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RESEARCH ARTICLE

Parametric correlation of arterial blood gas status with the duration of stay in hospital in cases of acute severe asthmatic children

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ABSTRACT

Background: Asthma is one of the common causes of chronic illness in early childhood having frequent admitting diagnosis in pediatric ward. It needs proper evaluation for their treatment and management. Determination of arterial blood gas (ABG) analysis plays important role as pulmonary function test; it is important laboratory test for critically ill asthmatic patients where acid-base status interpretation is needed for their hospital admission and proper management. **Aims and Objectives:** The aims of the study were to assess the severity of disorders with the parameters of ABG report with their hospital stay of severe asthmatics pediatric patients during their acute exacerbations. **Materials and Methods:** A hospital-based prospective study conducted in forty-three severe acute bronchial asthmatic patients of 1–17 years done using automated ABG analyzer machine (COMBISYS-II), analysis of ABG report done using mean, median, and standard deviation. **Results:** Their comparison with the dysfunction of ABG report with their hospital stay showed positive correlation. **Conclusion:** Our study supported the hypothesis of enhanced hospital stay with abnormal and mixed type of ABG report.

KEY WORDS: Acute Bronchial Asthma Exacerbations; Arterial Blood Gas Analysis; Acid-base Status; Hypoxemia

INTRODUCTION

In childhood, asthma is one of the chronic respiratory diseases, which needs proper management and regular follow-up. The increasing prevalence of pediatric asthma has led to increasing burden of admissions in hospitals with severe acute asthma exacerbation. It was seen that the cases of it were one of the causes which resulted in 5–7 days of lost school days/year/child.[1] The global prevalence of asthma and the burden it is imposing with the associated high health care has led to extensive researches in management and treatment areas.[2] Many precipitating factors are involved which causes excessive narrowing of respiratory passages leading to reduced airflow symptomatic wheezing and dyspnea. Edema and bronchospasm with excessive abnormality of airways cause airway obstruction in bronchial asthma latter resulting in distress, progressive hypoxia, and respiratory failure. Hence, stepwise treatment therapy is given in these patients in addition to continuous monitoring of their cardiorespiratory status through non-invasive and invasive devices by serial clinical examination and appropriate diagnostic tests. There is number of clinical and functional parameters for assessment of these patients with asthma symptoms such as spirometric test, peak expiratory flow rate (PEFR), and arterial blood gas (ABG) analysis tension. Evaluating acid-base status in critically ill asthmatic patients plays important role for the diagnostic and therapeutic modalities of asthma. Effectiveness of gaseous exchange and ventilation can be assessed by ABG analysis; Jeffrey (1999) reported that to master the complex concept of acid-base balance and ABG analysis, one requires great deal of study of interpretation of

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report that will help to analyze able to choose appropriate action.

With the advent of ABG analysis, a revolution in the field of respiratory medicines has occurred so, now, it is possible to predict and prognoses the condition of the patients and also their need for effective management.[3]

ABG analysis plays an important role as pulmonary function test. ABG test indicates how well lung and kidney are interacting to maintain normal blood pH (acid-base balance). It also provides patients oxygenation status and acid-base balance of high-risk patients. A blood gas analysis and the evaluation of the parameters such as pH, pCO_2, bicarbonate, and base deviation are required to determine whether a respiratory or metabolic disorder is present or not.

Disorders of acid-base balance can lead to severe complications in many states and may also be so severe as to become a life-threatening risk factor. The usefulness of this diagnostic tool is dependent on being able to correctly interpret the results. An ABG evaluates how effectively lungs are delivering O_2 to blood and eliminating carbon dioxide (CO_2).[4]

The exacerbations of asthma can be acute; they can be rapid or gradual in onset; however, the utilization of ABG analysis gives following benefits; it aids in establishing diagnosis, guides treatment plan, and aids in ventilator management.[5]

The discussion of this article includes all those methods such as analysis, interpretation of ABGs, and logical and systemic approach to enable us to make proper management and decision of hospital admission and discharge much easier through them.

MATERIALS AND METHODS

The hospital-based prospective study was undertaken on patients of the pediatric ward of SMIMER Hospital, Surat, from the period of April 2013 to April 2014 with collaboration of the physiology department.

Our study was first approved by "The Institutional Ethical Committee of College SMIMER" and clearance was obtained. Data were collected from forty-three bronchial asthma patients as per the American Thoracic Society guidelines in the age group of 1–17 years.[6]

Before the collection of samples, informed consent was obtained from their parents/guardians.

The following inclusion and exclusion criteria were applied for selection process.

Inclusion Criteria

All children of acute severe asthma exacerbation (SAE) admitted in pediatric intensive care unit (PICU).

Exclusion Criteria

Foreign body aspiration, pneumonia, coronary heart disease with wheeze undiagnosed cases of breathlessness, bronchiectasis, and mild-to-moderate cases of asthma were excluded from the study.

Hence, the present study was carried out to find the influence of hypoxic status, hematological parameters, and its complications with exacerbation of acute asthma in accordance with their hospital stay.

Statistical Analysis

A descriptive analysis test is used to find the mean, median, and standard deviation so that significance of proportion of severity between normal and abnormal ABG findings and its outcome can be determined. Analysis of variance was been carried out to find out significance of mean duration of stay in the hospital with their ABG findings and severity of grading.

RESULTS

Of the total 364 patients admitted with wheeze associated respiratory infections during the period of 1 year. The acute severe asthma constituted 11.8% of all the PICU hospital admission [Table 1]. ABG revealed a majority with normal values 16 (37.20%). Among abnormal values respiratory acidosis (RA) 12 (27.9%) followed by alkalosis with 10 (23.25%). Less common was mixed type with respiratory and combined metabolic disturbances five in number constituting (11.62%) [Table 2]. Some patients suffered SAE characterized by respiratory distress, tachypnea, tachycardia, increased arterial CO_2 tensions, and respiratory muscle fatigue. A silent chest, cyanosis, and confusion or unconsciousness were characteristic signs of a SAE. ABG

Table 1: Distribution of asthma admission

Variables	*n* (%)
Total no. of hospital admission of respiratory pts	364 (100.0)
Total no. of acute severe asthma patients	43 (11.8)

Table 2: ABG analysis at the time of admission (*n*=43)

ABG status	*n* (%)
Normal	16 (37.20)
RA	12 (27.9)
Respiratory alkalosis	10 (23.2)
RA with metabolic acidosis	5 (11.62)

ABG: Arterial blood gas, RA: Respiratory acidosis

status with the duration of stay in days was described in Table 3.

DISCUSSION

The present study was a hospital-based prospective study conducted in a period of April 2013–April 2014, seasonal variation presented in month of November with respiratory infections as common precipitating factor.

Among the primary findings of the study, the youngest child was 11 months old and the eldest being 16 years. Twenty-one patients had normal pO_2, whereas 4 pts showed hypoxemia of them 2 pts had severe hypoxemia with pO_2 <60 mmHg. The pH was less in 5 pts, whereas it was of normal range in 22 cases. The $PaCO_2$ showed clear cut RA in 7 cases with $PaCO_2$ above 45 mm Hg and pH <7.35.

Clinical signs and symptoms were the presence of rhonchi, crepitations, tachypnea, and use of accessory muscles; those who had asthma exacerbations were usually tachypneic, with low pCO_2 which indicated respiratory failure. Pre- and post-treatment ABG analysis and interpretation were done and consecutively compared so as to judge their asthma severity status and choose appropriate action and also predict the outcome in 43 episodes of acute bronchial asthma pts.

The duration of hospital stay was maximum in mixed type of ABG disturbance with RA+metabolic acidosis (MA) or respiratory alkalosis (RALK)+metabolic alkalosis (MALK) of (14.3 days) mean duration followed by RA of 8.07 days and RALK of 7.0 days. In patients of normal report with intermittent episodic, acute attack of asthma least stay of 3.08 days was seen. Mixed acid-base disorders occur when there is a combination of primary acid-base disturbances (but not combined RA and alkalosis). The therapy is directed towards correction of each primary acid-base disturbance.[7]

Significant gender distribution of their gender was observed. Males constituting 67.4% and females 32.5% showing clear sex differences existing in asthma and atopy with a preponderance of boys before puberty and then a reversal of this sex ratio after puberty with girls having more asthma which correlates with study done by Oberger and Engstrom.[8]

Strength of Study

Our study was comparable from reports and investigations are done by others which confirm previous observations that there is reversal of this sex ratio and ventilatory failure is not uncommon in severe acute asthma in children. The study done by Oberger and Engstrom proved reversal of sex ratio.

Hurwitz *et al*. did a study where he concluded that clinical scoring was inaccurate for assessment of hypoxemia in pediatric age group and so, only ABG determination should be used to assess the severity of hypoxemia in emergency conditions of treatment of pediatric asthma patients.[9]

According to Sanchez-Lerma *et al*. study, early recognition is important for improving the outcomes. A number of asthma scores have been shown to correlate with the need for hospitalization and with the severity of asthma exacerbation.[10] The correlation with the asthma score in hospitalized children would lead to a decrease in length of stay and also reduce the total cost with overall improvement of quality of care.

In our study, three separate measurements – pH, pCO_2, and pO_2 were generally made together to evaluate acid-base status, ventilation, and arterial oxygenation. Oxygen (O_2) and CO_2 are the most important respiratory gases and their partial pressures in arterial blood reflect the overall adequacy of gas exchange.[11]

In the present study, 10 cases showing decreased $PaCO_2$ are examples of the early stage of severe acute asthma. Of the 10 cases, 4 are associated with severe hypoxemia. The clear cut 12 cases of RA are the typical cases in which the condition has worsened and where the overall ventilation-perfusion ratio of the whole lung is clearly reduced as in our study hypercapnia was seen in 7 patients of 43 (16%) and hypocapnia in 10 patients (23.2%).

The study by Saharan *et al*. in "Management of Status Asthmaticus in Children" in 2010, blood gas analysis should be obtained in all children at the baseline and subsequently as indicated. The presentation varies by severity, asthmatic triggers, and patient's age.[12]

Metabolic acidosis when present did not need correction with sodium bicarbonate, this observation was similar to

Table 3: ABG status with the duration of stay in days

ABG analysis status	No. of admission	Duration of stay (days)				
		Min.	Max.	Mean	Standard deviation	Median
Normal	16	2	5	3.04	1.16	4.0
RA	12	6	14	8.07	2.06	8.0
Ralk	10	5	10	7.04	1.49	7.0
Mixed type, i.e., metabolic with respiratory (RA+MA, RALK+MALK)	5	10	30	14.3	12.7	10.00

RA: Respiratory acidosis, ABG: Arterial blood gas, RALK: Respiratory alkalosis, MALK: Metabolic alkalosis, MA: Metabolic acidosis

that of Rudolf *et al*., where Rudolf *et al*. studied the serial changes in ABGs in 14 patients with acute asthma, and similar measurements made at identical times intervals under standard conditions.[13] Moreover, when present was mild and needed no specific treatment.

RA is positively associated with symptoms as breathlessness, altered sensorium, or refusal to feed. Respiratory alkalosis is positively associated with breathlessness.

Hurried breathing, tachypnea, and altered sensorium or refusal to feed with cyanosis were signs of mixed type of acid-base disorder with respiratory and MA and more likely to have abnormal ABG report. The study correlates with Obata *et al*. in "study relationship between ABG tension and a clinical scoring system in asthmatics" were clinical score had statistically significant correlation with $PaCO_2$ and PaO_2, pH in children both under 5 years, and over 6 years.[14] Feldman (1962) emphasized the grave prognostic significance of an increase in arterial pCO_2 in adults with severe asthma.

The more severe the airway obstruction, the more likely ventilation-perfusion mismatching will result in impaired gas exchange and hypoxemia. This observation closely correlates with that of Nowak *et al*. where all the patients with hypercarbia and hypoxemia had PEFR below 200 lt/min. And thus, use of ABG analysis would help decrease diagnostic cost and discomfort without jeopardizing health care.[15]

Another study by Schatz and Camargo, during an asthma attack, MA may initially be compensated for by hyperventilation and a respiratory alkalosis, but as respiratory failure develops, increasing arterial CO_2 will result in a RA and a further decrease in arterial pH.[16]

Limitations of Study

Nonetheless, this study had a few limitations; first, arterial blood sampling should be properly obtained and carefully measured. The most common problems include non-arterial samples, air bubbles in the sample, either inadequate or excessive anticoagulant in the samples, and delayed analysis.

Corrupted factors in ABG sampling can change results significantly and adversely affecting patients care decisions when the magnitude of errors is clinically important for handling the plan of care, as the smallest of errors may be life-threatening.[17]

Hypoxemia on admission was a constant finding and the arterial O_2 tension took a week or longer to return to a normal level. Treatment with 60% inspired O_2 provided a safe means of relieving hypoxemia and provided that blood gases were measured before and during O_2 therapy.

CONCLUSION

The present study aimed at determining the correlation of parameters of normal and abnormal ABG report with the duration of stay in hospital carried out using 43 children of both sex showed positive correlation with their ABG analysis. Analysis of variance of the mean duration of stay concluded that children with abnormal ABG, which was mixed type of ABG disturbance with RA+MA or RALK+MALK had longer duration of stay in hospitals constituting mean duration of 14.3 days.

REFERENCES

1. Masoli M, Fabian D, Holt S, Beasley R. Global initiative for asthma-global strategy for asthma management and prevention GINA dissemination committee report. Allergy 2004;59:469-78. Available from: http://www.ginaasthma.org. [Last accessed on 2015 May 23].
2. Barnes PJ. Harrison's Principles of Internal Medicine. 18th ed., Vol. 2. USA: McGraw Hill Co.; 2012. p. 2102-15.
3. Suguna S. Arterial blood gas analysis-A predicting factor in the outcome of acute severe asthma in children. Int J Health Sci Res 2013;3:72-80. Available from: http://www.ijhsr.org. [Last accessed on 2015 May 23].
4. Odhiambo JA, Chwalard RD. Arterial blood gases and acid base status of patients presenting with acute severe asthma at Kenyatta national hospital, Nairobi. East Afr Med J 1992;69:319-22.
5. Sood P, Paul G, Puri S. Interpretation of arterial blood gas. Indian J Crit Care Med 2010;14:57-64.
6. American Thoracic Society. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease (COPD) and Asthma. Am Rev Respir Dis 1987;136:225-44.
7. Papiris S, Kotanidou A, Malagari K, Roussos C. Clinical review: Severe asthma. Crit Care 2002;6:30-44.
8. Oberger E, Engstrom I. Blood gases and acid base balance in children with bronchial asthma. Lung 1978;155:111-22.
9. Hurwitz ME, Burney RE, Howatt WF, Crowley D, Mackenzie JR. Clinical scoring does not accurately assess hypoxemia in pediatric asthma patients. Ann Emerg Med 1984;13:1040-3.
10. Sanchez-Lerma B, Morels-Chirivella FJ, Peñuelas I, Guerra CB, Lugo FM, Aguinaga-Ontoso I, *et al*. High prevalence of asthma and allergic disease in children aged 6-7 years. The international study of asthma and allergies in childhood. J Investig Allergol Clin Immunol 2009;19:383-90.
11. Mikulcik P. Rapid Gas Analysis-Blood Gases and More. 1st ed. Denmark: Radiometer; 2009. p. 5-22.
12. Saharan S, Lodha R, Kabra SK. Management of status asthmaticus in children. Indian J Pediatr 2010;77:1417-23.
13. Rudolf M, Riordan JF, Grant BJ, Maberly DJ, Saunders KB. Arterial blood gas tensions in acute severe asthma. Eur J Clin Invest 1988;10:55-62.
14. Obata T, Kimura Y, Tikura Y. Relationship between Arterial blood gas and a clinical score in asthmatic children. J Ann Allergy 1992;68:530.
15. Nowak RM, Tomlanovich MC, Sarkar DD, Kvale PA, Anderson JA. Arterial blood gases and pulmonary function testing in acute bronchial asthma. Predicting patients outcome.

JAMA 1983;249:2043-6.
16. Schatz M, Camargo CA Jr. The Relationship of sex to asthma prevalence, health care utilization, and medications in a large managed care organization. Ann Allergy Asthma Immonol 2003;91:553-8.
17. Youssef W, Yahia A, Ali NS, Elhabashy S. Factors affecting validity of arterial blood gas results among critically ill patients: Nursing perspectives. J Educ pract 2013;4:201.

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