Do We Need This Blood Culture?

abstract

OBJECTIVES: This study describes blood culture collection rates, results, and microbiology laboratory charges for 4 leading pediatric inpatient diagnoses (asthma, bronchiolitis, pneumonia, and skin and soft tissue infection [SSTI]) in low-risk patients.

METHODS: This retrospective cohort study was conducted at an urban, academic, quaternary children’s hospital. The study period was from January 1, 2011, to December 31, 2011. Inclusion criteria were as follows: 6 months to 18 years of age and primary diagnosis of asthma (International Classification of Diseases, Ninth Revision [ICD-9] codes 493.91–493.92), bronchiolitis (ICD-9 codes 466.11 and 466.19), SSTI (ICD-9 codes 680.00–686.99), or pneumonia (community-acquired pneumonia; ICD-9 codes 481.00–486.00). Patients with complex chronic conditions were excluded. Data were collected via administrative billing data and chart review. Descriptive statistics were performed; χ² tests were used for categorical variables, and nonparametric tests were used for continuous variables because of non-normal distributions.

RESULTS: Administrative data review included 5159 encounters, with 1629 (32%) inpatient encounters and 3530 (68%) emergency department/outpatient encounters. Twenty-one percent (n = 343) of inpatient encounters had blood cultures performed, whereas 3% (n = 111) of emergency department/outpatient encounters had blood culture testing performed. Inpatient blood culture utilization varied according to diagnosis: asthma, 4%; bronchiolitis, 15%; pneumonia, 36%; and SSTI, 46%. Charts were reviewed for all 343 inpatients with blood culture testing. Results of all the blood cultures obtained for asthma and bronchiolitis admissions were negative, with 98% and 99% negative or false-positive (contaminant) for SSTI and community-acquired pneumonia, respectively. The approximate financial impact of blood culture utilization (according to gross microbiology laboratory charges) approximated $100 000 over the year for all 4 diagnoses.

CONCLUSIONS: There was a high rate of negative or false-positive blood culture results for these common inpatient diagnoses. In addition, there was a low rate of clinically significant true-positive (pathogenic) culture results. These results identify points of potential blood culture overutilization.

There is increasing concern about the quality and cost of health care delivered in the United States. This concern has led to a focus on value-driven health care, meaning how we can achieve better quality outcomes per dollar spent on health care. Blood culture overutilization is a potential example of a widespread quality and cost issue with broad impact in the pediatric population. A blood culture is a critical tool to detect the presence of dangerous bacteria in the bloodstream.
However, false-positive results (ie, contaminant blood cultures) can limit test utility, expand resource utilization, and increase hospital charges via repeat testing, antibiotic exposure, hospitalization, additional invasive testing and management (eg, lumbar puncture, central catheter), and specialty consultations.3–5 For example, Segal and Chamberlain4 described contaminant blood cultures in 85 children that added more than $78,000 in unnecessary charges. This amount does not include unmeasured costs, such as the financial and emotional impact on patients and their families. There have been numerous studies to identify best practices to prevent blood culture contamination, many of which have shown significant reduction in contamination rates.6–11

Resource overutilization can also occur when blood cultures are collected unnecessarily. To reduce unnecessary blood culture collection, the initial step is assessing risk of bacteremia to avoid blood culture collection in low-risk patients. For example, well-established clinical practice guidelines for children with asthma and bronchiolitis do not support routine blood culture collection.12–14 Similarly, the literature demonstrates no evidence of clinically significant bacteremia in patients with skin and soft tissue infection (SSTI), even in the era of methicillin-resistant Staphylococcus aureus (MRSA).15,16 In contrast, guidelines for inpatient community-acquired pneumonia (CAP) management do recommend considering blood culture testing for inpatients with moderate to severe bacterial pneumonia.17,18 However, high rates of negative culture results can represent overutilization as well, and they suggest a need to define or refine clinical practice guidelines. Although true-positive results of blood cultures may represent pathogenic bacteremia, they may be unnecessary if they do not change empirical management, thereby representing another form of resource overutilization. In addition, it is possible that even when a true-positive result on blood culture changes management, the change made may not be evidence based and therefore may not provide a true benefit to the patient.

Given these increased charges and burden on our health care system, reducing blood culture overutilization is an opportunity to improve value-driven care. The present study describes blood culture collection rates, results, and microbiology laboratory charges as a proxy for financial impact for 4 leading pediatric inpatient diagnoses (ie, asthma, bronchiolitis, CAP, SSTI) in low-risk patients. We hypothesized that there is potential resource overutilization with regard to blood culture usage for these 4 common diagnoses among hospitalized children.

METHODS

Overview

This retrospective descriptive cohort study was conducted at an urban, academic, quaternary children’s hospital from January 1, 2011, to December 31, 2011. This study qualified for exempt status from the local institutional review board.

Patient Selection

We included patients 6 months to 18 years of age with a primary diagnosis of asthma (International Classification of Diseases, Ninth Revision [ICD-9] codes 493.91–493.92), bronchiolitis (ICD-9 codes 466.11 and 466.19), SSTI (ICD-9 codes 680.00–686.99), and bacterial or unidentified pneumonia (ICD-9 codes 481.00–486.00). We excluded patients with any secondary diagnoses of complex chronic conditions to establish a cohort of patients without other comorbid conditions.19

Data Collection

We used administrative billing data to identify all inpatient, outpatient, and emergency department (ED) setting visits for the study diagnoses during the study period. Patients with ICD-9 codes consistent with complex chronic conditions were excluded. Blood culture utilization was determined for each setting and diagnosis. Inpatients with blood culture collection were identified, and chart review was completed for all inpatients with blood cultures collected.

The primary outcome was to describe blood culture utilization rates according to diagnosis and setting. Secondary outcomes were description of blood culture results and, as a proxy for financial impact, gross microbiology laboratory charges. These approximate charges included blood culture collection ($300), organism identification ($100), and antibiotic sensitivity ($150). These charges represent what a facility bills payers and are different and typically much higher than “costs,” which represent actual expenses incurred by the facility. Charges vary among institutions and are a function of overhead expenses and negotiated payer reimbursements. Despite this limitation of overrepresenting health care expenses, charges are easier to ascertain than cost and thus commonly used a proxy for financial burden.20

Finally, when a blood culture result was positive, we recorded whether the organism represented a true-positive
or a false-positive result based on the treatment team’s chart documentation and any apparent change in clinical management. These changes included further testing; change in antibiotic selection, duration, or route; and extended length of stay (LOS).

Analysis

Descriptive statistics were performed to determine blood culture utilization rates overall and according to diagnosis. Comparisons with categorical variables were conducted by using χ² tests, and nonparametric tests were used for continuous variables due to non-normal distributions. SPSS version 21.0 (IBM SPSS Statistics, IBM Corporation, Armonk, NY) was used for analysis.

RESULTS

Blood Culture Utilization According to Diagnosis and Setting

Administrative data review identified 5159 encounters from January 1, 2011, to December 31, 2011. Thirty-two percent (n = 1629) were inpatient encounters and 68% (n = 3530) were ED or outpatient encounters. Overall, blood cultures were collected in 3% (n = 111) of total ED or outpatient encounters and 21% (n = 343) of inpatient encounters. Inpatient blood culture utilization varied by diagnosis, ranging from 4% for asthma and 46% for SSTI (Fig 1). Specifically, over the 1-year study period, there were 29 blood cultures in 707 inpatients with asthma, 35 blood cultures in 237 inpatients with bronchiolitis, 139 blood cultures in 381 inpatients with CAP, and 140 blood cultures in 304 inpatients with SSTI.

Inpatient Blood Culture Utilization According to Diagnosis

Table 1 describes characteristics of all inpatients according to diagnosis and shows variation between those with and without blood culture collection. For inpatients with asthma and bronchiolitis, LOS was statistically greater in the cohort that had blood cultures drawn compared with the cohort that did not have blood cultures drawn, and a similar trend toward statistical significance was seen in patients with SSTI. No change in LOS was seen in patients with CAP. For patients with CAP, there was a statistically significant difference in median age (2 vs 3 years) in the cohort with blood culture collection compared with the cohort without blood culture collection, respectively.

Blood Culture Results

All blood culture results were negative in patients with asthma and bronchiolitis. In patients with CAP, only 1% had true-positive results and 99% were negative or false-positive. In patients with SSTI, 2% were true-positive, and 98% were negative or false-positive (Fig 2).

Table 2 details results of these 4 false-positive blood culture results, as well as the 5 true-positive blood culture results, for which there was no apparent change in antibiotic management or hospital stay, although blood culture testing was repeated in several patients.

Financial Impact

In our institution, the approximate charge for a blood culture is $300, with an additional $100 for identification and $150 for sensitivity reports. As mentioned in the Methods section, we used hospital charges but acknowledge that these charges are higher than the true costs of the laboratory tests. In this cohort, for the 1-year study period, there were ~$8700 in charges for blood cultures among the patients with asthma and $10,500 in charges for blood cultures among the patients with bronchiolitis. Among the patients with SSTI, charges for both the 2 true-positive blood culture results and the 134 negative blood culture results totaled ~$41,300; this amount does not include the subsequent charges associated with the 3 false-positive blood culture results. For the patients with SSTI, charges for the 3 true-positive and 136 negative culture results totaled ~$42,450; again, this total does not include the charges and costs associated with the false-positive culture result. Gross microbiology charges in our sample approximated $100,000 over the single

FIGURE 1 Inpatient and outpatient/ED blood culture utilization.
year. Patients with SSTI and CAP had the highest rates of blood culture collection, thus contributing to the highest financial burden.

**DISCUSSION**

In the present study, blood culture utilization varied according to diagnosis as well as setting; specifically, patients admitted with CAP and SSTI had the highest rate of blood culture utilization (36% and 46%, respectively). The rate of blood culture utilization for these common inpatient diagnoses was notable, particularly because blood culture utilization did not seem consistent with existing guidelines or literature, nor did it appear to alter clinical management.

Current guidelines and literature do not support blood culture utilization for inpatients with asthma or bronchiolitis. However, in our study population, 4% and 15% of patients with asthma and bronchiolitis, respectively, had blood cultures obtained as part of their inpatient evaluation and management. We acknowledge that these patients with a primary diagnosis of asthma or bronchiolitis may have also been co-diagnosed with pneumonia, which might have influenced the decision to obtain a blood culture. However, given that all of the blood culture results for these patients with asthma and bronchiolitis were negative based on our chart review, this represents an area of potential overutilization.

We found no available guidelines specifically targeting evaluation and management of SSTI management in pediatrics; however, there are recent guidelines for the management of MRSA, a common cause of SSTI, across different infection types. Even in the era of increasing MRSA colonization and infection, the literature does not support routine blood culture use for SSTI. Wathen and Halloran conducted a single-center, retrospective chart review and found no clinically significant organisms isolated in blood cultures for patients with cellulitis. Malone et al also conducted a single-center chart review study of >500 patients admitted with SSTI. They found no positive blood culture results in patients with uncomplicated SSTI, whereas 12.5% of patients with complicated SSTI (ie, “surgical or

<table>
<thead>
<tr>
<th>TABLE 1 Patient Characteristics According to Diagnosis</th>
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<tbody>
<tr>
<td>Diagnosis</td>
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</tr>
<tr>
<td>Asthma (n = 707)</td>
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<tr>
<td>% Female</td>
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<tr>
<td>Age, y, median (IQR)</td>
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<tr>
<td>LOS, d, median (IQR)</td>
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<tr>
<td>Bronchiolitis (n = 237)</td>
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<td>% Female</td>
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<tr>
<td>Age, mo, median (IQR)</td>
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<td>LOS, d, median (IQR)</td>
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<tr>
<td>CAP (n = 381)</td>
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<td>% Female</td>
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<tr>
<td>Age, y, median (IQR)</td>
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<td>LOS, d, median (IQR)</td>
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<tr>
<td>SSTI (n = 304)</td>
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<tr>
<td>% Female</td>
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<td>Age, y, median (IQR)</td>
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<td>LOS, d, median (IQR)</td>
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<table>
<thead>
<tr>
<th>TABLE 2 Details of True- and False-Positive Blood Culture Results</th>
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<tbody>
<tr>
<td>Result</td>
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<td>--------</td>
</tr>
<tr>
<td>True-positive</td>
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<tr>
<td>False-positive (contaminants)</td>
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CoNS, coagulase-negative staphylococci.
traumatic wound infection, need for surgical intervention, or infected ulcers or burns) had positive blood culture results. Although Malone et al identified that blood culture collection was associated with a higher mean LOS, and we identified a similar trend, neither study controlled for patient severity or other factors predisposing to longer LOS. Although nearly one-half of our patients with SSTI had blood cultures collected, most of the results were negative or contaminant, and patients with true-positive blood culture results had no apparent change in management. Thus, there may be low utility of blood cultures in patients admitted with SSTIs. However, as the study by Malone et al found, there may be opportunities to identify patients at higher risk for bacteremia, and further research is needed to determine if bacteremia requires a management change.

Blood culture utilization for inpatient pneumonia management is controversial. The Infectious Diseases Society of America guidelines recommend that blood cultures be obtained in children who fail to demonstrate improvement after the start of appropriate antibiotic therapy or who require hospitalization for moderate to severe and complicated CAP. However, there are no clear guidelines regarding blood culture utility in mild and uncomplicated CAP, and there is a low reported prevalence of bacteremia in children hospitalized with uncomplicated CAP (range: 1.1%–2.7%). As a result, recent literature questions the need for routine blood cultures in all inpatients with CAP. A recent multicenter, retrospective study found that 56% of hospitalized children with CAP underwent blood culture testing, and there was a 71% overall rate of true bacteremia. However, there was less bacteremia in patients with uncomplicated CAP (5.9%) than in those with complicated CAP (10.0%), and in patients who had a pleural drainage (21.2%) than in those with no drainage procedure (5.7%). In another recent single-center study with >300 children, Heine et al determined that 47% of inpatients with pneumonia had blood cultures obtained, and that only 1.5% of all patients had a true-positive blood culture result. However, all 5 positive blood culture results occurred in patients with radiographic effusion or empyema. These authors propose that not all patients admitted for CAP are "moderately to severely ill" and therefore do not warrant routine blood culture testing. Specifically, they suggest that well-appearing patients without evidence of effusion or empyema do not need a blood culture collected. Although we did not stratify uncomplicated from complicated CAP, one-third of these patients had a blood culture collected; 99% were negative or false-positive, and the 2 true-positive results yielded no apparent change in clinical management. These findings may demonstrate low utility of blood culture testing in CAP, although there is evidence to support blood culture collection in complicated pneumonia. However, future research is also needed to determine if bacteremia requires a management change. Overall, these findings suggest blood culture overcollection for most of the diagnoses studied. In our study, 99% of collected blood culture (338 of 343 blood cultures) results were identified as negative or false-positive (contaminants), which suggests overcollection of blood cultures for these common diagnoses at our institution. These outcomes identify opportunities for clinical practice guideline development or refinement. At a minimum,
this represents ~$100,000 in microbiology charges over the single year at our institution. Although these charges overrepresent true hospital cost, it is a useful proxy for the economic burden. In addition, these charges do not account for the impact on the patient and family. However, in the era of value-based health care, every dollar counts; therefore, reducing blood culture utilization is a key component of high-quality care.

Our study has several limitations. First, this was a retrospective study. Data collection was limited by what was coded according to the ICD-9 scheme, and it was not possible to determine whether there were other risk factors (eg, ill appearance, failure of outpatient management) for bacteremia present that prompted blood culture utilization. This study was conducted at a single center, and therefore practice patterns reflect only those at this center. Also, we did not exclude patients who may have been pretreated with antibiotics at referring facilities, which could have led to a falsely low positive blood culture rate. Finally, we describe only microbiology charges as a marker for financial burden, rather than true costs as described earlier, and do not account for other costs of care, including other laboratory tests, antibiotics, professional services, procedures, and hospital room, as well as family loss of income and emotional impact on the patient and family.

CONCLUSIONS
In the era of value-based health care, every dollar spent must yield high-quality care. We identified multiple areas of potential resource overutilization in common inpatient pediatric diagnoses, primarily related to overcollection of blood cultures. These represent opportunities for clinical practice guideline development or refinement. In addition, quality improvement efforts can further refine collection technique. Finally, clinical research is necessary to determine optimal management of clinically meaningful bacteremia.

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