Prevalence, Risk Factors, and Outcomes of Bacteremic Pneumonia in Children

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abstract

BACKGROUND: Previous studies examining bacteremia in hospitalized children with pneumonia are limited by incomplete culture data. We sought to determine characteristics of children with bacteremic pneumonia using data from a large prospective study with systematic blood culturing.

METHODS: Children <18 years hospitalized with pneumonia and enrolled in the multicenter Etiology of Pneumonia in the Community study between January 2010 and June 2012 were eligible. Bivariate comparisons were used to identify factors associated with bacteremia. Associations between bacteremia and clinical outcomes were assessed by using Cox proportional hazards regression for length of stay and logistic regression for ICU admission and invasive mechanical ventilation or shock.

RESULTS: Blood cultures were obtained in 2143 (91%) of 2358 children; 46 (2.2%) had bacteremia. The most common pathogens were *Streptococcus pneumoniae* (*n* = 23, 50%), *Staphylococcus aureus* (*n* = 6, 13%), and *Streptococcus pyogenes* (*n* = 4, 9%). Characteristics associated with bacteremia included male sex, parapneumonic effusion, lack of chest indrawing or wheezing, and no previous receipt of antibiotics. Children with bacteremia had longer lengths of stay (median: 5.8 vs 2.8 days; adjusted hazard ratio: 0.79 [0.73–0.86]) and increased odds of ICU admission (43% vs 21%; adjusted odds ratio: 5.21 [3.82–6.84]) and invasive mechanical ventilation or shock (30% vs 8%; adjusted odds ratio: 5.28 [2.41–11.57]).

CONCLUSIONS: Bacteremia was uncommonly detected in this large multicenter cohort of children hospitalized with community-acquired pneumonia but was associated with severe disease. *S pneumoniae* was detected most often. Blood culture was of low yield in general but may have greater use in those with parapneumonic effusion and ICU admission.

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Drs Fritz and Williams conceptualized and designed the study, designed the data collection instruments, collected data, conducted the initial analyses, and drafted the initial manuscript; Drs Arnold, McCullers, Pavia, and Ampofo collected data; Drs Edwards, Self, Grijalva, Zhu, Wunderink, Anderson, Jain, and Ms Bramley conceptualized and designed the study and assisted with interpretation of the data; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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WHAT'S KNOWN ON THIS SUBJECT: The prevalence of bacteremia in children admitted to the hospital for community-acquired pneumonia is low.

WHAT THIS STUDY ADDS: Blood culture yield is low overall among children admitted with community-acquired pneumonia, but obtaining cultures in those with parapneumonic effusion or requiring ICU admission may be warranted.

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Pneumonia is one of the most common reasons for hospitalization among children in the United States.[1–3] It is caused by bacteria, viruses, and simultaneous infection with both types of pathogens. For bacteria, culture-based methods remain the most common method for identifying pneumonia pathogens. The 2011 national guidelines for the management of community-acquired pneumonia (CAP) published by the Pediatric Infectious Diseases Society (PIDS) and the Infectious Diseases Society of America (IDSA) recommended obtaining blood cultures in all children hospitalized with moderate to severe CAP,[4] although classification of moderate disease was not explicitly defined.

The potential benefits of positive blood culture results in CAP patients include the ability to narrow antibiotic spectrum, predict outcomes, and inform assessments of vaccine efficacy; but the yield and impact of blood cultures have not been adequately studied. In a meta-analysis of smaller studies, blood culture results were rarely positive among children with CAP.[5] In addition, *S pneumoniae* remains the most common bacterial organism in culture-positive CAP cases,[5–12] and recommendations for empirical treatment already target this pathogen. Moreover, isolation of contaminants from blood cultures is relatively common and may lead to unnecessary broad-spectrum antibiotic exposure and prolonged hospitalization.[13] Thus, although recommended by the PIDS and IDSA guidelines for most hospitalized children with CAP, clear evidence demonstrating the use of routine blood cultures in all children hospitalized with pneumonia is uncertain.[9,12,14] Previous studies have been limited by selective collection of cultures, resulting in a lack of culture data for 20% to 65% of children enrolled in the studies of interest.[6–10,12,14]

The goal of this study was to estimate the prevalence, risk factors, and clinical outcomes of bacteremic CAP among children enrolled in a multicenter, prospective study of pediatric CAP hospitalizations in the United States, which included systematic blood culture collection. We also examined associations between positive blood culture results, empirical antibiotics, and modifications in antibiotic therapy.

METHODS

Study Population

We analyzed data from the Etiology of Pneumonia in the Community (EPIC) study, a prospective, active surveillance study of children <18 years who were hospitalized with CAP in 3 US children's hospitals (Le Bonheur Children's Hospital, Memphis, TN; Primary Children's Medical Center, Salt Lake City, UT; Monroe Carell Jr. Children's Hospital at Vanderbilt, Nashville, TN) from January 1, 2010 to June 30, 2012.[15] Data analysis was completed in January 2018. The institutional review board at each hospital and the Centers for Disease Control and Prevention approved the study protocol.

Children were included in the study if they resided in a predetermined catchment area and were hospitalized at one of the study hospitals with (1) signs or symptoms of acute infection (eg, fever), (2) evidence of acute respiratory illness (eg, cough), and (3) evidence of pneumonia on chest radiograph as judged by a study radiologist at each site. Children with a recent hospitalization (<7 days for immunocompetent children and <90 days for immunocompromised children), residence in an extended-care facility, a tracheostomy tube, cystic fibrosis, severe immunosuppression, or a clear alternative diagnosis were excluded from the study.[15] Demographic information, medical history, and history of present illness were collected, and medical record reviews were conducted (medical history, hospital course, antibiotic therapy, clinical outcomes, and laboratory data). Procalcitonin levels were collected in a subset of patients.[16] Clinical outcomes included hospital length of stay (LOS) in days, ICU admission, and severe pneumonia as defined by the need for invasive mechanical ventilation (IMV) and/or shock requiring vasoactive medications.

Definition of Bacteremia

Blood cultures were routinely collected at the time of enrollment if not previously collected for clinical care. All positive culture results were made available to the clinical teams. For the current analysis, children with no blood culture data were excluded.

Bacteremia was defined as isolation of a pathogen by blood culture collected within 72 hours of admission. The following organisms, when isolated, were identified as contaminants on the basis of expert consensus at the time of the original EPIC study: *Aeroccocus*, *Alcaligenes faecalis*, *Bacillus*, *Citrobacter*, coagulase-negative staphylococci, *Corynebacterium*, *Enterococcus*, *Micrococcus*, *Neisseria subflava*, *Propionibacterium*, *Stomatococcus*, *Streptococcus bovis*, and *Veillonella*. More-virulent viridans streptococci (*Streptococcus anginosus*, *Streptococcus mitis*) were considered to be pathogens. Less-virulent viridans streptococci (*Streptococcus salivarius* and viridans streptococci without further speciation) were considered contaminants when isolated concurrently with another bacterial pathogen. Otherwise, less-virulent viridans group streptococci were considered to be pathogens.[15]

For purposes of this study, a study member at each institution reviewed the medical record of each patient meeting the above criteria for bacteremia to confirm that the positive culture result was treated as a true pathogen by the clinical team. Positive culture results not treated as true bacteremia by the clinical team were also excluded from further analysis.

Antibiotic Use

Empirical antibiotics were defined as the antibiotic(s) initiated in the emergency department or inpatient ward as documented in the patient's electronic medical record before availability of any culture data. Empirical antibiotics were classified as the following: cephalosporin (with or without a macrolide), cephalosporin plus vancomycin or clindamycin (with or without a macrolide), aminopenicillin, other, and none. Chart review was performed for each patient with bacteremia to obtain additional information on antibiotic management in response to the positive culture result. For these patients, definitive therapy refers to the antibiotic(s) selected after culture data, including speciation and susceptibility testing, which was added to the medical chart for clinical providers to view.

Statistical Analysis

We compared characteristics of children with and without bacteremia, including age, race and ethnicity, comorbidities, antibiotic exposure before blood culture, temperature, physical examination findings on presentation (eg, wheezing), concomitant viral detection, procalcitonin level, white blood cell count, and radiographic findings. For bivariate comparisons between children with and without bacteremia, we used χ^2 or Wilcoxon rank-sum tests. Binomial exact 95% confidence intervals (CIs) were calculated.

Associations between bacteremia and clinical outcomes were assessed by using Cox proportional hazards regression for time to discharge (equivalent to LOS) (hazard ratio <1 indicates that the rate of discharge for patients with bacteremia was lower as compared with patients without bacteremia at any particular point in time) and logistic regression for ICU admission while adjusting for demographic, clinical, laboratory, and radiographic characteristics. There were no in-hospital deaths or other censoring events. A Firth logistic regression[17] (penalized maximum likelihood estimation) was used for IMV and/or shock to minimize potential model overfitting.

To explore the influence of individual pathogens causing bacteremia, we also compared clinical outcomes among children without bacteremia to those with bacteremia caused by specific pathogens, including *S pneumoniae*, *S aureus*, *S pyogenes*, and a group composed of all remaining pathogens or "other."

RESULTS

Study Population

Of the 2358 children enrolled in the EPIC study, 2143 (91%) had blood cultures obtained and were included in this analysis (baseline characteristics of children with and without blood culture obtained are shown in Supplemental Table 4). The median time from triage to blood culture collection was 2.6 hours (interquartile range [IQR]: 1.0–7.3 hours), with 92.5% of cultures collected within 24 hours and 96.9% collected within 36 hours. Of the 461 children requiring ICU care, 429 (93.1%) were admitted to the ICU within 1 calendar day of presentation and 450 (98%) were admitted within 2 calendar days.

Fifty-three patients had positive blood culture results. Seven (13%) blood culture results met criteria for a real pathogen but were excluded from our study because the clinical team did not consider them to be true pathogens. Those 7 cultures grew *Acinetobacter* (n = 1), *Moraxella* (n = 2), and viridans group streptococci (*Streptococcus parasanguinis*, n = 2 and *S salivarius*, n = 2). Analysis including these pathogens was conducted with no significant difference in results, so the data were not reported.

Forty-six (2.2%, 95% CI: 1.6%–2.9%) children had bacteremia treated as true pathogens by the clinician caring for these patients. The most common pathogens were *S pneumoniae* (n = 21, 46%), *S aureus* (n = 6, 13%), and *S pyogenes* (n = 4, 9%). Other pathogens included viridans group streptococci (n = 8, 17%); group B, C, or G streptococci (n = 2, 4%); *Haemophilus influenzae* (n = 1, 2%); *Fusobacterium* (n = 2, 4%); both *S pneumoniae* and *H influenzae* (n = 1, 2%); and both viridans group streptococci and *Moraxella* (n = 1, 2%).

Bacteremia prevalence was similar among children with reported outpatient antibiotic use before admission (2.2%, CI: 1.3%–3.9%) and those without (2.2%, CI: 1.5%–3.0%). However, patients who did not receive inpatient antibiotics before culture had a higher prevalence of bacteremia than those who did (2.6%, CI: 1.8%–3.4% vs 0.82%, CI: 0.2%–2.1%; P = .021). Patients admitted to the ICU (4.3%, CI: 2.8%–6.6%) and those with pleural effusion (8.4%, CI: 5.6%–12.4%) also had an increased prevalence of bacteremia. The number needed to test for a positive isolate was 24 among children admitted to the ICU, 12 for children with parapneumonic effusion, and 91 for children without ICU admission or parapneumonic effusion. Among 1501 children with vaccine data available, 90% of those without bacteremia and 100% with

bacteremia received at least 3 doses of pneumococcal conjugate vaccine.

Factors Associated With Bacteremia

Children with bacteremia were significantly more likely to be male, have a higher P/F (Pao_2Fio_2) ratio, have a parapneumonic effusion or pleural drainage procedure, and have blood collected before inpatient antibiotics but significantly less likely to have chest indrawing or wheezing. Among a subset of 502 children with procalcitonin obtained at enrollment, the procalcitonin level was significantly higher in children with bacteremia (Table 1). Other characteristics, including initiation of outpatient antibiotics before hospitalization and concomitant viral detection, were not significantly different between the 2 groups.

Clinical Outcomes

Bacteremic children had a median LOS of 5.8 days compared with 2.8 days in children without bacteremia (adjusted hazard ratio: 0.79; CI: 0.73–0.86) (Table 2, Fig 1). Bacteremia was also associated with increased odds of ICU admission (43% vs 21%; adjusted odds ratio: 5.12; CI: 3.82–6.84) and IMV and/or shock (30% vs 8%; adjusted odds ratio: 5.28; CI: 2.41–11.57) compared with those without bacteremia.

In exploratory analyses comparing clinical outcomes among children with bacteremia caused by specific pathogens, median LOS varied from 3 days for *S pneumoniae* to 15 days for *S aureus* (Table 3). Children with *S aureus* and *S pyogenes* bacteremia had a marked increase in the frequency of ICU admission (100% and 73%) and IMV and/or shock (67% and 75%) compared with children with *S pneumoniae* bacteremia (27% ICU, 18% IMV and/or shock).

The most common empirical antibiotic choices (before report of positive culture results) among children with bacteremia included vancomycin or clindamycin plus a third-generation cephalosporin (43%), monotherapy with a third-generation cephalosporin (26%), or other broad-spectrum coverage with ≥3 agents (15%). Only 3 (7%) children were treated with an aminopenicillin alone. This was significantly different in children without bacteremia, who most often

TABLE 1 Baseline Characteristics of Children Hospitalized With Pneumonia With and Without Bacteremia

Baseline Characteristics	No Bacteremia, *n* = 2090	Bacteremia, *n* = 46	*P*
Age in mo, median (IQR)	28 (12–73)	27.5 (16–69)	.806
Male sex, *n* (%)	1136 (54)	34 (74)	.008
Race and ethnicity, *n* (%)			.258
Non-Hispanic white	805 (39)	22 (48)	
Non-Hispanic African American	723 (35)	15 (33)	
Hispanic	395 (19)	4 (9)	
Other	167 (8)	5 (11)	
No. chronic comorbidities, *n* (%)			.191
0	1006 (48)	27 (59)	
1	779 (37)	16 (35)	
2	239 (11)	1 (2)	
3+	66 (3)	2 (4)	
Household smoke exposure, *n* (%)	731 (35)	16 (35)	.956
PCV vaccination,[a,b] *n* (%)	1320 (90)	32 (100)	.067
Temperature in Celsius, median (IQR)	37.9 (37.2–38.8)	38.2 (37.5–39.4)	.064
Altered mental status, *n* (%)	52 (3)	2 (4)	.421
Chest indrawing, *n* (%)	1128 (54)	16 (35)	.012
Asymmetric breath sounds, *n* (%)	1354 (65)	28 (61)	.583
Wheezing, *n* (%)	840 (40)	11 (24)	.026
PF ratio,[c] median (IQR)	451 (423–474)	462 (445–479)	.033
White blood count,[d] median (IQR)	12 (9–17)	16 (7–20)	.406
Procalcitonin,[e] median (IQR)[f]	0.32 (0.1–1.48)	4.1 (0.99–19.97)	.001
Viral detection, *n* (%)	1490 (71)	32 (70)	.798
Respiratory syncytial virus	584 (29)	10 (22)	.352
Rhinovirus	546 (27)	11 (26)	.811
Human metapneumovirus	260 (13)	7 (16)	.571
Adenovirus	221 (11)	7 (16)	.311
Influenza A or B	140 (7)	4 (9)	.251
Radiographic infiltrate pattern, *n* (%)			.186
Consolidation, single lobar	446 (22)	15 (33)	
Consolidation, multilobar	621 (30)	12 (26)	
Other infiltrate	848 (41)	13 (28)	
Mixed	151 (7)	6 (13)	
Parapneumonic effusion on CXR, *n* (%)	241 (12)	22 (48)	<.001
Empyema with drainage procedure, *n* (%)	76 (4)	8 (17)	<.001
Antibiotics before hospitalization, *n* (%)	528 (25)	12 (26)	.926
Inpatient antibiotics before culture, *n* (%)	484 (21)	4 (9)	.021
Any antibiotics before culture, *n* (%)	866 (41)	15 (33)	.229
Empirical antibiotics, *n* (%)			<.001
Cephalosporin[g]	1154 (55)	12 (26)	
Cephalosporin + vancomycin or clindamycin[g]	356 (17)	20 (43)	
None	308 (15)	3 (7)	
Aminopenicillin	130 (6)	3 (7)	
Other	142 (7)	8 (17)	

CXR, chest radiograph.

[a] Children age 9 mo to 12 y of age that received ≥3 doses of pneumococcal conjugate vaccine.

[b] Sample size: no bacteremia, *n* = 1469; bacteremia, *n* = 32.

[c] Estimated from the P/F (Pao_2Fio_2) ratio.

[d] Cells × 10^3 per mm^3.

[e] Nanograms per milliliter.

[f] Sample size: no bacteremia, *n* = 486; bacteremia, *n* = 16.

[g] With or without a macrolide.

TABLE 2 LOS, ICU Admission, and IMV or Shock for Children Hospitalized With Pneumonia With and Without Bacteremia

Outcomes	No Bacteremia, *n* = 2090	Bacteremia, *n* = 49	Odds Ratio or Hazard Ratio (CI)
Intensive care admission, *n* (%)	441 (21)	20 (43)	5.12 (3.82–6.84)
IMV or shock, *n* (%)	160 (8)	14 (30)	5.28 (2.41–11.57)
Hospital LOS in d, median (IQR)	2.8 (1.8–4.7)	5.8 (2.8–13.4)	0.79 (0.73–0.86)

received third-generation cephalosporin monotherapy (55%) followed by vancomycin or clindamycin plus a third-generation cephalosporin (17%), no therapy (15%), and aminopenicillin monotherapy (6%) (Table 1).

In children with bacteremia, empirical therapy was broadened in 11 (24%) children at initial positive culture report but before final culture speciation. After final speciation and availability of antibiotic susceptibility data, definitive therapy was narrowed as compared with empirical therapy in 31 children (67%), unchanged in 14 children (30%), and broadened in 1 child with Streptococcus *viridans* (2%) isolated in culture. Among *S pneumoniae* isolates, 5% were penicillin resistant and 9% were clindamycin resistant. Among the *S aureus* isolates, 67% were methicillin resistant but none were resistant to clindamycin.

DISCUSSION

In our study, we demonstrated that bacteremia was uncommonly detected among more than 2000 children hospitalized in the United States with clinical and radiographically confirmed CAP. *S pneumoniae* accounted for half of the cases of bacteremia; *S aureus* and *S pyogenes* were less commonly identified. Children with bacteremia had more severe clinical outcomes, including longer LOS, more frequent ICU admission, and IMV and/or shock. The majority of children with bacteremic pneumonia received broad-spectrum empirical antibiotics, although therapy was narrowed in two-thirds of these children after the bacterial pathogens were characterized.

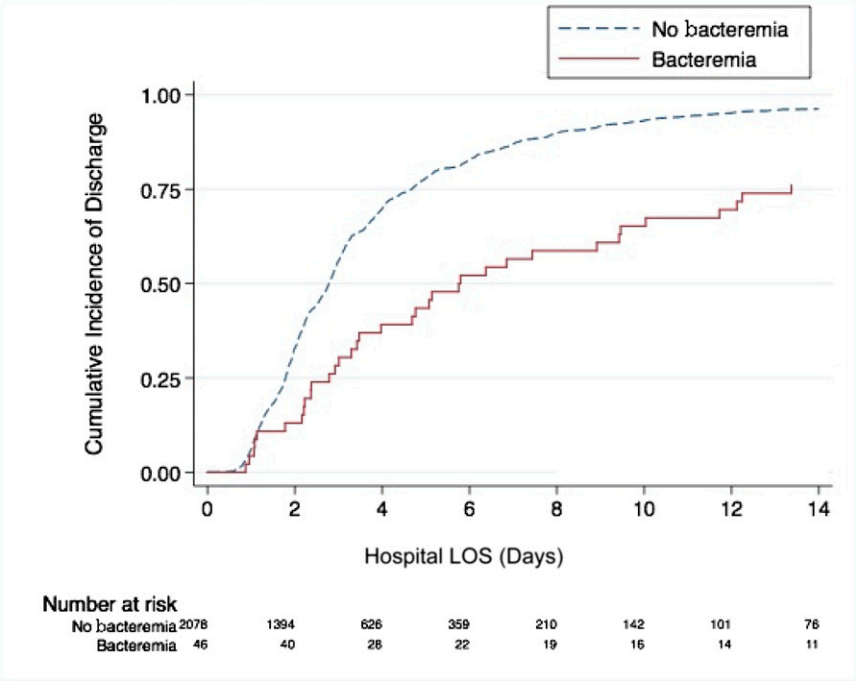

FIGURE 1
Hospital LOS for children hospitalized with pneumonia with and without bacteremia. Time to discharge was modeled by using Cox proportional hazards regression while controlling for demographic variables, number of comorbidities, household smoke exposure, any antibiotics before blood culture, temperature, PF ratio, altered mental status, chest indrawing, asymmetric breath sounds, wheezing, white blood cell count, infiltrate pattern, parapneumonic effusion, and ICU admission.

Authors of previous studies have found a prevalence of bacteremia in children with CAP ranging from 1.1% to 7.1%.[6–10,12,14,18,19] A recent meta-analysis by Iroh Tam et al[5] reported a pooled prevalence of 5.1%. The 2.2% prevalence of bacteremia in our study is lower than that reported by Iroh Tam et al[5] but within the range of other reports. A potential limitation of previous studies, however, is that culture data were only available for a portion of all enrolled children (median: 47%, IQR: 34%–64%). Because cultures were obtained at the discretion of the treating clinician in the majority of studies, blood cultures were likely obtained more often in those with more severe illness or who had not already received antibiotics,[8,12] overestimating the prevalence of bacteremia. Murtagh Kurowski et al[19] found a similar prevalence (2.5%) using systematic blood culture collection as part of quality improvement methodology, but cultures were only available for 79% of patients. In contrast, >90% of children had blood cultures collected in our study, and children with blood cultures were not different from those not cultured, suggesting that the population sampled was unbiased.

Several factors likely contribute to the low prevalence of positive blood culture results in pediatric

TABLE 3 LOS, ICU Admission, and IMV or Shock for Children Hospitalized With Pneumonia by Pathogen

Culture pathogen	*n*	Median LOS (IQR), d	ICU Admission, *n* (%)	IMV and/or Shock, *n* (%)
None	2090	3 (2–5)	441 (21)	160 (7)
S pneumoniae[a]	22	3 (2–9)	6 (27)	4 (18)
S aureus	6	15 (12–20)	6 (100)	4 (67)
S pyogenes	4	14 (10–23)	3 (75)	3 (75)
Other[b]	14	6 (2–9)	5 (36)	3 (21)

[a] Serotypes isolated in bacteremic cases: 19A (*n* = 6, 27%), 7F (*n* = 2, 9%), 31 (*n* = 1, 5%), 11A (*n* = 1, 5%), 15A and 15F (*n* = 1, 5%), 22F (*n* = 1, 5%), 33F (*n* = 1, 5%), and unknown (*n* = 9, 41%). 19A and 7F were included in PCV13.

[b] Viridans group streptococci; group B, C, or G streptococci; *H influenzae*; and *Fusobacterium*.

pneumonia. These include the high burden of viral etiologies of pneumonia,[15] the use of antibiotics before culture,[20] the limited sensitivity of culture-based methods,[21,22] and a marked decrease in the prevalence of bacterial CAP after introduction of the pneumococcal conjugate and *H influenzae* type B vaccines.[5] We found that bacteremia was less commonly detected in children who received inpatient antibiotics before cultures were obtained (0.8% vs 2.5%, $P = .021$).

The 2011 PIDS and IDSA pediatric CAP guideline recommends that blood cultures be obtained in all children hospitalized with moderate to severe CAP,[4] although there is no agreed-on definition of moderate CAP in children. The presence of pleural effusion on chest radiograph is one factor consistently shown to be associated with bacteremic pneumonia, both in our study and in other reports.[9,12,23,24] Previous studies support obtaining cultures in children with effusion, need for ICU care, central line(s), younger age, immunocompromise, or chronic medical conditions.[7,24] We did not find a difference in bacteremia on the basis of age or comorbidities, but it is suggested in our data that the yield of blood cultures could be improved by focusing on children who require ICU admission or have pleural effusion on chest radiograph while still identifying the majority (76%) of bacteremic children. Additionally, in a previous study of children presenting to the emergency department with CAP, researchers found the need to culture 909 children to identify one positive isolate.[25] We estimated a number needed to culture of 24 for children admitted to the ICU and 12 for children with parapneumonic effusion, compared with 91 for children admitted to acute care with no effusion. Therefore, obtaining blood cultures in each of these clinical scenarios seems prudent. Values of the biomarker procalcitonin, associated with bacterial disease,[16] was higher in children with bacteremia in our study. Thus, this information could influence decisions around culturing if results are rapidly available. Risk stratification tools may also prove useful in identifying children with moderate to severe pneumonia who are at increased risk for bacterial CAP.[26]

Broad-spectrum empirical antibiotics were commonly used before availability of culture results in children who ultimately proved to have bacteremia and included coverage for *S aureus* more often than in nonbacteremic children, likely because of severe illness at presentation. Nonetheless, penicillin-susceptible *S pneumoniae* was the most common etiology of bacteremic CAP, and definitive antibiotic therapy was ultimately narrowed in two-thirds of bacteremic children. The frequent use of a cephalosporin in both groups is likely because these data were collected from 2010 to 2012, before widespread adoption of the IDSA's recommendation for aminopenicillin monotherapy in CAP. Our findings are similar to those reported by Neuman et al,[10] in which it was demonstrated that the majority of pathogens recovered in children with bacteremic CAP was penicillin susceptible. Taken together, these 2 studies support the 2011 PIDS and IDSA guideline recommendation for the use of narrow-spectrum aminopenicillins in children hospitalized with suspected bacterial CAP.[4]

Although limited by small sample size, our analysis examining outcomes by pathogen suggested that children with bacteremia due to *S aureus* and *S pyogenes* experienced increased morbidity, including longer LOS, increased frequency of ICU admission, and IMV and/or shock, compared with children with *S pneumoniae*.

Several limitations must be kept in mind when interpreting the results of this study. Although this is one of the largest, most comprehensive studies to date in which researchers have assessed the microbiologic etiology and burden of bacteremic CAP in US children, the sample size of children with bacteremia was limited. This precluded more robust analyses examining risk factors associated with bacteremia as well as our pathogen-specific analyses. Because a quarter of children received inpatient antibiotics before blood culture collection, the prevalence of bacteremia may be underestimated and certain risk

factors may not be identified because of misclassification bias. However, sensitivity analyses excluding patients who received antibiotics before culture did not differ substantially, suggesting limited impact of this bias (Supplemental Ta bles 6 through 9). The use of blood culture rather than the more-sensitive method of whole-blood polymerase chain reaction also likely results in underestimation of true bacteremia prevalence.[15] Additionally, cultures were not obtained on all patients. However, if selection bias does exist, the influence on outcomes is likely minimal given the low percentage (8%) of patients without culture data. We were unable to determine the rate of false-positive blood culture results, relationship between the time of ICU admission and positive blood culture results, specific serotypes of *S pneumoniae* that caused bacteremia, or differences in cultures obtained for clinical versus research purposes because of lack of availability of these data. Finally, our study was conducted within 3 tertiary care children's hospitals in the United States, and these findings may not be generalizable.

CONCLUSIONS

Blood culture results identified a causative pathogen in only 2.2% of children hospitalized with CAP, and culture results were more often positive in those with parapneumonic effusions on chest radiograph and those with severe disease requiring ICU care. Penicillin-susceptible *S pneumoniae* was the most common cause of bacteremic CAP in our study, supporting the existing recommendation for empirical use of narrow-spectrum aminopenicillins for most children hospitalized with suspected bacterial CAP. In an era with widespread pneumococcal vaccination and low prevalence of bacteremia in the United States, children admitted with CAP that have pleural effusion or require ICU admission may represent a high-yield population for identifying bacteremia.

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ABBREVIATIONS

CAP: community-acquired pneumonia
CI: confidence interval
EPIC: Etiology of Pneumonia in the Community
IDSA: Infectious Diseases Society of America
IMV: invasive mechanical ventilation
IQR: interquartile range
LOS: length of stay
PIDS: Pediatric Infectious Diseases Society
P/F Ratio: Pao_2FIo_2 ratio

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