Contamination Rates of Blood Cultures Obtained by Dedicated Phlebotomy vs Intravenous Catheter

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FEVER IS THE PRIMARY COMPLAINT in up to 20% of children presenting to emergency departments,¹ and bacteremia is the source of fever in 1.5% to 2.3% of these patients.²,³ Blood culture is the criterion standard for identifying children with bacteremia⁴-⁷; however, false-positive blood cultures are common and may add significantly to health care costs.⁸-¹¹ High rates of contamination are common among pediatric patients, likely related to difficulties inherent to phlebotomy in young patients.¹² To minimize the number of venipunctures in children, blood culture specimens are obtained simultaneously with intravenous catheter placement in many emergency departments. The impact of using intravenous catheters to obtain blood cultures is unclear.¹³⁻¹⁶ We hypothesized that the blood culture contamination rate would be less when blood culture specimens were obtained from a remote site rather than through a newly inserted intravenous catheter.

METHODS

A preintervention and postintervention observational study of patients who had a blood culture obtained as part of their routine emergency department course was conducted. Patients 18 years old or younger who presented to the emergency department at a free-standing tertiary care children’s hospital that evaluates more than 65,000 children annually and required a blood culture as part of their routine care were eligible. Medical records were reviewed in all cases with a positive blood culture. Patients with indwelling vascular catheters were excluded.

Context Blood culture is the criterion standard for identifying children with bacteremia. However, elevated false-positive rates are common and are associated with substantial health care costs.

Objective To compare contamination rates in blood culture specimens obtained from separate sites vs through newly inserted intravenous catheters.

Design, Setting, and Participants Observational study conducted January 1998 through December 1999 among patients aged 18 years or younger who were seen at a US children’s hospital emergency department and had a blood culture obtained as part of their care. Medical records were reviewed in all cases with a positive blood culture. Patients with indwelling vascular catheters were excluded.

Intervention All phlebotomy was performed by emergency department registered nurses. During the baseline phase, blood specimens for culture were obtained simultaneously with intravenous catheter insertion. During the postintervention phase, specimens were obtained by a separate, dedicated procedure.

Main Outcome Measure Contamination rate in the postintervention period compared with the baseline period.

Results A total of 4108 blood cultures were evaluated, including 2108 during the baseline phase and 2000 in the postintervention phase. The false-positive blood culture rate decreased from 9.1% to 2.8% (P < .001). A statistical process control chart demonstrated a steady-state process in the baseline phase and the establishment of a significantly improved steady state in the postintervention phase. Young age was associated with increased contamination rate in both the baseline and postintervention periods.

Conclusion Blood culture contamination rates were lower when specimens were drawn from a separate site compared with when they were drawn through a newly inserted intravenous catheter.

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for specimen collection and inoculation were standardized and remained unchanged during the study. Nursing staff members were unaware of ongoing data collection and analysis. In cases where a positive blood culture was reported, the patient’s medical record was reviewed. Patients with indwelling devices (central venous lines, ventricular catheters) were excluded.

**Baseline Phase**

During the baseline phase (January 1, 1998- November 19, 1998), culture specimens were obtained through a newly inserted peripheral intravenous catheter using the standard over-the-needle approach. A sterile 5-mL syringe was attached to the catheter hub, and blood for both culture and for laboratory studies was withdrawn; the first portion of the sample was used for culture.

During the first 4 months of the baseline phase, focused efforts to decrease the contamination rate were implemented. Because these interventions failed to reduce the contamination rate, the standard technique was abandoned in favor of obtaining specimens from a separate phlebotomy site. Data from a 6-week implementation phase (November 20, 1998-December 31, 1998) were not included in the analysis.

**Postintervention Phase**

During the postintervention phase (January 1, 1999-December 31, 1999), culture specimens were obtained by venipuncture at a dedicated site. If a patient required an intravenous catheter, it was placed using the standard approach at a site distant from the blood culture venipuncture site. While laboratory specimens were sometimes obtained through the newly inserted intravenous catheter, all specimens for culture were obtained by phlebotomy dedicated to that procedure.

**Classification of Blood Culture Isolates**

Blood culture isolates were categorized as contaminants or pathogens. In all cases, *Neisseria meningitidis*, *Streptococcus pneumoniae*, *Salmonella* species, *Hae-

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**Table 1. Patient Demographics**

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n = 2108)</th>
<th>Postintervention (n = 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (IQR), y</td>
<td>1.4 (0.47-3.8)</td>
<td>1.4 (0.42-3.4)</td>
</tr>
<tr>
<td>Emergency department disposition, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admit</td>
<td>1099 (52.0)</td>
<td>1042 (52.0)</td>
</tr>
<tr>
<td>Discharge</td>
<td>1009 (48.0)</td>
<td>958 (48.0)</td>
</tr>
<tr>
<td>Age category, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;12 wk</td>
<td>385 (18.3)</td>
<td>353 (17.7)</td>
</tr>
<tr>
<td>3 mo-≤2 y</td>
<td>887 (42.1)</td>
<td>891 (44.6)</td>
</tr>
<tr>
<td>&gt;2 - ≤5 y</td>
<td>391 (18.5)</td>
<td>381 (19.1)</td>
</tr>
<tr>
<td>&gt;5 y</td>
<td>445 (21.1)</td>
<td>375 (18.8)</td>
</tr>
</tbody>
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Abbreviation: IQR, interquartile range.

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RESULTS

During the study, 4448 blood culture specimens were obtained. We excluded 289 specimens obtained during the 6-week implementation phase, 14 with incomplete data in the medical record and 37 because of the presence of central venous catheters, leaving 4108 emergency department visits for analysis (2108 in the baseline phase and 2000 in the postintervention phase). Overall, there were 324 positive blood culture specimens.

Patient demographics are presented in Table 1. There were no statistically or clinically important differences between patients in the baseline and in the postintervention phases.

During the baseline phase, 223 positive blood culture specimens were reported; of these, 32 specimens grew a pathogen. In the 191 blood culture specimens categorized as contaminated, 243 organisms were cultured (Table 2). The overall false-positive rate was 9.1% and the true-positive rate was 1.5%. In the postintervention period, there were 101 positive blood cultures; of these, 45 grew a pathogen. In the 56 contaminated specimens, 65 organisms were cultured (Table 2). The overall false-positive rate during the
Table 2. Blood Culture Contaminants in the Baseline and Postintervention Periods of Study

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>No. of Organisms ( % of Total Contaminated Specimens)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>Baseline 140 (73) Postintervention 37 (67)</td>
</tr>
<tr>
<td>Streptococcus viridans</td>
<td>Baseline 57 (30) Postintervention 8 (14)</td>
</tr>
<tr>
<td>Corynebacterium species</td>
<td>Baseline 13 (7) Postintervention 7 (12)</td>
</tr>
<tr>
<td>Micrococcus species</td>
<td>Baseline 13 (7) Postintervention 5 (8)</td>
</tr>
<tr>
<td>Bacillus species</td>
<td>Baseline 3 (1.6) Postintervention 3 (5)</td>
</tr>
<tr>
<td>Propionibacterium acnes</td>
<td>Baseline 4 (2) Postintervention 0</td>
</tr>
<tr>
<td>Neisseria species</td>
<td>Baseline 3 (1.6) Postintervention 0</td>
</tr>
<tr>
<td>Others</td>
<td>Baseline 10 (5) Postintervention 5 (8)</td>
</tr>
<tr>
<td><strong>Total No. of Organisms</strong></td>
<td><strong>243</strong> Postintervention 65</td>
</tr>
</tbody>
</table>

*There were 191 contaminated specimens growing 243 organisms in the baseline phase and 56 contaminated specimens growing 65 organisms in the postintervention phase of the study.

The statistical quality control methodology we applied provides a simple graphical display of process data that enhances our ability to understand outcomes that occur over time.17 This methodology has been used increasingly in the evaluation of processes occurring in the health care setting.18,19 The premise is that when a process achieves steady state, it is likely to remain there until events cause it to shift to a new steady state.18,19

This study addresses a common problem that has been linked to substantial and unnecessary resource utilization.8,10,12-24 The contamination rate in our emergency department was resistant to change in spite of several specific interventions intended to address the problem. The sole procedural change was in the method by which blood culture specimens were obtained. During the baseline phase, the overall false-positive blood culture rate was 9.1% compared with a rate of 2.8% after the intervention, representing a decrease of 70%. While not statistically significant, the true-positive rate increased from 1.5% at baseline to 2.3% after the intervention. We believe that at least some of this increase is due to more selective ordering of blood cultures during the postintervention phase, when all cultures were obtained in response to other diagnostic tests obtained during the patient’s emergency department evaluation. Since it is easier to obtain blood for culture from an intravenous catheter, cultures may have been obtained more indiscriminately in the baseline phase.

Previous studies comparing contamination rates in specimens obtained through newly inserted intravenous catheters or by phlebotomy at a remote...
site suggest that the 2 techniques are essentially equivalent. Smart and Baggo-
ley\textsuperscript{22} failed to show a difference in the contamination rate in 940 adult pa-
tients randomized to phlebotomy by ei-
ther venipuncture or by placement of an intravenous catheter. Isaacman and Karasic\textsuperscript{23} prospectively evaluated a con-
venience sample of 99 pediatric pa-
tients, each of whom had 2 blood cul-
tures obtained, one by venipuncture and one through a newly inserted intrave-
nous catheter. The authors demon-
strated a low contamination rate with both techniques, concluding that newly inserted intravenous catheters offer an alter-
native to a separate venipuncture
procedure in patients requiring blood
culture. The small number of patients enrolled and the impact of the nursing
staff’s awareness of the study protocol
may have biased the results.

On the other hand, a study by Ram-
sook et al\textsuperscript{24} suggested that blood cul-
ture contamination rates were decreased when using dedicated phlebotomy com-
pared with those obtained through a
newly inserted intravenous catheter. Importantly, this study demonstrated the highest contamination rates in patients younger than 3 months of age, regardless of the collection method used, a finding confirmed in our study. Because staff
members were aware of ongoing data
collection, the potential effect on their
phlebotomy technique is unknown.

However, our study also has limita-
tions; because medical records were reviewed only for those patients with
positive blood cultures, detailed infor-
mation about patients with negative
blood cultures is not known. In par-
ticular, information about antibiotic pre-
treatment is unknown. While it is likely
that some patients were prescribed systemic antibiotic therapy prior to or
during their emergency department
evaluation, the rates of antibiotic pre-
treatment in the baseline and postint-
ervention phases of the study are likely
to be similar and unlikely to affect the
study’s conclusions. In addition, this
protocol was implemented in a single
unit and may not be generalizable to
other settings. Finally, no concurrent
control group was included to account
for secular temporal changes.

Obtaining blood cultures from a sepa-
rate site requires the patient to un-
dergo an additional procedure for phle-
botomy, but the overall benefit in terms
of costs associated with a high contami-
nation rate is likely to be substantial.
During the baseline period, there were 6 contaminated specimens for every true-positive blood culture, compared with a ratio of 1.2:1 after implementa-
tion of the intervention. If subsequent
patient management is based on pre-
liminary blood culture results, false-
positive test results will result in repeat
emergency department visits, unneces-
sary medical interventions, unness-
ecessary antibiotic therapy, and even hos-
pital admission. One study\textsuperscript{9} found that 26% of children followed as outpa-
tients who had false-positive blood cul-
tures were hospitalized unnecessarily, and that unnecessary use of antibiotics
was significantly increased in the pres-
ence of false-positive blood culture re-
sults. Additional costs that are more dif-
ficult to quantify include staff effort and
time required to arrange follow-up
for patients, exposure of patients to unnec-
essary procedures, and cost and incon-
vienience related to repeat emergency
department and/or hospital visits.\textsuperscript{10,11}

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Acquisition of data: Norberg, Christopher, Ramundo, Berman.
Analysis and interpretation of data: Norberg, Christopher, Bower.
Drafting of the manuscript: Norberg, Christopher, Bower.
Critical revision of the manuscript for important in-
tellectual content: Norberg, Christopher, Ramundo, Bower, Berman.
Statistical expertise: Christopher.
Administrative, technical, or material support: Norberg, Berman.
Study supervision: Christopher, Ramundo, Bower.

REFERENCES

1. Nelson DS, Walsh K, Fleisher GR. Spectrum and fre-
quency of pediatric illness presenting to a general com-
2. Alpern ER, Alessandri EA, Bell LM, et al. Occult bac-
teriaemia from a pediatric emergency department: current prevalence, time to detection, and outcome. Pediatr.
2000;106:505-511.
3. Lee GM, Harper MB. Risk of bacteremia for fe-
brile young children in the post-Haemophilus influ-
152:624-628.
line for the management of infants and children 0 to
36 months of age with fever without source. Ann Emerg
5. Kupperman N. Occult bacteremia in young fe-
1109.
6. Downs SM, McNutt RA, Margolis PA. Manage-
ment of infants at risk for occult bacteremia: a deci-
7. Yamauchi LG, Worthley RG, Mellish ME, et al. A revised decision analysis of strategies in the manage-
ment of febrile children at risk for occult bacteremia.
the first time: quality improvement and the contami-
nant blood culture. J Clin Microbiol. 1997;35:563-
565.
9. Thuler LCS, Jenicek M. Impact of a false positive
blood culture result on the management of febrile chil-
10. Bates DW, Goldman L. Contaminant blood cul-
ture and resource utilization: the true consequences
11. Lieu TA, Schwartz JS. Strategies for diagnosis and
treatment of children at risk for occult bacteremia: clin-
118:21-29.
12. Campos JM. Detection of blood stream infec-
8:815-824.
13. Tonnesen A, Peuler M, Lockwood WR. Cultures of
blood drawn by catheter vs venipuncture. JAMA. 1976;
235:1877-1879.
14. Isaacman DJ, Karasic RB. Utility of collecting blood
cultures through newly inserted intravenous cath-
15. Ramsook C, Childers K, Cron SG, Nirkem M. Com-
parison of blood culture contamination rates in a pe-
diatric emergency room: newly inserted intravenous
catheters versus venipuncture. Infect Control Hosp Epi-
16. Schwab RA, DeSorbo SM, Cunningham MR, Cra-
ven K, Watson WA. Using statistical process control to
demonstrate the effect of operational interven-
tions on quality indicators in the emergency depart-
17. Benneyan JC. Statistical quality control methods
in infection control and hospital epidemiology, part I:
introduction and basic theory. Infect Control Epi-
18. Benneyan JC. Statistical quality control methods
in infection control and hospital epidemiology, part II:
chart use, statistical properties, and research is-
sues. Infect Control Hosp Epidemiol. 1998;19:265-
283.
19. Humbles C. Caveats regarding the use of control
charts. Infect Control Hosp Epidemiol. 1998;19:865-
868.
20. Mylotte JM, White D, McDermott C, Hodan C. Nosoc-
omial bloodstream infection at a veterans hos-
10:455-464.
21. Koska MT. Using CQI methods to lower postsur-
gical wound infection rates. Hospitals. 1992;66:62-
64.
22. Smart D, Baggeley C. Effect of needle changing
and intravenous cannula collection on blood culture
1168.
23. Kornberg A. Evaluation of false positive blood cul-
ture: guidelines for early detection of contaminated
10:20-23.
24. Segal GS, Chamberlain JM. Resource utilization
and contaminated blood cultures in children at risk for
154:469-473.