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Association of Arterial Blood Gas Parameters with Length of Hospital Stay in Children With Acute Severe Asthma

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Abstract

Asthma stands as a prevalent chronic illness in early childhood, often leading to frequent hospital admissions in pediatric wards. Its proper evaluation and management are crucial. Arterial blood gas (ABG) analysis plays a pivotal role, akin to pulmonary function tests, serving as a vital laboratory test for critically ill asthmatic patients. It aids in interpreting acid-base status, facilitating appropriate hospital admission and management strategies. The study aimed to assess the severity of disorders through ABG parameters among severe asthmatic pediatric patients during acute exacerbations. This hospital-based prospective study involved 67 severe acute bronchial asthmatic patients aged 1-17 years. Automated ABG analysis was performed using latest automated machine, with the ABG report analyzed using mean, median and standard deviation. Duration of hospital stay was calculated from the day of admission to the day of final discharge. The results indicated a positive correlation between ABG report abnormalities and the duration of hospital stay. Specifically, dysfunction observed in ABG reports corresponded to an extended hospital stay among these patients. Our study lends support to the hypothesis that abnormal and mixed types of ABG reports are associated with prolonged hospitalization in severe asthmatic pediatric patients during acute exacerbations.

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Key Words
Asthma, arterial blood gas analysis, exacerbation, acid-base status

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INTRODUCTION

Childhood asthma is a chronic respiratory condition necessitating consistent management and regular monitoring. The rising prevalence of pediatric asthma has led to increased hospital admissions due to severe acute asthma exacerbations. These cases contribute significantly to the loss of school days, averaging 5-7 days per child annually. Globally, the escalating prevalence of asthma and its associated healthcare burden have spurred extensive research into management and treatment strategies. Various triggering factors lead to excessive narrowing of the respiratory passages, resulting in reduced airflow, symptomatic wheezing and dyspnea. This is accompanied by edema, broncho spasm and airway obstruction, eventually culminating in respiratory distress, progressive hypoxia and respiratory failure in bronchial asthma patients[1-3].

Therefore, a stepwise treatment approach is employed alongside continuous monitoring of cardiorespiratory status using non-invasive and invasive devices, serial clinical assessments and relevant diagnostic tests. Clinical and functional parameters such as spirometry, peak expiratory flow rate (PEFR) and arterial blood gas (ABG) analysis are crucial for evaluating asthma symptoms. ABG analysis plays a pivotal role in assessing gas exchange and ventilation efficiency, aiding in diagnostic and therapeutic decision-making[4].

The introduction of ABG analysis has revolutionized respiratory medicine, enabling prediction, prognosis and effective management planning for patients. ABG analysis is akin to a pulmonary function test, reflecting lung-kidney interaction for maintaining normal blood pH and oxygenation status, particularly in high-risk patients. It assesses parameters like pH, pCO2, bicarbonate and base deviation to identify respiratory or metabolic disorders and gauge acid-base balance[4,5].

Disorders in acid-base balance can lead to severe complications and become life-threatening if not managed appropriately. Correct interpretation of ABG results is essential for determining lung function, oxygenation and CO2 elimination efficiency. Utilizing ABG analysis aids in diagnosing acute asthma exacerbations, guides treatment strategies and informs ventilator management, thereby enhancing patient care and outcomes[5.6].

This article comprehensively discusses ABG analysis methods, interpretation and a systematic approach to facilitate informed management decisions for childhood asthma.

MATERIAL AND METHODS

The hospital-based prospective study was conducted on patients from the pediatric ward. Data collection involved 67 bronchial asthma patients aged 1-17 years, following the guidelines of the American Thoracic Society[7].

Before sample collection, informed consent was obtained from the guardians of the patients. Inclusion criteria encompassed children experiencing acute severe asthma exacerbation (SAE) and admitted to the pediatric intensive care unit (PICU). Exclusion criteria excluded cases involving foreign body aspiration, pneumonia, coronary heart disease with wheeze, undiagnosed cases of breathlessness, bronchiectasis and mild-to-moderate asthma.

The study aimed to investigate the impact of hypoxic status, hematological parameters and their complications on the exacerbation of acute asthma, correlating these factors with the duration of hospital stay. Automated ABG analysis was performed using latest automated machine, with the ABG report analyzed using mean, median and standard deviation. Duration of hospital stay was calculated from the day of admission to the day of final discharge.

Statistical analysis utilized descriptive tests to determine the mean, median and standard deviation, facilitating the assessment of the significance of severity proportions between normal and abnormal ABG findings and their outcomes. Additionally, analysis of variance was performed to ascertain the significance of the mean duration of hospital stay concerning ABG findings and severity grading.

RESULTS AND DISCUSSIONS

(Table 1) illustrates the percentage of admitted asthma cases out of a total of 567 hospital admissions, revealing that acute severe asthma accounted for 11.82% of cases.

(Fig. 1) depicts the ABG status at admission, indicating that 29% of patients had respiratory acidosis, 20% had respiratory alkalosis and 13% had mixed acid-base disorders.

(Table 2) presents the association between ABG diagnosis and the length of hospital stay. It shows that patients with mixed acid-base disorders had a significantly longer hospital stay (P<0.05) compared to those with simple acid-base disorders.

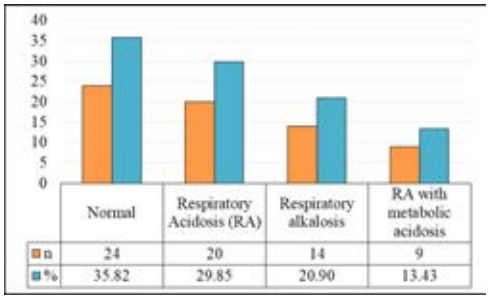

Fig. 1: ABG status at admission

Table 1: Proportion of admitted asthma cases

Variable	n	percentage
Total Hospital admissions for respiratory patient	567	100.00
Total no. of acute severe asthma cases	67	11.82

Table 2: Association of ABG diagnosis with length of hospital stay

Condition	Hospital Stay (in Days), Mean±SD
Normal	3.20±1.22
Respiratory Acidosis (RA)	7.67±1.96
Respiratory alkalosis	6.69±1.42
Mixed Acid Base Disorder	13.59±12.07

Key findings from the study included patients spanning from 10 months to 17 years old, with the youngest being 10 months and the eldest 17 years. Clinical signs such as rhonchi, crepitations, tachypnea and use of accessory muscles were prevalent. Patients with asthma exacerbations typically displayed tachypnea and low pCO2, indicating respiratory failure. Pre- and post-treatment ABG analyses were conducted to assess asthma severity and guide appropriate management strategies across 67 episodes of acute bronchial asthma.

Hospital stays varied significantly based on ABG disturbances, with mixed-type disorders (RA+metabolic acidosis or respiratory alkalosis+metabolic alkalosis) having the longest duration, followed by RA and respiratory alkalosis. Patients with normal ABG reports and intermittent asthma attacks had the shortest stay. Management of mixed acid-base disorders focused on correcting each primary acid-base disturbance individually[8].

Gender distribution was also significant, with males comprising majority than females. This disparity in gender reflects existing differences in asthma and atopy, with boys showing a higher prevalence before puberty and a reversal of this trend after puberty, where girls exhibit a higher incidence of asthma. These findings align with previous study[9].

Hurwitz *et al*. conducted a study highlighting the inaccuracy of clinical scoring for assessing hypoxemia in pediatric patients. They emphasized the necessity of relying on arterial blood gas (ABG) determination to accurately evaluate hypoxemia severity during emergency treatment of pediatric asthma patients[10]. Sanchez-Lerma *et al*.'s study emphasized the importance of early recognition in improving outcomes for asthma patients. They noted that various asthma scoring systems correlate with hospitalization need and exacerbation severity. Utilizing asthma scores in hospitalized children could potentially reduce the length of stay, decrease total costs and enhance overall quality of care[11].

In the current study, pH, pCO2 and pO2 measurements were performed together to assess acid-base status, ventilation and arterial oxygenation. These parameters are crucial for evaluating gas exchange adequacy, with oxygen (O2) and carbon dioxide (CO2) partial pressures in arterial blood serving as key indicators[12]. According to Saharan *et al*.'s study on "Management of Status Asthmaticus in Children" in 2010, blood gas analysis should be routinely conducted in children, both initially and as indicated during the course of treatment. The presentation of status asthmaticus varies based on severity, asthma triggers, and the patient's age[13].

Metabolic acidosis, when observed, typically did not require correction with sodium bicarbonate. This finding aligns with Rudolf *et al*.'s study, where they examined serial ABG changes in 14 patients with acute asthma. Similarly, Rudolf *et al*. noted that mild metabolic acidosis in acute asthma cases often did not necessitate specific treatment[14].

Signs such as hurried breathing, tachypnea, altered sensorium, refusal to feed and cyanosis were indicative of a mixed-type acid-base disorder involving both respiratory and metabolic acidosis, often leading to abnormal ABG reports. This observation is consistent with Obata *et al*.'s study on the relationship between ABG parameters and a clinical scoring system in asthmatics. Obata *et al*. found a statistically significant correlation between clinical scores and PaCO2, PaO2 and pH in children aged under 5 years and over 6 years[15].

Feldman (1962) emphasized the prognostic significance of increased arterial pCO2 in adults with severe asthma, highlighting its grave implications. The severity of airway obstruction increases the likelihood of ventilation-perfusion mismatching, impairing gas exchange and leading to hypoxemia. This finding is in line with Nowak *et al*.'s study, where patients with hypercarbia and hypoxemia had low peak expiratory flow rates (PEFR) below 200 lt/min. The utilization of ABG analysis can aid in reducing diagnostic costs and discomfort without compromising healthcare quality[16].

Moreover, Schatz and Camargo noted that during an asthma attack, metabolic acidosis may initially be compensated for by hyperventilation and respiratory alkalosis. However, as respiratory failure progresses, arterial CO2 levels rise, leading to respiratory acidosis and a further decrease in arterial pH[17].

CONCLUSION

The study observed that children with abnormal ABG results, specifically a mixed type of ABG disturbance characterized by RA+MA or RALK+MALK, had a longer duration of hospital stay. On average, these children spent more days in the hospital, highlighting the impact of abnormal ABG findings on the length of hospitalization. Our study lends support to the hypothesis that abnormal and mixed types of ABG reports are associated with prolonged hospitalization in severe asthmatic pediatric patients during acute exacerbations.

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