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Original Research Article

A Hospital Based Evaluation of the Clinical Predictors of Hypoxemia in Patients of Acute Lower Respiratory Tract Infections in Children

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Abstract

Aim: The aim of this study was to determine clinical predictors of hypoxemia in patients of acute lower respiratory tract infections in children.

Material & Methods: The study was conducted in the Department of Pediatrics, AIIMS, New Delhi in New Delhi region. This was a hospital-based study completed from April 2018 to March 2019. It was an observational prospective study. A total of 50 patients were enrolled in the study. All children admitted with acute lower respiratory tract infections between the age group of 1 month to 5 years of age and diagnosed with pneumonia or bronchiolitis were included in the study.

Results: A total of 50 cases were enrolled in the study, out of which 32 were male and 18 were female. Out of the 50 cases enrolled, 24 were below the age of 12 months and 26 were above 12 months of age. The mean age was 18.2 months. The most common and significant symptoms were rapid breathing and difficulty breathing. The least common symptom was noisy breathing (significant association) and pain in the abdomen (no significant association). Tachypnea (90%), pallor (88%) and nasal flaring (82%), crepitations (added sounds), and subcostal retractions had better sensitivity for detecting hypoxemia. However, these signs had low specificity for hypoxemia. Head nodding (98%), intercostal retractions (86%), and cyanosis (85%) were highly specific for predicting hypoxemia.

Conclusion: It was observed that a combination of clinical signs and symptoms can be used to predict hypoxemia when facilities of pulse oximetry and arterial blood gas analysis are not available, especially in low-resource settings.

Keywords: Bronchiolitis, Clinical predictors, Hypoxemia, Pneumonia

Introduction

Acute lower respiratory tract infections are a major cause of morbidity and mortality among children in developing countries, accounting for about 30% of mortality in children under 5 years of age. [1,2] According to National Family Health Survey-4, the prevalence of ARI is 3.7% with a maximum rate of acute respiratory tract infection in children at 4.7% [3]. While upper respiratory infections are often self-limiting, lower respiratory tract infections particularly pneumonia pose life-threatening situations. For the effective management of all pneumonia cases, the

Government of India has devised an ARI control program. [4] Hypoxemia is the most serious manifestation of severe respiratory illness in children and a strong risk factor for mortality. [5] Hypoxemia is defined as arterial oxygen saturation (SpO2) <94%. Oxygen is an essential medicine. It is the most serious manifestation of severe pneumonia in children. The case fatality rate of pneumonia is inversely related to the arterial haemoglobin oxygen saturation (SaO2). [6] As respiratory infections are one of the main causes of death in children in developing countries, [7,8] and the delivery of oxygen to hypoxemic children may improve the outcome, the detection of hypoxaemia is important. Oxygen therapy improves the outcome of children with moderate or severe acute lower respiratory tract infection and, in those with hypoxaemia, the severity of hypoxia correlates with outcome. [6,9] The duration and severity of hypoxemia are important and its early recognition and appropriate treatment improve the outcome of these children. Pulse oximetry is a non-invasive and accurate method of measuring arterial oxygen saturation. [10] It is a useful predictor of hypoxaemia and pneumonia. [11] Cyanosis is the most specific predictor and the best clinical correlate of arterial oxygen saturation, but it is difficult to detect. [6,11,12] Although the most reliable way to detect hypoxemia is ABG, by which direct determination of arterial SpO2 is done, machines to make these measurements are expensive and need constant maintenance and are not widely available in developing countries, thus making clinical predictors of hypoxemia important in the initiation of oxygen therapy. However, standard treatment guidelines [13] recommend that in all children with pneumonia admitted to in-patient care, pulse oximetry (non-invasive estimation of arterial oxygenation) should be used to guide oxygen therapy, but it is also not extensively available so the study was planned with the objectives to calculate the sensitivity, specificity, positive predictive value, and negative predictive value of clinical parameters in predicting hypoxemia– cyanosis, level of consciousness, tachypnea, retractions, head nodding, wheeze, and crepitations and to correlate the degree of hypoxemia. The diagnosis is clinical and is made on the basis of symptoms and signs such as fever, cough, rapid breathing, grunting, wheeze, crepitations without performing any investigations, and due to the unavailability of pulse oximetry at peripheral level, it is important to study which clinical predictors of hypoxemia we can reliably sort out for initiation of oxygen therapy.

The aim of this study was to study clinical predictors of hypoxemia in patients of acute lower respiratory infections in children.

Material & Methods

The study was conducted in the Department of Pediatrics, AIIMS, New Delhi in new Delhi region. This was a hospital-based study completed from April 2018 to March 2019. It was an observational prospective study. A total of 50 patients were enrolled in the study. All children admitted with acute lower respiratory tract infections between the age group of 1 month to 5 years of age and diagnosed with pneumonia or bronchiolitis were included in the study. Any child suffering from chronic respiratory illness, congenital heart disease, severe dehydration, severe anaemia, and congestive cardiac failure or shock were excluded from the study. Diagnosis of acute lower respiratory tract infection is purely clinical on the basis of the presence of symptoms such as fever, cough, rapid breathing, noisy breathing, difficulty in breathing, refusal to feed, and convulsions and signs such as tachypnea, cyanosis, wheezing, grunting, use of accessory muscles of respiration, and presence of added sounds on auscultation or abnormal sounds. [14]

Hypoxemia has been defined as per Pediatric Advanced Life support guidelines

as SpO2 less than 94% and classified as [15]

• Mild – 94–90%

• Moderate – 85–90%

• Severe – <85%

After due approval from the Ethical Committee, any child presenting with difficulty in breathing and coughing as per the ARI control program and diagnosed with Pneumonia or bronchiolitis and after obtaining consent from parents were included in the study. He/she was subjected to detailed history and clinical examination for the presence of the above signs and symptoms. Arterial saturation of all patients was recorded using a portable pulse oximeter and ABG was done. The degree of hypoxemia between ABG and SpO2was correlated. After obtaining a detailed history, and examination, vital parameters were recorded such as the general condition of the child/infant, heart rate, respiratory rate, saturation (SpO2), temperature, level of consciousness, pallor, cyanosis, and head nodding and other significant clinical findings such as tachypnea, retractions, adventitious sounds such as crepitations, wheeze, and rhonchi were also taken into account. Tachypnea which is considered to be a compensatory mechanism to maintain minute ventilation [16] was defined as per the WHO. ABG was recorded in all patients as it is the gold standard to diagnose hypoxemia to correlate the degree of hypoxemia as per the ABG with the clinical predictors mentioned above. [15]

Statistical analysis

The severity of symptoms and signs and arterial saturation was tabulated and correlated. Analysis of the result was done in the form of sensitivity, specificity, positive predictive value, and negative predictive value. p-value of <0.05% was considered to be statistically significant and the Chi-square test, t-test, and ANOVA was used.

Results

Table 1: Demographic details

Gender	N%
Male	32 (64)
Female	18 (36)
Age groups	
Below 12 months	24 (48)
Above 12 months	26 (52)

A total of 50 cases were enrolled in the study, out of which 32 were male and 18 were female. Out of the 50 cases enrolled, 24 were below the age of 12 months and 26 were above 12 months of age. The mean age was 18.2 months.

Table 2: Symptoms and their frequency in hypoxemia stage

Symptoms		**Mild hypoxemia (18)**	**Moderate hypoxemia (16)**	**Severe hypoxemia (10)**	**No hypoxemia (6)**
Rapid breathing	Yes	18	14	10	5
	No	0	2	0	1
Fever	Yes	10	12	5	5
	No	8	4	5	1
Nasal discharge	Yes	10	6	5	4
	No	8	10	5	2

Feeding difficulty	Yes	12	6	6	2
	No	6	10	4	4
Cough	Yes	15	12	8	6
	No	3	4	2	0
Difficulty breathing	Yes	18	14	7	6
	No	0	2	3	0
Noisy breathing	Yes	3	5	7	0
	No	15	11	3	6
Pain in abdomen	Yes	15	0	2	0
	No	3	16	8	6

The most common and significant symptoms were rapid breathing and difficulty breathing. The least common symptom was noisy breathing (significant association) and pain in the abdomen (no significant association).

Table 3: Sensitivity and specificity of hypoxemic signs

Signs	Sensitivity	Specificity
Pallor	88	36
Cyanosis	40	85
Level of consciousness	30	77
Tachypnea	90	26
Nasal flaring	82	40
Supraclavicular	80	36
Intercostal	56	86
Subcostal	75	23
Wheeze	30	94
Crepitations	80	20
Head nodding	18	98

Tachypnea (90%), pallor (88%) and nasal flaring (82%), crepitations (added sounds), and subcostal retractions had better sensitivity for detecting hypoxemia. However, these signs had low specificity for hypoxemia. Head nodding (98%), intercostal retractions (86%), and cyanosis (85%) were highly specific for predicting hypoxemia.

Table 4: Staging of hypoxemia and its gender-wise distribution

Hypoxemia	Male (%)	Female	p-value
Mild (n=18)	12	6	p=0.0002
Moderate (n=16)	11	5	
Severe (n=10)	6	4	
No (n=6)	3	3	

Males 29 out of 32 were significantly more hypoxemic than females 15 out of 18. Most cases have moderate hypoxemia.

Discussion

Acute lower respiratory tract infections are a major cause of morbidity and mortality among children in developing countries accounting for about 30% of mortality in children <5 years of age. [17] Acute respiratory infections (ARIs) contribute to 15–30% of all under-five deaths in India and most of these are preventable. [18] According to National Family Health

Survey-4, the prevalence of ARI is 3.7% with a maximum rate of acute respiratory tract infection in children at 4.7%. [19] While upper respiratory infections are often self-limiting, lower respiratory tract infections particularly pneumonia pose life-threatening situations. For the effective management of all pneumonia cases, the Government of India has devised an ARI control program. [20] Hypoxemia is the most serious manifestation of severe respiratory illness in children and a strong risk factor for mortality. [21,22]

A total of 50 cases were enrolled in the study, out of which 32 were male and 18 were female. Out of the 50 cases enrolled, 24 were below the age of 12 months and 26 were above 12 months of age. The mean age was 18.2 months. We found that 18 (36%) cases each were present in the mild and 16 (32%) moderate hypoxemia categories. 10 cases (20%) had severe hypoxemia and 6 (12%) cases had no hypoxemia. In contrast, Motwani et al21, in their study of 204 cases, observed hypoxemia to be more common in females as compared to males. The most common and significant symptoms were rapid breathing and difficulty breathing. The least common symptom was noisy breathing (significant association) and pain in the abdomen (no significant association). Basnet et al [23], in their study on 150 children under 5 years, assessed the accuracy of clinical signs to differentiate lower and upper respiratory tract infections and observed that rapid breathing and fast breathing were significantly associated with hypoxemia. Redd et al [24] in their study on 950 children ascertained that the most common symptoms were cough (99%) and difficulty in breathing (17%), running nose was observed to be the next most common symptom in their study.

Tachypnea (90%), pallor (88%) and nasal flaring (82%), crepitations (added sounds), and subcostal retractions had better sensitivity for detecting hypoxemia. However, these signs had low specificity for hypoxemia. Head nodding (98%), intercostal retractions (86%), and cyanosis (85%) were highly specific for predicting hypoxemia. it was observed that SpO2 and PaO2 had a positive correlation which means that decreased levels of SpO2 were associated with a decrease in PaO2, whereas SpO2 and respiratory rate had a negative correlation which means that a higher degree of tachypnea, lesser the SpO2. A relatively smaller sample size and the short duration of the study are the two main limitations of this study.

Conclusion

It was observed that a combination of clinical signs and symptoms can be used to predict hypoxemia when facilities of pulse oximetry and ABG analysis are unavailable. Tachypnea, pallor and nasal flaring, crepitations, and subcostal retractions are highly sensitive, whereas head nodding, intercostal retractions, and cyanosis were highly specific clinical signs for predicting hypoxemia. However, ABG analysis remains the gold standard to predict hypoxemia. Early detection can lead to prompt intervention by instituting oxygen therapy, thus reducing mortality and morbidity due to acute lower respiratory tract infections.

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