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Presenting Signs and Symptoms of Rapidly Progressing Severe Pneumonia in the Pediatric Emergency Department

Porter Moore C*, Craig Huang, Adriana Rodriguez, Robert Wiebe and Jane Siegel

Department of Pediatrics, Divisions of Emergency Medicine and Infectious Disease, UT South Western Medical Center Dallas, Children's Medical Center Dallas, USA

Abstract

Background: Children with pneumonia are often diagnosed in the emergency department based on clinical and/or radiographic findings. Many of these patients can be treated as outpatients. However, patients with severe pneumonia often require Intensive Care Unit (ICU) admission and have significant morbidity. There is no published data to aide in rapid identification of children with severe pneumonia who require ICU admission.

Objectives: To identify clinical variables, laboratory and radiographic data that may predict the need for ICU admission.

Methods: Retrospective analysis of ED patients aged 0 to 18 years, admitted to a tertiary pediatric hospital with a diagnosis of severe pneumonia between 2002 and 2007 was performed. Severe pneumonia was defined as: empyema and/or pleural effusion. Patients were assigned into two cohorts: 1) admitted to the ICU and 2) admitted to general inpatient unit. Patients with significant past medical history were excluded. Demographic information, signs, symptoms, laboratory, and radiographic data were collected and compared. The Student *t*-test was used to compare the means for continuous variables and Chi Square for categorical variables.

Results: Patients admitted to ICU (n=113) had similar symptoms compared with the non ICU admission group (n=180), however the ICU cohort presented with a more acute onset of illness with significantly fewer days of fever and cough prior to presentation. They were also significantly more tachypenic and tachycardic on presentation. Laboratory analysis found the ICU patients had significantly greater bandemia with mean band count of 20.4 (95% CI 17.0, 23.8) compared to 11.8, (95% CI 9.8, 13.7). The general inpatient pneumonia patients had significantly higher mean platelet counts at 389 (95% CI 364,414) versus the ICU patients at 304 (95% CI 276, 332) as well as ESR values at 79 (95% CI 73, 85) versus the ICU patients at 58 (95% CI 49, 67).

Conclusions: This data suggest that children with severe pneumonia with rapid illness onset and bandemia are at higher risk for ICU admission. More insidious onset, elevated platelet counts and ESR may predict a more stable course of illness. Continued analysis of these variables may be helpful in constructing a diagnostic algorithm for pediatric pneumonia patients at presentation, facilitating earlier detection, treatment, and appropriate in-patient disposition.

Keywords: Severe pneumonia; Radiographic data; Pediatric pneumonia

Introduction

Pneumonia has been a long standing cause of morbidity and mortality in the pediatric population. Pneumonia is the most common cause of hospitalization of children [1], and the leading infectious cause of death in the United States.

The presentation and diagnosis of pneumonia has been widely studied in adults. In 1997 Fine et al. published a prediction rule to identify low-risk patients with community-acquired pneumonia in adults [2]. The Pneumonia Severity Index, (PSI) was developed from the prediction rule and now can be calculated with handheld software. This prediction rule utilizes multiple factors: gender, age, co morbidities, physical examination findings, laboratory and radiographic studies as well as whether or not the patient lives in a nursing home. The pneumonia severity index (PSI) has been rigorously studied and validated [3-7]. Initially utilized as a prognostic indicator, the PSI has become an accepted tool to aid disposition from the Emergency Department (ED) and outpatient clinics for adults presenting with community-acquired pneumonia.

A significant percentage of pediatric patients with community acquired pneumonia present for evaluation through the emergency department. In 1997 a Canadian task force established guidelines noting the absence of respiratory distress, tachypnea, crackles and diminished breath sounds to be specific enough to rule out pneumonia [8,9]. Rigorous evaluation by Rothrock et al. [10] determined these evidencebased guidelines to be unreliable in excluding those pneumonia-free patients.

Of pediatric hospital admissions, a subset with severe pneumonia has rapid clinical deterioration and requires intensive care. This group of patients is often radio graphically indistinguishable from their clinically-stable counterparts. Early recognition of this vulnerable group of patients may reduce pediatric morbidity and mortality. No published data exists to aid in the rapid identification of children with severe pneumonia who require ICU admission. There is no PSI valid for pediatric populations.

We undertook a retrospective analysis to determine if there were clinical or laboratory determinants that would identify previously healthy patients requiring ICU admission. Examining clinical and laboratory variables in these patients with radiographic evidence

*Corresponding author: Porter Moore C, Department of Pediatrics, Divisions of Emergency Medicine and Infectious Disease, UT South Western Medical Center Dallas, Children's Medical Center Dallas, USA, E-mail: Porter.Moore@cookchildrens.org

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of severe pneumonia with empyema or effusion, we had hopes of generating a pediatric prediction rule for those requiring intensive care admission at our tertiary care center.

Methods

A cohort of patients 2 months-18 years of age seen in a tertiary care free-standing children's hospital ED diagnosed with severe pneumonia from 2002-2007, was examined. Retrospective review was IRB approved. Severe pneumonia was defined by pulmonary infiltrates with empyema or effusion as determined by radiological evaluation on presentation to our pediatric ED.

Patients were excluded if they were directly admitted to the hospital, bypassing the ED or had significant past medical history, including history of:

- Prematurity (born at less than 36 weeks gestation)
- congenital anomalies including: metabolic, chromosomal, cardiac, pulmonary, facial/airway anomalies, diaphragmatic hernia, etc.
- hydrocephalus with VPS
- sickle cell disease
- immunocompromised state
- neuromuscular disease
- HIE/neurodevastation
- Tracheosotmy dependent
- rheumatologic disease including Lupus, JRA, mixed connective tissue disorder
- spinal cord lesion
- witnessed aspiration
- Pulmonary disease including: CF, chronic lung disease, asthma/reactive airway disease with any recent activity

The remaining patients with radiographically- determined severe pneumonia was assigned to one of two groups: one group of patients admitted to the ICU, and the other group were pneumonia patients admitted to the general pediatric ward. Demographic information, signs, symptoms, laboratory and radiographic data were compared. Continuous variable means were compared using a student *t*-test. Categorical variables were compared using a chi square analysis.

Results

Charts were retrieved based on International Classification of Disease-9 codes for pneumonia. After exclusion for past medical history or direct admission without transit through the emergency department, there were 180 patients with severe pneumonia admitted to the general inpatient floor and 113 requiring PICU admission. Standard criteria for PICU admission include cardiovascular compromise requiring vasopressor support and/or respiratory compromise requiring significant ventilatory or oxygenation support. In this particular tertiary children's hospital, the need for positive pressure ventilation necessitates PICU admission.

The demographics between patients admitted to the general pediatrics ward and PICU are shown in table 1, of note, the average age was not significantly different between the groups.

Table 2 shows the historical variables of cough and fever duration. In those patients presenting with cough and/or fever, these were both significantly of shorter duration prior to presentation in the ICU cohort, with the average cough lasting 5.7 (standard deviation of 6) days prior to presentation in the ICU group versus 7.4 (standard deviation of 6.5) days prior to presentation in the general inpatient group. Also, of note

the ICU cohort reported, on average two fewer days of febrile illness preceding their ER presentation with an average of 4.2 days of fever (SD 3.5) versus the general inpatient with 6.3 ± 4.7 days of fever.

The clinical variables examined included basic vital signs (temperature, heart rate, respiratory rate, blood pressure) and documentation of physical signs/symptoms of respiratory distress by either the nurse, resident, or attending physician who assessed the patient in the ED. The ICU cohort was more likely to be in respiratory distress on presentation to the ED (Table 3). The relative risk of ICU admission in patients with respiratory distress is 1.77. These patients were not more likely to be febrile on their presentation to the ED, although we did not control for antipyretic use prior to presentation. The ICU cohort were also more likely to be tachycardic and tachypenic than their general inpatient counterpart (Figure 1). Relative risk of tachycardia and tachypnea for ICU admission was 1.58 and 1.34 respectively. Patients admitted to the general inpatient unit were more likely to have a widened pulse pressure, (50.6% of these patients), determined by noninvasive methods, as compared to the ICU cohort (20.4% patients).

Table 4 shows the results of complete blood count (CBC) obtained on presentation in 111/113 (98%) of our ICU patient cohort and 162/180 (90%) of the general inpatient ward cohort. The ICU cohort demonstrated significantly higher band counts than the general

	Floor n=180	ICU n=113	
% male	62	56	
Mean age (years)	4.0 [sd 4.0, 95%Cl 3.9-5.0]	4.4 [sd 3.7, 95%Cl 3.3-4.8]	
% black	18	24	
% Hispanic	33	26	
%other/white	8	5	

Table 1: Demographics.

	ICU	General Inpatient	P value
Cough duration(days)	5.7 ± 6.0	7.4 ± 6.5	0.0377
Fever duration(days)	4.2 ± 3.5	6.3 ± 4.7	<0.0001

Table 2: Historical variables.

	ICU	General Inpatient	p value
Temp @ presentation	37.4 ± 1.1	37.5 ± 1.1	0.47
% of patients in resp. distress	88.5	50	<0.0001

Table 3: Clinical Variables.



inpatient group. The general inpatient cohort had a significantly higher thrombocytosis.

Inflammatory indices were assayed in some of the patients. The C- reactive protein (CRP) values did not differ significantly between the ICU cohort (91 patients tested=91/113=80.5%) and the general inpatient cohort (129 patients tested=129/180=71.7%) (Table 5) The Erythrocyte Sedimentation Rate (ESR) assayed in 69/113=61% of ICU patients was on average 57.8, significantly lower than the general pediatric average value of 78.2 in 110/180=61%.

Discussion and Conclusions

This study retrospectively examined patients without significant past medical history who initially presented to a pediatric tertiary care emergency department with severe pneumonia from 2002-2007. Severe pneumonia was defined radiographically in this study as pulmonary infiltrates with empyema or effusion. All patients in this study were admitted to the hospital for inpatient therapy. Our interest in these patients initially developed from an apparently common presentation of rapid cardiorespiratory decompensation. We hoped to determine and characterize particular presenting signs and symptoms that might predict a critical care unit admission.

Our analysis reveals that patients requiring ICU admission reported rapid onset of illness. Clinical history reveals a shorter pre-presentation duration of illness with approximately two fewer days of cough and fever. This suggests that these patients got sicker faster. The ICU cohort was more likely to be tachycardic, tachypneic, and manifest respiratory distress on presentation. This seems logical in that sicker patients generally require a higher level of care. Blood pressure measurements, when normalized for age, demonstrated that the general inpatient floor patients were more likely to demonstrate widened pulse pressures while the ICU cohort was more likely to be normotensive. Possible explanation for this disparity might be attributable to the volatile nature of non-invasive blood pressure measurements. Moreover, since children are more likely to remain normotensive from compensatory mechanisms, blood pressure is an inconsistent predictor of clinical outcome based on their initial ED presentation.

The ICU cohort did not have statistically significant differences in white blood cell counts, or hemoglobin/hematocrit measurements. The ICU cohort had significantly higher average white blood cell band form counts, as well as lower platelet counts. However, the average number of segmented neutrophils (segs) was significantly higher in the general inpatient cohort. Possible explanations include differences in the two cohort's bone marrow activity, pathogenic organism causes, or contributions from cytokines and the systemic inflammatory response. It seems logical that the sicker patients would exhibit higher

	ICU (n=111)	General Inpatient (n=162)	p value
WBC	18.1 ± 11.7	21.2 ± 25.5	0.22
Bands	20.4 ± 18.1	11.8 ± 12.8	<0.0001
Segs	50.5 ± 21.7	62.6 ± 15.6	<0.0001
Hbg	10.8 ± 2.0	11.1 ± 1.4	0.21
Hct	32.0 ± 5.5	32.8 ± 3.9	0.15
Plts	304 ± 149	389 ± 169	<0.0001

Table 4: CBC.

	ICU N=113	General Inpatient N=180	р
CRP	19.9 ± 12.3 [n=91]	17.9 ± 11.0 [n=129]	0.206
ESR	57.8 ± 37.1 [n=69]	78.2 ± 31.6 [n=110]	<0.0001

Table 5: Inflammatory indices.

band counts. In a meta-review, Joanne Cornbleet examined the clinical utility of the band count, and determined the count was in imperfect laboratory test and could find no evidence for its clinical utility in patients older than three months of age [11]. We are uncertain about the prognostic significance of these hematologic differences.

Inflammatory indices of CRP and ESR were checked in several patients although their role is still controversial in children. Studies have reported elevated C- reactive protein (CRP) measurement in adults with higher pneumonia severity index scores [12]. However, in our pediatric pneumonia patients, we found no differences in CRP between the ICU and general inpatient cohort. The Erythrocyte Sedimentation Rate (ESR) however, was significantly higher in the general inpatient unit group. The difference may be due to their longer duration of illness, marked by a longer duration of cough and fever or potentially their presentation at a later phase of inflammation than the ICU patients. Currently, there are no studies that clearly define the role any inflammatory markers play in the clinical disposition of pediatric patients from the emergency department. Prospective research with regards to its clinical prognostic significance should be undertaken in light of this retrospective data. Finally, our study was underpowered to determine the predictive contributions of blood gas analysis, as it was not broadly utilized in our patients. Prospective studies are needed to elucidate the utility of blood gas analysis in these patients.

Limitations of this study include its retrospective nature, as certain interpretations are made based on clinical documentation and not realtime evaluation of the patients. Furthermore, in the case of laboratory studies, it is impossible from this retrospective analysis to ascertain why particular patients had certain tests ordered while others did not. We also did not take into account those patients with any past medical history in order to determine risk factors in otherwise healthy patients. Our study protocol eliminated a significant population of patients with pneumonia who presented through our emergency department. This at-risk population is paramount in establishing a decision rule if one intends to validate a decision rule in the pediatric population similar to the PSI.

We believe a pediatric pneumonia clinical prediction rule similar to the PSI can be developed and prospectively validated based on the retrospective analysis of 293 previously healthy patients that presented to our ED with severe pneumonia. Patients with significant medical history will be important in defining the risk associated with particular conditions, to parallel with the adult pneumonia severity index. Initial clinical history/physical examination findings, radiographic data and subsequent evaluation, including data from ancillary studies should be assessed. Although some evidence indicates that Procalcitonin (PCT) is a diagnostic indicator of bacterial pneumonia and is important for treatment decisions [13,14], it is unclear if it is an important component of prognostic algorithm yet to be delineated [15].

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