Original Article

Detection of Hypoxaemia by Arterial Blood Gas 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 the majority of this is secondary to hypoxemia. Early detection of hypoxemia and treatment improves the outcome in these children. The aim of the study is to detection of hypoxaemia by analysis of arterial blood gas in children with ALRI admitted to Paediatrics ward of Chattogram Medical College Hospital (CMCH), Chattogram, Bangladesh.* ***Materials and Methods:*** *Ethical permission was taken from the Institutional Review Board of Chittagong Medical College (CMC) for this study. In this hospital based cross sectional study a total of 100 patients with ALRI aged between 2 to 60 months in paediatrics ward of CMCH were included. Besides demographic factors (age, sex, place of residence) and presenting symptoms were recorded. Oxygen saturation of these children was recorded by ABG analysis to detect hypoxaemia. Children having PaO_2<60 mmHg are considered hypoxaemic. Continuous variables were reported as the mean±SD and categorical variables were reported as frequency (percentages). Frequency of different symptoms and signs in both groups was calculated and analysis by $\chi 2$ tests. Statistical significance was defined as $p<0.05$ and confidence interval was set at 95%.* ***Results:*** *Among the 100 children, 46% had hypoxaemia as per ABG criteria (pO_2 <60 mmHg). In this study we found that age 2-12 months 41 (89.1%), female children 21 (45.7%) and residence of rural area 32 (69.65) were more hypoxemic. Among hypoxaemic patients' pH ranges from 7.04-7.50, pO_2 ranges from 9-58 mmHg and pCO_2 ranges from 18.30-60.40 mmHg. Among ALRI patients the majority were diagnosed with bronchopneumonia (50%) followed by bronchiolitis (41%), bronchial asthma (5%) and kerosene poisoning (4%).* ***Conclusion:*** *Hypoxaemia is a very common and treatable complication of childhood respiratory infections in developing countries. It is a life-threatening condition that requires early detection and prompt treatment.*

Keywords: Acute lower respiratory illness (ALRI), Hypoxemia, ABG.
Received: July 03, 2024; **Accepted:** July 28, 2024
https://doi.org/10.3329/emcj.v10i1.82510

Introduction

Acute lower respiratory illness (ALRI) is the major cause of morbidity and mortality in paediatric age group and responsible for 120 million episodes of pneumonia and 1.3 million under-five childhood global deaths[1]. It poses a major challenge to the health system in developing countries because of high morbidity and mortality[2]. It is estimated that Bangladesh, India, Indonesia, and Nepal together account for 40% of the global ARI mortality[3,4]. The two most common causes of ALRI in children under 2 years of age are bronchiolitis and community acquired pneumonia (CAP)[5,6].

Hypoxemia is a serious complication that can arise from acute lower respiratory infections (ALRI). Hypoxaemia means low levels of oxygen in the blood (low blood oxygen saturation or content). Hypoxia is inadequate oxygen in tissues for normal cell and organ function and hypoxia results from hypoxaemia. As all the functions of the human body require oxygen, oxygen deprivation can have severe adverse effects on the cells that perform important biological processes. Lack of oxygen leads very quickly to dysfunction of the organ systems, and death. Therefore, hypoxaemia is a life-threatening condition that requires early detection and treatment[7].

Hypoxaemia occurs when ALRI is severe enough to impair gas exchange, and is therefore an objective indicator of ARI severity, suggesting the need for hospitalization and oxygen treatment[8]. Over the past two decades, numerous studies have been conducted to assess the accuracy of clinical symptoms and signs in detecting hypoxaemia among children with ALRI. The most assessed symptoms and signs include fast breathing, breathing difficulty, inability to feed or drink, lethargy, cyanosis, grunting, nasal flaring, head nodding, chest indrawing, rhonchi and crepitations (crackles) in lung auscultation[9-12]. The most reliable way to diagnose hypoxaemia is an arterial blood gas (ABG) analysis. It is used to

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measure the partial pressure of oxygen (PaO_2) to detect hypoxaemia and carbon dioxide in blood (pCO2) and blood pH and the concentrations of the main electrolytes.

Hypoxaemia has also been considered a predictor of pneumonia related mortality[13] and the delivery of oxygen to hypoxaemic children can improve disease outcome[14]. Early detection of hypoxaemia among children with ARI is therefore a key point for adequate management and favorable outcomes.

Materials and Methods

This hospital based cross sectional study was conducted from March 2018 to February 2019 at Paediatrics department of Chittagong Medical College and Hospital (CMCH), Chittagong, Bangladesh. Ethical permission was taken from the Institutional Review Board of Chittagong Medical College (CMC) (ref: CMC/PG/2018/441). By purposive sampling, a total of 100 children aged 2 months to 5 years of either gender attended in Paediatrics ward of CMCH with the diagnosis of ALRI were included. Patients with broncho pulmonary dysplasia, cystic fibrosis, congenital heart disease, CCF, severe dehydration, severe anemia, congenital cystic malformation, neuromuscular disorders were excluded from the study.

ALRI included Bronchiolitis, Bronchopneumonia, Bronchial asthma and kerosene poisoning. Informed written consent was obtained from the patient's guardians or attendants for clinical examinations. The respiratory rate was counted for one minute. Respiratory system examination including central cyanosis, head nodding, grunting, nasal flaring, chest indrawing, fast breathing, crepitation, and rhonchi was noted. A chest x-ray was taken, and findings were reported independently by a radiologist. Based on history, clinical and radiological findings, a diagnosis was assigned. Fast breathing was described as, RR ≥50/minute for age 2-12 months and RR ≥40/minute for age 12-60 months by IMCI 2016[15]. Chest wall retractions were defined as inward movement of the lower chest during breathing[15]. Central cyanosis was documented when a child has bluish discoloration of tongue or oral mucosa[7]. Head nodding was described as synchronous movement of the head with each breath which usually denotes a sign of severe respiratory distress[7]. The presence of wheeze and crepitations was documented. Nasal flaring was defined as the visible movement of ala nasei[16].

Then the blood samples were collected for ABG analysis. Prior to an arterial puncture, the Modified Allen test was performed where it was applicable to check for the ability of the radial and ulnar arteries to return blood to the hand. Then all available aseptic precaution blood was drawn. Arterial blood was confirmed by bright red color and high-pressure during drawing. Then the sample was analyzed within 30 minutes. To prevent hematoma at the puncture site pressure was applied for 5 -10 minutes. pH, pCO_2, pO_2 was measured by using electrochemistry principles (RADIOMETER ABL80 FLEX) at delta health care in Chattogram. Then according to the ABG report, the study sample was divided into two groups: Hypoxemic group of children having PaO_2 <60 mmHg and non-hypoxemic group of children having PaO_2 ≥60 mmHg.

Data was processed and then statistical analysis was carried out using SPSS version 23. Continuous variables were reported as the mean±SD and categorical variables were reported as frequency (percentages). Frequency of different symptoms and signs in both groups was calculated and analysis by $\chi 2$ tests. Statistical significance was defined as $p<0.05$ and confidence interval was set at 95%.

Results

In this study 100 patients with ALRI were selected. Then patients were divided into two groups according to ABG result. 46 (46%) patients were hypoxaemic due to PaO_2 <60 mmHg and remaining 54 (54%) patients were non-hypoxaemic due to PaO_2 ≥60 mmHg. This finding is presented in figure-1.

Table-I demonstrates the demographic features of study subjects in terms of age, gender and residence which are compared between hypoxemic and non-hypoxemic group. In the age of 2-12 months 41 (89.1%), female children 21 (45.7%) and residence of rural area 32 (69.65) were more hypoxemic but the difference was not statistically significant between the two groups. On the other hand, age of 13-60 months 5 (10.9%), male children 25 (54.3%) and residence of urban area 14 (30.4%) were hypoxaemic but was not statistically significant.

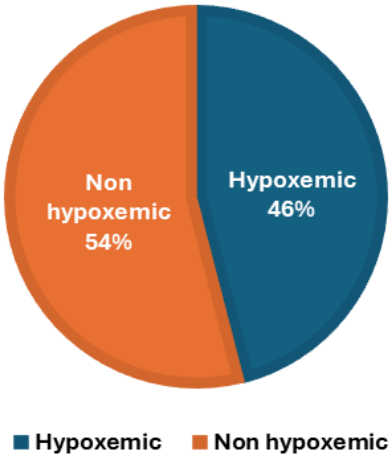

Figure-1: Frequency distribution of hypoxaemia in the study patients (n=100)

The ABG findings are shown in Table-II. Among the hypoxaemic patients pH ranges from 7.04-7.50, PaO_2 ranges from 9-58 mmHg and $PaCO_2$ ranges from 18.30-60.40 mmHg. Among the ALRI patients majority were diagnosed with bronchopneumonia (50%) followed by bronchiolitis (41%), bronchial asthma (5%) and kerosene poisoning (4%) that is shown in Figure-2.

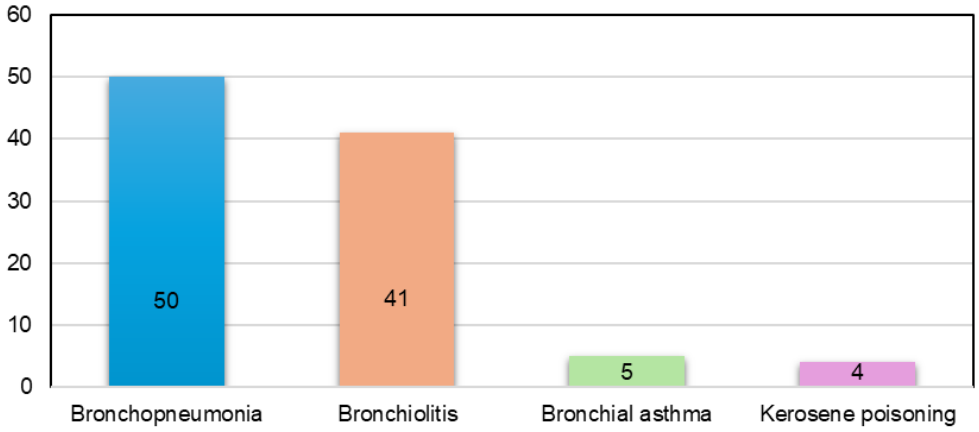

Figure-2: Types of ALRI patients in study subjects (n=100)

Table-I: Frequency distribution of demographic variables in ALRI patients of both groups (n=100)

Variables		Non-hypoxemic (n=54)	Hypoxemic (n=46)	p-value
Age groups	2-12 months	46 (85.2%)	41 (89.1%)	0.559
	13-60 months	08 (14.8%)	05 (10.9%)	
Gender	Male	37 (68.5%)	25 (54.3%)	0.146
	Female	17 (31.5%)	21 (45.7%)	
Residence	Rural	31 (57.4%)	32 (69.6%)	0.209
	Urban	23 (42.6%)	14 (30.4%)	

*p-values were derived from χ^2 test.

Table-II: Summary of investigations findings among studied cases with ALRI (n=100)

Variables		Non-hypoxemic (n=54)	Hypoxemic (n=46)	Total (n=100)
pH	Mean±SD	7.38±0.12	7.35±0.10	7.37±0.11
	Range	6.92-7.60	7.04-7.50	6.92-7.60
PaO_2 (mmHg)	Mean±SD	124.47±50.46	35.82±11.60	86.62±58.72
	Range	63-336	9-58	9-336
pCO_2 (mmHg)	Mean±SD	33.15±13.41	38.94±9.48	35.62±12.18
	Range	8.70-79.20	18.30-60.40	8.7-79.2

Discussion

The present study was conducted to determine the predictors of hypoxaemia in children with acute lower respiratory illness (ALRI) aged between 2 months to 60 months having cough, fast breathing, chest indrawing and positive chest X-ray findings. Hypoxaemia was assessed by ABG criteria. The result of the study indicated that hypoxaemia (PaO_2 <60 mmHg) occurred in approximately 46% of the recruited patients in this study at presentation. This rate of hypoxemia was similar to 46% reported by Chisti, et al[17] where the study populations were enrolled form another tertiary care hospital of Bangladesh. It was also similar to 42.3% reported by Laman, et al[12] which was conducted among hospitalized children of under 5 years of age with ALRI. However, the rate of present study was higher than 4% and 20% reported by Usen, et al[11] and Kuti, et al[18] respectively, among Gambian children aged from 2-33 months with ALRI who presented to urban hospital setup. The much higher prevalence observed in our study may be related to the fact that the difference in study population.

In the present study only severe cases of ALRI were included unlike the previous studies where both non

severe cases of ARI and reactive airway diseases like bronchial asthma were included. Nascimento-Carvalho, et al[19] however, reported a much lower prevalence of 6% among American infants with ARI and 10% among children with ALRI despite setting the cutoff of diagnosing hypoxaemia at <95%. This may be due to early presentation of the patients to hospital where prompt and appropriate treatment was established before complications set in, as prevalence of hypoxaemia correlates well with increasing severity of ARI[19]. In the present study, we reported the prevalence of hypoxaemia by ABG criteria studies reporting the prevalence of hypoxemia measured by pulse oximeter showed wide variations and are not comparable because the cut off values used to define hypoxemia; study population, setting and the altitude in which they were conducted differ[20].

Overall, there was male predominance in our study population but, prevalence of hypoxaemia was insignificantly more among female than male. This finding was similar while other studies reported insignificant difference between males and females regarding prevalence of hypoxemia[21,22]. In our analysis, though we found that children in the age group of ≤12 months were more likely to be hypoxemic than their counterpart, this difference failed to reach statistical significance. However, in the present study only 11 (12.4%) of the children were in the age group of 13 months to 60 months. This finding was similar to that seen in the study by Kabra, et al[23], which had 64.2% children of the age group 13-60 months in the hypoxemic category. Basnet, et al[21] found that infancy group was more vulnerable to hypoxemia. Infants are vulnerable to ARI because, not only do they have less mature immune systems[24] but are also unable to clear secretions. They also cannot verbally communicate their distress, and this may predispose them to present with hypoxemia on arrival at the hospital.

In this study we found that among ALRI the majority of patients were Bronchopneumonia (50%) followed by bronchiolitis (41%). Hypoxaemia was more in bronchopneumonia (58%) than Bronchiolitis (36.6%). These findings were similar with the study of Nagarajan, et al[20], where hypoxaemia in pneumonia was 65%. As hypoxaemia may have serious health consequences if oxygen is not given and oxygen treatment itself has minimal adverse effects, it can be argued that in settings with adequate resources a very sensitive test is required. Development of guidelines will improve the quality of treatment delivered, thereby reducing morbidity and mortality.

Conclusion

Hypoxaemia is a very common and treatable complication of childhood respiratory infections in developing countries. It is a life-threatening condition that requires early detection and prompt treatment. However, in Bangladesh 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 where adequate care is available.

Conflict of interest

The authors declared that they have no conflict of interest.

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Citation of this article
Bhuyan MMR, Ahmed ATMF, Sufian A, Hossain A, Sultana S. Detection of Hypoxaemia by Arterial Blood Gas in Children with Acute Lower Respiratory Illness. Eastern Med Coll J. 2025; 10 (1): 1-5.