A Multifaceted Intervention Program to Prevent Bloodstream Infection in an IntensiveCare Unit Running Head: An Intervention for the Reduction of Bacteraemia in ICU

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Abstract

Objective: Bloodstream infections (BSIs) are associated with increased morbidity and mortality among critically ill patients. The aim of this prospective multifaceted interventional study is to investigate the effect of a bundle of measures on BSI rates.

Methods: The study was divided in a baseline and an intervention period. The interventions initiated consisted of a central venous catheter (CVC) insertion and maintenance bundle, an educational program promoting hand hygiene among health-care workers as well as weekly performance feedback. Patient data collected included demographics, days of antimicrobial therapy and CVC catheterizations and episodes of bacteraemia. Altogether, 267 patients were enrolled in the study.

Results: Bacteraemia occurred in 35 out of 143 patients in the baseline period (14.7 incidents per 1000 patient-days) and in 18 out of 124 patients in the intervention period (8.8 incidents per 1000 patient-days). This indicates a statistically significant lower BSI incidence after implementing the intervention (p < 0.05, OR 1.9).

Conclusions: An intervention program including modifying CVC insertion and maintenance as well as promoting hand hygiene seems to be an effective way of preventing BSI in intensive care units.

Keywords: Bloodstream infection; Central venous catheter bundle; Hand hygiene; Education intervention

Abbreviation: BSI: Blood Stream Infection; CVC: Central Venous Catheter; CLABSI: Central Line-Associated Blood Stream Infection; ICU: Intensive Care Unit; COPD: Chronic Obstructive Pulmonary Disease; APACHE II: Acute Physiology and Chronic Health Evaluation II; SAPS III: Simplified Acute Physiology Score III; SOFA: Sequential Organ Failure Assessment

Introduction

Bloodstream infection (BSI) is a major cause of morbidity and mortality worldwide and is associated with prolonged hospital stay and additional health care costs [1-4].

Compared to the general hospital population, critically ill patients are at increased risk of BSI because of underlying comorbid conditions [5,6], prior receipt of antimicrobial therapy and widespread use of invasive devices such as central venous

catheters (CVCs). The presence of the latter is a common predisposing factor for BSI (central line associated bloodstream infection - CLABSI) [7]. The risk varies depending on ward-type, institution and geographical region [8].

Specific strategies have been shown to significantly reduce the rate of CLABSIs in intensive care units (ICUs) [9] and have been adopted in the Centers for Disease Control and Prevention (CDC) and other guidelines [10-12]: full barrier technique during CVC insertion, skin antisepsis with chlorhexidine, catheter site selection with avoidance of the femoral vein, preinsertion hand hygiene and early removal of unnecessary catheters. Behavioral interventions that improve the compliance of the personnel also seem to play a significant role [13]. The efficacy of these measures has been confirmed in several large scale studies in the recent years [14-18], whereas the goal of a zero CLABSI rate has not been achieved.

Moreover, hand hygiene is generally regarded as an effective way to reduce health-care infection rates - and consequently BSI rates - caused by cross-transmission of pathogens [19]. Based on the World Health Organization initiative [20], several campaigns aiming at promoting hand hygiene in healthcare have been introduced in the last years [21]. However, compliance between healthcare workers still remains low [22].

The objective of the present study is to evaluate the impact of a series of technical and educational interventions consisting of CLABSI prevention measures and a hand hygiene promotion program on the rates of BSI in an ICU.

Methods

Study design

This prospective interventional study was conducted in the 30-bed intensive care unit (ICU) of Evangelismos hospital, a 1000-bed tertiary care hospital in Athens, over a 17-month period (October 2010 to February 2012).

All adult patients admitted to the ICU for more than 48 hours were eligible to participate in the study. The exclusion criteria were ICU hospitalization in the previous three months, brain death, pregnancy and microbiologically confirmed sepsis at the admission point.

Data collected included demographics, preexisting medical conditions, severity scores on admission, days of antimicrobial therapy, days of central venous catheterization as well as number of catheter-insertions during the ICU stay. All episodes of bacteraemia were recorded. The patients were followed until acquiring a BSI, until discharge from the ICU or for a maximum of 30 days.

The study was divided in two periods: a baseline observation period (October 2010 - April 2011) and an intervention period (May 2011 - February 2012). The study protocol was approved by the Ethical Committee of the hospital.

Interventions

We introduced a CVC insertion and maintenance bundle consisting of:

Full barrier precautions during the insertion including donning of sterile gloves, sterile gown, cap and mask by the physician inserting the catheter, large sterile draping of the patient, skin antisepsis with 2 % chlorhexidine preparation and avoidance of the femoral site when possible. Compliance with best practices was ensured by a checklist which had to be filled by the physician at every new insertion.

Regular inspection of the insertion site for signs of infection and replace of the dressing when dump or soiled or routinely once per week.

Moreover, we implemented a series of measures in order to promote hand hygiene among healthcare workers:

Indications for hand hygiene were posted at strategic locations throughout the ICU.

Healthcare workers were informed about the necessity of hand hygiene in a lecture.

In order to further support our measures, a booklet of standards regarding central line care and hand hygiene according to recommended guidelines was distributed to the personnel.

Definitions

A BSI was considered to be ICU-related if it was detected at least 48 hours after admission. Both primary and secondary BSIs were considered in the analysis. Cultures of common skin contaminants were not included in the analysis, unless the microorganism was isolated in two different samples. An antimicrobial day was defined as a day for which any amount of an antimicrobial agent was administered to an individual patient.

Microbiological methods

Blood cultures were obtained when indicated by the treating physician in case of clinical suspicion of infection. All specimens were processed using standard methods at the microbiological laboratory of the hospital. Detection of microorganisms was performed by the automatic blood culture system BD BACTEC™ 9000 Series.

Statistical analysis

The data analysis was performed using SPSS for Windows Version 19.0. Continuous variables are expressed as mean (standard deviation - SD) and categorical variables as counts and percentages.

Variables were compared using the independent-sample t-test or Pearson chi square test, as appropriate. Risks were compared using odds ratios (OD) with corresponding 95 % confidence intervals (CI). All tests were two-tailed, and p-values less than 0.05 were considered to indicate statistical significance.

Outcome measures

The primary endpoint of the study was the acquisition of bacteraemia. The BSI rate was expressed as the number of BSIs per 1000 patient days.
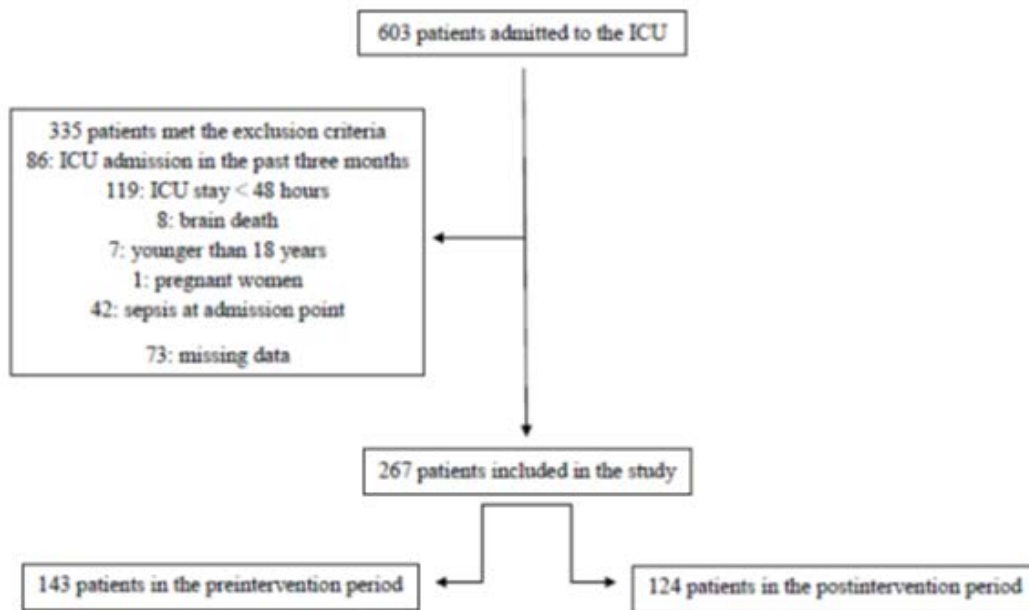
Figure 1 Flow chart of patients enrolled in the study.

Results

As shown in **Figure 1**, a total of 603 patients were admitted to the ICU during the study period, of which 267 were eligible for enrolment in the study (143 in the baseline and 124 in the intervention period) and were included in further analysis.

Their main demographic and clinical characteristics are summarized in **Table 1**. Overall, the study groups were similar in both periods. An exception to this is the higher SOFA gravity score in the intervention period ($p = 0.017$), indicating a larger extent of organ failure in this group of patients. Nevertheless, such a difference in the two populations was not confirmed by the APACHE II ($p = 0.438$, death prediction: $p = 0.244$) or SAPS III ($p = 0.493$, death prediction $p = 0.693$) severity scores.

The distribution of BSI rates during the study period is illustrated in **Figure 2**. Bacteraemic incidents occurred in 35 out of 143 patients in the baseline period (24.5 %, 14.7 incidents per 1000 patient-days) as well as in 18 out of 124 patients in the intervention period (14.5 %, 8.8 incidents per 1000-patient days), indicating a statistically significant lower incidence of BSI after implementing the intervention ($p = 0.042$, OR 1.9, CI 1.02 - 3.58). The type of isolated microorganisms can be seen in **Table 2**.

Days of central line catheterization, number of catheter-insertions, days of antimicrobial therapy and patient mortality did not change significantly during the two study phases, neither in the study population **(Table 1)** nor in the patients that developed bacteraemia **(Table 3)**.

Discussion

Main findings

The present study has addressed the effects of changing practice, education and feedback on decreasing BSI rates. Our findings demonstrate that implementation of a CVC-care bundle and a program to improve hand hygiene was associated with a significant reduction in BSIs.

Our study was completed one year after an intervention regarding ventilator-associated pneumonia in the same ICU, which could have already positively affected the working practices of the ICU personnel.

Factors that could have played an independent role to the reduction of BSI like device utilization and antibiotic use remained at the same level during the two study periods, indicating that the observed difference occurred through our intervention. Moreover, although SOFA gravity score at ICU admission has been shown to be independently associated with the acquisition of bacteraemia [23], we observed a higher admission SOFA in the postintervention period. The lower BSI incidence in this phase despite this additional risk factor supports further the effectiveness of our measures.

The prospective character of our study and the large sample size also confirm the reliability of our findings. We applied a program of multifaceted interventions which, although challenged in the recent years [24], are still widely recognized to be more effective than single component ones. The interventions we used are simple and inexpensive and would, therefore, be easily implemented in other ICUs.

Relation to previous findings

Our results support the findings of previous studies demonstrating significant reduction in CLABSI after introducing a series of interventions, as first shown in the landmark study of Berenholtz et al. [9] and then adopted in the CDC guidelines [10]. Based on

Table 1 Patient demographic data and clinical characteristics.

	Preintervention (n=143)	Postintervention (n=124)	*p* value
Patient-days	2379	2037	
Male, n (%)	90 (62.9)	89 (71.8)	0.126
Age, years, mean (SD)	56.8 (18.6)	56.5 (19.7)	0.906
Length of stay, days, mean (SD)	16.6 (9.8)	16.4 (10.9)	0.869
ICU-Mortality, n (%)	46 (32.2)	38 (30.6)	0.789
Severity scores on admission, mean (SD)			
SOFA	6.4 (2.9)	7.4 (3.7)	**0.017**
APACHE II	15.0 (6.0)	15.6 (6.8)	0.438
APACHE II death prediction	23.9 (15.7)	26.2 (16.6)	0.244
SAPS III	57.6 (15.0)	56.2 (18.4)	0.493
SAPS III death prediction	33.1 (22.9)	32.0 (23.5)	0.693
Type of admission, n (%)			
Medical	76 (53.1)	52 (41.9)	0.067
Elective surgery	22 (15.4)	24 (19.4)	0.392
Emergency surgery	24 (16.8)	21 (16.9)	0.974
Trauma, non-surgical	20 (14.0)	28 (22.6)	0.068
Comorbid conditions, n (%)			
Diabetes mellitus	22 (15.4)	22 (17.7)	0.605
Cancer	27 (18.9)	18 (14.5)	0.342
COPD	8 (5.6)	9 (7.3)	0.579
Immunosuppression	10 (7.0)	11 (8.9)	0.570
Chronic heart failure	7 (4.9)	4 (3.2)	0.494
Chronic renal failure	3 (2.1)	5 (4.0)	0.355
Total antimicrobial days, mean (SD)	16.3 (10.0)	15.6 (11.1)	0.568
CVC-days, mean (SD)			
Internal jugular / subclavian	15.1 (9.8)	15.4 (11.3)	0.808
Femoral	1.8 (3.9)	2.0 (4.7)	0.679
No of CVC-insertions, mean (SD)			
Internal jugular / subclavian	2.2 (1.7)	1.8 (1.5)	0.065
Femoral	0.4 (0.7)	0.3 (0.7)	0.599

these guidelines, we introduced an intervention to prevent CLABSI and combined it with a hand hygiene improvement program. By promoting hand hygiene as a means of general infection prevention we were able to affect not only the catheter-related but also the secondary bacteraemia, which has been suggested to be associated with a higher attributable mortality [25].

On the other hand, our findings show that this quality improvement intervention resulting in reduction of BSI was not associated with a better prognosis and are in opposition to the widely accepted reasoning that bacteraemia is a negative prognostic factor for critically ill patients [1-5]. This common belief has already been challenged in previous studies that did not demonstrate excess mortality between bacteraemic patients [26,27], leaving the matter of the clinical significance of BSI still open. However, it has to be pointed out that our study was not

designed to control the effect of a BSI preventing intervention on the ICU outcome and, consequently, the role of factors like type of microorganism and antimicrobial treatment on the prognosis has not been evaluated.

Limitations

A limitation of our study is that it is quasi-experimental and conducted at a single medical center. Furthermore, during the study period there was no hospital-wide change in the CVC-insertion technique or in the hand hygiene promotion. The catheters inserted outside the ICU, where the quality of insertion and maintenance could not be controlled, were not removed upon admittance unless there were clinical signs of infection. In addition, our BSI rate may be underestimated given that patients
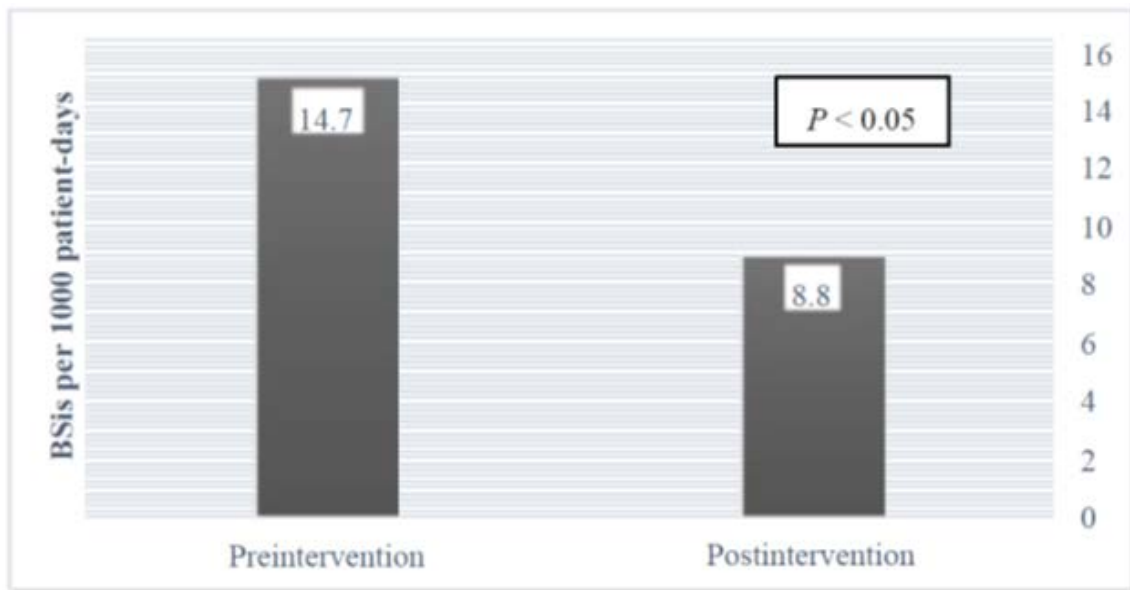
Figure 2 BSI-rates during the two study phases.

Table 2 Type of isolated pathogens.

Isolated pathogen, n (%)	Preintervention (n=35)	Postintervention (n=18)
Klebsiella pneumoniae	12 (34.3)	7 (38.9)
Acinetobacter baumannii	12 (34.3)	5 (27.8)
Providencia stuartii	4 (11.4)	4 (22.2)
Pseudomonas aeruginosa	2 (5.7)	1 (5.6)
Proteus mirabilis	2 (5.7)	0 (0.0)
Serratia marcesens	1 (2.9)	0 (0.0)
Staphylococcus aureus	1 (2.9)	0 (0.0)
Staphylococcus epidermidis	1 (2.9)	0 (0.0)
Candida albicans	0 (0.0)	1 (5.6)

Table 3 Catheter characteristics and antimicrobial therapy until the acquisition of BSI.

	Preintervention (n=35)	Postintervention (n=18)	*p* value
CVC-days, mean (SD)			
Internal jugular /Subclavian	10.0 (5.9)	11.8 (5.9)	0.304
Femoral	1.5 (3.0)	1.9 (3.2)	0.656
CVC-insertions, mean (SD)			
Internal jugular /Subclavian	1.7 (1.4)	1.7 (0.9)	0.954
Femoral	0.4 (0.8)	0.4 (0.8)	0.845
Antimicrobial days, mean (SD)	11.8 (5.8)	12.4 (5.4)	0.701

BSI: Blood Stream Infection; CVC: Central Venous Catheter; SD: Standard Deviation

were not followed after discharge from the ICU. Furthermore, by concurrently undertaking a CVC care bundle and a hand hygiene promoting program, we were not able to differentiate at what point each of the two infection preventive strategies is responsible for our final result.

Conclusion

The existing data suggest that BSIs may be preventable to a large extent. Our intervention study supports this evidence by demonstrating a significant decrease in BSI rates after the implementation of a simple series of measures. Nevertheless, there is definitely still room for improvement in this area, as zero risk for infection has yet not been reported.

Conflicts of Interest

None

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