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Authors
Light, Jennifer K.
Hoelle, Robyn M.
Herndon, Jill Boylston
et al.

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Emergency Department Crowding and Time to Antibiotic Administration in Febrile Infants

Jennifer K. Light, MD*
Robyn M. Hoelle, MD*
Jill Boylston Herndon, PhD†
Wei Hou, PhD‡
Marie-Carmelle Elie, MD*
Kelly Jackman, PhD*
J. Adrian Tyndall, MD, MPH*
Donna L. Carden, MD*

* University of Florida, College of Medicine, Department of Emergency Medicine Gainesville, Florida
† University of Florida, College of Medicine, Institute for Child Health Policy, Department of Health Outcomes and Policy, Gainesville, Florida
‡ Stony Brook University Medical Center, Division of Epidemiology, Department of Preventive Medicine, Stony Brook, New York

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Introduction: Early antibiotic administration is recommended in newborns presenting with febrile illness to emergency departments (ED) to avert the sequelae of serious bacterial infection. Although ED crowding has been associated with delays in antibiotic administration in a dedicated pediatric ED, the majority of children that receive emergency medical care in the United States present to EDs that treat both adult and pediatric emergencies. The purpose of this study was to examine the relationship between time to antibiotic administration in febrile newborns and crowding in a general ED serving both an adult and pediatric population.

Methods: We conducted a retrospective chart review of 159 newborns presenting to a general ED between 2005 and 2011 and analyzed the association between time to antibiotic administration and ED occupancy rate at the time of, prior to, and following infant presentation to the ED.

Results: We observed delayed and variable time to antibiotic administration and found no association between time to antibiotic administration and occupancy rate prior to, at the time of, or following infant presentation ($p>0.05$). ED time to antibiotic administration was not associated with hospital length of stay, and there was no inpatient mortality.

Conclusion: Delayed and highly variable time to antibiotic treatment in febrile newborns was common but unrelated to ED crowding in the general ED study site. Guidelines for time to antibiotic administration in this population may reduce variability in ED practice patterns. [West J Emerg Med. 2013;14(5):518–524.]

INTRODUCTION

Emergency department (ED) crowding has become a prominent public health concern, compromising patient safety and the delivery of emergency medical care.[1-11] Children are at particular risk for poor outcomes because not all EDs have the requisite skills, staffing, and equipment necessary to comprehensively treat pediatric emergencies.[1,12] The majority of children in the U.S. are treated in general, community EDs with a minority cared for in a dedicated pediatric ED.[12-14] It has been suggested that children may be vulnerable to delays in treatment in the crowded general ED if time-sensitive quality performance indicators for adults take precedence over the treatment of children.[13] Although less likely, concerns have also been raised that pediatric patients may suffer delays in emergency medical care due to the need for age- and weight-specific medication administration by providers unfamiliar with pediatric dosing regimens.[13] Despite concern over the potential effect of ED crowding on children, few studies have addressed the impact of crowding on pediatric outcomes specifically.[13,15,16]

The febrile infant ≤ 28 days of age represents a clinical challenge due to the immaturity of the newborn's immune system and the potential for serious infection without clinical signs of illness.[17] Despite a normal examination, approximately 10% of these children may have a serious bacterial infection, including up to 3% with meningitis or bacteremia.[18-20] Thus, these infants may be at increased risk for adverse outcomes if delays in treatment occur due to ED crowding. Although specific guidelines for timing of antibiotic administration in this population do not exist, it is well established that early antibiotic administration reduces morbidity and mortality in patients with sepsis, especially in immune compromised children with fever.[21-25] One single-site study suggested that febrile infants ≤ 28 days of age be given antibiotics within 120 minutes of ED triage to prevent morbidity associated with serious bacterial infection.[26] Although delays in antibiotic administration have been reported in this population,[16,26] the relationship between crowding in the general ED, where the majority of children receive emergency care, and time to antibiotic administration has not been examined.[16] The purpose of this study was to test the hypothesis that crowding in a general ED is associated with prolonged time to antibiotic administration in febrile newborns.

METHODS

Study Design and Setting

Researchers performed a retrospective review of the electronic medical record (EMR) of all infants ≤ 28 days of age who were admitted to the hospital from the ED with a chief complaint of fever, respiratory or gastrointestinal symptoms or a final ED or hospital diagnosis of fever, pneumonia, urinary tract infection, pyelonephritis, meningitis, peritonitis, cellulitis, sepsis, severe sepsis, septic shock, bacteremia, other infections specific to the perinatal period, congenital pneumonia or omphalitis of the newborn from October 1, 2005 to July 1, 2011.

The study site is a tertiary-care, university hospital and Level I Trauma Center located in the Southeastern United States. The hospital contained 740 beds in 2005 and 850 beds in 2011. The study site is located in a moderately-sized urban community with a county-wide population of approximately 250,000. The ED annual patient census was 43,000 in 2005, increasing to 80,000 visits in 2011. The ED serves a mostly White (62%) population with a range of payer sources (40% public, 36% private and 24% uninsured), and children comprised 20% of the general ED patient population from 2005-2011. During the study period, the ED provided treatment to pediatric and adult emergencies.

Sample Size Determination

Based on a pediatric ED study in which hourly boarding was associated with significantly delayed antibiotic administration (adjusted R^2 of a multiple regression model = 0.153),[16] a sample size of 80 infants was required to detect an $R^2 = 0.15$ or higher for a multiple regression model with 5 predictors between time to antibiotic administration and ED crowding with a power of 80% and significance set at 0.05.

Selection of Participants

Inclusion Criteria

Infants ≤ 28 days of age admitted through the ED with the previously defined ED chief complaints or final ED or hospital diagnoses were eligible for study inclusion.

Exclusion Criteria

Newborns who did not receive parenteral antibiotics in the ED or whose time to antibiotic administration was not recorded in the EMR were excluded from analysis.

Study Protocol

Data collection was performed by 4 trained abstractors. At least 2 abstractors reviewed each infant chart, and discrepancies were resolved by consensus. For each infant ED visit, the following time-related data elements were extracted from the EMR through the hospital's information system or by abstractor review: (1) date and time of arrival; (2) date and time of triage; (3) date and time seen by a physician; (4) date and time antibiotic ordered; and (5) date and time antibiotic administered. Demographic and clinical data collected from the EMR included age (in days), gender, race, payer category (Medicaid, private or uninsured), initial temperature, triage severity score, chief complaint, ED and hospital discharge diagnosis, hospital length of stay and inpatient mortality. Crowding measures for the 6 hours prior to, the hour of, and 4 hours following infant arrival were obtained from the ED's information system designed for operational monitoring.

Measures

Predictor Variables

We determined ED occupancy rate by dividing the ED hourly census, regardless of patient location, by the total number of licensed ED treatment bays (which exclude hallways).[27] Occupancy rates were calculated at the top of the nearest hour, based on time of infant arrival. ED occupancy rate is a simple, reproducible and validated measure of ED crowding that has been identified as a preferred method for comparing crowding across treatment sites.[27]

A limitation of prior studies that link crowding to patient outcomes is that most studies report crowding as a static measure at a single point in time.[16,28] In fact, ED crowding is a dynamic measure that may vary substantially prior to or during a patient's ED encounter, thereby affecting quality of care and outcomes.[28] To determine the effect of changes in crowding on time to antibiotic administration, our study assessed occupancy rate at the top of each hour for the 6 hours prior to, the hour of, and 4 hours following infant presentation.

Outcome Variables

Consistent with previous reports, the primary outcome is defined as time from infant arrival to antibiotic administration.[16] Additional timeliness-of-care measures were recorded so that if delays in care were observed, it would be possible to assess at what stage(s) in the care process delays occurred and to target quality improvement initiatives accordingly. Timeliness-of-care measures were (1) time from arrival to triage, (2) time from triage to physician assessment, (3) time from physician assessment to antibiotic order, (4) time from antibiotic order to drug administration and (5) time from triage to antibiotic administration.[16,26]

Secondary Outcome Measures

To examine the potential effect of delays in processes of care on time to ED drug treatment, we determined the association of each of the timeliness-of-care measures on time to antibiotic administration. To examine the effect of time to ED treatment on patient outcome, the association of time to antibiotic administration with hospital length of stay and inpatient mortality was determined.

Analysis

We calculated frequency distributions for categorical variables and medians and ranges for continuous variables. Bivariate analysis using Spearman correlation coefficients were calculated to test the association between ED occupancy rate prior to, at the time of, and after infant arrival with time to antibiotic administration and the timeliness of care measures. We developed multiple linear regression models for time to antibiotic administration and timeliness of care measures to control for patient age, triage severity score, and time of infant arrival (day, afternoon or night) as previously described.[16] We also conducted bivariate analysis to test the association between time to antibiotic administration and the timeliness-of-care measures, as well as length of hospital stay. Occupancy rate and time to antibiotic administration were positively skewed and therefore, the analysis was focused on the median rather than the mean rates and times. We considered a p-value < 0.05 statistically significant. The statistical software JMP v9.2 (SAS Institute, Cary, North Carolina) was used for the analyses. The institutional review board of the study site approved the study in advance.

RESULTS

Characterization of Study Subjects

One hundred ninety newborns admitted through the ED during the study period met the chief complaint or discharge diagnosis eligibility criteria. Of these, 31 were excluded due to: (1) failure to receive antibiotics during the ED encounter (22 infants); (2) the time of antibiotic administration was not recorded in the EMR (2 patients); or (3) age > 28 days at the time of ED presentation (7 infants). Baseline characteristics of the study population (159 infants) are outlined in Table 1.

Table 1. Patient characteristics and presenting complaints.

Sample size	159
Age in days (mean ±SD)	15.4±8
Gender (number of males, %)	89 (55%)
Race (n, %)	
White	105 (66%)
Black	30 (18%)
Other	24 (16%)
Payer status (n, %)	
Medicaid	71 (45%)
Private	26 (16%)
Uninsured	62 (38%)
Chief complaint	
Fever	103 (65%)
Respiratory complaint	18 (11%)
Gastrointestinal complaint	9 (6%)
Other	29 (18%)

SD: Standard Deviation

Main Results

Effect of Occupancy Rate on Time to Antibiotic Administration

Table 2 summarizes the results of the bivariate analyses examining the association between occupancy rate and time to antibiotic administration. Median occupancy rate on infant arrival was 75.4% (range 25.5-161.3%). Median time from infant arrival to antibiotic administration was 216 minutes (range 43-848 minutes) and was not significantly associated with occupancy rate at the time of infant presentation (p>0.05) (Table 2) or to occupancy rate in any of the 6 hours prior to or 4 hours following patient arrival (all p>0.05). When adjusted for patient characteristics, only triage severity on infant arrival had a significant positive association with overall time to antibiotic administration (R^2 0.07, p<0.02).

Table 2 also summarizes the results of bivariate analyses examining the association between occupancy rate and other timeliness-of-care measures. There was marked variation in all timeliness-of -care measures. Time from infant arrival to triage ranged from 0-102 minutes and time from physician assessment to antibiotic order ranged from 3-494 minutes. With the exception of time from triage to physician assessment, occupancy rate prior to, at the time of, or following infant presentation was not significantly associated with timeliness-of-care measures in bivariate tests (all p>0.05). There was a positive and significant association between time from triage to physician assessment and occupancy rate at the time of (r=0.2, p =0.005) and for the 4 hours after infant arrival (Table 2). Timeliness-of-care measures did not have a statistically significant relationship with occupancy rate in models adjusted for patient age, triage severity, or time of arrival (all p>0.05) (data not shown).

Table 2. Correlation of timeliness-of-care measures with overall time to antibiotic administration and emergency department (ED) occupancy rate. Time to antibiotic administration is defined as the time in minutes from infant arrival to antibiotic administration. Non-significant (NS) at p>0.05. T-6 represents hour 6 prior to infant presentation; T0 represents time of infant arrival and T+4 represents hour 4 following infant arrival.

Timeliness-of-care Time in minutes (range)	Correlation with time to antibiotic administration r (significance)	Correlation with ED occupancy rate before, at the time of, and following infant arrival	r (significance)
Infant arrival to triage 21 (0-102)	r=0.1 (ns)	T-6 T 0 T+4	r=0.0 (ns) r=0.1 (ns) r=0.1 (ns)
Triage to physician assessment 8 (-78-208)	r=0.5 (p<0.0001)	T-6 T 0 T+4	r=0.1 (ns) r=0.2 (p=0.005) r=0.2 (p=0.0027)
Physician assessment to antibiotic order 85 (3-494)	r=0.8 (p<0.0001)	T-6 T 0 T+4	r=0.0 (ns) r=0.0 (ns) r=0.0 (ns)
Antibiotic order to administration 64 (48-333)	r=0.4 (p<0.0001)	T-6 T 0 T+4	r=0.0 (ns) r=0.0 (ns) r=0.0 (ns)
Triage to antibiotic administration 187 (25-817)	r=0.9 (p<0.0001)	T-6 T 0 T+4	r=0.0 (ns) r=0.0 (ns) r=0.0 (ns)
Time to antibiotic administration 216 (43-848)		T-6 T 0 T+4	r=0.0 (ns) r=0.1 (ns) r=0.0 (ns)

Effect of Timeliness of Care Measures on Time to Antibiotic Administration

With the exception of time of arrival to infant triage, there was a significant association between each of the timeliness-of-care measures and overall time to antibiotic administration (all $p<0.0001$) (Table 2). Time from physician assessment to antibiotic order accounted for the greatest variability in time to ED antibiotic administration ($R^2 = 0.58$, $p<0.0001$) (Table 2).

Effect of Time to Antibiotic Administration on Patient Outcome

There was no association between time to antibiotic administration and overall length of hospital stay (median 2 days; range 1-45 days) ($r = 0.0$; $p>0.05$) and there were no inpatient deaths in the study population.

DISCUSSION

Dramatic increases in ED crowding have occurred over the past 2 decades associated with patient and provider dissatisfaction, treatment delays, and patient mortality.[1-11,29] Although the Institute of Medicine identified the impact of ED crowding on children as a priority research area, few studies have examined the relationship between ED crowding and pediatric specific outcomes.[12-16] We undertook this investigation to examine the relationship between time to antibiotic administration in febrile newborns and crowding in a general ED. The results of this study demonstrate that delays in antibiotic administration are common in febrile neonates presenting to the general ED, but these delays do not appear to be related to ED crowding. To evaluate the robustness of this finding, we tested occupancy rate measured at different points before, during, and after infant presentation. We were unable to detect a significant correlation between occupancy rate and the primary outcome measure of time from infant arrival to antibiotic administration. The results of this study address a significant gap in the literature by examining the dynamic effect of ED crowding on time to antibiotic administration in febrile newborns. Further, the majority of children in the U.S. receive emergency care in facilities treating both adult and pediatric populations.[12-14] Our results are relevant to the emergency care received by most children in that we report the effect of ED crowding on time to antibiotic administration in an ED treating both adults and children.

Although we documented prolonged and variable time to antibiotic administration in this study, we did not detect an association between delayed antibiotic administration and length of hospital stay in these children. Further, there was no inpatient mortality in this cohort. This finding is consistent with the decreasing trend in mortality of all infants presenting with febrile illness and sepsis in the U.S. Other, more sensitive, determinants of patient outcome may be necessary to fully examine the potential effect of delays in ED treatment on the outcome of neonatal sepsis.

Although it is important to evaluate the impact of ED crowding on pediatric outcomes, these evaluations need to be considered in the context of initiatives that improve the quality of ED care delivered to children. For example, although Sills et al[15] found an inverse relationship between crowding and good quality care, they also reported an adjusted relative risk of receipt of good quality fracture care that was less than 20% during the least crowded conditions.Thus, focus on lower quality care during periods of greatest crowding may obscure the more significant issue that most children did not receive good quality fracture care, even when the pediatric ED was least crowded.[15]

The delayed and variable time to antibiotic administration reported in this and other investigations may speak to the need for improvement in ED quality-of-care processes for children, regardless of crowding conditions.[16,26] In this context, it is noteworthy that with the exception of time from infant arrival to triage, each of the process-of-care measures was positively and significantly associated with time to antibiotic administration. Importantly, time from physician assessment to placement of antibiotic order accounted for the greatest variability in overall time to antibiotic treatment. Ensuring emergency physicians recognize neonatal sepsis and are aware of treatment recommendations in newborns with fever or other presenting complaints may impact time to treatment. In addition, in regression models adjusted for patient characteristics, time to antibiotic administration was significantly associated with triage severity score at infant presentation. These results suggest that ensuring febrile newborns are assigned an emergent triage classification may reduce time to antibiotic administration.

The prolonged time to antibiotics observed in very young febrile infants suggests there may be a need for clear guidelines for timing of antibiotic administration in these children.[16,26] Although infants > 28 days and older children with low risk of serious bacterial infection can be successfully identified through careful screening procedures,[30-32] these screening protocols are not sufficiently sensitive in infants ≤ 28 days of age to detect serious bacterial infection.[19,33] Although controversy exists regarding routine use and timing of antibiotic administration,[34] investigators have demonstrated adverse outcomes in children with serious infection secondary to delayed antibiotic administration.[23] Taken together, the existing evidence suggests that the risk of serious bacterial infection in very young infants may be present without clinical signs of illness and that adverse outcomes may be associated with delays in appropriate antibiotic therapy. Although current recommendations suggest that infants 28 days of age and younger with fever require *immediate* empirical antibiotic administration, clearly defined time-to-treatment guidelines do not exist. [17-20,25,26]

Physician adherence to clinical practice guidelines in the ED is historically poor.[35] This may be in part a consequence of the perception that guidelines are cumbersome and time-consuming.[35] However clinical practice guidelines are designed to communicate the best available evidence to busy clinicians and if used effectively, reduce variations in healthcare practice. Examples of successful quality improvement initiatives in emergency care have been published. For example, clinical guidelines have been used in a pediatric ED to improve the efficient treatment of acute exacerbations of childhood asthma.[35] Further evidence of the benefit of treatment guidelines is provided by findings from a pilot quality improvement project in which investigators reported decreased time to antibiotic administration and an increased proportion of children receiving antibiotics in response to newly established quality guidelines.[36] Of particular relevance to the present study, an ED quality improvement process reduced time to antibiotic administration by 25% in febrile infants less than 3 months of age.[26] Thus, clinical guidelines may improve timeliness of care and may also remove observed variation in processes of care.

LIMITATIONS

A limitation of this investigation is the fact that long-term patient follow up was not possible because many children had inconsistent or no subsequent care at the study institution. Further, time to antibiotic administration was determined in one ED treating adult and pediatric emergencies and therefore, the results may not be generalizable to all general and community EDs, particularly those with protocols to initiate pediatric consultation immediately after ED physician evaluation. However, the prolonged and variable time to antibiotics reported here is similar to a recent study in a pediatric ED[16] and suggests that delayed and variable time to antibiotic administration may be a pervasive problem in this population. Importantly, although time from physician assessment to placement of antibiotic order accounted for much of the variation in time to ED treatment in this study, the reasons for the observed variations in practice patterns are not clear. Our models explained only some of the observed variation in time to antibiotic administration, suggesting that undefined confounding variables influence this measure. Some have reported that differences in provider experience and confidence in recognizing serious bacterial infection[37] and variations in clinical presentation and illness severity of the child may account for variations in clinical practice.[38]

CONCLUSION

The results of this investigation demonstrate that prolonged and highly variable time to antibiotic administration was common in very young infants with fever presenting to a general ED. Time to antibiotic administration was not significantly associated with ED crowding before, during, or after infant presentation. Importantly, time to ED antibiotic administration in febrile newborns was significantly associated with several processes-of-care measures and patient characteristics, including time from physician assessment to placement of drug order and infant Emergency Severity Index (ESI). Efforts to raise awareness of the emergent nature of neonatal fever and guidelines on time to ED antibiotic treatment in this population merit consideration.

Address for Correspondence: Donna L. Carden, MD. Department of Emergency Medicine, 1329 SW 16th Street, PO Box 100186, Gainesville, FL 32610. Email: dcarden@ufl.edu.

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