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# Impact of Blood Cultures Drawn by Phlebotomy on Contamination Rates and Health Care Costs in a Hospital Emergency Department▽

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**We conducted a prospective comparison of blood culture contamination rates associated with dedicated phlebotomists and nonphlebotomy staff in the emergency department (ED) at Parkland Memorial Hospital in Dallas, TX. In addition, hospital charges and lengths of stay were determined for patients with negative, false-positive, and true-positive blood culture results. A total of 5,432 blood culture collections from two ED areas, the western wing of the ED (ED west) and the nonwestern wing of the ED (ED nonwest), were evaluated over a 13-month period. Phlebotomists drew 2,012 (55%) of the blood cultures in ED west while nonphlebotomy staff drew 1,650 (45%) in ED west and 1,770 (100%) in ED nonwest. The contamination rates of blood cultures collected by phlebotomists were significantly lower than those collected by nonphlebotomists in ED west (62/2,012 [3.1%] versus 122/1,650 [7.4%]; $P < 0.001$). Similar results were observed when rates between phlebotomists in ED west and nonphlebotomy staff in ED nonwest were compared (62/2,012 [3.1%] versus 100/1,770 [5.6%]; $P < 0.001$). Comparison of median patient charges between negative and false-positive episodes ($18,752 versus $27,472) showed $8,720 in additional charges per contamination event while the median length of stay increased marginally from 4 to 5 days. By utilizing phlebotomists to collect blood cultures in the ED, contamination rates were lowered to recommended levels, with projected reductions in patient charges of approximately $4.1 million per year.**

Blood cultures are the most direct method for detecting bacteremia in patients (12). However, interpretation of blood culture results may be complicated by recovery of bacteria that are potential contaminants. False-positive cultures comprise up to half of all positive blood cultures in adult patients (1, 18).

Contaminated cultures significantly impact patients, hospital staff, and health care costs. Patients may experience unnecessary hospitalizations or extended lengths of stay (LOS) with consequent financial burdens (3, 4). False-positive cultures may lead to errors in clinical interpretation (13), administration of unnecessary antimicrobial therapy (9), and the need for additional cultures and other diagnostic tests (10). The workload of technologists and other staff (2, 14) as well as overall health care costs (2, 16) may increase.

Strategies to decrease blood culture contamination rates have included the use of specific disinfection materials (13, 20), educational interventions (7, 9, 20), collection from separate venipuncture sites (4, 10, 11), the use of the outmoded double-needle technique (4), and reliance on specially trained staff or dedicated phlebotomists (4, 16, 20). A previous study in the Parkland emergency department (ED) replaced povidone-iodine with ChloraPrep antiseptic but did not reduce contamination rates (data not shown). Areas of the hospital such as the ED present special challenges during attempts to reduce blood culture contamination. In the ED, many unique factors impact contamination rates: rapid staff turnover, limited staff to handle high patient census, the nature of presenting patients, and multiple emergencies which may rush the collection of blood samples (1, 9).

A prospective study was conducted at Parkland Memorial Hospital, a large county teaching hospital, to determine whether the addition of phlebotomists in the ED would significantly lower blood culture contamination rates. Contamination rates were compared between phlebotomists and nonphlebotomists in the ED every 3 months for a 13-month period. In addition, the financial impact of false-positive blood cultures was analyzed by comparing incremental charge differences and LOS between patients with false-positive, negative, and true-positive blood cultures.

## MATERIALS AND METHODS

**Patients and blood culture method.** Parkland Memorial Hospital is a 968-bed tertiary-care teaching hospital serving primarily the medically indigent of Dallas County. Blood culture data were reviewed for 2,642 patients seen in the ED during each third month for a 13-month period from 1 December 2006 through 31 December 2007.

Blood culture data were stratified into two groups, those from the western wing of the ED (ED west) and those from the nonwestern wing of the ED (ED nonwest). The patients seen in ED west included individuals with chest pain, asthma, human immunodeficiency virus infection, and diabetes and those evaluated for strokes or infections. ED nonwest patients included those with burns or other traumatic injuries, abdominal pain, diabetes-associated wound infections, psychiatric disorders, and orthopedic complications.

In ED west, full-time phlebotomists covering three shifts collected 2,012 (55%) of the blood cultures. The remaining 1,650 (45%) blood cultures were collected by nursing staff, residents, emergency medical technicians/students, and nursing and medical students.

In ED nonwest, nonphlebotomy staff similar in composition to that from ED west drew blood for 1,770 blood cultures. No phlebotomists were employed in the ED nonwest units.

The routine blood culture set included a BacT/Alert SN anaerobic bottle

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TABLE 1. Comparison of contaminated blood cultures collected by phlebotomists to those collected by other staff[a]

| Location | Total no. of blood cultures | No. (%) of positive blood cultures | No. (%) of contaminated blood cultures | | |
|---|---|---|---|---|---|
| | | | Collected by phlebotomists | Collected by nonphlebotomists | Total |
| ED west | 3,662 | 503 (13.7) | 62 (3.1) | 122 (7.4) | 184 (5.0) |
| ED nonwest | 1,770 | 229 (12.9) | NA[b] | 100 (5.6) | 100 (5.6) |

[a] Phlebotomists in ED west collected 2,012 blood cultures. Nonphlebotomists, which include nursing staff, residents, emergency medical technicians/students, nursing students, and medical students, collected 1,650 blood cultures in ED west. None of the 1,770 blood cultures in ED nonwest were collected by phlebotomists.
[b] NA, not applicable.

(bioMérieux, Inc., Durham, NC) and a BacT/Alert FA aerobic bottle (bioMérieux, Inc., Durham, NC). Bottles were transported to the laboratory and incubated until flagged as positive or for 5 days in BacT/Alert continuous-monitoring instruments. Broth from positive bottles was Gram stained and subcultured using standard techniques (17).

**Skin disinfection.** The venipuncture site was disinfected first with 70% isopropyl alcohol, with cleansing in concentric circles beginning at the center of the site. Then, the skin was disinfected with 10% povidone-iodine, again in concentric circles, and allowed to air dry for 1 min before venesection. The tops of the blood culture bottles were cleaned with 70% isopropyl alcohol.

**Definition of contamination.** A bacterial blood culture is defined as a set of bottles into which a single blood specimen is inoculated, regardless of the number of bottles. A blood culture was considered to be contaminated if one or more of the following organisms were identified in only one of a series of blood cultures: coagulase-negative *Staphylococcus* species (CoNS), *Corynebacterium* species, alpha- or gamma-hemolytic streptococci, *Micrococcus* species, *Bacillus* species, and *Propionibacterium* species (4). This includes blood cultures with a potential pathogen in addition to a contaminant. Polymicrobic cultures with more than one contaminant species were counted as a single contaminated blood culture (14).

**Estimation of hospital charges and LOS.** Inpatient charges from 61 cost centers, including laboratory, pharmacy, and radiology, were collected for 1,233 patient encounters from December 2005 through April 2006. The dates of service for each patient encounter, defined by a medical record number and encounter number, were linked to a blood culture that was defined by a medical record number and accession date. The patient charges generated from the day following collection of the blood culture through the last day of the associated encounter were tallied. In addition, the LOS was recorded for each patient encounter.

**Statistical analysis.** Blood culture groups were compared using chi-square contingency table analysis. Statistical significance for all tests was set at a $P$ value of $\leq 0.05$. Medians were determined, and 95% confidence intervals (CI) were calculated for encounter charges and LOS associated with patients with negative, false-positive, or true-positive blood cultures. Means for patient ages within the three groups were determined.

## RESULTS

A total of 5,432 blood cultures collected from 2,642 adult patients in two ED areas, ED west and ED nonwest, were evaluated. Data from 5 months over a 13-month period were used to calculate blood culture contamination rates.

Blood cultures from patients in ED west were divided into two groups, those drawn by phlebotomists and those collected by other staff members. For the 2,012 blood cultures collected by phlebotomists, contamination rates ranged from 2.4 to 3.6%, with an overall rate of 3.1%, as shown in Table 1. Nonphlebotomy staff collected 1,650, and contamination rates ranged from 6.2 to 10.2%, with an overall rate of 7.4%. Blood cultures collected by staff members were significantly more likely to be contaminated than those collected by phlebotomists ($\chi^2 = 34.41$, df = 1, $P < 0.001$). Approximately one-third of the positive blood cultures were classified as contaminated in ED west.

Blood culture contamination rates from ED nonwest, an area without phlebotomists, were also compared to the rates for phlebotomy-served patients in ED west. A total of 1,770 blood cultures were collected, with an overall contamination rate of 5.6% (range of 4.9 to 7.0%). Staff-collected blood cultures in ED nonwest were significantly more likely to be contaminated than those collected by phlebotomists in ED west ($\chi^2 = 15.18$, df = 1, $P < 0.001$). In ED nonwest, more than 40% of all positive blood cultures were contaminated as defined by laboratory criteria.

In both ED west and ED nonwest, most patients, 2,569 (97.2%), had two or more blood culture sets drawn to determine whether bacteria were present in their bloodstream. However, a minority of patients, 73 (2.8%), had a single blood culture collected. In ED west, where both phlebotomists and staff collected blood cultures, more than two-thirds of the single blood culture sets were collected by nonphlebotomists.

Table 2 shows the 10 most common bacteria recovered from blood cultures of Parkland's ED patients. Organisms established as frequent blood culture contaminants, CoNS, *Corynebacterium* species, *Propionibacterium* species, and alpha-hemolytic streptococci, accounted for more than 40% of the isolates, with CoNS predominating. *Staphylococcus aureus*, both methicillin-resistant and methicillin-susceptible strains, and *Escherichia coli* represented the most frequent potential pathogens cultured.

More than one bacterial species was demonstrated in 48 of 5,432 blood cultures (<1.0%). At least one bacterial contaminant was recovered from the majority (64.6%) of the mixed cultures.

The total inpatient charges generated from 1 day after blood culture collection until discharge were compared for patients

TABLE 2. Ten most common microorganisms recovered from blood cultures in a teaching hospital ED[a]

| Organism | No. (%) of isolates[b] |
|---|---|
| CoNS | 287 (35.8) |
| *Escherichia coli* | 100 (12.5) |
| MRSA[c] | 68 (8.5) |
| MSSA[d] | 54 (6.7) |
| *Streptococcus pneumoniae* | 32 (4.0) |
| *Enterococcus* species | 25 (3.1) |
| *Corynebacterium* species | 23 (2.9) |
| *Enterobacter cloacae* | 19 (2.4) |
| *Propionibacterium* species | 16 (2.0) |
| Alpha-hemolytic streptococci | 16 (2.0) |

[a] Total of 5,432 blood cultures with 801 bacterial isolates.
[b] Includes ED west and ED nonwest blood culture isolates.
[c] Methicillin-resistant *Staphylococcus aureus*.
[d] Methicillin-sensitive *Staphylococcus aureus*.

TABLE 3. Patient charges associated with blood culture results[a]

| Blood culture designation | No. of patient episodes | Median charge (25th quartile, 75th quartile) |
|---|---|---|
| Negative | 960 | $18,752 ($17,046, $20,315) |
| False positive | 120 | $27,472 ($21,063, $37,841) |
| True positive | 153 | $51,055 ($39,957, $69,459) |

[a] All inpatient charges were tallied; 61 cost centers were surveyed, including laboratory, pharmacy, and radiology departments.

with negative, false-positive, and true-positive blood culture results (Table 3). Patient demographics were determined for the three groups and found to be similar. The mean ages (± standard deviations) of patients with negative, false-positive, and true-positive blood cultures were 47.9 ± 15.6, 51.8 ± 16.3, and 49.7 ± 12.6, respectively. The patients in each of the above groups were predominately male, 54.7%, 62.8%, and 61.0%, respectively. The major populations in the study were black (43 to 48%), white non-Hispanic (28.9 to 33.7%), and white Hispanic (20.9 to 22.8%). The difference in median patient charges between negative and false-positive episodes ($18,752 versus $27,472) resulted in $8,720 in additional charges from each contamination event. There was no charge overlap within the 95% CI between patients with negative results and those with false-positive blood cultures. Compared to patients with negative cultures, those with culture-documented bacteremia had an additional median charge of $32,303.

LOS were also compared among patients with negative, false-positive, and true-positive blood culture results. The median LOS increased marginally for patients with false-positive blood cultures (5 days; 95% CI, 4 to 7 days) compared to that for patients with negative cultures (4 days; 95% CI, 4 to 5 days). Patients with significant blood culture isolates had an 8-day median LOS (95% CI, 6 to 10 days).

## DISCUSSION

Our pathology department had the unique opportunity to perform a simultaneous comparison of blood culture contamination rates between phlebotomists and nonphlebotomists in the same area of a large ED. Previously, only ED staff collected blood cultures. As part of a pilot study, the hospital administration agreed to hire phlebotomists to supplement the blood-drawing capacity of the ED west staff. Most other studies of adult patients have compared contamination rates for phlebotomists and nonphlebotomists between institutions (1, 4, 14) or compared retrospective data before and after phlebotomy teams were eliminated from or reinstituted in hospital units (16, 20).

Previous studies have demonstrated that blood culture contamination rates are usually higher at teaching hospitals, sometimes exceeding 7% (1, 2, 14). Standards published by the American Society for Microbiology state that acceptable contamination rates should be no higher than 2 to 3% (6). By using phlebotomists in our study, this goal was almost attained in ED west, with an overall contamination rate of 3.1%. However, nonphlebotomy staff in ED west had a higher overall rate (7.4%) that was more than twice the recommended limit. Blood cultures collected in the ED at Duke University Medical Center, a 900-bed tertiary-care teaching hospital, had a similar overall blood culture contamination rate (7.8%) (1).

The addition of dedicated phlebotomists to ED west resulted in a statistically significant reduction in the blood culture contamination rate compared to staff rates in both areas of the ED, west and nonwest. Two large interinstitutional comparisons of blood culture data conducted by the College of American Pathologists showed similar findings, with significantly lower contamination rates in facilities using a dedicated phlebotomy service (4, 14). Interestingly, when a community teaching hospital in Cleveland, OH, eliminated their phlebotomy team, blood culture contamination rates approximately doubled, from 2.6% to 5.6% (16).

Phlebotomists may also impact the number of blood culture sets collected per patient. In our study, a small proportion of patients (2.8%) had only a single blood culture collected in the ED. Of the 47 single sets collected, the majority were drawn by nonphlebotomy staff. One possible explanation is that nonphlebotomy staff in the ED were distracted by multiple emergencies (1) that took them away from patients before blood culture draws were completed while phlebotomists were focused only on blood collection. Another possibility is that staff members received less-intensive training in the collection of blood cultures than the phlebotomists. House staff education concerning the proper performance of blood culture collection has had various outcomes (7, 9, 20). One successful program at a tertiary-care hospital provided individual training to physicians and remedial sessions when needed (7).

The 2007 CLSI blood culture guidelines recommended two to three blood culture sets per septic episode for optimal detection of bacteremia (22). Generally, more than 96% of bacteremias are detected with two or three blood culture sets (5). In a study by Cockerill and colleagues, a group of patients with documented bloodstream infections had only 65% of their episodes detected with the first blood culture (5). The only exception was patients with endocarditis whose first blood culture was positive in approximately 90% of the episodes (5). Utilizing phlebotomists in the ED might ensure that multiple sets are collected from each patient.

In addition, the collection of multiple blood cultures would aid physicians in the clinical interpretation of possible false-positive culture results. In a study by MacGregor and Beaty, only 11% of patients whose blood cultures were categorized as contaminated had multiple positive sets in contrast to 69% of patients with clinical bacteremia (8). Also, in the minority of patients with additional positive cultures, the organisms recovered were often different from those in the initial blood culture (8).

The most common blood culture contaminant is CoNS (4, 8, 18). However, CoNS also cause bloodstream infections in immunocompromised populations and in those with indwelling foreign devices (15, 19), so differentiation between contamination and true bacteremia may be difficult. CoNS was the most frequent microorganism recovered in our study, similar to results from an ED study at Duke University Medical Center and at other institutions (1, 7, 9, 10, 11, 18). Approximately 20% of our CoNS were not designated as contaminants because the bacteria were isolated from patients with more than one positive blood culture. However, less than 1 percent of our ED patients had indwelling vascular catheters, so the significance

of these findings is unknown. In Weinstein and colleagues' evaluation of bacteremia in adults, the clinical significance of two blood cultures yielding *Staphylococcus epidermidis* with the same biotype was frequently uncertain (21). Using laboratory-based criteria to determine contamination rates is adequate for monitoring quality performance (14) but may underestimate the number of false-positive blood cultures, especially those containing CoNS.

In our study, false-positive blood cultures increased patient charges by 47% compared to charges for patients without laboratory evidence of bacteremia. The median additional hospital charge was calculated to be $8,720 per patient encounter. In 1989, Bates and colleagues collected similar charge data from adult inpatients at Brigham and Women's Hospital in Boston, MA, estimating a charge differential of $4,385 between patients with false-positive blood cultures and those with negative cultures (2). Although the total charges have doubled since that time, the percent increase in patient charges (47%) associated with contaminated blood cultures is similar to that determined in the study by Bates et al. (50%) (2). A 1998 investigation at St. Luke's Hospital in Cleveland, OH, found an even larger charge differential (150%) between patients with contaminated cultures and those with negative cultures, $16,177 and $6,482, respectively (16). This was a small study of 46 patients, with a focus on CoNS-contaminated cultures only. Also, the parameters for collecting charge information were not delineated in the paper (16).

At Parkland, the median LOS for patients with false-positive blood cultures was 1 day longer than that for patients with negative blood culture results. Bates and colleagues also found a trend toward increased LOS (2). However, only Surdulescu et al.'s study of 46 patients demonstrated a statistically significant extension in the LOS (16). With the current emphasis on cost containment, patients with documented bacteremia in 2006 to 2007 were hospitalized for shorter periods than patients with contaminated blood cultures in the 1990s (2). Interestingly, Parkland patients with positive blood cultures had a median LOS of 8 days, similar to that for patients with negative blood cultures in Bates et al.'s study in 1989 (2).

In an era of rising health care costs, the financial impact of false-positive blood cultures is significant. In 2007, approximately 13,800 blood cultures were collected in the Parkland ED. If nonphlebotomy staff, with contamination rates between 5.6% and 7.4%, drew all of the blood cultures, then additional charges for evaluation of patients with false-positive blood cultures would range from $6.7 million to $8.9 million annually. However, if full-time coverage with phlebotomists was implemented, then the potential reduction in the overall ED contamination rate from 6.5% to 3.1% might save approximately $4.1 million in excess charges per year. The quality improvement realized by hiring dedicated phlebotomists in the ED could counterbalance the cost of such a program. By using the study's estimated additional charge of $8,720 for each patient episode associated with a false-positive blood culture, the prevention of five contaminated blood cultures might fund the yearly salary ($35,650) for one mid-level phlebotomist. After reviewing the study data, administrators at Parkland Memorial Hospital agreed to staff the ED with phlebotomists on all three shifts.

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