamic monitoring possible with critical patients. However, CVCs involve a risk of infection which increases morbidity and mortality and treatment costs.

Over recent years, the results of studies into the risk factors for central venous catheter-associated bloodstream infections (CVC-BSI) allied to newly-developed technologies and improved CVC insertion and maintenance techniques have made it possible to establish guidelines for the control of these infections[1-4].

A recent intervention study demonstrated a 40% reduction in CVC-BSI rates among patients in a clinical intensive care unit at a Brazilian University Hospital after an educational program and implementation of surveillance strategies[5].

The motive for improving the surveillance guidelines was the significance of CVC-BSI as a public health problem[6,7]. The National Healthcare Safety Network (NHSN) is an information network that is administrated by the Centers for Disease Control (CDC) and is responsible for unifying surveillance systems aimed to ensure the safety of patients and health professionals. Its data is uploaded voluntarily by participating institutions over the internet. One of its functions is to monitor CVC-BSI rates. Its most recent report contains data from 2006 provided by 36 pediatric intensive care units (PICUs) in the United States and the median CVC-BSI rate is 3.5 per 1,000 central venous catheter days[8].

During 2003 and 2004, we observed an elevated incidence of CVC-BSI per 1,000 CVC days in the PICU of a Brazilian University Hospital, when compared with the NHSN data, which is what prompted the creation of a task force to update the guidelines for central catheter care at the unit[7].

Good hospital infection prevention results have been described after the implementation of structured programs and coordinated efforts to reduce and prevent care-related infections[5,9]. The objective of this study was to monitor the progress of interdisciplinary interventions and assess their impact on CVC-BSI rates in a PICU and on the microorganisms isolated from the blood of infected patients.

Methods

This study was conducted at a tertiary University Hospital with 377 beds, 10 of which are in a PICU that treats children with both clinical and surgical pathologies. It admits patients under the age of 14, excluding the neonatal period. Patients with CVCs who spent more than 24 hours in the PICU were recruited to one of three prospective cohorts. The pre-intervention cohort included all children admitted between the 1st of June of 2003 and the 31st of May of 2004. Implementation of the interventions started in June of 2004. Two further cohorts were recruited in order to assess the impact of the interventions and their progress over time, while the educational component was continued. The early post-intervention cohort included all children admitted from the 1st of June of 2004 to the 31st of May of 2005 and the late post-intervention cohort included children admitted from 1st of June of 2005 to the 31st of May of 2006. Patients who remained in the PICU for less than 24 hours were excluded. The institution's Research Ethics Committee has approved this article for publication without reservations.

Epidemiological surveillance of infections was conducted in accordance with the National Nosocomial Infection Surveillance (NNIS) system's criteria[10]. The gold standard used by the Hospital Infection Control Team (HICT) to diagnose CVC-BSI was clinical evidence of systemic infection with no other apparent source of infection in patients who had semiquantitative culture results from the catheter tip and from peripheral blood positive for the same microorganism. Patients were also classified as having suffered a CVC-BSI if there was clinical evidence of systemic infection with no other apparent source of infection in patients who had inconclusive culture results, but whose fever improved after removal of the catheter and antimicrobial treatment for clinical suspicion of CVC-BSI. Severity was graded according to the NNIS Average Severity of Illness Score (ASIS)[11,12].

The task force charged with updating central catheter care at the hospital was made up of nurses and doctors from the PICU

Chart 1 – Indirect intervention measures of an educational nature

1. Publication and discussion of step-by-step guidelines on CVC insertion aimed at the medical team.

2. On-the-spot information bulletins aimed at the nursing team listing the processes to be changed, distributed with their clocking-in cards and discussed within the team in order to ensure understanding of the following items:

   a. compliance with hand hygiene;

   b. antisepsis of catheter connections and access points, before opening, using 70% alcohol;

   c. changing disposable caps after catheters are opened for infusions;

   d. encourage the use of saline sets' side injection ports;

   e.replacement of immersion bathing by bed baths for patients with CVCs.

3.Discussion of the independent risk factors for CVC-BSI, in line with CDC guidelines[1].

CVC: central venous catheter; CVC-BSI: central venous catheter-related bloodstream infection; CDC: Centers for Disease Control and Prevention.

Chart 2 – Direct intervention measures

1. Implementation of a process-led surveillance system for insertion of central venous catheters, with a nonconformity register maintained by the nurse, covering the following items:

   a. correct hand antisepsis and wearing of cap, mask, protective glasses and sterile apron by professional performing the task;

   b. other people involved wearing cap and mask;

   c. antisepsis of insertion point;

   d. use of correct size sterile field in correct position;

   e. correct hand antisepsis, gowning and draping by the staff doctor supervising a resident doctor performing the insertion;

   f. Failures are identified for correction immediately.

2. Changing the antiseptics used prior to insertion and for catheter dressing from 10% povidone iodine tincture in squeezable dropper bottles for a sequence of 2% degerming chlorhexidine followed by saline and then 0.5% alcoholic chlorhexidine, all in single-use presentations.

who volunteered spontaneously and by the nurse responsible for epidemiological surveillance of healthcare-related infections in the PICU and the doctor responsible for the HICT.

The technical procedures for insertion and handling of CVCs were reviewed by the catheter task force and compared with HICT and CDC guidelines[1]. In the pre-intervention phase, incomplete surgical gowning and draping was observed during insertion; particularly failure of physicians to use sterile aprons and small fenestrated fields, sporadic wearing of surgical masks and surgical cap by professionals helping and supervising the procedure. During day-to-day care observations included exposure of catheters to water when bathing patients, sporadic compliance with sterilization of catheter access points before opening and preferential use of infusion stopcocks to access the lumen. The bathing procedure had been modified 2 years previously as a humanization measure and all infants were washed by immersion in a plastic bath. Interventions were classified as direct or indirect and are described in Charts 1 and 2.

The microorganisms described as responsible for CVC-BSI were those identified in peripheral blood cultures that had been ordered by the PICU treating team according to their own criteria. Blood was injected into aerobic pediatric blood culture bottles and then incubated for up to five days at a temperature of 36°C using a BacT/Alert® system by Biomérieux. Positive bottles were removed from the machine and aliquots of the culture were subjected to Gram staining and seeded on blood agar and MacConkey plates and incubated for up to 48 hours.

Bacteria were identified according to the criteria laid out in the Manual of Clinical Microbiology[13], using an automated process in a Vitek® machine, Biolab Mérieux.

Infection indicators were processed using EpiInfo® version 6.04a and the monthly infection incidence densities of CVC-BSI were compared between the three cohorts using ANOVA to a significance level of 5%[11,12,14].

Results

Between the 1st of June of 2003 and the 31st of May of 2006, 1,234 patients were analyzed; 426 (34.5%) during the pre-intervention phase, 395 (32%) during the early

post-intervention phase and 413 (33.5%) during the late phase. The density of CVC use was 3,523 catheter days; 1,012 (28.7%) during the pre-intervention phase, 1,320 (37.5%) in the early post-intervention phase and 1,191 (33.8%) in the late phase. The CVC utilization ratios were 0.33 for the pre-intervention phase and 0.41 for subsequent phases (Table 1).

The mean PICU stay was 12.93 days during the pre-intervention phase and 14.91 and 9.24 days, during the two post-intervention phases. The mean ASIS score was 2.22 during the pre-intervention phase and 2.54 and 2.31 in the two later phases (Table 1).

Thirty-nine microorganisms were identified in the blood of CVC-BSI victims, 23 (59%) during the pre-intervention phase, nine (23%) in the early post-intervention phase and seven (18%) in the late post-intervention phase. Gram-positive bacteria accounted for 57% of the microorganisms identified in the pre-intervention phase and 45 and 58% respectively in the two post-intervention phases. *Staphylococcus aureus* was the bacteria with the highest incidence among Gram-positive strains in all three phases, while coagulase negative *Staphylococci* were identified exclusively during the pre-intervention phase. *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* were also only identified during the pre-intervention phase. Two cases of fungemia (22%) were diagnosed, both during the early post-intervention phase (Table 2).

A comparison between the CVC-BSI rate during the pre-intervention phase with that for the early and late post-intervention phases identified a statistically significant reduction ($p<0.01$). There was no difference between the two post-intervention phases (Figure 1).

Discussion

Comparing the data from this patient sample with the CVC-BSI indicators from the NHSN for the same period, we observed that before the intervention, the CVC-BSI rate at the PICU was above the 90th percentile of the NHSN data (9.4 CVC-BSI/thousand CVC days), dropping to close to the 75th percentile (6.5 CVC-BSI/thousand CVC days) in the early and late post-intervention phases[5]. The CVC utilization ratio remained below the 50th percentile of the NHSN figures (0.44 CVC days per patient day) in all three phases.

There was a concentration of CVC-BSI diagnoses during February of 2004, while in January no cases of infection had been notified (Figure 1). The unit had low occupancy during both months and the peak is caused by the low denominator in the infection rate calculation. Additionally, the microorganisms involved were varied, so this was not an outbreak. No outbreaks occurred after the intervention either.

A recent multi-institution initiative undertaken in the United States to prevent CVC-BSI achieved a 68% reduction in the incidence of this type of infection[15]. That intervention, in common with the intervention described here, included the establishment of an educational module dealing with the problem and its prevention, promotion of good

Table 1 – Demographic data and CVC-BSI rate at the PICU during the pre-intervention phase and the two post-intervention phases

	Pre-intervention 1 June 2003 to 31 May 2004	Early post-intervention 1 June 2004 to 31 May 2005	Late post-intervention 1 June 2005 to 31 May 2006
Number of patients in PICU	426	395	413
Mean days in PICU	12.93	14.91	9.24
CVC days	1012	1320	1191
Number of CVC-BSIs	23	9	7
CVC-BSI rate	22.72	6.81	5.87
CVC-utilization ratio	0.33	0.41	0.41
Mean ASIS score	2.22	2.54	2.31

CVC: central venous catheter; CVC-BSI: CVC-associated bloodstream infection; CVC days: the sum of the total number of days that each patient had a CVC fitted during the study period; patient days: the sum of the number of days that each patient stayed in the unit during the study period; CVC-BSI rate (CVC-BSI / 1,000 CVC days): number of CVC-BSI divided by the number of CVC days during the study period, multiplied by one thousand; CVC utilization ratio: number of CVC days divided by number of patient days; Mean ASIS score: total Average Severity of Illness Score points divided by total number of patients.

Table 2 – Microorganisms isolated from cultures of blood from patients with CVC-BSI, before and after intervention

	Pre-intervention 1 June 2003 to 31 May 2004		Early post-intervention 1 June 2004 to 31 May 2005		Late post-intervention 1 June 2005 to 31 May 2006	
	n	(%)	n	(%)	n	(%)
Microorganisms Gram-positive	13	-57	4	-45	4	-58
Staphylococcus aureus	8	-35	4	-45	4	-58
Coagulase-neg *Staphylococcus*	5	-22	0	0	0	0
Gram-negative Microorganisms	10	-43	3	-33	3	-42
Enterobacter sp	2	-9	1	-11	0	0
Serratia marcescens	0	0	0	0	1	-14
Acinetobacter baumanii	2	-9	0	0	1	-14
Escherichia coli	1	-4	1	-11	0	0
Pseudomonas aeruginosa	4	-17	0	0	0	0
Proteus mirabilis	0	0	1	-11	0	0
Klebsiella pneumoniae	1	-4	0	0	0	0
Burkholderia cepacea	0	0	0	0	1	-14
Fungi	0	0	2	-22	0	0
Candida sp	0	0	2	-22	0	0
Total	23	-100	9	-100	7	-100

CVC-BSI: central venous catheter-associated bloodstream infection.

catheter insertion practices (such as using maximum sterile barrier technique and using chlorhexidine for skin disinfection) and the development of a standardized instrument to record compliance with the techniques recommended. The CDC later began to recommend surveillance of processes related to nosocomial infections, in addition to surveillance of actual catheter-related bloodstream infection events[16].

While the hospital studied here has had technical and educational standards for CVC use since 1992, our study found that there were failures of the care received by patients in the PICU related to the procedures for insertion, utilization and maintenance of CVCs, demonstrating that technical knowledge alone does not guarantee compliance with infection prevention techniques. We found that failures were related to changes to technical standards caused by supply shortages, to humanization initiatives, such as immersive bathing, and to the absence of specific process surveillance policies for insertion and maintenance of central catheters. Nevertheless, the results of this study suggest that there was significant commitment to and acceptance of the changes proposed in the educational intervention.

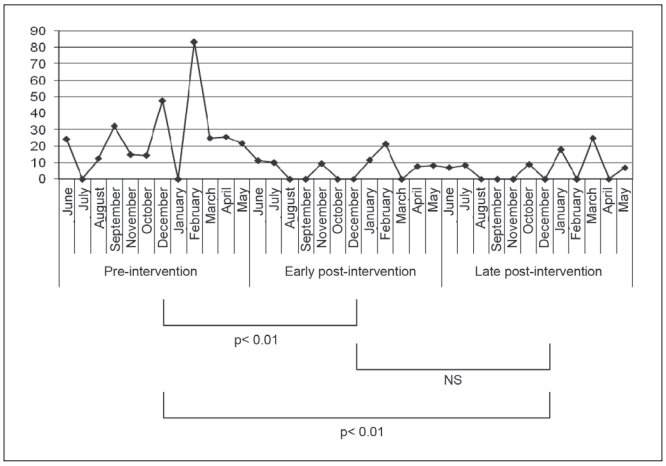

Figure 1 – Monthly break-down of rate of bloodstream infections per thousand central venous catheter days, before and after intervention. Statistical comparison made between the three phases using ANOVA.

The positive impact of the interventions could be detected both during the early post-intervention phase and during the late phase, as represented by the cohorts recruited during

the first and second years after intervention. The HICT was responsible for supervising and facilitating the preventative measures rather than for policing them. The PICU medical and nursing professionals fully committed to the surveillance processes for insertion and maintenance of catheters, which meant that the preventative measures were maintained. We therefore believe that the lasting nature of the results is a reflection of the interdisciplinary nature of the project. The catheter task force runs a continuing education programme and CVC-BSI cases are discussed with the rest of the PICU healthcare team and one of the HICT team is an active member of the catheter task force.

On the basis of the ratio of 23 infections out of 1,012 catheter-days during the pre-intervention phase, were this CVC-BSI rate to have been maintained after the intervention there would have been 30 CVC-BSI cases in 1,320 CVC days during the early post-intervention phase and 27 cases in 1,191 CVC days in the late phase. We therefore estimate that 41 cases of CVC-BSI may have been prevented.

Prevention of nosocomial infections leads to cost reductions that outweigh the costs of implementing preventative measures[17]. Although the cost of CVC-BSIs was not one of the subjects of this investigation, in addition to the direct benefits to patients, the reduction of infection cases by 41 in two years apparently resulted in savings for the healthcare system.

The PICU admission criteria remained unaltered throughout the three phases and the impact of seasonality was reduced by the 12-month duration of each observation period. This study has found statistically significant results for CVC-BSI rate reduction, but suffers from certain limitations, since it did not analyze independent risk factors for CVC-BSI such as length of stay, length of time catheter kept in place, insertion site or use of parenteral nutrition[2].

The efficacy of chlorhexidine-based solutions for reducing the cutaneous bacterial flora is considered superior to that of povidone iodine solutions, including alcohol-based preparations, and the use of single-dose presentations reduces the risk of contamination observed when antiseptics are packaged for multiple use[18-21]. It is probable that the use of chlorhexidine solution and single doses as part of this intervention have also had a favorable impact on reducing infection indicators.

The incidence rates of the microorganisms identified in blood cultures from patients with CVC-BSI exhibited certain differences from the NNIS data[1]. The incidence of *Staphylococcus aureus* as the etiologic agent of bloodstream infections was greater than the incidence of coagulase-negative *Staphylococcus*, which has been observed before in pediatric and neonatal intensive care units in South America[9,22]. *Enterococcus sp* was not identified as an agent of infection among this sample, despite its ascendancy in the United States. In contrast, the incidence of Gram-negative bacilli is reducing in the US, while in our sample its incidence was considerable[1].

A systematic observation of CVC care identified simple problems, probably the result of habits acquired over the years and not from technical ignorance. Easily-assimilated, on-the-spot educational measures and a process-led surveillance system for insertion of central venous catheters led to a reduction in the high levels of CVC-BSI to the level that is to be expected of a PICU. Changing the antiseptic to chlorhexidine may also have contributed to this result.

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