American Journal of Infection Control 43 (2015) 844-7

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Blood culture contamination rate in an intensive care setting: Effectiveness of an education-based intervention

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Key Words:
Coagulase-negative staphylococci
Critical care
False positive blood cultures

Background: Blood culture (BC) contamination rate is an indicator of quality of care scarcely explored in intensive care units (ICUs). We analyzed the BC contamination rate in our ICU to assess the effectiveness of an education-based intervention.
Methods: We conducted an interventional study with concurrent controls. Consecutive BCs drawn during a 6-month period were included. An education-based intervention was presented to case nurses (optimal technique). The remaining nurses comprised the control group (standard technique). Two independent observers assessed clinical significance of saprophytic skin bacteria isolated in BCs.
Results: Six hundred fifty-six BCs were obtained: 308 (47%) via optimal technique and 348 (53%) via standard technique (47%). One hundred eighty-seven BCs were positive for saprophytic microorganisms; 127 (89%) were considered unrelated to infection. Coagulase-negative staphylococci isolation was lower in the optimal technique group (14% vs 26%; $P < .001$), as well as contamination due to coagulase-negative staphylococci (12% vs 21%; $P = .002$) or *Acinetobacter baumannii* (0.3% vs 2%; $P = .013$). BC contamination rate was 13% in the optimal technique group versus 23% in the standard group ($P < .005$). In the optimal technique group, BC contamination rate was higher in BCs drawn through the catheter (17% vs 7%; $P = .028$).
Conclusions: An education-based intervention significantly reduced the BC contamination rate in our ICU. It seems necessary to design a tool to extract BCs through the catheter to minimize the risk of contamination.

Blood culture (BC) contamination rate (false positive BC/total of BC) is a well-known indicator of quality of care in the field of pediatrics, in emergency departments, and in general medicine wards.[1-3] However, its application in the care of critically ill patients has hardly been extended.[4,5] The possibility of false positive BC in critically ill patients is elevated by the high frequency with which BCs are extracted, by the use of the catheter for sampling (sometimes due to the repeated inability to perform venipuncture in these patients), and by the workload on nurses who have to perform the extraction.[6] On the other hand, microorganisms usually involved in false-positive BCs (as coagulase-negative *Staphylococcus* [CNS]), are 1 of the most frequent etiologies of some nosocomial infections such us catheter-related bloodstream infections.[7] Therefore, discrimination between bloodstream infection and false-positive BCs (ie, contaminated BC) is crucial to not omit the treatment of an actual infection or to administer unnecessary antibiotics. A high number of published studies addressing the correct interpretation of CNS isolated in BCs features the inherent difficulties of this task.[8-12] Regrettably, due to the need for proper and early treatment in critically ill patients, CNS BC frequently causes the repetition of diagnostic tests, the use of antibiotics, or even the replacement of intravenous catheters. The major human and economic effect of the consequences of a high rate of contamination of BCs has been described.[13-19] Controlling the BC

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Conflicts of interest: None to report.

0196-6553/$36.00 -
http://dx.doi.org/10.1016/j.ajic.2015.04.183

contamination rate would avoid largely the problem of clinical interpretation of CNS BC. In this sense, some successful interventions in pediatrics, general wards, and emergency departments have been published, but according to our data there are not any specific applications in critical care patients.[20-26]

We performed an interventional study (concurrent cohorts) to analyze the BC contamination rate in our critical care unit and the effects of an education-based program on critical care nurses.

MATERIALS AND METHODS

Study design

Prospective observational study with concurrent controls.

Site of study

We conducted the study in a medical intensive care unit (ICU) in a university tertiary referral hospital. During the study our ICU was experiencing multidrug-resistant *Acinetobacter baumannii* epidemic. In fact, cutaneous colonization by multidrug-resistant *A baumannii* was detected in at least 15% of patients admitted to our ICU for more than 48 hours. *A baumannii* is an epidemiologic problem in many Spanish ICUs and is not associated with a specific type of patient but to a deficit in nosocomial infections control programs. Fortunately the results of this study helped boost the implementation of a bundle of measures that finally managed to control the epidemic.

Duration of study and inclusion criteria

All consecutive BCs drawn during a 6-month period were included.

Intervention on the BC collection technique

The education-based intervention was performed in half of the nurses and consisted of a 2-hour course on the technique of extracting BCs. The remaining nurses comprised the control group (standard technique). BCs extracted by trained nurses were identified using a specific checklist (optimal technique).

BC collection protocol was designed following the recommendations of the Spanish Society of Microbiology and Infectious Diseases[27]: use of sterile gloves, cleansing the skin with 2% aqueous chlorhexidine, cleansing the tops of the BC bottles with antiseptic (2% aqueous chlorhexidine), and injection of at least 5 mL blood in each blood culture bottle without needle exchange. Blood sampling through the catheter was not recommended unless there was a suspicion of catheter-related bacteremia or it was impossible to perform a venipuncture. If samples were extracted through a catheter, nurses had to maintain sterile technique and the catheter hub was cleaned with 2% aqueous chlorhexidine.

Microbiologic analysis of BCs

BCs were processed in BD Bactec 9420 (Becton Dickinson, East Rutherford, NJ), BacT/Alert (Organon Teknika, Oss, The Netherlands) and BacT/Alert 3D (bioMérieux S.A., Marcy L'Etoile, France) devices, in tripticasein soy agar broth culture medium in aerobic and anaerobic atmosphere. Peptone-enriched medium, brain-heart infusion broth, and activated charcoal were used for patients who had previously received antibiotic agents. Once BCs were positive, Gram's stain and acridine orange stain were performed for detection of microorganisms. Microorganisms were isolated on blood agar, chocolate agar, and Levine culture medium (selective medium for gram-negative bacilli). After the macroscopic description of the colony, the microorganism was typified by routine biochemical tests (ie, indole, TSI (triple sugar iron agar), ONPG (o-Nitrophenyl-beta-D-galactopyranosidase), APP (Fenil alanina agar), urea, gelatin, citrate, lysine, and mannitol) or by automated systems like Vitek 1 and Vitek 2 (bioMérieux S. A.) or BD Phoenix.

Clinical significance of BCs positive for skin commensals

In the case of isolation of common saprophytic skin bacteria (eg, *Corynebacterium* spp, *Bacillus* spp [not *B anthracis*] spp, *Propionibacterium* spp, CNS [including *S epidermidis*], viridans group streptococci, *Aerococcus* spp, and *Micrococcus* spp), the diagnosis of catheter-related bacteremia was done according to the Centers for Disease Control and Prevention (CDC) definition, which includes the presence of at least 1 of the following: fever (>38°C), chills, or hypotension; not attributable to another focus of infection; and at least 2 positive BCs for the same microorganism.[28] Given the epidemiologic characteristics of our ICU, with up to 15% of cases of cutaneous colonization by *A baumannii* in patients with more than 48 hours of stay, this microorganism was evaluated the same as the rest of skin commensals. Two independent observers applied the CDC criteria. Observers were unaware of the technique used for obtaining the BC (ie, standard or optimal). The final diagnosis of infection or contamination was established if there was agreement between the 2 observers; otherwise the BC was classified as "indeterminate." The suitability of this method was evaluated by the kappa index.

Contamination rate of BCs

The contamination rate was calculated as the number of false-positive BCs (ie, contaminated) divided by the total of drawn BCs.

Statistical analysis

Means and standard deviation were calculated for continuous variables and absolute and relative frequencies were calculated for discrete variables. Categorical variables were compared using the χ^2 test. Comparison of continuous variables was performed with the Student *t* test. The agreement between the verdicts of the 2 independent observers was evaluated by the kappa index. All data recorded were analyzed using the statistical program SPSS version 16.0 (IBM-SPSS Inc, Armonk, NY).

RESULTS

During the 6-month study period, 656 BCs (grouped into 343 episodes) were obtained from 145 patients. The optimal technique was performed in 308 BCs (47%) and the standard technique in 348 BCs (53%). Fifty-two patients (35%) had BC extracted with both techniques.

In 69% of BCs (n = 450) there was no microbiologic isolation. Among positive BCs (n = 206; 31%), the most commonly isolated microorganisms were CNS (n = 136; 20% of all BCs and 66% of positive BCs), *A baumannii* (n = 45; 7% of all BCs and 22% of positive BCs), and *Candida* spp (n = 12; 2% of all BCs and 5% of positive BCs). Other etiologic agents are described in Table 1.

One hundred eighty-seven BCs were positive for saprophytic microorganisms (CNS, *Corynebacterium* spp, and viridans streptococcal species [n = 142] and *A baumannii* [n =45]) and the 2 independent observers evaluated the clinical significance of these findings. One hundred twenty-seven of the saprophytic microorganisms (89%) were considered unrelated to infection (ie, a contaminated BC). Eighty percent of CNS-positive BCs, 24% of *A baumannii*-positive BCs, and 100% of *Corynebacterium* spp- and viridans streptococcal species-positive BCs were considered contaminated BCs. Observers did not agree in 12 cases (6%). The