Clinical predictors of hypoxemia in children with acute lower respiratory tract infections

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Abstract

Background and objectives: Acute lower respiratory tract infections (ALRI) are the leading cause of morbidity and mortality among children in developing countries. Pulse oxymetry is a simple technique to determine the oxygen saturation. However, the detection of hypoxemia by use of pulse oxymetry is not available in most situations in developing countries; in addition, the availability of supplementary oxygen is inadequate. It is therefore, important to identify hypoxemia accurately in children by using of clinical signs.

The objective of this study was to find out the clinical signs and symptoms that predict hypoxemia in acute lower respiratory tract infection.

Methods: A well matched case control study was performed on 120 children from 2 months to 5 years of age admitted with acute lower respiratory tract infections (ALRI) to the emergency department of Raparin Pediatric Teaching Hospital -Erbil, from 1st January 2009 to 1st April 2010.Clinical symptoms and signs were recorded .Hypoxemia was defined as oxygen saturation less than 95%. A portable oxymeter was used to measure oxygen saturation with an appropriately sized sensor on the finger or the toe. The reading was taken while the child was breathing room air. The clinical symptoms and signs to predict the presence of hypoxemia were evaluated.

Results: Sixty (50%) children were hypoxemic. The median O_2 saturation was 91.2%with a range of 72-93.8%. Physical signs including intercostal and subtotal retractions, supraclavicular recessions, grunting, nasal flaring, cyanosis, head nodding, were statistically associated with hypoxemia.

Conclusion: None of the clinical features either alone or in combinations has sufficient sensitively and specificity to predict hypoxemia in children with acute lower respiratory tract infections, therefore pulse oxymetry is desirable for identification of hypoxemia.

Key words: Predictors; Hypoxemia; Acute lower respiratory tract infection.

Introduction

Acute lower respiratory tract infections account for 5% of all respiratory infections and include bronchiolitis, pneumonias, pertussis, lung abscess and mycobacterial infections.[1]

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 less than 5 years of age[1]. Most of these deaths occur at home before children's admission to the healthcare system[2, 3, 4]. Oxygen therapy improves the outcome of children with moderate or severe acute lower respiratory tract infection and, in those with hypoxemia, the severity of hypoxia correlates with outcome[5, 6]. Pulse oxymetry is a non-invasive and accurate method of measuring arterial oxygen saturation[7]. Pulse oxymetry is, however, not available in most health centers in developing countries. For this reason clinical signs that best predict hypoxemia has been evaluated in earlier studies[6, 7]. No single sign has been found to be a reliable predictor of hypoxemia[6, 8]. Cyanosis is the most specific predictor and the best clinical

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correlate arterial oxygen saturation, but it is difficult to detect[6, 9, 10]. In some studies, mainly those undertaken at high altitude, a rapid respiratory rate was found useful as a predictor of hypoxemia, but this was not the case in all studies [11, 12]. Moreover, children with anemia, who are not necessarily hypoxemic, may present with a rapid respiratory rate that is attributable to cardiac failure. Chest retractions have been found useful as a predictor of hypoxemia in children with bronchiolitis[11, 13].

Methods

A well matched case control study was performed on 120 children admitted with acute lower respiratory tract infections (ALRI) to the emergency department of Raparin Pediatric Teaching Hospital -Erbil in the period of 1st January 2009 to 1st April 2010.Children between 2 months and 5 years of age presenting with an acute history of cough and rapid respiration or difficulty in breathing were included in the study, according to WHO criteria for ALRI [(5)]. Children with congenital heart disease, hypotonia , cerebral palsy, peripheral circulatory failure, severe anemia, dehydration and Asthma were excluded. History was obtained about the presence and duration of symptoms like alteration in feeding pattern; sleep pattern. Clinical signs recorded were general condition, weight, consciousness, intercostal, subcostal suprasternal recessions, tachypnea (defined as respiratory rate more than 60/min. in babies less than 2 months of age ,50/min in babies 2 months -one year ,and 40/min in those more than one year) [5], grunting, nasal flaring and head nodding (movement of head synchronous with each breath , which is caused by increased use of auxiliary muscles of respiration and therefore indicates severe respiratory distress) and cyanosis.

A portable oxymeter (BCI 3303) was used to measure oxygen saturation with an appropriately sized sensor on the finger or the toe. The reading was taken while the child was breathing room air. Hypoxemia was defined as oxygen saturation less than 95% [14.] Statistical analysis was performed with software package "SPSS program version 13" .The study sample was divided into two groups: Group1(cases, hypoxic) children having oxygen saturation <95%, Group 2(control, non-hypoxic) children complaining from lower respiratory tract infections that having oxygen saturation ≥95%. Cases and controls were matched for age, sex, weight and other possible confounding factors that might play role in one way or another in tachypnea in children like feeding pattern, family history of atopy, parental smoking, previous history of wheezing and fever. Baseline characteristics were compared. Frequency of different symptoms and signs in both groups was calculated. Sensitivity, specificity, positive and negative predictive values were calculated for different signs. Chi-square and t-test were used as indicated. Different combinations of signs found to be significant in the univariate analysis were evaluated for their ability to predict hypoxemia. P.value of <0.05 was considered significant.

Results

One hundred twenty children from two months to five years of age with acute lower respiratory tract infections were evaluated. Sixty nine (57.5%) were males and 51 (42.5%) were females with male: female ratio1.3:1. Twenty one (17.5%) were exclusively breast fed. The mean age was 13.59 (SD ±2.3) months, family history of atopy was present in 23(19.1%) of cases. Smoking at home was present in 61 (50.8%) of cases. The SaO_2 (oxygen saturation) was< 95% in 60(50%) of cases and it was <90% in 21 of them .The median O_2 saturation was 91.2%with a range of -93.8%in group -1, while it was ≥95% in 60 (50%) of group-2. The mean (SD) age of patients in group 1(hypoxemic) was 13.38 (±11.14) months and Group2 (non-hypoxemic) was 13.8 (±13.9) months. The sex was comparable (group 1– boys 37, girls23) (Group 2– boys32, girls 28). The mean (SD) weight children in both groups

was 14.19 (±2.66) kilograms and 14.69 (3.33) kg respectively. Non of these differences between the two groups were statistically significant, (P.values for age 0.33, sex 0.22 and weight 0.41).Other factors studied were also Comparable in both groups (p.values for feeding pattern 0.9, family history of atopy 0.3, parental smoking 0.6, fever 0.28).The characteristics of the sample are shown in (Table 1). Reduced ability to feed was recorded in 74 (61.7%) of cases, 40 of them were hypoxemic and 34(38.3%) were non hypoxemic. Disturbed feeding was higher in hypoxemic group but its association with hypoxemia was not significant (p.value: 0. 9). Normal sleeping was recorded in 53(44.1%) of cases, 22 of them were hypoxemic. Reduced sleep was recorded in 67(55.9%) of cases, 36 of them were hypoxemic, and sleeping most of the time was recorded in 2 (1.9%) of cases, both of them were hypoxemic. No symptom evaluated was found to have a statistically significant association with hypoxemia (p.value 0.6). Clinical signs that showed statistically significant association with hypoxemia, were intercostal and subcostal recessions (P. 0.0001), suprasternal recessions(P. 0.006), grunting(P 0.0001),head nodding (0.002), cyanosis(0.0016) and nasal flaring (P 0.009) (Table 2). Combinations of signs that showed statistically significant association with hypoxemia were intercostal and subcostal recessions or supra-clavicular recession (P 0.0001), grunting or head nodding (P 0.0001),intercostal recessions or Supra-clavicular recession(P 0.0001), intercostal recessions or grunting (P 0.0001), intercostal recessions or cyanosis(0.0001), cyanosis or head nodding (P 0.0001),tachypnea or sleep disturbance (P 0.02), tachypnea or head nodding (P 0.01),tachypnea or supraclavicular recession (0.0167) . Highest sensitivity in combination was observed in intercostal recessions or supra-clavicular recession (sensitivity 91% but with low specificity 65%), while the cyanosis or head nodding combination showed highest specificity 98% while sensitivity was 34 %.(Table3).

Table 1: Characteristics of the study group of children with ALRI

Characters		Number	%
Gender	**Male**	69	57.5
	Female	51	42.5
Exclusive Breast Feeding	**Present**	21	17.5
Family History Of Atopy	**positive**	23	19.1
	Negative	97	80.9
Smoking At Home	**Present**	61	50.8
	Absent	59	49.2
Sleep Pattern	**Normal**	53	44.1
	Disturbed	67	55.9
Feeding Pattern	**Normal**	46	38.3
	Disturbed	74	61.7
Consciousness	**Normal**	82	68.3
	Disturbed	38	31.7
General Condition	**Well**	24	18.4
	Ill	98	81.6

Table 2: Statistical description of possible Predictive symptoms and signs in children with ALRI

Symptoms and Signs	Hypoxemic Children	Non-hypoxemic Children	P. Value	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Disturbed sleep	36	31	0.5915	57	48	55	50
Disturbed feeding	40	34	0.8484	53	24	39	36
Disturbed consciousness	27	11	0.0030	45	81	71	59
Ill appearance	57	41	0.0002	95	31	58	86
Tachypnea	46	37	0.1132	76	38	55	62
Intercostal & subcostal recession	49	23	0.0001	81	71	68	77
Supraclavicular recession	27	12	0.006	45	80	69	59
Grunting	16	1	0.0001	26	98	94	57
Head nodding	12	1	0.002	20	98	95	52
Nasal flaring	32	17	0.009	53	71	63	61
Cyanosis	11	0	0.0016	18	100	100	55

Table 3: Utility of different combinations to predict hypoxemia

Symptoms and Signs in combinations	Hypoxemic Children	Non-Hypoxemic Children	P.value	Sensitivity (%)	Specificity (%)	Positive Predictive Value(%)	Negative Predictive Value(%)
Tachypnea or intercostal and subcostal recessions	53	45	0.0443	81	33	55	64
Tachypnea or supra-clavicular recession	46	38	0.01632	76	36	54	61
Intercostal and subcostal recessions or supra-clavicular recession	55	29	0.0001	91	51	68	87
Intercostal recessions or grunting	52	23	0.0001	86	61	69	82
Intercostal recessions or head nodding	46	21	0.0001	76	65	68	73
Intercostal recessions or cyanosis	46	23	0.0001	76	61	66	72
Cyanosis or head nodding	17	1	0.0001	34	98	94	64
Cyanosis or grunting	21	1	0.0001	35	98	95	60
Tachypnea or intercostals recession or grunting	53	37	0.0013	88	38	58	76
Intercostals recession or grunting or cyanosis	51	24	0.0001	87	58	68	80
Supra-clavicular Recession or grunting or head nodding	39	13	0.0001	84	73	75	69

Note: combination of symptoms means the patient has either one of symptoms or both.

Discussion

The mean age of all studied children with ALRI was 13.59 months, 57.5% of them were males with a male: female ratio 1.3:1.This is in agreement with previously published data [15]. Disturbed consciousness was noted to be higher in hypoxemic group with significant association with hypoxemia (p.0.003).This is in agreement with Radish L. et al [16]. Decreased feeding and disturbed sleep pattern were noted to be higher in hypoxemic group but did not score a significant association with hypoxemia (p0.59, 0.84 respectively). This is in agreement with Margolic PA et al[14]. The presence of cyanosis is clinically significant because it implies severely decreased oxygen content of blood [17]. Mai et al [18] concluded that, in respiratory illnesses all cyanosed babies required supplemental oxygen therapy on the basis of pulse oxymetry, as well as Stanly et al [19] stated that cyanosis was one of best independent predictors of hypoxemia. Cyanosis is ominous sign when present [20.] This study found that tachypnea is not a good predictor of hypoxia ; the same result established by Mulholland E K[11] et al, Reynolds EOR[13] et al and Martin et al[15], this probably belongs to the reason that tachypnea was present in both study groups. Furthermore, respiratory rate is likely to be affected by the presence of fever that may explain the finding. While others found that tachypnea is a good predictor of sever hypoxia[6, 8]. Chest retractions is a useful predictor of hypoxemia in children with respiratory infections [11, 13], as it is regarded a major criteria for admission and oxygen supplementation therapy in children with acute lower respiratory tract infection[5]. Chest retractions showed a significant association with hypoxemia as intercostal and supraclavicular recessions, which scored p.values 0.0001, 0.006, respectively.

None of the symptoms or signs evaluated was both sufficiently sensitive and specific (Table2).Use of combinations e.g. Tachypnea or intercostal recessions (P 0.0443, sensitivity 81%, specificity 33%), tachypnea or suprasternal recessions (P 0.0162, sensitivity 86%,specificity 61%) improved the predictive ability. Intercostal and subcostal recessions or supra-clavicular recession, intercostal recessions or grunting, intercostal recessions or head nodding, intercostal recessions or cyanosis were highly improved the predictive ability of hypoxia(p.0.0001) for each. There is lack of agreement among different studies. Stanly et al [19] concluded that in children with acute lower respiratory tract infections, simple physical signs that require minimal expertise to recognize like a combination of inability to cry, head nodding and respiratory rate of $\geq$90 breath /min can be used to determine oxygen therapy and to aid in screening for referral (sensitivity 70%, specificity 79%).This might be attributed to the combination of three signs and the different respiratory rate cutoff points in different age groups in this study where tachypnea is defined as respiratory rate more than 60/min in babies less than 3 months of age ,50/min in babies 3 months to one year ,and 40/min in those more than one year according to WHO criteria for ALRI[5)].

In spite of all mentioned associations of some physical signs with hypoxemia which made it possible to predict hypoxemia in some children with ALRI, it is evident that signs or combinations that improve the sensitivity comprise specificity .So still pulse oxymetry is the best indicator of hypoxemia in children with ALRI and though relatively expensive. It's use might be cost - effective in controlling oxygen requirements. The use of pulse oxymetry allows children in need of oxygen to be identified, and the amount of oxygen given can be titrated to the actual need of the patient thus avoiding wastage. However in the absence of pulse oxymetry, a simple model such as combinations use of combinations e.g. tachypnea or intercostal recessions, tachypnea or suprasternal recessions. Intercostal and subcostal recessions or supra-clavicular recession, intercostal recessions or grunting, Intercostal recessions or head nodding, intercostal recessions

or cyanosis for detection of hypoxemia in children with ALRI.

Conclusion

None of the clinical features either alone or in combinations has sufficient sensitively and specificity to predict hypoxemia in children with acute lower respiratory tract infections, therefore pulse oxymetry is desirable for identification of hypoxemia.

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