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A DESCRIPTIVE STUDY OF ARTERIAL BLOOD GAS PATTERNS IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Pulmonary Medicine

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ABSTRACT

Background: COPD is one of the major causes of chronic morbidity and mortality worldwide. It is the fourth leading cause of death in the world(1). Chronic airflow limitation of COPD is caused by a mixture of small airway disease (obstructive bronchiolitis) and parenchymal destruction (emphysema), the relative contributions of which vary from person to person. **Aim and Objective of the study:** To Study the changes of Arterial blood gases in COPD phenotypes. **Methods:** This Descriptive study was carried out on the patients with chronic obstructive pulmonary disease who were admitted to Victoria hospital, Bangalore from AUGUST 2021 to OCTOBER 2021. Arterial blood gas analysis was used as a diagnostic test in 110 cases of Chronic Obstructive Pulmonary Disease. **Interpretation and Conclusion:** ABG sampling constitutes a more precise measure of successful gas exchange, oxygenation and happens to be only reliable determination of ventilation success as reflected by CO2 content . It also provides valuable information on the acid base balance at a specific point in the course of a patient's illness and plays an important role in the management of Chronic Obstructive Pulmonary Disease. Patients regularly treated in phases of Remission and Exacerbations of COPD the course of illness is slower. Decrease of pH and PaO2 and increase of PaCO2 is statistically significantly smaller in those received regular treatment in phases of remissions. ABG analysis is indicated in acute exacerbations, during assisted ventilation and to decide prognosis. It should become an integral part of patient management.

KEYWORDS

BACKGROUND –

COPD is one of the major causes of chronic morbidity and mortality worldwide. It is the fourth leading cause of death in the world[(1)].Its pulmonary component is characterized by airflow limitation that is not fully reversible, usually is progressive and can lead to respiratory failure[(2)] .

Cigarette smoking is the most common risk factor for COPD, although in many countries, various kinds of air pollution have also been identified as COPD risk factors[(3)]. Chronic airflow limitation of COPD is caused by a mixture of small airway disease (obstructive bronchiolitis) and parenchymal destruction (emphysema), the relative contributions of which vary from person to person[(1)].

Chronic inflammation causes structural changes and narrowing of small airways. Destruction of the lung parenchyma leads to the loss of alveolar attachments to the small airways and decreases lung elastic recoil which diminish the ability of the airways to remain open during expiration [(4,5,6,7)]. So in COPD inflammation causes small airway disease (airway inflammation, airway remodelling) and parenchymal destruction that all lead to airflow limitation [(8,9,10)].

COPD – EXACERBATION :

COPD exacerbations are defined (as per GOLD guidelines) as acute events characterized by a worsening of the patient's respiratory symptoms (baseline dyspnea, cough, and/or sputum production) that is beyond normal day-to-day variation and leads to a change in medication periods of acute worsening of respiratory symptoms[(1)].

COPD – EMPHYSEMA :

Is defined as abnormal permanent enlargement of air spaces distal to terminal bronchiole accompanied by destruction of their walls and without obvious fibrosis. It leads to collapse of alveoli during expiration. Classified into Centriacinar, Pan acinar, Paraseptal and Mixed types. Centriacinar emphysema invariably occurs in smokers and involves Upper lobes of lungs and can co exist with Chronic bronchitis. These patients are referred to as Pink puffers and have increased respiratory drive to maintain normal PCO2 levels.

COPD – CHRONIC BRONCHITIS:

Is defined as presence of productive cough on most days for atleast 3 months for 2 consecutive years. These patients have excessive mucus secretion and are referred to as Blue bloaters . There is Hypoventilation despite Hypoxia . Corpulmonale is commonly associated with this condition.

COPD – ASTHMA Overlap:

Individuals may have a history of childhood asthma or asthma as young adults. Patients with coexisting asthma and COPD present similarly to pure asthma or COPD, manifesting signs and symptoms of obstructive lung physiology. However, patients with overlap syndrome have worse lung function, more respiratory symptoms and a lower health-related quality of life than either disease alone [(11,12)]. Smoking influences the pattern of inflammation and steroid responsiveness [(13,14)]. Asthmatics who smoke have more neutrophils in their airways, rather than eosinophils, resembling COPD. Smoking promotes neutrophilic inflammation in both asthma and COPD which results in increased steroid resistance [(15,16)] . Mucosal eosinophils increase in acute exacerbations of mild COPD, a feature normally seen in asthma [(17)]. This similarity in inflammatory responses may be one patho-physiological link to the clinical phenotype of asthma-COPD overlap.

COPD – OSA Overlap:

Increased lung volumes and low BMI are associated with predominant Emphysema phenotype protects against OSA whereas peripheral edema and increased BMI are associated with predominant Chronic bronchitis phenotype promotes OSA. Both OSA and COPD are associated with similar physiological and molecular consequences such as hypoxia , systemic inflammation, pulmonary hypertension and is highly prevalent in patients with overlap syndrome. Survival of patients in Overlap syndrome is better in those treated with positive airway pressure along with management of COPD.

COPD- BRONCHIECTASIS overlap:

Prevalence of bronchiectasis in COPD is high especially in advanced stages. Patients have greater symptomatic severity, more frequent infections and exacerbations with poor prognosis.

COPD with Comorbidities:

In persistently symptomatic COPD patients on optimal respiratory therapy and a significant comorbid burden of cardiovascular and

metabolic comorbidities, targeting aggressive disease management of comorbidities may help improve symptoms and health outcomes.

ABG is helpful to assess hypoxemia and to provide information regarding hypercapnia, particularly in individuals with more severe disease or during an acute exacerbation. Respiratory failure is defined as a PaO2< 60 mmHg (8kPa) and is divided into Type I Respiratory failure (PaCO2< 45 mmHg , PaO2 <80 mmHg) and Type 2 Respiratory failure (PaCO2> 45 mmHg (6kPa), PaO2< 60 mmHg)[18] .

To understand the pathophysiology of respiratory disturbances, it is necessary to study blood gas & acid base balance in COPD patients.

METHODS:

This is a Descriptive study conducted in Victoria Hospital, Bangalore Medical College and Research Institute (BMCRI), Bangalore from AUGUST 2021 – OCTOBER 2021 . After obtaining informed written consent 110 patients were included in the study.

This study was approved by the ethics committee of Bangalore Medical College and Research Institute with approval number BMCRI/PS/163/2021-22.

Sample size calculation :

Based on the previous study conducted by **Kumar A** et al [19] , by assuming equal SD, considering the mean values one of the parameters of ABG –HCO3 in stable COPD patients and Exacerbated COPD patients, the sample size can be calculated as follows,

Formula, $n = \frac{1.96^2 \times 59.3^2}{7^2}$

Where , n = sample size
Z_α = Standard table value for 95% confidence interval (CI)
σ = mean SD values of HCO3 in both groups = 30.8 and 40.78 in stable and exacerbated patients respectively = (30.8+40.78)÷2 = 35.39
d = estimated precision = 7%
on substitution,
n = 98.19
by adding 10% to attrition 98.19 + 9.82=108.01
Therefore the samples size is 108 rounded up to 110.

ABG:

Collection of Blood:

The blood was commonly drawn from the radial artery. This site of collection had less risk for occlusion and easy to compress for controlling bleeding[18] .The femoral artery (or less often, the brachial artery) was also used, especially during emergency situations.

Blood Sample Handling and Transfer:

The syringes were pre-packaged and contained a small amount of heparin to prevent coagulation,by drawing up a small amount of heparin and squirting it out again[11].Once the sample was obtained care was taken to eliminate visible gas bubbles, as these bubbles can dissolve into the sample and cause inaccurate results. The sealed syringe was taken to a blood gas analyzer. If the sample could not immediately analyzed, it was chilled in an ice bath in a glass syringe to slow metabolic processes which could cause inaccuracy. Samples drawn in plastic syringes ware not iced and were analyzed within 30 minutes.

Blood Gas Analysis:

The blood gas analysis were done in the 'RADIOMETER ABL 9' which was a fully automatic, microprocessor controlled pH /blood gas analyzer with an integrated thermo printer for quantitative "in vitro" measurement of pH, PCO2, PO2. A complete pH/ blood gas analysis was performed on only 100 µl of whole blood. Quick and precise analysis was completed within 20 seconds from sample introduction to result[12] Data collected and analysed.

RESULTS:

TABLE -1 : ABG in Different PHENOTYPES OF COPD

ABG	COPD– Emphysema (Mean+/-SD) Total -35 patients		COPD – Chronic Bronchitis (Mean+/-SD) Total-30 patients		COPD-ASTHMA Overlap (Mean+/-SD) Total-15 patients		COPD-OSA Overlap (Mean+/-SD) Total-12 patients		COPD– Bronchiectasis Overlap (Mean+/-SD) Total – 18 patients	
	Stable (12)	A/E (23)	Stable (10)	A/E (20)	Stable (3)	A/E (12)	Stable (4)	A/E (8)	Stable (10)	A/E (8)
pH	7.35 +/- 0.3	7.32+/- 0.4	7.37+/-0.2	7.33+/-0.3	7.38+/- 0.2	7.36+/-0.5	7.34+/-0.3	7.30+/-0.6	7.37+/-0.3	7.34+/- 0.2
PCO2 (mm Hg)	49 +/-6	60 +/-8	52 +/-5	58 +/-12	42 +/-6	45 +/- 5	45 +/-7	58 +/-12	43 +/-8	54 +/-10
PO2 (mm Hg)	80 +/-8	62 +/-14	75 +/-14	64 +/-12	78 +/-10	67 +/-8	80 +/-16	58 +/-9	83 +/-11	69 +/-10
HCO3 (mmol/L)	28 +/- 9	34+/- 12	26 +/-14	30 +/-10	24 +/-4	28 +/-8	26 +/- 7	32 +/-9	27 +/-5	29 +/-6
SO2 (%)	90 +/-4	84 +/-12	92 +/-8	80 +/-9	92 +/-4	82 +/-16	88 +/-7	78 +/-10	89 +/-6	83 +/-11

In our study we had included 110 patients who were known cases of COPD. 64.5% (71/110) patients presented with Acute Exacerbation and 35.5% (39/110) were Stable COPD.

In our study we observed 5 types of phenotypes in COPD :- 35 Patients of COPD- Emphysema Phenotype, 30 patients of COPD-Chronic bronchitis phenotype, 15 patients of COPD-Asthma overlap phenotype, 12 patients of COPD-OSA overlap phenotype, 18 patients were of COPD-Bronchiectasis phenotype.

In our study we observed that 34.5% (38/110) patients were Stable COPD while 65.45% (72/110) patients presented in Acute exacerbation of COPD.

In our study we observed that 64.5% (71/110) patients were using Bronchodilators, 31.8% (35/110) patients were using Oxygen supplementation at home, 13.635 (15/110) patients were using Home NIV.

Among 39 Stable COPD patients – All 39 patients were using Bronchodilators, 12.8%(5/39) were on oxygen supplementation, 17.9% (7/39) were using Home NIV.

Among 71 COPD-Exacerbation patients – 45.07% (32/71) patients were using Bronchodilators, 42.25%(30/71) were on oxygen supplementation, 11.2% (8/71) were using Home NIV.

Mean Ph among Stable COPD phenotype was found to be 7.35+/-0.5 and 7.31+/-0.7 in COPD exacerbation patients. In our study P value of PCO2- 0.04 , PO2 - 0.03, HCO3 – 0.021, SO2 – 0.043

In our study among **COPD-Emphysema phenotype** patients - Mean Ph value among stable COPD patients was found to be 7.35 +/- 0.3 whereas in Exacerbation Mean Ph was much lower 7.32 +/- 0.4 . Mean PCO2 in stable patients was found to be 49+/-6 and PCO2 was increased in acute exacerbation 60+/-8 . Mean PO2 levels were 70+/-8 in stable patients, more Hypoxemic 62+/- 14 in exacerbation. Mean Bicarbonate levels were 28+/-9 in stable patients, 34+/-12 in Exacerbation. Mean Saturation (SO2) levels were 90+/-4 in stable patients, 84+/-12 in Exacerbation.

In our study among **COPD-Chronic bronchitis phenotype** patients - Mean Ph value among stable COPD patients was found to be 7.37 +/- 0.2 whereas in Exacerbation Mean Ph was much lower 7.33 +/- 0.3 . Mean PCO2 in stable patients was found to be 52+/-5 and PCO2 was increased in acute exacerbation 58+/-12 . Mean PO2 levels were 75+/-14 in stable patients, more Hypoxemic 64+/- 12 in exacerbation. Mean Bicarbonate levels were 26+/-14 in stable patients, 30+/-10 in Exacerbation. Mean Saturation (SO2) levels were 92+/-8 in stable patients, 80+/-9 in Exacerbation.

In our study among **COPD-Asthma overlap phenotype** patients - Mean Ph value among stable COPD patients was found to be 7.38 +/- 0.2 whereas in Exacerbation Mean Ph was much lower 7.36 +/- 0.5 .

Mean PCO2 in stable patients was found to be 42+/-6 and PCO2 was increased in acute exacerbation 45+/-5 . Mean PO2 levels were 78+/-10 in stable patients, more Hypoxemic 67+/-8 in exacerbation. Mean Bicarbonate levels were 24+/-4 in stable patients, 28+/-8 in Exacerbation. Mean Saturation (SO2) levels were 92+/-4 in stable patients, 82+/-16 in Exacerbation.

In our study among **COPD-OSA overlap phenotype** patients - Mean Ph value among stable COPD patients was found to be 7.34 +/- 0.3 whereas in Exacerbation Mean Ph was much lower 7.30 +/- 0.6 . Mean PCO2 in stable patients was found to be 44+/-7 and PCO2 was increased in acute exacerbation 58+/-12 . Mean PO2 levels were 80+/-16 in stable patients, more Hypoxemic 58+/- 9 in exacerbation. Mean Bicarbonate levels were 26+/-7 in stable patients, 32+/-9 in Exacerbation. Mean Saturation (SO2) levels were 88+/-7 in stable patients, 78+/-10 in Exacerbation.

In our study among **COPD-Bronchiectasis overlap phenotype** patients - Mean Ph value among stable COPD patients was found to be 7.37 +/- 0.3 whereas in Exacerbation Mean Ph was much lower 7.34 +/- 0.2 . Mean PCO2 in stable patients was found to be 43+/-8 and PCO2 was increased in acute exacerbation 54+/-10 . Mean PO2 levels were 83+/-11 in stable patients, more Hypoxemic 69+/- 10 in exacerbation. Mean Bicarbonate levels were 27+/-5 in stable patients, 29+/-6 in Exacerbation. Mean Saturation (SO2) levels were 89+/-6 in stable patients, 83+/-11 in Exacerbation.

TABLE -2 : Comorbidities in Different Phenotypes of COPD

	Diabetes Mellitus	Systemic Hyper-tension	Hypothy -roidism	Retro-viral Disease	Cor Pulmo -nale
COPD-Emphysema (Total -35)	12	10	5	3	8
COPD-Chronic Bronchitis (Total -30)	10	7	4	2	15
COPD-ASTHMA overlap (Total - 15)	4	6	1	0	0
COPD-OSA overlap (Total – 12)	8	6	3	1	3
COPD–Bronchiectasis overlap (Total - 18)	5	4	2	1	3
Total - 110	39	33	15	7	29

We analysed Comorbidities among different phenotypes of COPD. We found that among 35 patients with COPD-Emphysema phenotype – 12 patients were Diabetic , 10 patients were Hypertensive, 5 patients had Hypothyroidism, 3 patients had RVD , 8 patients had Cor pulmonale. Among 30 patients with COPD- Chronic Bronchitis phenotype – 10 patients were Diabetic , 7 patients were Hypertensive, 4 patients had Hypothyroidism, 2 patients had RVD , 15 patients had Cor pulmonale. Among 15 patients with COPD ASTHMA overlap - 4 patients were Diabetic , 6 patients were Hypertensive, 1 patient had Hypothyroidism . Among 12 patients with COPD OSA overlap - 8 patients were Diabetic , 6 patients were Hypertensive, 3 patients had Hypothyroidism, 1 patient had RVD, 1 patient had Cor pulmonale. Among 5 patients with COPD Bronchiectasis overlap patients - 5 patients were Diabetic , 4 patients were Hypertensive, 2 patients had Hypothyroidism, 1 patient had RVD, 3 patient had Cor pulmonale.

DISCUSSION:

In our study Arterial blood gas analysis was done in known case of COPD patients . Acid base abnormality was noted among Stable and Exacerbation of COPD patients, results obtained were compared among different phenotypes of COPD.

In our study Male (66 patients) : Female (44 patients) ratio of Chronic Obstructive Pulmonary Disease was found to be 3:2. Maximum number of patients were in 46-55 years age group (41.8%) followed by 56-65 years of age group (34.54%). The mean age of study population of COPD was found to be 55+/-3 years.

Increased incidence of COPD among females can be attributed to history of Biomass fuel exposure and history of smoking. Exposure to biomass combustion fuels inside the home can lead to hazardous indoor air effluents that are associated with an increased of COPD, is worse in houses which are more poorly ventilated. COPD was more prevalent in Men due to higher rates of cigarette smoking and their greater likelihood of exposure to significant occupational respiratory irritants.

In our study 60% of COPD patients were residents of urban areas and 40% of patients came from rural areas. This can be attributed to increased air pollution in urban areas along with smoking habits. Incidence of COPD was higher in females of rural areas (54.54%).Whereas incidence of COPD amongst male was higher in urban area. Most of the males (66.36%) were smokers and (10%) were ex smokers. Out of 110 COPD patients majority 72.72% (80/110) patients had history of smoking with smoking history of 10-20 pack years (70%) followed by 20-30 pack years (12%) and (8%) of patients smoked less than 10 pack years. These results were in correlation with study done by Kumar A et al [19]

In our study majority of the patients were Diabetic (35.35%) followed by Systemic Hypertension (30%) and Cor Pulmonale (26.36%). Diabetes mellitus causes immune impairment and increases risk of Infections in patients of COPD.

In our study majority patients had Breathlessness as predominant symptom (64%) followed by cough (48%) . These were in correlation with results obtained by a study done by Kessler et al [20] where Breathlessness was most common symptom (72.5%) among 2258 patients.

Stable COPD - Among stable COPD patients (39/110) Mean pH was 7.35 +/- 0.5 in the arterial blood samples. These values lie within normal range of 7.35 to 7.45. Mean PCO_2 was found to be 49.1 +/- 8.9 mm Hg. This value is slightly higher for normal values of 35-45 mm Hg. Mean PO_2 was found to be 75 +/- 10 mm Hg indicating mild hypoxemia as normal values of PO_2 range from 80-100 mm Hg. Mean HCO_3 levels was found to be 30.83 +/- 4.5 mmol/L in stable COPD patients . Raised bicarbonate levels are as a result of renal compensation to maintain near normal Ph. Mean SO_2 in stable COPD group was found to be 89 +/- 5.3 % .These results are in correlation with results obtained by Kumar A et al[19].

COPD exacerbation phase – Among COPD with exacerbation patients (71/110) Mean pH amongst was found to be 7.31 +/- 0.7. Mean PCO_2 was found to be 58.7+/-10.3mm Hg indicating hypercapnea . Respiratory acidosis due to hypercapnia is a common and severe complication observed in patients with chronic obstructive pulmonary disease. Development of acidosis worsens the prognosis and is associated with higher mortality rate. Mean PO_2 exacerbation was found to be 55 +/- 9 which indicate severe hypoxemia and the patient is having respiratory insufficiency. Mean HCO3 levels was found to be 34 +/- 6 mmol/L. Bicarbonate is produced by the kidneys and acts as a buffer to maintain a normal pH. The normal range for bicarbonate is 22 – 26mmol/l. Kidney plays a pivotal role in acid base balance. They excrete H+ ions in exchange of HCO_3 whenever H+ ions rise above normal. Thus near normal pH is maintained in stable COPD patients . However in exacerbation of COPD patients , H+ ions are overloaded to such a extent that renal compensation is not able to maintain normal/near normal arterial pH. These patients are thus having respiratory acidosis inspite of increase in bicarbonate ions.

In our study All 39 patients of Stable COPD were using Bronchodilators, 12.8%(5/39) were on oxygen supplementation and 17.9% (7/39) were using Home NIV and among 71 COPD-Exacerbation patients–45.07% (32/7) patients were using Bronchodilators, 42.25%(30/71) were on oxygen supplementation, 11.2% (8/71) were using Home NIV.

Patients who regularly used Bronchodilators, Oxygen supplementation and NIV at home belonged to Stable COPD category whereas those patients who discontinued bronchodilators / Home oxygen /NIV therapy landed up in exacerbation.

In our study on comparison with different phenotypes of COPD :- COPD- ASTHMA overlap type was characterized by highest probability of exacerbation (80%) Indicating severe airway obstruction followed by COPD –OSA and Chronic bronchitis phenotypes (66.67%) each.

In our study patients with Ph value less than 7.25 needed admission to critical care unit and had a high mortality rate whereas patients with Ph in above 7.35 had a better survival rate hence, Arterial Ph is a important

prognostic marker for survival in COPD patients . These results were in correlation with a study done by Goodhart et al[21]

In our study Survival of patients in Overlap syndrome was better in those treated with positive airway pressure along with management of COPD.

CONCLUSION:

Arterial blood gas analysis is a simple procedure to determine gas exchange levels in the blood related to respiratory, metabolic, and renal function in COPD patients. In Critically ill patients its an important tool to initiate and redirect the treatment of the patients. In this study out of 110 patients 66 (60%) were males and 44(40%) were females. Mean age of study population of COPD was found to be 55+/-3 years . In our study 60% of COPD patients were residents of urban areas and 40% of patients came from rural areas.

In our study we found that Smoking is a important risk factor for COPD. 72.72% (80/110) patients had history of smoking, majority had history of 10-20 pack years of smoking .Cessation of smoking was found to be associated with a better outcome in COPD patients.

COPD exacerbation patients presented with respiratory acidosis and hypercarbia. It was found to be associated with poorer outcome and longer hospital stay. Whereas COPD patients in stable phase were having near normal ABG values and better outcome with short hospital stay time.

In persistently symptomatic COPD patients on optimal respiratory therapy and a significant comorbid burden of cardiovascular and metabolic comorbidities, targeting aggressive disease management of comorbidities may help improve symptoms and health outcomes.

In patients with Asthma-COPD overlap phenotype, therapy with inhaled steroids should be strongly considered in addition to long-acting bronchodilators. Addition of anti-inflammatory medication (antibiotics or PDE4 inhibitors) and/or acetylcysteine for exacerbation prevention may be a valuable and cost-effective add-on therapy in patients experiencing two or more moderate-severe exacerbations per year. In patients with significant symptoms despite maximal therapy and upper lobe-predominant emphysema, consideration should be given to surgical LVRS

ABG sampling constitutes a more precise measure of successful gas exchange, oxygenation and happens to be only reliable determination of ventilation success as reflected by CO2 content . It also provides valuable information on the acid base balance at a specific point in the course of a patient's illness and plays an important role in the management of Chronic Obstructive Pulmonary Disease.

Patients regularly treated in phases of Remission and Exacerbations of COPD the course of illness is slower. Decrease of pH and PaO2 and increase of PaCO2 is statistically significantly smaller in those received regular treatment in phases of remissions.

ABG analysis is indicated in acute exacerbations, during assisted ventilation and to decide prognosis. It should become an integral part of patient management.

Abbreviations : COPD,ABG

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