Original Article

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Evaluation of Arterial Blood Gas Patterns in Bronchiolitis: A Cross-Sectional Study at a Tertiary Care Center

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ABSTRACT

Background: *Bronchiolitis is the most common lower respiratory tract infection in infants and a major cause of pediatric hospitalization. Arterial Blood Gas (ABG) analysis can provide critical insights into respiratory function and disease severity, especially in moderate to severe cases. This study aimed to evaluate the arterial blood gas patterns in pediatric patients diagnosed with moderate and severe bronchiolitis at a tertiary care center.*

Materials and methods: *This cross-sectional study was conducted in the Department of Paediatrics, Chattagram Maa-O-Shishu Hospital Medical College, Chattogram, Bangladesh, from January 2015 to July 2015. This study, included 50 pediatric patients with bronchiolitis aged 2 months to 2 years attending the OPD or admitted to the Paediatric Department of Chattagram Maa Shishu-O-General Hospital.*

Results: *Most children were between 7–18 months old, with a male predominance (70%). Cough and respiratory distress were universal symptoms and chest indrawing with rhonchi was present in all cases. Hypoxemia (SpO_2 <95%) and tachypnea (R/R >60) were common. ABG analysis revealed that most moderate cases had normal pH and elevated PaO levels, while severe cases showed higher proportions of hypoxemia and low bicarbonate levels. Hypocapnia was observed across both groups. However, no significant differences were found between moderate and severe cases for pH (p=0.503) PaO_2 (p=0.432) $PaCO_2$ (p=0.453) or HCO_3 (p=0.231).*

Conclusion: *This study showed that while ABG patterns revealed mild differences between moderate and severe pediatric bronchiolitis cases, these variations were not statistically significant. ABG analysis may still serve as a supportive tool in assessing respiratory compromise in severe cases, aiding in the early recognition of respiratory failure.*

Key words: ABG Pattern; Arterial Blood Gas; Bronchiolitis; Pediatric; Severity.

Introduction

Bronchiolitis is a viral infection of the lower respiratory tract, characterized by acute inflammation, edema, necrosis of epithelial cells in the small airways, increased mucus production and bronchospasm-all contributing to airway obstruction.[1] Clinically, it presents with symptoms such as rhinitis, tachypnea, wheezing, cough, crackles, nasal flaring and use of accessory respiratory muscles. The condition is typically classified into mild (Managed as an outpatient), moderate (Requiring hospitalization) and severe (Involving respiratory failure requiring ventilatory support). The severity of bronchiolitis is influenced by factors such as the infant's age, weight, the presence of comorbidities like prematurity, Chronic Lung Disease (CLD) or Bronchopulmonary Dysplasia (BPD), congenital heart disease, as well as environmental factors like multiple births or having siblings at home.[2,3]

Bronchiolitis is the most common lower respiratory tract infection among infants. In North America, about 21% of infants experience lower respiratory tract infections annually, with approximately 3% of children under one year requiring hospitalization for bronchiolitis.[1] Respiratory syncytial virus (RSV) accounts for the majority of cases, around 70% overall and between 80–100% during the winter season, while other viruses such as parainfluenza, adenovirus and influenza contribute to the remaining cases.[4]

Most affected infants have a mild form of the illness and are treated on an outpatient basis. However, since 1980, bronchiolitis-related hospitalizations have increased significantly. Among infants under one year, the hospitalization rate rose from 12.9 per 1,000 in 1980 to 31.2 per 1,000 in 1996. During the period from 1988

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to 1996, this increase was statistically significant ($p < 0.001$) while hospitalizations due to other lower respiratory infections remained relatively stable ($p = 0.20$). The proportion of hospitalizations for lower respiratory tract illnesses attributable to bronchiolitis rose from 22.2% in 1980 to 47.4%.[5]

Infants with acute bronchiolitis are at greatest risk for deterioration within the first 48 to 72 hours following the onset of cough and dyspnea. During this critical window, they may present with severe symptoms such as air hunger, apnea and respiratory acidosis.[6] Arterial Blood Gas (ABG) analysis is a vital tool in evaluating acid-base balance in such patients. Typically, arterial pH reflects the effectiveness of ventilation. A combination of low PaO_2 and elevated $PaCO_2$ is a strong indicator of impending respiratory failure.[7,8]

ABG analysis remains the gold standard for assessing blood oxygenation, carbon dioxide levels and acid-base status. It offers insight into how effectively the lungs are delivering oxygen and eliminating carbon dioxide and how well the lungs and kidneys are cooperating to maintain normal pH levels.[9] Studies have shown that among various clinical parameters, oxygen saturation and $PaCO_2$ are better predictors of the need for high-concentration oxygen therapy, while PaO_2 levels are less reliable for this purpose.[10-13]

Although routine blood gas analysis (Capillary or arterial) is not generally indicated in mild cases of bronchiolitis, it becomes crucial in infants with severe respiratory distress or signs of impending respiratory failure.[10,13] The management of acute bronchiolitis is primarily supportive, as no pharmacologic intervention has demonstrated a significant impact on outcomes such as hospital stay duration, use of supportive measures or ICU admission.[14-16]

In this study, evaluation the Arterial Blood Gas (ABG) patterns in pediatric patients with acute bronchiolitis admitted to the pulmonology Department.

Materials and methods

This cross-sectional study was conducted in the Department of Paediatrics, Chattagram Maa-O-Shishu Hospital Medical College (CMOSHMC) Chittagong, Bangladesh, from January 2015 to July 2015. This study included 50 patients with bronchiolitis aged 2 months to 2 years were included attending the OPD or admitted to the Paediatric department of Chattagram Maa Shishu-O-General Hospital.

These are the following criteria to be eligible for enrollment as study participants: a) Patients aged between 2 months to 2 years b) Patients diagnosed as having moderate and severe bronchiolitis based on clinical criteria c) Patients of those parents/guardians who were willing to participate were included in the study. a) Patients with known congenital heart disease that may affect ABG b) Patients with other comorbidities like secondary infection, congenital stridor, cerebral palsy, asthma c) Immunocompromised patients with respiratory infection were excluded from this study.

This Legal guardians of diagnosed bronchiolitis patients were asked to be included in the present study. Consent was taken after an explanation of the study procedure. Patients were to be evaluated clinically to assess the severity of the bronchiolitis. For assessment thorough, physical and respiratory system examination was done and noted in the data sheet. ABG was done to find the pattern of blood gas change with the severity of the disease. Arterial blood was collected from a suitable artery by the researcher herself or with the help of a laboratory technologist. For analysis, 5cc of arterial blood was taken and sent to the laboratory without delay. ABG was done in the Clinical Biochemistry Department of CMOSMCH. All relevant variables were included in the case record form. Sociodemographic characteristics, clinical history, physical findings and ABG parameters were recorded and analyzed. Patients were categorized into moderate and severe groups based on clinical severity. Key ABG variables (pH, PaO_2, $PaCO_2$, HCO_3) were compared between groups using statistical analysis.

All data were recorded systematically in a pre-formatted data collection form. Quantitative data were expressed as mean, standard deviation and qualitative data was expressed as frequency distribution and percentage. The data were analyzed using the chi-square test. A p-value <0.05 was considered significant. Statistical analysis was performed by using SPSS19 (Statistical Package for Social Sciences) for Windows version 10. This study was ethically approved by the Institutional Review Committeeof Chattagram Maa Shishu-O-General Hospital.

Table I Moderate and severe Bronchiolitis assessed according to NSW[17]

Results

Symptoms	Moderate	Severe
Appearance	Mildly unwell	Unwell
Respiratory rate	Moderate tachypnoea	Apnoeas
		Severe tachypnoea
		Greater than 70
		Bradypnoea less than 30
Work of breathing	Mild to moderate	Moderate to severe grunting
Cyanosis	Absent	May be cyanosed or pale
Oxygen saturation	90–95% in air	Less than 90% in the air
Oxygen requirement	—	Less than 92% in O
Heart rate	Mild tachycardia	Tachycardia greater than 180
Feeding	Difficulty feeding, but able to take more than 50% of normal feed	Difficulty feeding, taking less than 50% of the normal feed

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Table II Sociodemographic profile of our pediatric patients (n=50)

Characteristics	n=50	P (%)
Age		
2 – 6 months	6	12.0
7-11 months	15	30.0
12-16 months	17	34.0
17+ months	12	24.0
Gender		
Male	35	70.0
Female	15	30.0
Residents		
Rural	20	40.0
Urban	30	60.0
Occupation of the guardians		
Business	12	24.0
Service holder	17	34.0
Worker	6	12.0
Farmer	15	30.0
Socioeconomic status		
Poor	17	34.0
Middle class	29	58.0
Rich	4	8.0

Table II shows that the majority of children were aged between 7 to 16 months, with 30% in the 7–11 month range and 34% in the 12–16 month range. There was a male predominance, 70% of patients being male and 30% female. Most patients were from urban areas (60%) while 40% resided in rural settings. Regarding the occupation of the guardians, 34% were service holders, followed by farmers (30%) and business professionals (24%). In terms of socioeconomic status, the majority belonged to the middle class (58%), with 34% classified as poor and 8% as rich.

Table III Past disease History of pediatric patients (n=50)

History Evaluation	No.	P (%)
Cough	50	100.0
Respiratory distress	50	100.0
Fever	26	52.0
Feeding difficulty	25	50.0
Nasal congestion	30	60.0

Table III shows the clinical history of the patients. All 50 children (100%) presented with cough and respiratory distress, while more than half experienced fever (52%) and feeding difficulties (50%). Nasal congestion was reported by 60% of cases.

Table IV Distribution of pediatric patients by clinical & laboratory findings (n=50)

Findings	No.	P (%)
Ill looking	42	84.0
Cyanotic lips	2	4.0
R/R>60/min	38	76.0
Nasal flawing	27	54.0
Chest indrawing	50	100.0
Grunting	4	8.0
Palpable liver(visceroptosis)	18	36.0
Rhochi	50	100.0
Crepitations	26	52.0
SPO_2 on pulse oximetry (<95)	39	78.0
CRP(>l0)	12	24.0
Hyperinflation in CXR	38	76.0

This Table presents the distribution of laboratory findings observed among the 50 pediatric patients. The most prevalent signs included chest indrawing and rhonchi, both observed in 100% of the patients, indicating widespread lower respiratory tract involvement. A high respiratory rate (>60/min) was noted in 76% of cases, while 78% showed oxygen saturation below 95% on pulse oximetry, suggesting significant respiratory distress and hypoxemia. Ill appearance was noted in 84% of children and nasal flaring was present in over half (54%) reinforcing the severity of their respiratory compromise. Crepitations were heard in 52% of patients and 36% had a palpable liver, potentially due to respiratory strain or visceroptosis. Less frequent findings included grunting (8%) and cyanotic lips (4%). Laboratory evidence of inflammation, as indicated by elevated CRP (>10 mg/L) was found in 24% of cases. Radiographic evidence of hyperinflation was seen in 76%, further supporting a diagnosis of lower airway obstruction consistent with bronchiolitis.

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Table V Arterial Blood Gas (ABG) pattern distribution in moderate vs severe Bronchiolitis

ABG Pattern in Bronchiolitis	PH			PaO_2 (mmHg)			$PaCO_2$ (mmHg)			HCO_3 (mEq/L)		
	<7.35	7.35–7.45	>7.45	<80	80–100	>100	<35	35–45	>45	<22	22–28	>28
Moderate	3 (6%)	21 (42%)	4(8%)	0 (0.0)	0 (0.0)	28 (56%)	26 (52%)	2 (4%)	0 (0.0)	20 (40%)	8 (16%)	0 (0.0)
Severe	1 (2%)	17 (34%)	4 (8%)	8 (16%)	6 (12%)	8 (16%)	21 (42%)	1 (2%)	0 (0.0)	17 (34%)	5 (10%)	0 (0.0)
p-value		0.503			0.432			0.453			0.231	

Table V compares the distribution of Arterial Blood Gas (ABG) parameters between pediatric patients with moderate and severe bronchiolitis. Among moderate cases, the majority (42%) had a normal pH (7.35–7.45) while 6% showed acidemia (pH <7.35) and 8% had alkalemia (pH >7.45). Similarly, 34% of severe cases had a normal pH. Regarding oxygenation, 56% of moderate cases had elevated PaO_2 levels (>100 mmHg), whereas only 16% of severe cases fell into this range; in contrast, 16% of severe cases had hypoxemia (PaO_2 <80 mmHg) and 12% were in the normal range. For $PaCO_2$, hypocapnia ($PaCO_2$ <35 mmHg) was common in both groups, affecting 52% of moderate and 42% of severe cases, indicative of hyperventilation. Bicarbonate (HCO_3) levels were predominantly low (<22 mEq/L) in both moderate (40%) and severe (34%) cases. No statistically significant differences were observed between the two groups for any ABG parameter, as indicated by the respective p-values for pH (0.503) PaO_2 (0.432) $PaCO_2$ (0.453) and HCO_3 (0.231).

Discussion

Arterial blood gas (ABG) analysis is one of the initial investigations performed in critically ill patients, as it provides crucial information on oxygenation and ventilation status. In the present study, assessment of ABG parameters pH, PaO_2 and $PaCO_2$ in two groups of pediatric patients with moderate and severe bronchiolitis. The male-to-female ratio was 2.33:1. Most guardians were service holders (34%) and 40% of the patients were from rural areas. The most commonly reported symptoms were cough, dyspnea, and fever, which align with the Scottish Intercollegiate Guidelines Network that lists dry cough, dyspnea and wheezing as leading symptoms of bronchiolitis.[18]

In this study, 42 patients had normal PaO_2 levels, while 8 exhibited hypoxemia, and 3 had severe hypoxemia (PaO_2 <60 mmHg). The pH was low in 4 patients but remained within the normal range in 38. $PaCO_2$ was reduced in 4 cases, suggesting respiratory alkalosis, although pH remained normal. Notably, $PaCO_2$ was <32 mmHg in 46 patients, with normal pH in 38 of them. HCO_3 was <22 mEq/L in 37 cases, likely reflecting a compensatory response.

Early stages of bronchiolitis are characterized by hypocapnia from hyperventilation and hypoxemia due to Ventilation-perfusion (V/Q) mismatch.[8] This phenomenon can be explained by the non-uniform increase in airway resistance. Air is preferentially directed to lung regions with lower resistance, which may represent less than 25% of total lung volume, yet receive over 80% of the inspired air. These regions hyperventilate relative to their perfusion, raising the V/Q ratio and leading to hypocapnia and respiratory alkalosis. Meanwhile, other alveoli receive less ventilation, lowering the V/Q ratio and resulting in hypoxemia. Since the hyperventilating regions cannot fully compensate for the under-ventilated ones, overall PaO_2 drops. The degree of $PaCO_2$ alteration depends on the net effect of these imbalances: it may be low due to CO_2 washout, normal if ventilation is balanced, or elevated if overall ventilation is significantly impaired.[19]

In this study, 47 patients had decreased $PaCO_2$ levels, among these, 3 also exhibited severe hypoxemia. Four patients displayed clear signs of respiratory acidosis, indicating disease progression and reduced global lung ventilation. Normal PaO_2 in 42 cases likely reflects a compensatory balance between hyperventilated and hypoventilated lung regions.

Zuvdija Cecunjanin et al. studied 103 patients and found decreased $PaCO_2$ in 36 (35.3%) hypercapnia in 15 (14.7%) and normal $PaCO_2$ in 51 (50%).[20] Increased pH was observed in 7 (6.8%) and decreased pH in 11 (10.7%). Comparatively, this study revealed a higher prevalence of hypocapnia (84%) and no cases of hypercapnia. While 100% of patients in Cecunjanin's study had hypoxemia, only 16% of the cases had hypoxemia, possibly due to earlier presentation or milder disease.

Shaw et al. identified five predictors of severe bronchiolitis, one being oxygen saturation <95%.[21] Similarly, Mulholland et al. correlated clinical findings with disease severity based on pulse oximetry and ABG results, with an oxygen saturation <90% considered significant.[22] Findings of this study partially align with these studies: 8 patients had hypoxemia, including 3 with severe desaturation who required transfer to the PICU for intensive care.

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Although ABG analysis is not routinely indicated in acute bronchiolitis, it becomes relevant in cases with severe respiratory distress or impending respiratory failure.[10,13] Studies show that oxygen saturation and $PaCO_2$ levels are stronger predictors of disease severity and the need for high-concentration oxygen therapy than PaO_2 alone.[10,13] Even small variations in oxygen saturation (92–94%) may influence emergency department decisions regarding hospital admission or discharge.[11,14,16] Low SpO_2 on admission has also been associated with longer hospital stays and increased severity. Therefore, decisions to admit children with SpO_2 between 92–94% should be supported by clinical judgment, disease stage and socioeconomic context.[3,10,22]

Despite the high prevalence of bronchiolitis, there remains limited consensus on the most effective management strategies.[3,11,23] Wilson et al. highlighted significant institutional variability in the treatment of hospitalized infants with bronchiolitis, variations that were not attributable to differences in disease severity.[24] These inconsistencies in care were found to significantly impact both hospital costs and length of stay. Hospitalization is warranted for infants with acute bronchiolitis who exhibit signs of respiratory distress. The cornerstone of management is supportive care. Hypoxemic infants should receive cool, humidified oxygen to alleviate symptoms and maintain adequate oxygenation. Suctioning of nasal and pharyngeal secretions is also a critical component of care, especially in younger infants who are obligate nasal breathers.

Interestingly, one study found that "On-demand" use of inhaled epinephrine or saline may be more beneficial than scheduled dosing regimens. Reflecting this evolving understanding, the American Academy of Pediatrics (AAP) Committee on Infectious Diseases, in the 2000 edition of the Red Book, emphasized that supportive care, including hydration, supplemental oxygen and mechanical ventilation, when necessary, remains the foundation of bronchiolitis treatment.[25] Oxygen therapy is indicated in all infants with documented hypoxia. For those at risk of respiratory failure, High-Flow Nasal Cannula (HFNC) therapy can reduce the need for mechanical ventilation.

Limitations

This study was a single-center study, small sample size due to the short study period. After evaluating those patients did not follow up with them for the long term and did not know other possible interference that may happen in the long term with these patients.

Conclusion

In the study, highlighted the utility of Arterial Blood Gas (ABG) pattern analysis in assessing the severity of bronchiolitis in pediatric patients. Most children demonstrated normal or low $PaCO_2$ levels, even in severe cases, suggesting that early-stage compensation through hyperventilation is common. However, the presence of elevated $PaCO_2$ alongside hypoxemia was indicative of advanced respiratory compromise requiring prompt and intensive intervention. These findings underscore the importance of ABG analysis in guiding clinical decisions, particularly in moderate to severe bronchiolitis.

Recommendation

Further research with a prospective and longitudinal study design, including a larger sample size, needs to be done to validate the findings of this study.

Disclosure

The authors declared no competing interest.

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