Intravenous Catheter Blood Cultures: Utility and Contamination

Kemedy K. McQuillen, MD*; Karen A. Santucci, MD‡; Margaret A. Conrad, RN§; David G. Nelson, MD‡; William Lewander, MD‡; Susan J. Duffy, MD‡; and Angela C. Anderson, MD‡

ABSTRACT. Objective. In pediatrics, blood cultures (BCs) are often drawn as intravenous (IV) catheters are placed. This routine minimizes the number of painful and often difficult punctures a child must undergo but results in the discarding of multiple BC bottles when these cultures are later determined to be unnecessary. If the contamination rate of BCs drawn through an indwelling IV did not exceed the contamination rate of BCs drawn at the time of IV placement, BCs could be drawn from the IV without subjecting the patient to another venipuncture. This study was done to compare the contamination rates of BCs drawn by these two methods. Additionally, we sought to determine if the collection of two BCs enhances pathogen recovery.

Methods. Prospective comparison of contamination and bacteremia rates of BCs drawn by two different methods: the first BC was drawn at the time of IV line placement and the second BC was drawn from the previously placed IV at a later time.

Setting. Urban pediatric emergency department with an annual census of 40 000.

Participants. One thousand five hundred sixty-four patients between the ages of 3 days and 22.1 years. The median age was 2.2 years. Sixty-four patients were excluded because we were unable to draw the second BC. Forty-six percent of eligible patients (n = 690) were girls.

Results. Fifty-seven (1.9%) of 3000 grew contaminants: 27 in the first and 30 in the second BC for contamination rates of 1.8% and 2.0%. Thirty-eight (1.3%) of 3000 BCs grew pathogens: 24 represent 12 patients with growth in two out of two cultures and 14 represent 14 patients with growth in one out of two cultures. Pathogen rates were 1.1% (16/1500) with one BC per patient and 1.7% (22/1500) with two BCs per patient.

Conclusions. There is no difference in the contamination rates of two BCs drawn from the same site at two different times. The collection of two BCs per patient may enhance pathogen recovery. Pediatrics 1999;103(4). URL: http://www.pediatrics.org/cgi/content/full/103/4/e52; blood culture, bacteremia, contamination.

ABBREVIATIONS. BC, blood culture; IV, intravenous; ED, emergency department; SD, standard deviation.

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Address for reprint requests to K.K.M. Department of Emergency Medicine, Maine Medical Center, 22 Bramhall St, Portland, ME 04102-3175. PEDIATRICS (ISSN 0031-4005). Copyright © 1999 by the American Academy of Pediatrics.

The evaluation of a febrile child without a source frequently involves obtaining a blood culture (BC). Until recently, obtaining a sample for BC involved a separate venipuncture if an intravenous (IV) line was also required. In 1990, Isaacman and Karasci1 compared the contamination rates of two BCs simultaneously drawn from the same patient: one culture was drawn through a freshly inserted IV catheter and the second through a butterfly needle at a separate site. The rates of contamination were the same for each group. Their results were replicated in 1993 by a group from Australia2 and, since then, it has been standard practice to draw BCs through the IV at the time of insertion.

In our institution, BCs are frequently drawn in an anticipatory manner pending laboratory and radiographic results. During the past year, in our department alone, this routine has resulted in the wasting of more than 1000 BC bottles, at a cost of more than $5000, which were inoculated with blood and subsequently discarded when it was decided not to send the culture to the laboratory for processing. An alternative approach, which would minimize waste while maintaining quality care, would be to place an IV when initial blood work is drawn and draw the culture through the IV only if indicated by clinical, laboratory, or radiographic evaluation.

For the culture results to be clinically useful, the contamination rates of cultures drawn through previously placed IVs must not exceed the contamination rates of BCs obtained by standard techniques. Several researchers have already reported higher rates of contamination in BCs drawn through intravascular catheters. However, these studies investigated catheters that had been in place for lengthy periods of time and, therefore, had been colonized with bacteria.3–5 Emergency department (ED) IVs tend to be in place for a more limited amount of time thereby decreasing the opportunity for colonization. Therefore, we speculate that in an ED setting, IVs can serve as reliable BC sampling ports.

We undertook this prospective study to compare the contamination rate of BCs drawn during IV placement to the contamination rate of BCs drawn from the same site at a later time. Our secondary goal was to determine if the collection of two separate BCs enhances the detection of bacteremia in children.

PATIENTS AND METHODS

This prospective study was conducted from January 10, 1997 through April 26, 1998 in the ED at Hasbro Children’s Hospital in Providence, RI. The project was approved by the Rhode Island
Hospital Institutional Review Board and written consent was obtained from all families. Children who had a BC obtained when their IV line was placed were eligible for enrollment. The decision to draw a BC and place a line was made by the examining house officer in consultation with the attending physician. BCs were drawn only if clinically indicated and not for the sole purpose of enrolling patients into the study. Patients were excluded from the study if they had received IV or intramuscular antibiotics within 24 hours of BC collection, had an indwelling vascular catheter, or had a sensitivity to povidone-iodine.

The initial BCs were drawn at the time of IV line placement using a standardized technique of skin preparation with povidone-iodine and isopropyl alcohol as proscribed by ED protocols. The second sample was drawn from the previously placed IV catheter just before antibiotic administration or patient discharge from the ED. Before the blood sampling, the IV catheter hub or T connector was cleaned with povidone-iodine and isopropyl alcohol. The sample was then drawn using a sterile needle inserted through the hub or by attaching a syringe to the T connector. The blood sample was inoculated into aerobic BC media after the bottle top was wiped with an alcohol swab.

Between blood draws IVs were maintained as saline locks or, if IV fluids were ordered by the treating physician, as infusing lines. Saline locks were flushed once after the initial blood was drawn and then not remanipulated until the second sample of blood was drawn.

All BCs were processed by the Rhode Island Hospital Microbiology Laboratory using standard techniques. Before February, 1998, organism growth was measured by photodetection using the Organon Teknika Corporation (Durham, NC) system. All cultures processed after February 1, 1998, had organism growth measured by fluorescence using the Becton Dickinson Microbiology (Towson, MD) systems. In both systems growth was checked every 10 minutes by the laboratory’s automated system and positive cultures were reported to the ED. Hospital records were reviewed in all children with positive cultures so that follow-up could be arranged in person or by phone, depending on the clinical indications.

The following data were recorded for each study patient: age, sex, duration of time between the first and second blood draws, amount of blood inoculated into each BC bottle, size of the IV catheter, fluids in or through the IV catheter between blood draws, maximum temperature, administration of antipyretics, degree of difficulty of each blood draw, and white blood cell and differential counts.

In consultation with a pediatric infectious disease specialist, bacteria recovered from BCs were classified as either contaminants or pathogens. *Staphylococcus epidermidis*, *Corynebacterium*, and *Bacillus* in otherwise well, immunocompetent children were presumed to be contaminants. *Streptococcus pneumoniae*, *Neisseria meningitis*, *Salmonella* species, and Group A β-hemolytic streptococci were considered pathogens. Other bacteria were classified as either contaminants or pathogens based on the compatibility of the organism with the patient’s clinical picture. Additionally, microbiology records were reviewed to determine contamination rates of all cultures drawn in the ED during the study period.

Rates of contamination and bacteremia were determined for the entire study population. Groups were compared using χ² analysis or Fisher’s exact test for categorical data and Student’s t test for continuous variables. Nonparametric, multivariable data were analyzed using the Kruskal-Wallis one-way equality of populations rank test.

**RESULTS**

Of 1564 patients enrolled in the study, 64 were excluded from analysis because we were not able to draw second cultures from their IVs. This left 1500 matched pairs of cultures (3000 total cultures) for analysis. Factors that could influence the ability to draw the second culture are listed in Table 1. Forty-six percent (n = 690) of eligible patients were girls. Ages ranged from 3 days to 22.1 years with a mean of 4.2 years and a median of 2.2 years. The median time between first and second cultures was 66 minutes (range: 1–840 minutes). The mean volume of blood in the first culture was 1.67 mL (range: 0.2–6.0 mL; ±0.66 standard deviation [SD]) and the mean volume of blood in the second culture was 1.68 mL (range: 0.2–6.0 mL; ±0.80 SD; P = .78).

Of the 3000 total cultures, 95 (3.2%) grew an organism. Fifty-seven (1.9%) of these organisms were contaminants and 38 (1.3%) were pathogens. The mean time to growth for contaminants was 31.3 hours (±17.4 SD) with a range of 12.4 to 111.3 hours while the mean time to growth for pathogens was 18.7 hours (±6.0 SD) with a range of 10.7 to 36 hours. The difference in time to growth for pathogens versus contaminants was significant (P = .0008).

All 57 contaminants were found in only one of two cultures in a pair thereby representing 57 patients. Twenty-seven of these contaminants grew in the first culture set and 30 grew in the second culture set for contamination rates of 1.8% and 2.0%, respectively (P = .69). Forty-nine (86%) of the 57 contaminated cultures grew one organism and the remainder grew two organisms. The pattern of contamination was similar in both sets of BCs and included *S epidermidis* (n = 26), α-hemolytic *Streptococcus* (n = 20), *Corynebacterium* (n = 6), *Bacillus* (n = 2), and other organisms (n = 11).

Thirty-eight (1.3%) of the 3000 BCs grew organisms characterized as pathogens. Twenty-four of these cultures represent 12 patients whose blood grew pathogens in two out of two cultures. These concordant cultures are listed in Table 2. The other 14 positive cultures represent 14 patients with pathogen growth in only one of two cultures. These discordant cultures are listed in Table 3.

There was no statistically significant difference when comparing the rate of bacteremia when each patient had one culture drawn versus the rate of bacteremia when each patient had two cultures drawn. If only one culture had been obtained in each of our 1500 patients, the pathogen recovery rate would have been 1.1% (16/1500). When taking both cultures into account, the pathogen recovery rate was 1.7% (26/1500); P = .13.

The contamination rate of all cultures during the course of the study period was 2.0%. This was not significantly different from the contamination rate of study cultures (1.9%; P = .72).

### TABLE 1. Obtainable Versus Unobtainable Cultures

<table>
<thead>
<tr>
<th></th>
<th>Obtainable (n = 1500)</th>
<th>Unobtainable (n = 64)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (y)</td>
<td>2.1</td>
<td>0.9</td>
<td>.03</td>
</tr>
<tr>
<td>IV size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 gauge: 3</td>
<td>22 gauge: 20</td>
<td></td>
<td>.02</td>
</tr>
<tr>
<td>20 gauge: 70</td>
<td>22 gauge: 692</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 gauge: 683</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median time between</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cultures (min)</td>
<td>66</td>
<td>120</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>% with running IV fluid</td>
<td>30.59</td>
<td>21.31</td>
<td>NS</td>
</tr>
<tr>
<td>% with fever at time</td>
<td>31.48</td>
<td>18.18</td>
<td>NS</td>
</tr>
<tr>
<td>second BC drawn</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: IV, intravenous; BC, blood culture; NS, not significant.
DISCUSSION

In our population of ED patients, we were unable to demonstrate a difference in BC contamination rates when comparing BCs drawn through previously placed IVs to BCs drawn by standard technique. This is contrary to previously done studies that have shown higher contamination rates when blood was drawn through centrally placed vascular catheters and arterial lines. Our similarity in contamination rates is most likely because of the limited duration of time the catheters are in place. Other investigators drew cultures from lines that had been in place for days, whereas we used IVs that were no older than 14 hours. Therefore, our data are only applicable to the ED setting and we cannot extrapolate it to include catheters that have been in place for more than a few hours.

Knowing that a BC can be obtained from a previously placed IV line allows medical caregivers to draw the culture after a child has been fully evaluated. Depending on practice style, a culture can be drawn after the results of the laboratory and radiographic studies are known. Cultures can also be drawn if the clinical picture of the child changes during his or her stay in the ED.

Our secondary objective, to determine if the addition of a second culture from the same site would enhance the detection of bacteremia, was limited by our sample size and pathogen recovery rate. Although the adult literature endorses the drawing of at least two cultures in the evaluation of potentially bacteremic patients, our statistical power is insufficient to translate this practice to pediatric patients. It seems, however, that the addition of a second culture may be clinically helpful. Ten of our 26 bacteremic patients would have been missed if we had drawn only the first culture. In total, 14 of our patients had a pathogen grow in only one of two cultures. Of these 14 patients, 7 had their clinical course altered significantly by the isolation of the BC pathogen.

Two possible reasons have been postulated to explain falsely negative BCs. The first is related to the amount of blood inoculated into culture bottles. It is well documented in both the pediatric and adult literature that the detection of bacteremia is enhanced by sampling a larger amount of blood. This is especially true in pediatric patients without a serious focal infection in whom the density of bacteremia is low (<10 to 15 organisms/mL). In some of our patients this holds true. Five of our 14 discordant cultures had growth in the culture bottle with a greater amount of blood. One patient, however grew...

<table>
<thead>
<tr>
<th>Patient Age (y)</th>
<th>Pathogen</th>
<th>Clinical Diagnosis</th>
<th>Culture Results 1st</th>
<th>Culture Results 2nd</th>
<th>Blood Volume (mL) 1st</th>
<th>Blood Volume (mL) 2nd</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td><em>S. pneumoniae</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0.9</td>
<td><em>S. pneumoniae</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1.1</td>
<td><em>S. pneumoniae</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2.3</td>
<td><em>S. pneumoniae</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3.4</td>
<td><em>S. pneumoniae</em></td>
<td>Bacteremia and febrile seizure</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1.0</td>
<td><em>S. pneumoniae</em></td>
<td>Periorbital cellulitis</td>
<td>+</td>
<td>+</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1.4</td>
<td><em>S. pneumoniae</em></td>
<td>Meningitis</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
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<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1.0</td>
<td><em>alpha Streptococcus</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1.1</td>
<td>GABHS*</td>
<td>Adenitis</td>
<td>+</td>
<td>+</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>6.9</td>
<td>GABHS*</td>
<td>Osteomyelitis</td>
<td>+</td>
<td>+</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>7.2</td>
<td><em>N. meningitidis</em></td>
<td>Sepsis</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

* Group A beta-hemolytic Streptococcus.

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TABLE 2. Pathogens: Concordant Cultures

<table>
<thead>
<tr>
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<th>Pathogen</th>
<th>Clinical Diagnosis</th>
<th>Culture Results 1st</th>
<th>Culture Results 2nd</th>
<th>Blood Volume (mL) 1st</th>
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<td>+</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
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<td><em>S. pneumoniae</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1.1</td>
<td><em>S. pneumoniae</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2.3</td>
<td><em>S. pneumoniae</em></td>
<td>Bacteremia</td>
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<td>+</td>
<td>2</td>
<td>2</td>
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<td>+</td>
<td>2</td>
<td>2</td>
</tr>
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<td>+</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
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<td><em>S. pneumoniae</em></td>
<td>Meningitis</td>
<td>+</td>
<td>+</td>
<td>3</td>
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</tr>
<tr>
<td>0.9</td>
<td><em>S. pneumoniae</em></td>
<td>Meningitis</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>0.8</td>
<td><em>alpha Streptococcus</em></td>
<td>Bacteremia</td>
<td>+</td>
<td>+</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1.1</td>
<td>GABHS*</td>
<td>Adenitis</td>
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<td>+</td>
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<td>2</td>
</tr>
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* Group A beta-hemolytic Streptococcus.
a pathogen in the bottle with a smaller amount of blood and the other 8 patients grew a pathogen in one of two bottles with the same amount of blood. The previously described intermittent nature of bacteremia would account for this and suggests that the collection of multiple specimens throughout time would increase the likelihood of finding a pathogen.

Another intriguing aspect of the discordant cultures is the greater degree of bacteremia found in the second versus the first culture. Although this may be a function of chance in drawing the second sample at the opportune time, we speculate that it may be a function of the catheter itself. The catheter in the bloodstream may act as a nidus for any circulating bacteria that then would be retrieved when the second sample is drawn. Our sample size and contamination rates preclude more than speculation and more definitive studies are required to fully clarify this issue.

The pattern of organism growth was also helpful in identifying the organisms as pathogens or contaminants. As has been documented previously, the mean time to growth for pathogens was shorter than that for contaminants. Additionally, the presence of pathogens in two cultures helped identify children with true pathogens before organism identification.

Three limitations of this study must be acknowledged. First, despite our efforts to enroll as many patients as possible, we missed a large number of children who were potentially eligible. During the study time 6153 patients from our ED had BCs processed. A number of these children were not eligible because the first BC did not come from the IV site, they had received IV or intramuscular antibiotics in the preceding 24 hours, or they had a central line; we did not determine how many children were omitted for these reasons. No children were excluded for sensitivity to povidone-iodine. It is likely, however, that a larger number of potential enrollees were missed because they were not approached for enrollment into the study. The contamination rate of the 4653 unenrolled patients and the contamination rate of the 1500 enrolled patients were the same, however, suggesting that selection bias was not a factor.

The second concern involves the issue of statistical power. Our initial power analysis was based on a previous contamination rate of 4.0%, For unknown reasons, our contamination rate was much lower. Because of this low prevalence of contamination, it is possible that our sample size did not enable us to detect a small difference in the rates of contamination between the two methods. To achieve statistical significance given our rates of contamination (assuming an a error of 0.05 and a b error of 0.2), we would need to enroll an additional 70,000 patients. A study of this magnitude is not currently feasible.

The third issue that needs to be addressed is our pathogen recovery rate. Our rate is lower than rates previously reported by other investigators. Factors that may contribute to our low rate include the inclusion of children older than 3 years, two enteroviral seasons that generated an unusual number of children with fever and petechiae, and a meningococccemia scare during which time there were hundreds of referrals to our ED for clinical evaluation and BC.

Finally, although this project was undertaken in an attempt to find an effective, less wasteful method for drawing BCs it was not our goal to analyze the costs associated with the two different practices. Our focus was on the clinical feasibility and, now that we have shown that our approach is clinically sound, additional research is required to determine if it is fiscally beneficial.

CONCLUSION

From our data we conclude that there is no difference in the contamination rates when comparing BCs drawn from immediately placed IV lines to those drawn from the same site at a later time. Although our sample size precludes statistical significance, our data also suggest that the collection of two BCs instead of a single culture from each patient may enhance the detection of bacteremia in children. This will need further investigation.

ACKNOWLEDGMENTS

We thank all the residents, nurses, and technicians who helped with the blood culture study. Without your assistance, we would still be enrolling patients. We also thank Dianne Auld for her assistance with the microbiology records and all the microbiology technicians who processed the extra cultures and were invaluable in answering questions.

REFERENCES

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