Predictors of Hypoxemia in Children with Acute Lower Respiratory Tract Infections

Muhi K.Al-Janabi*; Ridha H. Al-Bayati ;Nadia Aziz*****

ABSTRACT:

BACKGROUND:

Acute lower respiratory tract infections (ALRI) are the leading cause of morbidity and mortality among children in developing countries, causing one – third of all deaths in childhood. Pulse oxymetry is a simple technique to determine the oxygen saturations.

OBJECTIVE:

It is important to accurately identify hypoxemic children by use of clinical signs alone.

METHODS:

A well matched case control study was performed on 104 children from 2 months to 5 years of age admitted with ALRI to the emergency department of Children Welfare Teaching Hospital -Medical City - Baghdad in the period from 15thMarch -15thJune 2006.Clinical symptoms and signs were recorded .Hypoxemia was defined as oxygen saturation less than 95%.The ability of various clinical symptoms and signs to predict the presence of hypoxemia was evaluated.

RESULTS:

Fifty (48.1%) children were hypoxemic. The median O_2 saturation was 91.2%with a range of 82-94% Physical signs including tachypnea, intercostal and subcostal retractions, supraclavicular recessions, grunting and nasal flaring were statistically significantly associated with hypoxemiUse of combinations e.g. Tachypnea or head nodding (P. 0.02 , sensitivity 70% , specificity 48%),tachypnea or suprasternal recessions(P.0.05 ,sensitivity 70% ,specificity 44%)only slightly improved the predictive ability.

CONCLUSION:

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

KEYWORDS: predictors; hypoxemia; alri; children.

INTRODUCTION:

Acute lower respiratory tract infections account for 5% of all respiratory infections and include bronchiolitis, pneumonias and. One in four children has a LTRI in the first year of life. [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. Most of these deaths occur at home before children's admission 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]. However, in countries with limited resources, oxygen is not always freely available. Thus it is important to have rational guidelines both for the use of oxygen and for the referral of patients to specialist hospitals.

Pulse oximetry is a non-invasive and accurate method of measuring arterial oxygen saturation [7].It is a useful predictor of hypoxemia [8, 9].

Pulse oximetry 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, 10]. No single sign has been found to be a reliable predictor of hypoxemia.

Cyanosis is the most specific predictor and the best clinical correlate arterial oxygen saturation, but it is difficult to detect [6, 8, 10]. In some studies, mainly those undertaken at high altitude [7, 9], 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

* Department of Pediatrics .College of Medicine . Baghdad University.
**Children Welfare Teaching Hospital -Medical City – Baghdad.
*** Ministry of Health.

attributable to cardiac failure. Chest retractions have been found useful as a predictor of hypoxemia in children with bronchiolitis [11, 13].

PATIENTS AND METHODS:

A well matched case control study was performed on 104 children admitted with ALRI to the emergency department of Children Welfare Teaching Hospital -Medical City-Baghdad in the period from 15thMarch -15thJune 2006.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 ARI [5]. Children with congenital heart disease, hypotonic or cerebral palsy, peripheral circulatory failure, sever anemia and dehydration 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, intercastal, 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 (Kontron Medical B.P:7845) 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- children having oxygen saturation <95%, Group 2 - children having oxygen saturation ≥95%.cases and controls were matched for age ,sex, weight and other possible confounding factors that might play in one way or another role in tachypnea in children like feeding pattern, family history of atopy, parental smoking, previous history of wheezing, fever, CXR findings, and Hb level). Baseline characteristics were compared. Frequency of different symptoms and signs in both groups were 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 and four children from two months to five years of age with acute lower respiratory tract infections were evaluated in the study. Sixty four (61.5%) were males and 40(38.5%) were females with male: female ratio was 1.6:1 Sixteen (15.4%) were exclusively breast fed.

The mean age was 12.64 (SD ±3.2) months, family history of atopy was present in 44(42.3%) of cases. Smoking at home was present in 73(70.2%) of cases. Chest x-rays done for all cases of whom 92(88.5%) had positive findings. The SiO_2 was< 95% in 50(48.1%) of cases and it was (<90% in 7of them) .The median O_2 saturation was 91.2%with a range of 82-94%in group -1(cases/hypoxemic), while it was ≥95% in 54 (51.9%) of group-2 (controls/non- hypoxemic). The characteristics of the sample are shown in table-1.

The mean (SD) age of patients in group 1(hypoxemic) was 11.38 (11.14) and Group2 (non –hypoxemic) was 13.8 (13.9).The sex was comparable (group 1- Boys 34, girls16) (Group 2- Boys30, girls 24). The mean (SD) weight children in both groups was 7.29 (2.66) kg and 7.69 (3.33) kg respectively. None of these differences between the two groups were statistically significant, (P.values for age 0.33, sex 0.2and weight 0.5).Other factors studied were also comparable in both groups (p.values for feeding pattern 0.9, family history of atopy 0.3, parental smoking0.6, previous history of wheezing 0.9, fever 0.7, CXR findings 0.3, and Hb level 0.5).

Normal feeding was present in 62(59.6%) of cases, 28 of them were hypoxemic. Reduced ability to feed was recorded in 38(36.5%) of cases, 18 of them were hypoxemic and 4(3.8%) were unable to feed, all of them were hypoxemic. Disturbed feeding was higher in hypoxemic group but its association with hypoxemia was not significant (p.value: 0. 12).

Normal sleeping was recorded in 56(53.8%) of cases, 27 of them were hypoxemic. Reduced sleep were recorded in 46(44.2%) of cases, 22 of them were hypoxemic, and sleeping most of time were 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.

Clinical signs that showed statistically significant association with hypoxemia were intercastal and subcostal recessions (P. 0.03), suprasternal recessions(P. 0.01), tachypnea (defined as respiratory rate more than 60/min. in babies less than 3 months of age ,50/minin babies 3 months to one year ,and 40/min in those more than one yea)

(P 0.02), grunting(P 0.04) and nasal flaring(P 0.002)(table-2).

Combinations of signs that showed statistically significant association with hypoxemia were grunting or head nodding (P 0.001), cyanosis or head nodding (P 0.01),tachypnea or sleep disturbance (P 0.02) , tachypnea or head nodding (P 0.02) tachypnea or suprasternal recessions(P 0.05),while the combination of tachypnea or intercastal and subcostal recessions showed no significant association with hypoxemia(P 0.08). Tachypnea or head nodding in a combination scored the highest sensitivity and specificity ,70% and 48% respectively , while in tachypnea or sleep disturbance combination sensitivity was 84% but specificity was 33%. Tachypnea or suprasternal recessions Combination showed a sensitivity of 70% and a specificity of 44 %. Tachypnea or intercastal and subcostal recessions scored high sensitivity (86% among various combinations evaluated; however the specificity was lower at 24% (table -3).

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

Characteristics		Number	%
Sex	Male	64	61.5
	Female	40	38.5
Exclusive breast feeding		16	15.4
Family history of atopy		44	42.3
Smoking at home		73	70.2
Sleep pattern	Normal	56	53.8
	Disturbed	48	46.2
Feeding pattern	Normal	62	59.6
	Disturbed	42	40.4
Consciousness	Normal	81	77.9
	Disturbed	23	22.1
General condition	Well	23	22.1
	ill	81	77.9
Grunting		7	6.7
Cyanosis		1	1
Chest X-R finding	Positive	92	88.5
	Negative	12	11.5
SiO2 <95%		50	48.1

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

	Hypoxemic Children	Non-Hypoxemic Children	P. Value	Sensitivity (%)	Specificity (%)	Positive Predictive Value(%)	Negative Predictive Value(%)
Tachypnea Or Supra-clavicular Recession	35	30	0.05	70	44	54	61
Tachypnea Or Head nodding	35	28	0.027	70	48	55	63
Tachypnea or intercostal and subcostal recessions	43	41	0.086	86	24	51	65
Tachypnea Or Sleep Disturbance	42	36	0.02	84	33	54	69
Cyanosis Or Head nodding	6	0	0.01	12	100	100	55
Grunting Or Head nodding	9	0	0.001	18	100	100	57

Table- 3: Utility of different combinations to predict hypoxemia

Symptoms and Signs	Hypoxemic Children No	(%)	Non-hypoxemic Children No	(%)	P. Value	Sensitivity (%)	Specificity (%)
Disturbed sleep	23	(21.1)	25	(24)	0.15	46	54
Disturbed feeding	22	(21.1)	20	(19.2)	0.12	44	63
Disturbed consciousness	14	(13.5)	9	(8.6)	0.07	28	83
Ill appearance	40	(38.5)	41	(39.4)	0.16	80	24
Tachypnea	34	(32.7)	26	(25)	0.02	68	51
Grunting	6	(5.8)	1	(1)	0.04	12	***98***
Head nodding	5	(4.8)	1	(1)	0.075	10	98
Nasal flaring	***24***	***(23.1)***	***11***	***(10.6)***	***0.002***	***48***	***80***
Intercostal &subcostal recession	43	(41.3)	38	(36.5)	0.03	86	30
Supraclavicular recession	21	(20.2)	12	(11.5)	0.016	42	***78***

DISCUSSION:

The association between hypoxemia and death highlight the need for early recognition of the condition and the potential benefit of treatment.

It is known that respiratory rate, , use of accessory muscles of respiration , level of consciousness, ability to feed, ability to sleep, are changed during respiratory illness [15,16,17].

The present study is designed to analyze these signs and symptoms to be used to predict hypoxemia in lower respiratory tract infections helping in the selection of sick infants and children for oxygen therapy especially where oximetry facility is not available.

A total of one hundred and four children from two months to five years of age were included in a well matched case control study where most of the possible confounding factors were taken into consideration and found to be comparable between the cases and the controls. The mean age of all studied childrenwith ALRI was 12.64 months,

61.5% of them were males with a male: female ratio 1.6:1.This is in agreement with previously published data [18, 19].

Significant association was found between the tachypnea and hypoxemia in this study (p.0.02). Many studies found a high respiratory rate to be a useful predictor of hypoxemia [6,8], even some stated that the higher the respiratory rate, the lower the arterial oxygen tension [15], whereas other did not [11,13] , which might be attributed partially to short counting time of respiratory rate. Further more respiratory rate is likely to be affected by the presence of fever that may explain the finding of Martin et al [16], who found that respiratory rate, is a poor predictive sign of hypoxemia in children with lower respiratory tract infection.

The brain has no anaerobic metabolism and requires a continuous supply of oxygen in order to sustain normal function, depletion of oxygen produce abnormal cerebral function which manifested as drowsiness, lassitude, seizure and even coma which may progress to death [20]. Disturbed consciousness was noted to be higher in hypoxemic group but did not score a significant association with hypoxemia (p.0.07).This is in agreement with Rakesh L. et al [21].

The presence of cyanosis is clinically significant because it implies severely decreased oxygen content of blood [22]. Mai et al [23] conclude that, in respiratory illnesses all cyanosed babies required supplemental oxygen therapy on the basis of pulse oximetry, as well as Stanley et al [24] stated that cyanoses was one of best independent predictors of hypoxemia. Although cyanosis was noted in one patient but it was associated with severe hypoxemia (SiO2:82%). Many factors may limit the usefulness of this sign in determining the hypoxemia, since it is late, subtle, and can easily missed in darkly pigmented skin child [24]. In addition it is influenced by skin perfusion and blood hemoglobin concentration [26]. But it is still an ominous sign when present [27].

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 specially supraclavicular recessions which scored a lower p.value (<0.02).

In general disturbed sleeping and feeding patterns were both higher in hypoxic group but both were not significantly associated with hypoxemia (P 0.15,0.12 respectively), but subgroup analysis such as the use of symptoms and signs like inability to feed and sleeping most of the time showed highly significant association with hypoxia(P< 0.001 for both)

The finding that children with inability to feed had a significantly lower SiO_2 than those normally fed is in agreement with previously published data [16,24]. It seems that rapid respiratory rate will not permit enough time for sucking or swallowing [28].

None of the symptoms or signs evaluated was both sufficiently sensitive and specific (Table-2).

Use of combinations e.g. Tachypnea or head nodding (P 0.02, sensitivity 70% , specificity 48%),tachypnea or suprasternal recessions (P 0.05 ,sensitivity 70% ,specificity 44%)only slightly improved the predictive ability. In addition to sensitivity and specificity, positive and negative predictive values were used to permit better evaluation of the utility of different clinical markers to predict hypoxemia. There is lack of agreement amongst different studies.Usen S. et al [29] 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/minin 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 oximetry 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 oximetry 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 oximetry ,a simple model such as a combinations of tachypnea or head nodding, tachypnea or suprasternal recessions may be used for detection of hypoxemia in children with ALRI.

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