Reducing the Blood Culture Contamination Rate in a Pediatric Emergency Department and Subsequent Cost Savings

abstract

BACKGROUND AND OBJECTIVE: Blood culture contamination in the pediatric population remains a significant quality and safety issue because false-positive blood cultures lead to unnecessary use of resources and testing. In addition, few studies describe interventions to reduce peripheral blood culture contamination rates in this population. We hypothesized that the introduction of a standardized sterile collection process would reduce the pediatric emergency department’s peripheral blood culture contamination rate and unnecessary use of resources.

METHODS: A sterile blood culture collection process was designed by analyzing current practice and identifying areas in which sterile technique could be introduced. To spread the new technique, a web-based educational model was developed and disseminated. Subsequently, all nursing staff members were expected to perform peripheral blood cultures by using the modified sterile technique.

RESULTS: The peripheral blood culture contamination rate was reduced from 3.9% during the baseline period to 1.6% during the intervention period (P < .0001), with yearly estimated savings of ~$250,000 in hospital charges.

CONCLUSIONS: Subsequent to our intervention, there was a significant reduction of the peripheral blood culture contamination rate as well as considerable cost savings to the institution. When performed in a standardized fashion by using sterile technique, blood culture collection with low contamination rates can be performed via the insertion of an intravenous catheter. Pediatrics 2013;131:e292–e297

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KEY WORDS
blood culture contamination, coagulase-negative staphylococcus, pediatric emergency department

ABBREVIATIONS
ED—emergency department
IV—intravenous

Drs Hall, Self, and Hain conceived the study; Dr Hall designed the study, and all authors participated in analysis, interpretation of data, writing of the manuscript, and final approval.

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Peripheral blood cultures are commonly obtained in the pediatric population to identify a treatable pathogen in the presence of a suspected bacterial infection. The blood culture collection process at our institution was non-standardized with many misconceptions regarding the sterility of the general technique. Blood cultures could be contaminated by inadvertent introduction of native skin bacteria into the specimen either from the patient or the care provider. In addition, improper preparation and placement of supplies could lead to accidental contamination of materials used in the collection process. The accepted benchmark for blood culture contamination rates in the hospital setting is between 2% and 3%. A review of peripheral blood cultures shows that contamination rates are highly variable between institutions and can approach 6%. More specifically, contamination rates in emergency departments (EDs) are reported as high as 11%. Increased blood culture contamination rates have been shown to be correlated with younger patient age as well as fewer years of experience of the individual performing the procedure. Many of the efforts to improve have been focused on a few key areas of the collection process. Skin antisepsis has been the primary focus with several studies looking at the differences between current commercial products. Lastly, decreases in blood culture contamination have been seen with implementation of trained phlebotomy teams to perform peripheral blood cultures. Pediatric ED data have shown improvements of blood culture contamination rates to 2.8% with use of dedicated phlebotomy teams and 2.3% with use of 2 separate venipunctures for blood culture collection and intravenous (IV) catheterization. To our knowledge, there have been no published quality improvement efforts focused on obtaining a blood culture at the time of peripheral IV catheter placement by using sterile technique.

Few data demonstrate the financial burden of blood culture contamination from an inpatient perspective, and the data that do exist are poorly generalizable to the pediatric population. Waltzman et al evaluated the cost of contamination in patients discharged from the ED, but that study restricted its population to healthy children. In our institution, contaminated blood cultures frequently result in a patient receiving antibiotics while the speciation of the culture is being completed. Additionally, for those admitted in the neonatal period to “rule out sepsis,” extra days in the hospital are a typical occurrence when a blood culture is contaminated. We are not aware of any literature quantifying the cost due to these sequelae of contaminated blood cultures in patients admitted to the hospital.

The pediatric ED collects ~30% of all peripheral blood cultures collected at the Monroe Carell Jr Children’s Hospital at Vanderbilt University. The initial contamination rate was 3.9%, which is higher than the 2% to 3% benchmark. After review of the literature, local nursing leadership approved a goal of 50% relative reduction in peripheral blood culture contamination. Although our hospital tracked peripheral blood culture contamination rates before this study, there were no continuing education programs regarding culture collection or standardized processes for collecting specimens. We hypothesized that the introduction of a standardized sterile collection process combined with continuous feedback would reduce the contamination rate and unnecessary use of resources.

**METHODS**

**Setting**

The intervention took place in the Emergency Department of the Monroe Carell Jr. Children’s Hospital at Vanderbilt. This study was deemed exempt by the Vanderbilt Institutional Review Board.

**Intervention**

The blood culture collection process for peripheral cultures in the pediatric ED was reviewed in December 2010. Over a 2-week period, the nursing staff was asked to demonstrate local commonly accepted practice for collecting peripheral blood cultures in patients admitted to the ED. The process was found to be highly variable with several problematic actions being observed. The identified actions potentially leading to contamination are listed in Table 1.

In addition, baseline data for peripheral blood culture contamination rates were determined over the 19 months before the intervention. A chart review of all peripheral blood culture contaminations before intervention was completed and assessed for resource use due to contamination such as administration of antibiotics and prolonged stay directly due to a contaminated blood culture.

A sterile peripheral IV catheter insertion process was devised and implemented in the ED. The process consisted of the use of sterile gloves and a sterile field to place a peripheral IV catheter from which a blood culture can be drawn during placement (Fig 1). It is standard practice in our institution and many children’s hospitals to obtain

**TABLE 1** Identified Deviations From Best Practice in Local Blood Culture Collection Techniques

| 1. Chlorhexidine solution not allowed to completely dry on skin |
| 2. Top of blood culture bottle not sterilized with alcohol or chlorhexidine |
| 3. Catheter site palpated with gloved nonsterile finger before insertion, but after cleansing |
| 4. Blood sample injected into nonsterile container, then injected into blood culture bottle |
| 5. Blood culture drawn from peripheral IV catheter placed at an outside hospital |
| 6. Blood specimen placed on bed, sheets, or nonsterile surface |
a solitary blood culture when bacteremia or sepsis is suspected. Also, our ED attempts to place an IV in all patients who need a blood culture drawn because of the likelihood of other blood specimens needing to be obtained. A standard BD BACTEC Peds Plus Culture Vial (Resin Containing) was used for specimen collection with a required 1 mL minimum amount of blood inoculation.

After designing this method of sterile IV insertion and blood draw technique, an educational campaign focused on teaching it was instated through a web-based presentation process. The presentation encompassed an exemplary case explaining the consequences of contamination that may not have been fully understood by the nursing staff. Additionally, the presentation taught the new process for placing a sterile IV, obtaining a blood sample, and the common deviations that lead to contamination, which are listed in Table 1. After implementation of the sterile peripheral blood culture process, all contaminations were reviewed on a bi-weekly basis. Nursing staff members were contacted via e-mail regarding a contamination in which they were involved.

**Analysis**

Blood cultures are analyzed by using the BD BACTEC FX Blood Culture System and the reports are managed by an electronic tracking system, VIPER (Vanderbilt Infection Prevention Electronic Resource), which can query all blood cultures processed at Vanderbilt Medical Center. The system was used to select for peripheral blood cultures drawn in the pediatric ED. Blood cultures were considered to be contaminated when peripheral blood samples grew any species on a predefined list of bacteria that commonly cause contamination (Table 2). The list of bacterial isolates commonly recognized as contaminants was compiled in conjunction with the hospital epidemiologist and well-accepted standards in the literature.

The contamination rate was recorded on a monthly basis through a periodic audit of the VIPER database. Additionally, specimens were not included if the patient had an in-dwelling central line or peripherally inserted central catheter at the time of blood draw. Patients with any known oncologic history, with immunodeficiency, or taking immunosuppressive medications were also excluded from the study.

One physician (RH) performed in depth chart reviews for every blood culture from July 2009 to July 2010 that fit the criteria for contaminated peripheral culture. Through individual chart review, resource use was examined, and each charge that was directly assignable to the contaminated culture was recorded. Table 3 summarizes the charges that were aggregated.

**Analytical Methods**

Contamination rates were measured during a 19-month preintervention period to establish a baseline contamination rate. During the preintervention period, there were 5402 blood cultures collected, 212 of which were contaminated (3.9% contamination rate). In the 9-month postintervention period, there were 2153 blood cultures collected, 35 of which were contaminated (1.6% contamination rate). By using R software, version 2.13.0, a Pearson’s $\chi^2$ test was used to assess the relationship between intervention period and contamination. Additionally, a statistical process control p-chart was used to evaluate the change in contamination rates over time.

**RESULTS**

Implementation of a standardized process for sterile insertion of a peripheral IV catheter to draw blood specimens resulted in a significant decrease in the percentage of cultures contaminated from 3.9% in the preintervention period to 1.6% in the postintervention period ($P < .0001$). On the statistical process control p-chart of blood culture contamination (Fig 2), all 9 points in the postintervention period are below the centerline defined by the preintervention period, indicating intervention.
TABLE 2 Bacteria Considered Contaminants in Peripheral Blood Specimens Obtained in the Pediatric ED From July 2009 to June 2010

<table>
<thead>
<tr>
<th>Type of Bacteria</th>
<th>n (% of Cultures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus (coagulase negative)</td>
<td>114 (70.3)</td>
</tr>
<tr>
<td>Streptococcus viridans (α)</td>
<td>31 (19.1)</td>
</tr>
<tr>
<td>Streptococcus γ</td>
<td>4 (2.5)</td>
</tr>
<tr>
<td>Diphtheroids species</td>
<td>3 (1.9)</td>
</tr>
<tr>
<td>Micrococcus species</td>
<td>3 (1.9)</td>
</tr>
<tr>
<td>Corynebacterium urealyticum</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Bacillus species</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Incomplete growth*</td>
<td>3 (1.9)</td>
</tr>
</tbody>
</table>

* Incomplete growth is used for cultures that grew bacteria but were not able to be speciated past Gram-positive or Gram-negative.

Results of the retrospective review of contaminated blood cultures collected July 2009 through June 2010 indicated that all 149 contaminated cultures resulted in ~$417 000 in excess hospital charges as seen in Table 3 (average $2800 per contaminated culture). Considering that the intervention was associated with a 59% relative reduction in the proportion of contaminated cultures, the corresponding annual reduction in hospital charges is ~$250 000.

**DISCUSSION**

Blood culture contamination has been reported to be as high as 9% to 11% in the pediatric emergency population, yet its burden on the health care system is not well characterized. There is a lack of data to describe interventions for improving peripheral blood culture contaminations in the pediatric population. We implemented a sterile technique for insertion of a peripheral IV catheter for blood culture collection that resulted in a decrease in contamination rate from 3.9% to a rate of 1.6%. In addition to improving the blood culture contamination rate, we determined the financial implications of such an intervention. On the basis of a retrospective review of contaminated cultures over a 19-month period, we estimated an average $2800 in excess hospital charges associated with each contaminated culture. Resource use extends beyond hospital charges and the direct burden to the health care system. There are many facets of resource use that cannot be directly measured. For example, in our chart review, we determined that as a result of contamination, there were >50 phone calls made to families and at least 11 visits to either an outside hospital or primary care physician. On 2 occasions, the police department had to be notified to track down a patient needing to be reevaluated after the return of a false-positive blood culture that was subsequently found to be contaminated. Our data captured 25 additional ED visits and 90 additional hospital days secondary to blood culture contamination, which leads to increased exposure to the hospital environment. The effects on patients and families are harder to measure. During the additional hospital days, parents must miss work, and patients are subjected to the risk of medical misadventures. Overall, reducing blood culture contamination rates can reduce health care expenditures while improving care and value for patients and their families.

Lastly, the opportunity cost of contaminated blood cultures is unable to be measured but never the less important. For those hospitals running at high census, extra bed days may cause either diversions of patients to other facilities or capital expenditures for new construction. Additionally, this is a fertile area for Medicaid and private payers to reduce payments similar to the current situation regarding central line–associated bloodstream infections. This data collection and quality improvement intervention was performed at 1 large free-standing children’s hospital, and the results may not be generalizable to all other types of hospitals. Specifically, at our institution, the ED attempts to place an IV in all patients who need a blood culture. Therefore, the difference in procedure pre- and postintervention only differs by the usage of sterile gloves, which are of negligible cost. Because our educational campaign was used to teach a new sterile technique for IV catheter insertion, it is impossible to quantify how much improvement might have taken place if there were merely an educational module stressing the previous nonsterile method of placing an IV catheter. Additionally, charges are based on the billing and accounting implementation was associated with a statistically significant reduction in contamination.

The preintervention average age of patients with peripheral blood cultures collected was 4.57 years (median age 1.9 years, interquartile range: 0.2–7.3) compared with 4.47 years (median 1.7 years, interquartile range: 0.2–7.0) in the postintervention group. By using a Mann-Whitney U test, there was no significant difference in age between the 2 time periods (P = .22). There was a significant difference in peripheral blood culture collection rate of 0.072 draws per ED visit preintervention compared with 0.061 draws per ED visit postintervention (P < .0001).

TABLE 3 Total Charges: July 2009 Through June 2010 (149 Contaminated Cultures)

<table>
<thead>
<tr>
<th>Charges (No. Occurrences)</th>
<th>Total Charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional days of hospital admission (90)</td>
<td>$267 840</td>
</tr>
<tr>
<td>Return ED admission (25)</td>
<td>$27 275</td>
</tr>
<tr>
<td>IV antibiotic charges (516)</td>
<td>$72 102</td>
</tr>
<tr>
<td>Laboratory charges (51)</td>
<td>$5802</td>
</tr>
<tr>
<td>Blood culture charges (115)</td>
<td>$17 480</td>
</tr>
<tr>
<td>Radiology charges (9)</td>
<td>$2079</td>
</tr>
<tr>
<td>Total procedure charges (14)</td>
<td>$23 665</td>
</tr>
<tr>
<td>Lumbar puncture (7)</td>
<td>$7623</td>
</tr>
<tr>
<td>PICC line placement (5)</td>
<td>$11 430</td>
</tr>
<tr>
<td>Echocardiogram (2)</td>
<td>$4612</td>
</tr>
<tr>
<td>Total charges</td>
<td>$416 243</td>
</tr>
</tbody>
</table>

In addition, there were 53 calls made to families, 2 needle sticks, 1 IV infiltrate, and, on 2 occasions, police sent to home of the patient. PICC, peripherally inserted central catheter.
system used at our institution and may vary between medical centers. Using charges as a surrogate for cost is well accepted; however, the true dollar cost to the hospital and health care system is difficult to determine.

Lastly, it is interesting to note that there was a statistically significant difference in the number of blood cultures drawn per ED visit pre- and post-intervention. It is unclear if there is a clinical significance related to this difference. Although the educational units were directed to nursing, it is possible that physicians became somewhat aware of the attention being paid and altered their ordering patterns. However, our improvement project was not set up to monitor ordering patterns and intentions, so we can therefore only hypothesize about the cause.

CONCLUSIONS

Blood culture collection via a standardized IV catheterization process performed by using sterile technique was effective in reducing peripheral blood culture contamination rates and unnecessary utilization of resources.

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patients: young children and young doctors. 
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