

Predictive Value of Hypoxemia in the Diagnosis of Pneumonia in the Pediatric Population

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Abstract

Pneumonia is the leading cause of morbidity and mortality in children less than 5 years of age¹. According to a systematic review, hypoxaemia as detected with pulse oximetry has been observed in 13% of children with WHO-defined pneumonia requiring hospitalisation (severe and very severe classifications). This corresponds to at least 1.5 to 2.7 million annual cases of hypoxaemic pneumonia presenting to health-care facilities². This study was aimed to identify the clinical predictive values of hypoxemia in children with radiographic evidence of Pneumonia. A retrospective cohort study was conducted at Dr. Soliman Fakeeh Hospital. The aim of the study was to seek an association between pulse oxygen saturation and radiographic pneumonia in the pediatric age group. Data was collected and analyzed in IBM SPSS Version 20. The results were significant for hypoxemia across all age groups, [$\chi^2(1, N=755) = 10.327, p = .001$]. Approximately 94% of patients with hypoxemia had pneumonia. Due to its statistical significance, evaluation of oxygen saturation for hypoxemia may be useful in the assessment of pneumonia risk among children in settings with underprivileged resources.

Keywords: Hypoxemia, Pediatrics, Pneumonia, Predictive Value

1. Introduction

Pneumonia is the leading cause of morbidity and mortality in children less than 5 years of age¹. Despite the high incidence of childhood pneumonia worldwide, data is limited regarding the ability to diagnose and predict the clinical course of pneumonia⁴. Studies on the values hypoxemia thresholds in the diagnosis of pneumonia in children are limited⁵. As of 2015, it has been estimated that approximately 120-156 million cases of acute lower respiratory tract infections occur worldwide and result in 1.4 million deaths with more than 95% of the morbidities in lower and middle income countries^{6,7}. In a recent study, it was found that children under the age of five years suffering from severe pneumonia associated with hypoxia had a higher chance of having age related tachypnea⁸. The clinical outcome of hypoxemic children is greatly improved with early recognition and treatment⁶.

We therefore found it appropriate to conduct this study to identify the clinical predictive values of hypoxemia in children with radiographic evidence of pneumonia.

2. Methods

2.1 Study Design

A retrospective cohort study was conducted at Dr. Soliman Fakeeh Hospital in the port city of Jeddah, Saudi Arabia. The aim of the study was to seek an association between pulse oxygen saturation and radiographic pneumonia in the pediatric age group.

2.2 Participants and Enrollment

Data was extracted retrospectively from, OASIS, the hospital electronic medical record operating system, between the dates of January 1, 2014 to December 18, 2018. Inclusion criteria were any pediatric patient that presented to the hospital with documented respiratory rate and pulse oxygen saturation and with physician diagnosed Pneumonia. Patients were excluded from the study if a chest x-ray was not done to show evidence of Pneumonia.

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2.3 Outcomes and Definitions

Patients were stratified into five categories based on age related respiratory rates as determined by the 2018 PALS study guide for age related respiratory rates (RR)⁹. The age categories were: less than one year of age (infant), one to three years (toddler), four to five years (preschooler), six to 12 years (school aged child), and 13 to 18 years of age (adolescent). Hypoxemia was considered as pulse oxygen saturation less than 95% across all age groups.

2.4 Data Collection and Analysis

Data was collected and analyzed in IBM SPSS Statistics version 20. Pearson Chi square and Fisher's exact appropriate tests were applied to compare the rate of radiological pneumonia among children with and without hypoxemia. Results were defined in terms of sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV). A probability below 0.05 was regarded as statistically significant. The strength of association of hypoxemia with radiological evidence of Pneumonia was determined by the Phi correlation coefficient. Each age group was analyzed for association of SPO₂ with age related RR using the Chi-square test.

3. Results

A total of 755 patients were enrolled in the study and were diagnosed to have clinical Pneumonia based on history and physical examination. The toddler age group constituted approximately 44% of the studied population and infants were around 29%. The adolescent age group did not contribute significantly to the study since only one participant qualified (Figure 1).

The study showed that 85% of those enrolled were found to have radiographic evidence of Pneumonia. Of the 755 patients enrolled, only 135 were found to have hypoxemia (18%).

All hypoxemic infants had pneumonia and tachypnea. 95.7% of infants with hypoxemia had pneumonia despite normal RR. There was a statistical significance in infant oxygen saturation and radiographic evidence of pneumonia despite a normal RR [$G^2(1, N=188) = 3.879, p=.049$]. More than 90% of toddlers who were hypoxemic had pneumonia regardless of RR. In the school age category, all children enrolled in the study and were tachypneic had radiographic evidence of pneumonia

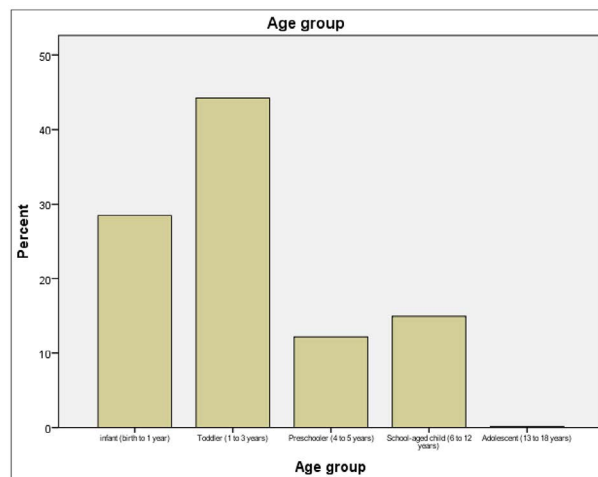


Figure 1. Distribution of participants based on age.

therefore no data exists for the specificity and negative predictive value in this subgroup. Overall, the results were significant for hypoxemia across all age groups, [$\chi^2(1, N=755) = 10.327, p=.001$]. Approximately 94% of patients with hypoxemia had pneumonia. Although the p value for hypoxemia was largely statistically significant in all age categories the phi correlation coefficient for hypoxemia was '.117'. This value correlates with a slightly positive association of hypoxemia with radiographic evidence of Pneumonia (Table 1).

4. Discussion

We retrospectively examined the association between hypoxemia with radiographic pneumonia among 755 children presenting to our hospital who had a CXR obtained for possible pneumonia. Hypoxemia was positively associated with radiographic pneumonia across all age groups. The majority of hypoxemic toddlers had pneumonia regardless of RR.

The systematic review and meta-analysis conducted⁶ supported the regular use of pulse oxygen saturation to aid in recognition children with increased morbidity due to acute lower respiratory tract infections.

The generalizability of our study may be limited because our study was conducted in a region of Saudi Arabia where there is widespread access to healthcare and clinicians are more likely to see patients earlier in the course of their illness and with less advanced pneumonias. In addition, the port city of Jeddah accommodates a massive variety of expatriates not found elsewhere in the

Table 1. Distribution of signs based on sensitivity and specificity

Sign	Sensitivity %	Specificity %	PPV %	NPV %	P- Value
SPO2	19.8	92.9	94.1	16.8	.001
Age Group: Infant					
SPO2 and Tachypnea (N = 27)	57.7	100	100	8.3	.196
SPO2 and Normal RR (N = 188)	14.1	96.9	95.7	18.8	.049
Age Group: Toddler					
SPO2 and Tachypnea (N = 81)	44.7	40	91.9	4.5	.507
SPO2 and Normal RR (N = 253)	11.1	97.8	95.8	19.2	.035
Age Group: Preschooler					
SPO2 and Tachypnea (N = 19)	35.3	50	85.7	8.3	.688
SPO2 and normal RR (N = 73)	6.7	92.3	80	17.6	.896
Age Group: School Age Child					
SPO2 and Tachypnea (N = 15)	80	-	100	-	-
SPO2 and Normal RR (N = 98)	13.1	92.9	91.7	15.1	.295

country and it is considered as the main entryway to the pilgrims hosted by Saudi Arabia, therefore the sample size in our study may not be reflective of the population in other areas of the country.

Moreover, we did not exclude children with underlying medical conditions that may affect the respiratory rate such as congenital heart disease and neuromuscular disorders. Although some patients presented with symptoms indicative of pneumonia such as fever or cough, patients that did not undergo chest radiography were not included in the study. Furthermore, respiratory rate was not adjusted for temperature.

Since there is no ideal standard for the definition of pneumonia we included equivocal radiographs to decrease the chance of missing a child with radiographic pneumonia. Due to the minimal enrollment in the adolescent age group, we did not have the statistical power to evaluate the association between tachypnea and radiographic pneumonia among children between 13 to 18 years of age.

5. Conclusion

In the modern health care setting, hypoxemia is not a sensitive indicator of pneumonia. However, due to its statistical significance, evaluation of oxygen saturation for hypoxemia may be useful in the assessment of pneumonia risk among children in settings with underprivileged resources. Further studies should focus on more rural areas of Saudi Arabia with fewer medical resources and

should include a larger sample. Medical facilities should strive to have pulse oximetry available in all areas.

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Conflict of Interest: none

Ethical Approval: Yes

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