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Clinical Predictors of Hypoxemia in Children with Acute Lower Respiratory Illness

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Abstract

Background: Acute lower respiratory illness (ALRI) contributes to significant mortality in developing countries and majority of this is secondary to hypoxemia. Early detection of hypoxemia and treatment improves outcome in these children. As pulse oximeter is not available in all health facilities in developing countries, clinical signs which predict hypoxemia should be identified. This study was done to assess the clinical predictors of hypoxemia in ALRI. A total of 204 children aged between 2-60 months, who were admitted with ALRI in emergency dept. of Kanchi Kamakoti Childs Trust Hospital (KKCTH) were studied. Clinical signs such as tachypnea, chest wall retractions, wheeze, crepitations, head nodding, cyanosis, poor feeding, grunt and impaired consciousness were recorded. Oxygen saturation of these children was recorded separately. Out of 204 children, 81 (39.7%) had hypoxemia. Of these, the prevalence of hypoxemia was noted in 57 infants (42.2%) and 24 children (34.8%) aged 12-59 months. Tachypnea had maximum sensitivity (88%).Chest wall Retractions (70%) and crepitations (73%) had fair sensitivity while specificity for these was 55% each. Signs such as poor feeding, grunt, cyanosis and head nodding had good specificity in predicting hypoxemia. None of the clinical signs of respiratory distress had all the attributes of a good predictor of hypoxemia. Clinical signs and symptoms such as chest wall retraction, inability to feed, grunting and cyanosis may be used by health workers to allow rational use of oxygen in places where there is shortage of oxygen and pulse-oximeter is not available.

Keywords: Acute LRI, Chennai, Clinical predictors, Hypoxemia, Pulse-oximeter.

Introduction

Acute lower respiratory tract illness is a leading cause of hospitalization in children, followed by diarrhea, in developing countries. In young children (<5 yrs of age) they account for about 1/3rd of mortality[1,2]. One of the serious manifestations of ALRI is hypoxemia and it is a major risk factor for mortality[3]. The duration and severity of hypoxemia is important as its early recognition and appropriate treatment improves the outcome in these children[4,5]. Health care provider should be able to detect hypoxemia early in any child with acute illness so as to start oxygen therapy.

Arterial blood gas analysis is most reliable to detect hypoxemia but it is expensive and not easily available in resource limited facilities. A simper and reasonably reliable method to detect hypoxemia is pulse- oximetry. Pulse- oximeter is non invasive, portable, and also better available[3]. That is the reason some consider pulse oximeter reading as fifth vital sign[6]. But in resource limited settings, even pulse oximeter and oxygen is not readily available. Hence in these facilities, health care workers have to rely on clinical signs and symptoms which can reliably predict hypoxemia in acutely ill children. In the past, some studies were done identify these clinical signs and symptoms which can predict hypoxemia in children with ALRI[5,7-12]. Majority of these studies were done at higher altitude[3, 5,12,14,15] and data from studies done at sea level is limited[16-18]. It was found that no single sign/symptom reliably predicts hypoxemia. With this background, it was found appropriate to conduct this study to identify the clinical predictors of hypoxemia in children with ALRI in a tertiary care hospital.

Methodology

The present prospective study was conducted at emergency department of Kanchi Kamakoti Childs Trust Hospital, a 250 bedded tertiary care hospital in Chennai, during March 2004 to February 2005. Total of 204 sick children admitted with ALRI and aged between 1-60 months were enrolled for study.

Inclusion criteria: Sick Children admitted with ALRI. Age between 1-60 months.

Exclusion criteria: Children with: Chronic respiratory illnesses (Broncho pulmonary dysplasia, cystic fibrosis, lung malformations), Congenital heart disease, Cardiopulmonary resuscitation in the past, Severe dehydration, Severe anemia, Shock, Congestive cardiac failure, CNS malformations and Neuron Muscular disorders.

On arrival to the emergency, a detailed history was obtained as per the proforma. Age, sex, weight and symptoms such as rapid breathing, difficulty in breathing, noisy breathing, feeding pattern, fever, cough, cyanosis, convulsions were recorded. Nutritional status, anthropometry, and vital signs were documented. Signs of respiratory illness such as tachypnea, chest wall in drawing, grunt, nasal flaring, wheeze, crepitations, head nodding, cyanosis and also non specific signs such as pallor, lethargy/level of consciousness were recorded. Chest x-ray was taken and findings were reported independently by a radiologist. Based on the history, clinical and radiological findings, a diagnosis was assigned.

Respiratory rate (RR) was counted, without disturbing the child, for one full minute. Tachypnea was described as a RR >50/min for age 1-11 months and RR >40/min for age 12-60 months. Chest wall retractions were defined as inward movement of lower chest during breathing. Central cyanosis was documented when child had bluish discoloration of tongue or oral mucosa. Head nodding was described as synchronous movement of head with each breath which usually denotes a sign of severe respiratory distress. Presence of wheeze and crepitations were documented. Level of consciousness was recorded as per AVPU scale (Alert/Responsive to verbal stimulus/ Responsive to painful stimulus/Unresponsive). Child was described as having impaired consciousness when they were responsive only to painful stimuli/unresponsive to any kind of stimuli. After stabilizing, a staff nurse recorded the oxygen saturation by keeping pulse oximeter (Nellcore TM) probe at finger/toe. Reading which was stable for at least 3 minutes was noted. Hypoxemia was defined as arterial oxygen saturation (SpO2) <90% as this usually indicates clinically significant hypoxemia in most children[20].

Analysis of results was done in the form of sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). Chi square test was applied to compare the signs between hypoxemic and non hypoxemic children. A Uni-variate analysis ($p<0.05$) of signs and symptoms predicting hypoxemia was done first and then multivariate logistic regression analysis was done to check independent utility of these signs.

Results and Discussion

In the current study, out of total 204 cases, majority in both the age group were males (64.7%). The mean age of the children in age 1 month-11months was 5.79 m and in those between 12-60 months it was 32.46 months. Out of total children, 39.7% were hypoxemic. It was found that of the 81 hypoxemic children, (42.2%) were aged 1-11 months and (34.8%) were in 12-60 months age group. The percentage of females with hypoxemia was higher than males. The mean SpO2 in hypoxemic infants and children were 87% and 86% respectively and both were highly significant (table-1-5).

Table-1
Age wise distribution of study subjects

Age (months)	No.	Percentage	Mean	Standard Deviation
1-11	135	66	5.79	3.384
12-60	69	34	32.46	15.715
Total	204	100	14.81	15.823

Table-2
Sex wise distribution of study subjects

Sex	No.	Percentage (%)
Male	132	64.7
Female	72	35.3
Total	204	100.0

Table-3
Prevalence of Hypoxemia

Variable	No.	Percentage (%)
Hypoxemic	81	39.7
Non-Hypoxemic	123	60.3
Total	204	100.0

Table-4
Back ground variables in relation to hypoxemia

Variable	No. of Hypoxemic (%)	No. of non-Hypoxemic (%)	Chi square test, d.f., p value
Age (months)			
1-11	57(42.2%)	78(57.8%)	X2=1.056, d.f=1, p=0.30
12-60	24(34.8%)	45(65.2%)	
Sex			
Male	50(37.9%)	82(62.1%)	X2=0.522, d.f.=1, p=0.47
Female	31(43.1%)	41(56.9%)	

Table -5
Age wise mean SpO2 (arterial oxygen saturation) values

Age (months)	SPO2 Mean ± S.D.		p value
	Hypoxemic`	Non-Hypoxemic	
1-11	87±4	95.2 ± 2	P< 0.001
12-60	86 ± 5	95 ± 2	P< 0.001

In those between 1-60 months with hypoxemia (87.7%) were tachypneic where as in those without hypoxemia (71.5%) were tachypneic ($p <0.01$). Tachypnea had maximum sensitivity (88%) but specificity was low (27%). Chest wall Retractions (70%) and crepitations (73%) had fair sensitivity while specificity for these were 55% each. Signs such as poor feeding, grunt, cyanosis and head nodding had good specificity but sensitivity was low (table-6).

Table-6
Predictors of Hypoxemia- Data from Uni-variate Analysis

Clinical Features	Hypoxemic Children (n=81) (%)	Non-hypoxemic Children (n=123) (%)	P value	Sensitivity	Specificity	Positive Predictive Value (PPV)	Negative Predictive Value (NPV)
Tachypnea	71(87.7)	88(71.5)	0.009	88	28	45	78
Poor feeding	19(23.5)	15(12.2)	0.054	24	88	56	64
Retractions	57(70.4)	68(55.3)	0.0003	70	55	51	74
Grunt	15(18.5)	2(1.6)	0.0000	19	98	88	65
Wheeze	62(76.5)	91(74.0)	0.742	77	26	41	63
Crepitations	59(72.8)	56(45.5)	0.0000	73	55	51	75
Cyanosis	8(9.9)	2(1.6)	0.015	10	98	80	62
Impaired Consciousness	14(17.8)	10(8.1)	0.074	17	92	58	63
Head Nodding	5(6.2)	-	0.009	6	100	100	62

Discussion: In the present study, means age of the children between 1-11 month age group was 5.79 (in hypoxemic group, mean age was 5.6 month and in non hypoxemic group it was 5.82 month) and among 12-60 month it was 32.46 months (31.9 among hypoxemic group and 32.65 among non-hypoxemic). Earlier studies were carried out on children between various age groups ranging from neonates to 5 yrs[13], 2-33 months[16] and 2 month -5 yrs[17, 21]. The difference of mean age group between hypoxemic and non- hypoxemic in this study was statistically significant which correlated with similar finding in an earlier study[18].

In the current study, overall prevalence of hypoxemia was more when compared to earlier studies in India[17,18,25]. It was found to be 39.7% (42.2% in aged 1-11months and 34.8% in aged 12-60months). The prevalence of hypoxemia in infants was comparable to some earlier studies[17,22]. The prevalence of hypoxemia in another study by Lozano et al[15] in emergency setting was 31-43%, which correlated well with our study, where as Duke et al[13] reported a higher prevalence of hypoxemia in children with ALRI. This difference may be partly due to their lower cut off (SpO2 88%) for defining hypoxemia. Similar study[16] in Gambian children had shown a lower prevalence of hypoxemia (5.9%). The difference between male and females, as regarding to prevalence of hypoxemia was not significant.

Respiratory rate (tachypnea) is an important sign in children with ALRI. Tachypnea as a marker of hypoxemia was found to be sensitive but its specificity is low[16-18,25]. As an independent predictor of hypoxemia, respiratory rate >60/min in infants was found to have better sensitivity and specificity[22]. In this study, tachypnea was more common in hypoxemic group (87.7% in hypoxemic and 71.5% in non- hypoxemic group).The sensitivity of tachypnea in predicting hypoxemia was high (88%), but its specificity was low(28%) which is comparable to previous studies[13,16-18,21,25]. Tachypnea though is also affected by other systemic disturbances such as fever, metabolic acidosis and decreased peripheral perfusion. So this limitation should be noted in using tachypnea as an independent marker to predict hypoxemia.

Chest wall in drawing (retractions) is considered more important sign of severe ALRI. Earlier studies have reported wide range of results[5,9-11,13]. It was highly sensitive (88% -90%) in predicting hypoxemia in some studies[17,25,26] where as it was reported to be more specific in some other study[18]. In the current study, this sign has better sensitivity (70%) than specificity (50%) in predicting hypoxemia.

Cyanosis is considered a more specific sign of hypoxemia but it may be an insensitive marker in dark complexioned individuals. In this study, its prevalence in hypoxemic group was 9.9 % (absent in non hypoxemic group). It had low sensitivity (10%) and high specificity (98%) in predicting hypoxemia. Its specificity was comparable with previous studies[13,16-18,25] but the sensitivity was variable (3-37.9%). If cyanosis alone is relied upon as a predictor of hypoxemia, one may miss significant number of cases due to its low sensitivity.

In children with ARLI, grunting is common in infants. Presence of this indicates severe respiratory distress. It was found in 18.5% of children with hypoxemia and it had high specificity (98%) though it is a less sensitive marker in predicting hypoxemia. This finding was consistent with result of previous studies[13,16,18] (sensitivity 14%-46% and specificity 86%-92.5%).

Head nodding is a sign of use of accessory muscles of respiration and it indicates severe respiratory distress children with ALRI. This is an important sign and health care providers must be trained to look for this sign as it is easy to detect and is shown to be more specific [13,16]. In the present study it had lower sensitivity (6%) and higher specificity (100%) in predicting hypoxemia which again was comparable to earlier studies[13,16].

One of the most important sign of auscultation in children with ALRI is presence of crepitations. In this study, presence of crepitations had sensitivity of 73% and specificity of 55% which was similar to earlier reported studies[16-18], but wheeze had lower specificity (26%) in current study compared to previous studies (70% -82.7%) though sensitivity was comparable[16-18].

Poor feeding can be associated with any severe systemic illness especially in infants and neonates, which are predominantly caused by gram negative organisms[27] and presence of it is an indicator for admission and immediate treatment. Poor feeding had shown high range of specificity[13,16,17] in predicting hypoxemia which was also observed in this study.

Impaired consciousness is considered a late sign of hypoxemia. In the present study, it is found to be a more specific sign (92%) of hypoxemia which was comparable with earlier study[16].

Conclusion

It is reasonable to conclude that there is no single clinical sign/symptom which can consistently and reliably predict hypoxemia with high accuracy in children with ALRI. Some signs have good specificity but low sensitivity and vice versa. In settings of limited resources, a combination of clinical signs/symptoms such as chest wall retractions, inability to feed, grunting and cyanosis may be used by health care workers in children with ALRI to allow rational use of oxygen. In health care settings, where pulse-oximeter is available, it is an important and fairly reliable tool to detect hypoxemia.

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