



Original Research Article

Arterial Blood Gas Analysis - A Predicting Factor in the Outcome of Acute Severe Asthma in Children

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ABSTRACT

Asthma is one of the leading causes of chronic illnesses in early childhood. Asthma is the most frequent admitting diagnosis in children's hospital and results nationally in 5-7 lost school days per year per child. Determination of arterial blood gas analysis is one of the most useful tests of pulmonary function to assess the severity of illness and also to predict the outcome of acute severe asthma.

This was a hospital based prospective study conducted between August 2003 and August 2004 at Vani Vilas children's hospital, Bangalore. All children admitted to paediatric intensive care unit with acute exacerbation of Asthma were selected for the study. The sample size was 65. Prior to the initiation of specific therapy arterial blood gas analysis was done. Clinical evaluations were used in conjunction with the objective laboratory measurements for the initiation of therapy. Patients were followed up at regular interval. After the clinical stabilization of the child, another sample of arterial blood was analyzed to prognosticate the patient and to take the decision to discharge.

A positive correlation was established between initial ABG values and parameters of clinical severity. In majority the initial ABG were normal and those who had abnormal ABG had to undergo more intensive management. Abnormal ABG had positive correlation with the duration of stay in the hospital.

So we conclude that the measurement of arterial blood gases, is necessary as a part of initial assessment, management and as a prognostic indicator in the outcome of acute exacerbation of Asthma.

Keywords: Asthma, Acute exacerbation, Arterial blood gas analysis.

INTRODUCTION

Asthma is a chronic inflammatory disease of air ways characterized by reversible air flow obstruction and bronchial hyper responsiveness.

The chronic inflammation causes an associated increase in airway hyper responsiveness that leads to recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night

or in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment.

Exacerbations of asthma (attacks or worsening of asthma symptoms and lung function) are acute; they can be rapid in onset or occur gradually. However, under both circumstances exacerbations can be

severe and even result in death in the absence of effective treatment. More often, presenting symptoms are less severe, and occasionally they may be totally absent.

Considerable advances have come up in the diagnostic & therapeutic modalities of Asthma. The advent of arterial blood gas analysis has revolutionized the field of respiratory medicine especially Bronchial Asthma.

It is now possible to predict & prognosticate critical patients following which decisions regarding intensive care unit admissions can be instituted as required.

The purpose of the study is to determine that the arterial blood gas analysis is important to assess the severity of illness and also to predict the outcome of acute severe asthma.

Decisions regarding intensive therapy were done after initial therapy with salbutamol nebulization measuring PEFr before and after an hour of therapy, continuous monitoring of SpO₂ with pulse oxymeter in selected patients.

The patients were subsequently followed up during their hospital stay assessed at regular intervals to find out prognosis in the hospital.

MATERIALS AND METHODS

This is hospital based prospective study. This study was conducted between 1-8-2003 to 1-8-2004 in the pediatric intensive care unit at Vani Vilas children's Hospital, attached to Bangalore Medical College.

Sample size:

All children admitted to pediatric intensive care unit with acute exacerbation of Asthma in the above mentioned period. The total number of children was 65.

Inclusion criteria:

All children admitted to pediatric intensive care unit with acute exacerbation of Asthma in the above mentioned period.

Exclusion criteria:

1. First attack / undiagnosed asthma
2. Aspiration
3. CHD with wheeze
4. Pneumonia with wheeze
5. Immunodeficiency
6. Cystic fibrosis
7. Foreign body
8. Tropical eosinophilia
9. Loeffler's syndrome
10. Broncho Pulmonary dysplasia
11. Bronchiectasis

Methods of collection of data: Children admitted to pediatric intensive care unit with acute exacerbation of Asthma were selected for the study. Prior to the initiation of specific therapy arterial blood was taken by Radial or Femoral artery puncturing by syringe technique. The blood sample was analyzed with the automated blood gas analyzer used in our intensive care unit. Clinical evaluations were used in conjunction with the objective laboratory measurements including Arterial blood gas analysis for the initiation of therapy. Patients are followed up at regular interval in the hospital. After the clinical stabilization of the child, another sample of arterial blood was analyzed to prognosticate the patient and to take the decision to discharge.

Statistical Methods: Chi-square and Fisher exact test have been used to find the significance of proportion of severity between normal and abnormal ABG and outcome. Odds ratio has been use to find strength of relationship between severity and outcome with the ABG findings. Analysis of variance has been carried out to find significance of mean duration of stay between ABG findings.

Statistical software: The Statistical software namely SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

OBSERVATIONS

Study design: A Prospective clinical study consisting of 65 acute severe asthma pediatric patients was undertaken in Vani Vilas hospital attached to Bangalore Medical College, between 1:8:2003 to 1:8:2004 to investigate the need of Arterial blood gas analysis and to know whether ABG has any predictive value in the prognosis and outcome of the patients.

Table-1. Percentage distribution of Asthma admissions.

	Number	Percentage
Total number of hospital admissions	1209	94.5
Number of Acute severe Asthma admissions	65	5.1

Asthma constituted 5.1 % of all the hospital admissions during the study period.

Table-2. Age distribution with sex.

Age groups	Male (%)	Female(%)	Total(%)
Less than 1 year	1(2.4)	-	1(1.5)
1-3 years	18(43.9)	11(45.8)	29(44.6)
3-6 years	10(24.4)	8(33.3)	18(27.7)
> 6 years	12(29.3)	5(20.8)	17(26.2)
Total	41(100.0)	24(100.0)	65(100.0)

Most common age group of presentation was age between 1-3 years. Among the study group males constituted 41(63.1%) and females 24 (36.9%) in number.

Table-3. Symptoms on presentation.

Symptoms	Number (n=65)	%
Fever	46	70.8
Breathlessness	52	80.0
Cough	47	72.3
Wheeze	52	80.0
Hurried breathing	56	86.2
Chest in drawing	20	30.8
Altered sensorium/refusal feeds	23	35.4

Common presenting symptoms were hurried breathing, breathlessness, wheeze, cough, fever and altered sensorium/refusal of feeds in the decreasing order of frequency.

Table-4. Presentation of signs.

Signs	Number(n=65)	%
Tachypnea	43	66.2
Cyanosis	14	21.5
Dehydration	24	36.9
Use of accessory muscles	20	30.8
Rhonchi	54	83.1
Creptations	28	43.1

On examination children had rhonchi, tachypnoea, creptations, dehydration, and use of accessory muscle of respiration in the decreasing order of frequency.

Most of the admissions were in the month of September. Season wise most common admissions were in winter followed by early spring.

Most common precipitating factor for Asthma attack was respiratory infections. Other common triggering factors were exposure to cold weather, specific food item and non compliance with the drug.

Most common relieving factor was using inhaler therapy followed by nebulization in the hospital on outpatient basis.

Table-5. Previous attacks.

Previous attacks	Number	%
Mild intermittent	10	15.4
Mild persistent	19	29.2
Moderate persistent	30	46.2
Severe persistent	6	9.2

Majority of children presented with acute attack fell in to the category moderate persistent Asthma 30 (46.2 %).

Table 6. Arterial blood gas analysis at the time of admission.

Arterial Blood Gas	Number (n=65)	%
Normal	35	53.8
Respiratory Acidosis	9	13.8
Respiratory alkalosis	18	27.7
Respiratory acidosis +Metabolic acidosis	3	4.6
Metabolic alkalosis	-	-

Arterial blood gas revealed normal values in majority 35 (53.8%). Among abnormal ABG findings Respiratory alkalosis 18 (27.7%), Respiratory acidosis 18 (27.7 %), least common was mixed acid-base disturbance of Respiratory acidosis and metabolic Acidosis 3 (4.6 %).

Table 7. Association of Arterial Blood gas with severity of illness.

Severity of illness	Arterial Blood gas				OR [#] (RA)	OR [#] (RALK)	OR [#] (RA+MA)	OR [#] (Overall)
	Normal* (n=35)	RA* (n=9)	RALK* (n=18)	RA+MA* (n=3)				
Breathlessness	23 (65.7)	8 (88.8)	18 (100.0)	3 (100.0)	2.36 (0.341)	6.88 (0.013)	0.79 (P>0.05)	15.13 (0.002)
Hurried Breathing	27 (77.1)	8 (88.8)	18 (100.0)	3 (100.0)	1.50 (0.586)	4.26 (0.053)	0.51 (P>0.05)	8.59 (0.031)
Chest indrawing	13 (37.1)	3 (33.3)	4 (22.2)	-	1.42 (0.693)	0.64 (0.757)	0.70 (0.547)	0.51 (0.286)
AS/RF	9 (25.7)	4 (44.4)	8 (44.4)	2 (66.7)	2.00 (0.439)	1.71 (0.393)	3.90 (0.284)	2.52 (0.118)
Tachypnea	20 (57.1)	5 (55.6)	15 (83.3)	3 (100.0)	0.83 (P>0.05)	3.39 (0.085)	1.65 (0.545)	2.46 (0.120)
Cyanosis	7 (20.0)	3 (33.3)	1 (5.6)	3 (100.0)	2.54 (0.354)	0.15 (0.089)	13.91 (0.008)	1.21 (0.771)
Use of Acc. muscles	13 (37.1)	3 (33.3)	4 (22.2)	-	1.42 (0.693)	0.64 (0.757)	-	0.51 (0.286)

Figures in parenthesis are p values.
 OR (Odds Ratio) = 1: Equally likely or not related
 >1: More likely or positively related
 <1: Less likely or negatively relate
 P value
 >0.500 not trend
 <0.500 but >0.10 trend observed
 <0.100 but >0.05 near significant
 <0.05 Significant

Breathlessness, altered sensorium/ refusal of feeds and Cyanosis are positively related with Respiratory acidosis. Breathlessness, Hurried breathing, Tachypnea are positively related with Respiratory alkalosis and altered sensorium/ refusal of feeds and Cyanosis are positively related with those children with mixed Respiratory and Metabolic acidosis.

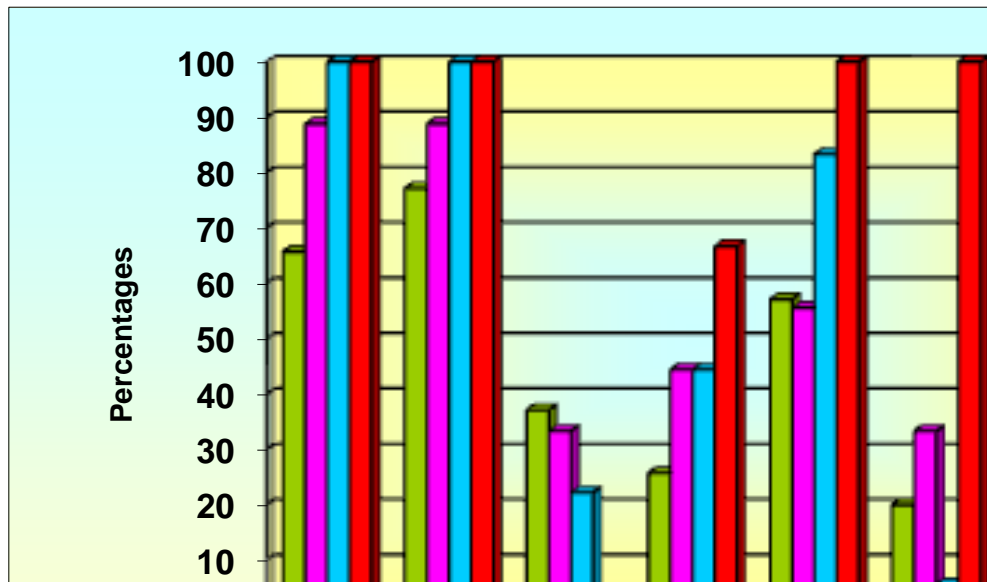


Figure- 1. Correlation of severity with ABG.

Chest X-ray was normal in 41 (63.1%). Perihilar congestion was present in 17 (26.2%) and hyper inflation was present in 7 (10.8%). Absolute eosinophil count was increased in 41.53%.

Oxygen saturation by pulse oximetry at the time of admission

Hypoxemia was present in 83.1% of the admitted children (P>0.05) at the time of admission.

PEFR pattern in hospitalized children

All the children had PEFR (24 children of > 5 years age) of below 70% of their personal best before bronchodilator therapy at the time admission. Among them 18 (75.0%) continued to have PEFR below 70% of their personal best after bronchodilator therapy. Only one child (4.2%) had PEFR below 70% and 23(95.8%) of the children had PEFR above 70% of their personal best at the time of discharge.

Table- 8.Treatment.

Treatment	Number	%
Inhalation of β_2 ago	65	100.0
Steroids	35	53.8
Oxygen inhalation	65	100.0
Inhalation of Ipratropium	12	18.5
S.C terbutaline	6	9.2
IV Methyl Xanthine	4	6.2
Antibiotic	30	46.5

All the children were treated with β_2 agonist; steroids were used in 35% of study groups, as all there was no response to initial bronchodilator therapy. Other drugs used were oxygen inhalation, inhalation with Ipratropium bromide and s.c terbutaline based on the initial drug response. Antibiotics were use in 30 (46.5%) children.

Table- 9. Association of ABG with Duration of stay.

ABG	Duration of stay in days		
	Number	Mean	SD
Normal	35	4.06	1.22
Respiratory Acidosis	9	4.83	0.90
Respiratory alkalosis	18	4.61	0.95
Metabolic acidosis	3	5.67	1.53

Children with abnormal ABG had a longer duration of stay as compared to those children with Normal ABG. Duration of stay was maximum in mixed acid–base disturbance with Respiratory acidosis and Metabolic acidosis (5.67 days) followed by Respiratory acidosis (4.83 days) and Respiratory alkalosis (4.61 days) as compared to children with normal ABG who had minimum duration of stay (4.06 days).

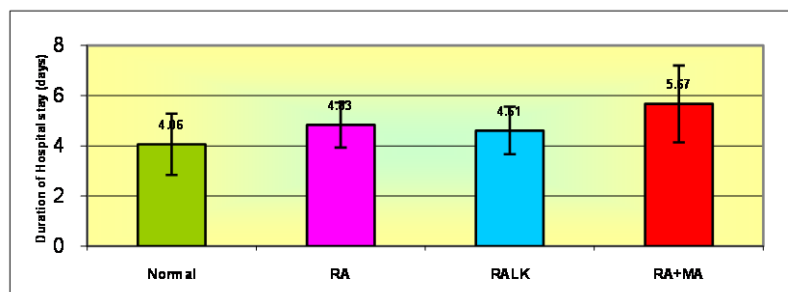


Fig- 2. Association of ABG with Duration of stay.

Table- 10. ABG findings and outcome.

ABG findings	Before treatment (%)	After treatment (%)
Normal	35(53.8)	65(100.0)
Respiratory acidosis	9(13.8)	-
Respiratory alkalosis	18(27.7)	-
Respiratory acidosis + Metabolic acidosis	3(4.6)	-
Metabolic alkalosis	-	-

All the children with abnormal ABG before treatment had significantly normal ABG values recorded at the time of discharge with $P < 0.001$. clinically all the children were improved.

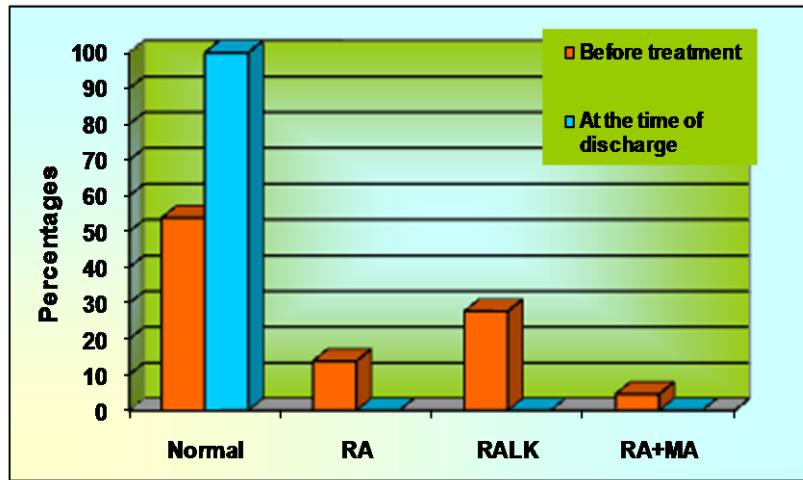


Fig- 3. ABG findings and outcome.

DISCUSSION

- The present study is a hospital based prospective study conducted at Vanivilas hospital, Bangalore Medical College from 1:8:2003 to 1:8:2004. Sixty five patients presented with exacerbation of asthma admitted to Pediatric intensive care Unit in the above mentioned period were included in the study.
- Among the study group the youngest child was 10 months old and eldest was 13 year old. 29 cases (44.6%) were between 1-3 years constituted majority of cases, which is similar to the age incidence quoted in GINA guidelines. ^[1]
- Male children were 41(65%), females 24(35%). This correlates with sex incidence quoted in GINA guidelines. ^[1]
- Most common precipitating factor for Asthma attack was respiratory infections 35(53.8%). This correlates with the common age group affected,

common season of presentation with the increased respiratory tract infections.

- Twelve (18.5%) of the study group had history of previous admission. History of Atopy was present in 23 (35.4%). Family history of Asthma was present in 32 (49.2%). These were taken as the diagnostic criterion for acute exacerbation of Chronic asthma. ^[2]

Arterial blood gas analysis was made at the time of admission and following observations were made. Breathlessness, altered sensorium/ refusal of feeds and Cyanosis are positively related with Respiratory acidosis. Breathlessness, Hurried breathing, Tachypnea are positively related with Respiratory alkalosis and altered sensorium/ refusal of feeds and Cyanosis are positively related with those children with mixed Respiratory and Metabolic acidosis. Those children presented with Breathlessness, Hurried breathing, altered sensorium/ refusal of feeds and Tachypnea are more likely to have

abnormal ABG. Statistical correlation though was significant with few clinical symptoms and signs in relation to ABG abnormalities, the treatment initiation could not be based on clinical parameters alone.

This correlates with Hurwitz et al. study where they concluded that clinical scoring is inaccurate for the assessment of hypoxemia in the pediatric age group and that Arterial blood gas determination should be used to assess the severity of hypoxemia in the emergency treatment of pediatric asthma patients. [3]

This also correlates positively with Karem E et al, study, where they concluded that for the optimal evaluation of acute asthma in children in emergency room, clinical evaluation should be used in conjunction with objective laboratory measurements. [4]

- SPO2 was <95% in majority of cases 54(83.1%) irrespective of presence or absence of clinical parameters of severity at the time of admission. For this reason correlation between SPO2 < 95% and parameters of clinical correlation could not be established and hence was statistically not significant. However this non invasive method used along with the clinical parameters was useful in taking the decisions regarding admission and management.
- Carruthers D M et al concluded that in the assessment of acute severe asthma, an oxygen saturation of more than 92% suggested that respiratory failure is unlikely and therefore arterial blood gas measurement is not necessary and that other parameters of the severity must be conjugally assessed irrespective of initial SaO2 and

blood gas measurement when clinically indicated. [5]

- All the children had PEFr (24 children of > 5 years age) of below 70% of their personal best before bronchodilator therapy at the time admission. Among them 48 (75.0%) continued to have PEFr below 70% of their personal best after bronchodilator therapy. PEFr was done daily morning and evening to monitor the response during hospital stay. Since PEFr was <70% in all the subjects irrespective of presence or absence of clinical parameters of severity at the time of admission no correlation could be established. However it was helpful in taking the decision to admit the child, to monitor the treatment response as well as taking the decision to discharge from continuous supervision.

This observation closely correlates with that of R. M .Nowak et al in April 1983 where all the patients with hypercarbia (PaCO2 greater than 42mmHg) and /or severe hypoxemia (PaO2 less than 60 mmHg) had PEFr below 200 liters / min and thus had recommended that selective use of arterial blood gas analysis should substantially decrease diagnostic cost and patient's discomfort without jeopardizing health care. [6]

- Treatment decision was individualized based on the initial drug response clinically along with SPO2 and PEFr values for the age.

None of the children required mechanical ventilation as ABG values and clinical manifestations were not suggestive.

This observation was similar to that of Blake Bulloch, MD. Richard M. Ruddy, MD. Published in National Heart, Lung, and Blood Institute 1997, that patients with an acute severe exacerbation in whom

respiratory failure was concerned and who had a significant O₂ requirement, ABG was useful and had recommended that ABG should be reserved for those patients who may require intubation and mechanical ventilation or who are clinically difficult to assess. [7]

McFadden ER Jr, Lyons HA said that a single PaCO₂ value does not predict the course of a patient with asthma. Elevated levels decrease with appropriate treatment and usually do not necessitate assisted ventilation. [8]

None of our study group required correction of metabolic acidosis with sodium bicarbonate. This observation was similar to that of Rudolf M et al, 1980 where Acid-base disturbances, when present, was mild and needed no specific treatment. [9] Children with abnormal ABG had a longer duration of stay as compared to those children with Normal ABG. Duration of stay was maximum in mixed acid-base disturbance with Respiratory acidosis and Metabolic acidosis (5.67 days) followed by Respiratory acidosis (4.83 days) and Respiratory alkalosis (4.61 days) as compared to children with normal ABG who had minimum duration of stay (4.06 days).

- All the children with abnormal ABG before treatment had significantly normal ABG values recorded at the time of discharge (P<0.001) with the treatment of Asthma alone.
- Clinically all the children improved. There were no deaths in the study period.

CONCLUSION

The present study was conducted to know the correlation between severity of asthma exacerbation clinically and Acid-base disturbances and the usefulness of this correlation decides upon the management options. ABG was performed in children who were admitted for asthma management

on the basis of parameters of clinical severity or SPO₂ <95% or PEFR <70% of personal best for the child.

A positive correlation was established between ABG values and some of parameters of clinical severity. Children presenting with acute exacerbation of Asthma are clinically judged for taking the decisions for admission, treatment as well as monitoring response in conjunction with the non invasive procedures like pulse oximetry and PEFR. Measurement of arterial blood gases (PaO₂ and PaCO₂) and pH, was necessary part of initial assessment, management in the hospital, especially in patients who are not responding to treatment and who have unexplained signs suggestive of impending respiratory failure and also as a prognostic factor for the outcome in correlation with number of days of hospital stay.

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