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RESEARCH ARTICLE

"COMPARATIVE EVALUATION OF CAPILLARY BLOOD GASES AS WITH ARTERIAL BLOOD GASES IN PATIENTS OF COPD WITH ACUTE EXACERBATION PRESENTING TO EMERGENCY DEPARTMENT: A PROSPECTIVE OBSERVATIONAL STUDY"

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Abstract

Aim: The aim of this study is to investigate the correlation between selected variables of capillary blood gas (CBG) and Arterial blood gas (ABG)values for assessing values of pH, bicarbonate (HCO3), partial pressure of oxygen (pO2), partial pressure of carbon dioxide (pCO2) in patients with acute exacerbation of COPD presenting to the Emergency department of Peerless hospital. Our study on reliability of CBG over ABG is aimed to make blood gas analysis easier, quicker, less painful and equally reliable.

Settings And Design: This was a prospective observational study carried out in a tertiary care centre in Kolkata.

Materials And Methods: This study was carried out in Peerless hospital and B.K.Roy Research Centre, Kolkata over a period of 1 year. Total of 90 patients who presented to Emergency department with acute exacerbation of COPD patients were included in the study. Informed consent was taken from all the patients recruited in this study. The blood samples were drawn simultaneously from the radial artery by an arterial puncture into a heparinized syringe and the fingertip by a finger prick into a capillary tube of every patient participating in the study. Initially, capillary sample was collected and immediately after that, an arterial sample was taken from the radial artery in order to assess the agreement between the capillary and arterial samples. These samples obtained were analysed immediately by the blood gas analyser (AVL Compact 3, Roche Diagnostics GmbH, Mannheim, Germany) of the Emergency Department for values of acid-base and oxygenation: pH, PO2, PCO2and HCO3 values. Blood gases were obtained only if the patient needed blood gases analysis for clinical decisions. Care was taken to avoid exposing the blood droplet to air, and the arterial sample was continuously turned to avoid clotting. In addition, the measurement of oxygen saturation (SpO2) was also obtained from the finger pulse oximeter in the emergency (Noninvasive pulse oximeter).

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Introduction:-

Chronic obstructive pulmonary disease (COPD) is the third leading cause of death worldwide (3). COPD includes emphysema, chronic bronchitis and small airway disease. It is characterized by a progressive decline in lung function associated with airway narrowing due to inflammation, fibrosis and mucus plugging, and parenchymal destruction with a loss of elasticity, less gas exchange surface area, and airway support with subsequent early airway closure. Exacerbations are a prominent feature of the natural history of COPD. Exacerbations are mainly caused by infectious (viral or bacterial) or environmental factors in nature (9).

According to World Health Organization, it is estimated that globally 3.17 million deaths were caused by COPD in 2015. The Global burden of Disease study reports a prevalence rate of 251 million cases of COPD globally in 2016. According to WHO, COPD is likely to increase in the upcoming years due to higher smoking rates and aging populations in many countries.

Acute exacerbation of COPD is a sudden worsening of COPD symptoms (shortness of breath, increased frequency and severity of coughing, colour and quantity of phlegm). Available evidence suggest that at least 75-80% of acute exacerbations of COPD are infectious in origin and rest 20-25% are due to Allergens (pollens, wood particles, house dust), Pulmonary embolism, Heart failure, Occupational hazards (coal miners, cotton fibre workers, hard rock miners, tunnel workers, concrete manufacturing workers), toxin including variety of different chemicals, air pollution, failing to follow proper drug therapy e.g. improper use of an Inhaler. Few exacerbation related deaths can be attributed to other co morbidities like arrhythmias, PE or heart disease(23).

Blood gases can be done by 3 ways: arterial, venous or capillary, used for evaluating oxygen and carbon dioxide gas exchange, respiratory functions, including hypoxia and acid base balances. It is also useful in assessment of asthma, COPD and other types of lung diseases and also for the decision of mode of management in COPD patients.

Arterial Blood Gas (ABG) is the most frequently used and gold standard investigation in COPD patients to get information regarding oxygenation, ventilation and acid base status in most of the patients(2). pO2 value of ABG also helps as an additional prognostic factor in predicting mortality in in-hospital patients with COPD(11). But it has some disadvantages. The risks associated with ABG include pain, hematoma, aneurysm formation, thrombosis or embolization, needle stick injuries to health care providers with the risk of transmission of blood borne diseases like hepatitis C and HIV. The procedure is more painful. Sometimes, it may also need multiple attempts, especially when the patient is obese or in shock. Radial artery puncture is contraindicated in deficiency of collateral circulation to distal upper extremity(15).

Because of the discomfort and complications associated with the procedure, researchers have been searching for alternative methods to ABG sampling with incomplete success.
Over the last eight decades, several studies have been performed assessing the accuracy, precision, and usefulness of venous blood gas(26)(21) , arterialized earlobe and fingertip capillary blood sampling in comparison to arterial blood sampling.

Though, numerous studies have been done comparing venous blood gas and capillary blood gas with arterial blood gas, some studies showed good correlation (20), while others gave contradictory results. However, the authors also pointed out that CBG might not be appropriate if precision is required, based on the fact that the residual standard error (SE) in the regression equation was 6 mmHg (20).

Capillary blood gas (CBG) is a less invasive way of evaluating blood gas. Capillary blood gases have been used for many years in children as a less distressing and safer alternative and some studies suggest that they agree well with arterial values (37). It avoids the risk of above mentioned arterial blood gas complications. CBG sampling can be done from finger pulp and ear lobe.

The earlobe oxygen tension resembles the arterial oxygen tension due to convergence of arterial and venous oxygen tension.

It has not been determined as to whether, in patients with acute exacerbations of COPD, capillary blood gases are a viable alternative to ABG in patients.

The present study has been undertaken to assess the correlation and level of agreement between measurements of pH, PO_2, PCO_2, calculated HCO_{3-}, in arterial and capillary blood samples in patients with acute exacerbation of COPD presenting to our Emergency Department.

Aim And Objectives:-

Aim:

The aim of this study is to assess the correlation between capillary blood gas (CBG) and arterial blood gas (ABG) for assessing values of pO2, pH, HCo3 and pCO2 in patients with acute exacerbation of COPD presenting to the Emergency department of Peerless hospital.

Objectives:-

1. To obtain arterial and capillary blood samples in the emergency room and to determine their agreement for pH, pCo2, pO2 and Hco3 values.
2. To make blood gas analysis easier, less painful, faster especially in patients with generalized oedema, feeble pulses and in anxious and psychiatric / psychotic patients where ABG can be difficult.

Review Of Literature:-

Early history of COPD:

COPD has been an old disease. In 1679, Swiss physician Theophile Bonet referred to as "voluminous lungs" (22). Later in 1814, British physician Charles Badham identified chronic bronchitis as a part of COPD (22). In 1821, Rene Laennec, found emphysema as another component of COPD. He has described the combination of emphysema and chronic bronchitis. In 1959, group of medical professionals, Cibia Guest symposium defined the components that make up the definition of COPD (22). In the past, COPD was referred as "chronic airflow obstruction" and "chronic obstructive lung disease". Dr.William Briscoe was the first one to use the term "Chronic Obstructive Pulmonary Disorder" at the 9th Aspen Emphysema Conference, June 1965 (22).

Epidemiology and prevalence of COPD:

Estimates by Centers for Disease Control and Prevention (CDC) suggest that COPD is the third most common cause of death in United States. The World Health Organization predicts that COPD will be the third leading cause of death worldwide by 2030 (22).

Before 20th century, there were only few studies in India to report prevalence of COPD patients. Most of them were limited by small population size and invalidated questionnaire (36). Then, "Indian study on Epidemiology of Asthma, Respiratory symptoms and Chronic Bronchitis in adults" (INSEARCH) phase II was published. INSEARCH I and INSEARCH II involved 16 centers across the country, included 1,21,766 individuals and had a validated questionnaire(17).

As per this study, the prevalence of COPD was found to be 3.67% (4.46 among males and 2.86% among females). In India, population prevalence of COPD is very high (24) and it causes about 5, 00,000 deaths per year (13).

Risk factors and pathogenesis:

Risk factors for COPD include cigarette smoking, airway hyper responsiveness, respiratory infections, occupational exposures, ambient air pollution, passive smoking and genetic factors. Tobacco smoke is the major risk factor for COPD (49) and the population-attributable risk of smoking in COPD patients has been estimated as 50 to 70% (30). Regarding sex predominance, few studies found higher incidence in male than in females (27,31).

Often, the prevalence of COPD is directly related to the prevalence of tobacco smoking, although in many countries outdoor, occupational and indoor air pollution (resulting from the burning of wood and other biomass fuels) are major COPD risk factors (16,19).

In one study (28) on AECOPD patients, even after allowing for considerable age related differences between elderly patients and younger patients, advanced age was a major adverse prognostic factor for inpatient mortality and 3 month mortality.

According to a study done by **Stone RA et al** (14), clinicians should consider increasing age as a specific risk factor in the management of COPD. He also concluded that community teams should review their protocols and pathways carefully for assessing, managing, discharging and follow-up of older patients with COPD exacerbation.

COPD is a slowly progressive disease which is characterized by airflow limitation, which is largely irreversible. A study done by **William Macnee et al in 2005** concluded that no single mechanism is responsible for the pathogenesis of COPD. It includes multiple factors like protease-antiprotease balance, oxidative stress and apoptosis in emphysema (32).

ABG in COPD:
Clinical history, physical examination and arterial blood gas analysis together can help in a proper diagnosis and mode of management in COPD patients. Arterial blood gas monitoring is the standard for assessing a patient's oxygenation, ventilation and acid base status (2).

Roberts CM et al in 2002, in their study found that some factors such as arterial blood gas pH on admission can be influenced positively by medical intervention, and it depends on the stage at which the patient presents. They also concluded that in the present study, admissions with a value pH < 7.26 showed a high mortality rate (34).

A few studies were done to show importance of ABG to decide regarding Long term oxygen therapy management in which PaO2 measurement is important(5) (35)(7).

A study done by **Paloma Oliver et al in 2015**, concluded that the point of care testing analysis of ABG , (ie) near the patient's bed side helped in diagnosis of chronic respiratory failure and the need for long term oxygen therapy if needed. They also found that the use of blood gas analyzer improved clinical, operational and economic outcomes of the patient comparing to the laboratory values (7).

In a study on 1750 patients , **Piquet J et al** in 2013, found that PaO2, PaCO2 and pH were all associated with mortality during follow-up (12).

Complications Of Abg
Arterial Blood Gas has been the gold standard to assess oxygenation in COPD patients, but it is also associated with few risks including being more painful and few studies were conducted to find out a technique which was more easier and less painful .They assessed and compared the pain score between the Arterial blood gas sampling and Capillary blood gas sampling and the correlation of some parameters between the two to find out an alternative method for assessing oxygenation and ventilation status in COPD patients.

Khavar dar et al, conducted a study in 1994 to compare the pain perception between capillary blood gas from the earlobe and arterial blood gas sampling with local anesthesia and without local anesthesia and also the data were compared. They found that even with local anesthesia, arterial puncture was painful and capillary blood samples should be preferred , as they both yield a similar biochemical data (44).

Another study by **Magnet FS et al in 2017,** was also done to assess the comparison of pain scores between ABG and CBG and also to compare arterial and capillary pO2 values and their correlation. The study was done on 102 patients, which also concluded ABG was more painful compared to CBG even though a very fine needle was used for ABG analysis. Also, PcO2 (capillary partial pressure of oxygen) and PaO2 (arterial partial pressure of oxygen) in hypoxic COPD patients did not correlate well and it also sometimes lead to unnecessary long term oxygen therapy for those patients. LTOT is an expensive therapy and it is also associated with psychological side effects (5).

Trica M Mckeever et al in 2016, conducted a prospective study on 234 patients. They assessed the agreement between pH, pCO2 and bicarbonate values and they also assessed the pain score between ABG and VBG sampling. They concluded that pH and pCO2 values had good correlation between ABG and VBG, so VBG can be used for assessing COPD exacerbation patients. They also found that ABG was more painful than VBG and sometimes needed more number of attempts (6).

Vincenzo et al in 2009 reported a case of radial artery pseudoaneurysm after a single direct radial arterial puncture for blood gas analysis in a 32 year old white man who was admitted in emergency for asthma attack(18).

Cbg Analysis

A recent study done by **Sergi Vaquer et al** in 2014 , evaluation of earlobe arterialized collector in critically ill patients. In this study, 55 patients capillary blood was collected from earlobe using the ear lobe arterialized blood collector after applying vasodilatory cream and earlobe massage. They found that this method was easier, required minimum training and decreased time to yield results and so they can offer good benefits for health care . They also suggested that few more studies should be done focusing on this new equipment (8).

Correlation Between Abg And CBG:

To assess the correlation and agreement between measurements of pH, PO_2, PCO_2, HCO_{3-}, in arterial and capillary blood gas samples and to assess the reliability of capillary measurement, a literature search was carried out to identify the extent of previous work in this area.

Few studies showed good correlation between the values of pH, pCo2, pO2 and bicarbonate between ABG and CBG values(45)(25)(50)(20)(10)(39).

Pitkin AP et al, in 1994, took simultaneous ear lobe samples and arterial samples from 40 patients with chronic lung problems. In this study, he found that ear lobe blood gas analysis was accurate with arterial blood gas values of pH, pCO2, pO2 and can be substituted for ABG , but due to lack of knowledge , many centers in UK did not use it(45).

Ross Murphy et al, in 2005 in U.K. did a study, which concludes that the values of pCo2, pH and HCo3 had good agreement between capillary blood gas and arterial blood gas samples. This showed that CBG can be used to assess the ventilation of the patient but not the oxygenation. It also states that when we combine with continuous pulse oximetry monitoring, CBG can be used as an alternate to ABG in acute exacerbations of COPD patients (25).

A comparative study of capillary and arterial acid-base parameters in patients with acute respiratory distress was performed by **Raymond begin et al in 1975.** Small differences were found between the samples for pH, pCO2, pO2 and bicarbonate values, the correlation was >0.97. So they concluded that capillary blood gas can be a valid substitute for arterial blood sample for management of patients with acute respiratory distress (50).

A meta-analysis was conducted in 2006 by **Gerald S Zavorsy et all,** comparing Po2, Pco2 and pH values between capillary blood gas samples (ear lobe and fingertip) and arterial blood gas sample. They found that earlobe capillary samples were accurately good in predicting arterial pO2 values in hypoxia because the arteriovenous difference in pO2 values will be minimum and also the oxyhemoglobin dissociation curve became more linear in lower pO2 values. For pCO2 values, capillary blood samples accurately reflected the arterial sample values, the ear lobe being the preferred site for sampling. For pH values, blood sampling from any of the capillary site gave accurate values to arterial sample (20). Another study done by **Hughes JM et all,** also concluded that earlobe arterialized pO2 values and arterial pO2 values were more accurate when the arterial pO2 is lower (41).

Torjussen.W et al in 1967, compared pH and pCO2 of 21 patients drawing arterial samples from femoral artery and capillary samples from ear lobe. No significant differences were found in the values between the two, but there was a tendency of increased pH and pCo2 values in the capillary samples (53).

A study was conducted comparing ABG and CBG in an ED by **Kamran Heidari et al in 2013**, in which 187 patient's samples were taken and values of pO2, pCO2, HCO3, pH and BE were compared. They concluded that hemoglobin oxygen saturation, pCO2, HCO3, pH, BE and also pO2 showed good statistical correlation between ABG and CBG, and so fingertip CBG samples can be used instead of ABG for the assessment of the above mentioned values (10).

A study investigating the possibility of obtaining the arterial pO2 values in a stored capillary blood gas specimen and measured in an oxygen microelectrode was conducted in 1968 by **J Macintyre et al**. They concluded that the finger pulp was not a suitable site for obtaining capillary samples even if the finger was massaged with a vasodilatory paste, but if ear lobe was massaged well with thurfyl nicotinate, they gave a po2 value that was in close association with arterial pO2 values in normal, hypoxic as well as hyperoxic patients (52).

A study done by **Harrison et al** on paediatric intensive care unit patients showed CBG values reflected ABG values of pH and pCO2 in most patients and can be used to assess the metabolic status of the patients(39).

Few studies showed good correlation between the values of pH, pCO2 and HCO3, but did not show good correlation between pO2 values(1) (42)(33)(37). They concluded that CBG cannot replace ABG for assessing oxygenation.

Heidi K.Kongstad et all in 2011, conducted a study on 62 patients aged from 34-89 years to compare agreement for values from non-arterialized fingertip samples and arterial blood gas samples. In this study they found that , agreement for values of pH, pCO2 and HCO3 was good between the two sample types, but the agreement for pO2 values were poor. A source of error was noted in the study population as that consisted of outpatient COPD patients (1).

A prospective study on 150 adult patients were conducted by **A Sauty et al in 1996,** comparing pO2 and pCO2 values from arterialized ear lobe samples and radial artery samples. In that he found, earlobes values of pO2 were lower than arterial samples and also more difference in limits of agreement. Whereas, pCO2 had smaller limits of agreement and so capillary blood gas can be used as an alternate to arterial pCO2 (42).

D Yildizdas et al in 2004, did a study comparing simultaneously obtained arterial, venous and capillary samples. A total of 116 samples were taken from PICU patients over a period of 2 years. In that he concluded, pH, pCO2 and HCO3 had good correlation among the three samples, whereas they did not recommend CBG and VBG for pO2 estimation (33).

A study was conducted to assess the accuracy of capillary sample for acid base values **Kasim Docrat et al** in 1965**.**This study was conducted on 50 patients during their routine abdominal surgery after giving anesthesia. Capillary samples from ear lobe and arterial samples from brachial or femoral artery was taken.

They were assessed for values of pH, pCO2 and bicarbonate values, there was difference in pH and pCO2 values between 2 samples, while bicarbonate had narrow limits (54).

A study comparing arterialized ear lobe sample and direct arterial puncture sample values of pO2 and pCO2 during exercise were compared by **Fajac et al ,** and he concluded that arterialized earlobe oxygen tension is not a good substitute for arterial oxygen tension and should not be used to assess oxygenation during exercise (37).

A descriptive study on 82 patients by **Rath A et al in 2018** , for comparing and correlating between arterial and capillary blood gas values in mechanically ventilated patients. He found that Bland Altman analysis for pCO2 and bicarbonate were scattered beyond 2 standard deviations. They concluded that CBG can be used to assess pH and paO2, but may be not for assessing pCO2 and bicarbonate (4).

A study done by **Eaton et all** in 2002, showed that arterialized earlobe sampling was inaccurate to replace radial arterial values in prescription of LTOT for patients(35).

Materials And Methods:-

Study Design

A Prospective observational study

Study Site

Emergency Department of Peerless Hospital and B.K.Roy Research Center, Kolkata, India.

Study Duration

The study was conducted over a period of one year (January 2019 – December 2019).

Study Population

For this study, data was collected after obtaining consent, from all patients who fulfilled the inclusion criteria, presenting to the Emergency Department. To calculate the sample size for this study, we has used the raosoft sample size calculator .
(http://www.raosoft.com/samplesize.html).

The following data were administered:
Population size: 150
Confidential level: 95%
Margin of error: 5%
Response Distribution: 50%

The sample size required for this survey was calculated as 110.
15 patients were eliminated due to sampling error (repeated squeezing of finger) and 5 patients were eliminated due to lack of consent from patient and family member. Totally, 90 samples were evaluated for this study.

Inclusion Criteria
1. age > 18 years,
2. Prior diagnosis of COPD
3. Symptoms of acute exacerbation like
4. cough (with or without sputum production),
5. wheeze
6. tachypnea
7. Dyspnea.

Exclusion Criteria
Patients were excluded if:
1. age < 18 years,
2. Pregnant
3. Dyspnoea of causes other than COPD.
4. Those patients whose diagnoses were changed during the course of admission.

Study Methodology:-

All patients with COPD exacerbation, attending Peerless hospital Emergency Department, who were thought to require ABG analysis by the treating physician, were identified and enrolled by Emergency Department doctor during the 12-month study period. A written informed consent was obtained from each patient or his or her family member before enrolment into this study and the patient was included only if the consent was obtained for the study.

The blood samples were drawn simultaneously from the radial artery by an arterial puncture into a heparinized syringe and the fingertip by a finger prick into a capillary tube of every patient participating in the study. Initially, capillary sample was collected and immediately after that, an arterial sample was taken from the radial artery in order to assess the agreement between the capillary and arterial samples.

These samples that were obtained was analysed immediately by the blood gas analyser (AVL Compact 3, Roche Diagnostics GmbH, Mannheim, Germany) of our Emergency Department for values of acid-base and oxygenation: pH, PO_2, PCO_2, HCO_3 and they were recorded.

Blood gases were only obtained if the patient needed blood gases analysis for clinical decisions and further management. In addition, the measurement of oxygen saturation (SpO_2) was also obtained from a finger pulse oximeter (Noninvasive pulse oximeter).

Obtaining Arterial sample:
Under strict aseptic precautions, arterial punctures were carried out and 1ml of arterial blood was collected with a heparinized syringe (BD ABG syringe) and was transferred as soon as possible for assessment by the blood gas analyser.

Obtaining Capillary sample:
After aseptic cleaning, the fingertip was punctured with a no 18 needle and blood gas samples were obtained by "contact" with the capillary tube's tip. The first drop of the blood was discarded. A short manual massage was necessary in some instances. After collection of blood in the capillary tube, two sides of the tube was kept closed by fingers to avoid air bubbles and was sent for analysis by the analyser.

Data analysis:
The data that were obtained were entered in an excel format and was sent for statistical analysis by a statistician. All the documented data were analyzed using Pearson's Chi Square test correlation coefficient test to assess the strength of the relationship between the arterial and capillary gas values.

Results And Observations:-

Statistical Methods
Categorical variables are expressed as Number of patients and percentage of patients and compared across the groups using Pearson's Chi Square test for Independence of Attributes/ Fisher's Exact Test as appropriate.

Continuous variables are expressed as Mean and Standard Deviation and compared using paired t test.

Association between continuous variables captured using Spearman's Rank Correlation Coefficient

The statistical software SPSS version 20 has been used for the analysis. An alpha level of 5% has been taken, i.e. if any p value is less than 0.05 it has been considered as significant.

AGE
Table 1:- Distribution of patients according to age group.

AGE	FREQUENCY	PERCENT
21-30	13	14.4
31-40	14	15.6
41-50	15	16.7
51-60	14	15.6
61-70	13	14.4
71-80	16	17.8
81-90	5	5.6
Total	90	100.0

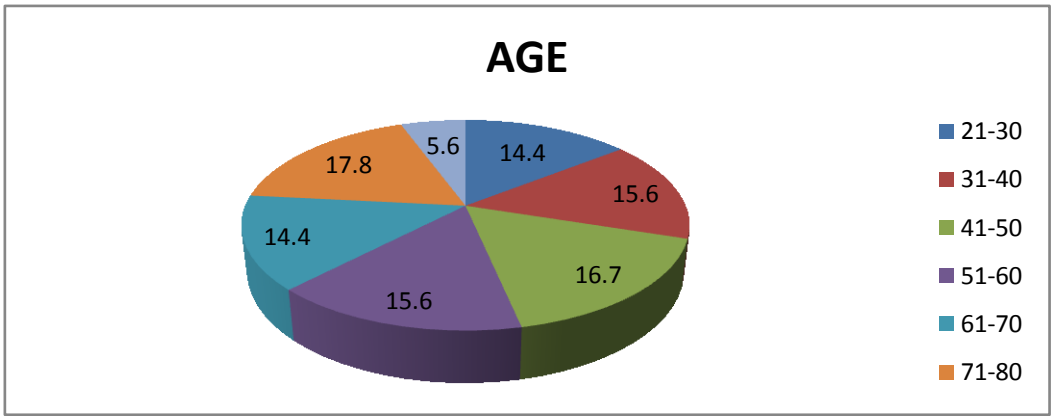

Figure 1:- Pie chart depicting age wise distribution of patients.

The above pie diagram shows majority of patients (17.8%) belonged to age group 71-80 years, followed by equal percentage (15.6%) between age groups 31-40years and 51-60 years.

GENDER
Table 2:- Distribution of patients according to gender.

GENDER	FREQUENCY	PERCENT
MALE	54	60.0
FEMALE	36	40.0
Total	90	100.0

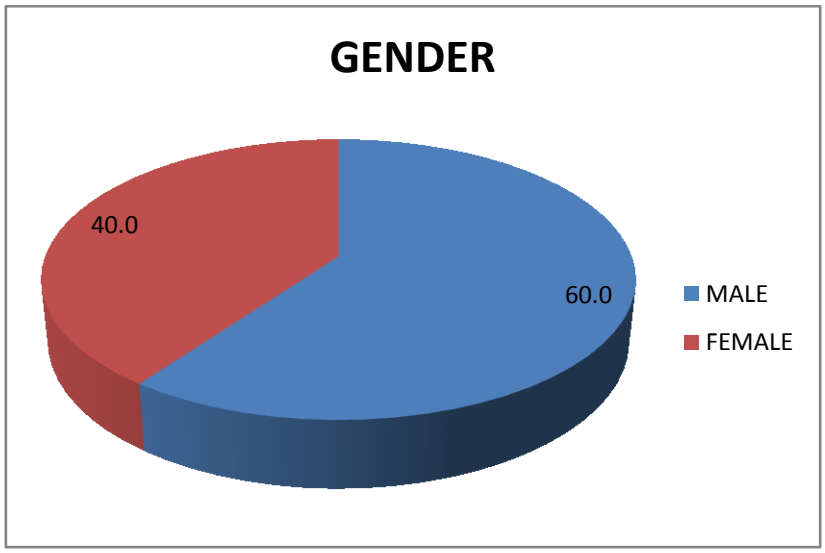

Figure 2:- Pie chart depicting gender wise distribution of patients.

The above pie chart shows that among the total patients, 60% were males and 40% were females.

Results and observation for pco2 values in ABG and CBG:-

AGE

Table 3:- Age wise pCO2 comparison of patients.

AGE		PCO2 (CBG)	PCO2 (ABG)	p Value
21-30	Mean	44.62	44.38	0.641
	SD	2.47	2.60	
31-40	Mean	40.36	40.64	0.659
	SD	2.87	3.41	
41-50	Mean	42.73	43.60	0.394
	SD	5.60	4.05	
51-60	Mean	41.93	41.00	0.234
	SD	4.36	3.28	
61-70	Mean	43.92	44.00	0.870
	SD	3.57	3.67	
71-80	Mean	47.13	45.56	0.099
	SD	5.90	4.10	
81-90	Mean	48.00	43.60	0.135
	SD	4.64	4.10	

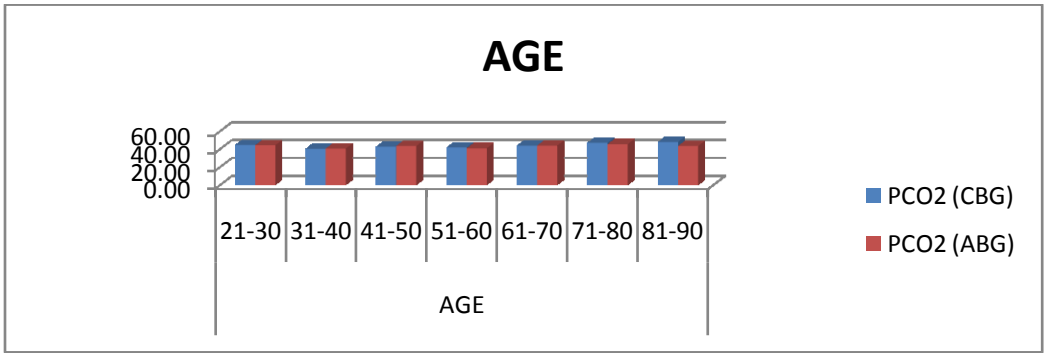

Figure 3:- Bar diagram depicting age wise comparison of pCo2.

Table 4:- p value and significance of age wise comparison of pCO2.

AGE		Paired Differences				p Value	Significance
		Mean	Std. Deviation	95% Confidence Interval of the Difference			
				Lower	Upper		
21-30	PCO2(CB) - PCO2(AB)	0.23	1.74	-0.82	1.28	0.641	Not Significant
31-40	PCO2(CB) - PCO2(AB)	-0.29	2.37	-1.65	1.08	0.659	Not Significant
41-50	PCO2(CB) - PCO2(AB)	-0.87	3.81	-2.98	1.25	0.394	Not Significant
51-60	PCO2(CB) - PCO2(AB)	0.93	2.79	-0.68	2.54	0.234	Not Significant
61-70	PCO2(CB) - PCO2(AB)	-0.08	1.66	-1.08	0.92	0.870	Not Significant
71-80	PCO2(CB) - PCO2(AB)	1.56	3.56	-0.33	3.46	0.099	Not Significant
81-90	PCO2(CB) - PCO2(AB)	4.40	5.27	-2.15	10.95	0.135	Not Significant

The above bar diagram and the tables show that the maximum pCO2 of 48 in CBG is seen in the age group above 81 years and the maximum pCO2 of 45.56 in ABG is seen in the age group 71-80 years. The minimum pCO2 values of 40 in both ABG and CBG were seen in the age group 31-40 years. The p values in all age groups are insignificant (>0.05)

Table 5:- Age wise % normal values of pCO2 in CBG.

PCO2 (CBG)	AGE							TOTAL	P VALUE	SIGNIFICANCE
	21-30	31-40	41-50	51-60	61-70	71-80	81-90			
NORMAL	9 (69.23)	13 (92.86)	13 (86.67)	11 (78.57)	8 (61.54)	7 (43.75)	1 (20)	62 (68.89)	0.008	Significant
ABNORMAL	4 (30.77)	1(7.14)	2 (13.33)	3 (21.43)	5 (38.46)	9 (56.25)	4 (80)	28 (31.11)		
TOTAL	13(100)	14 (100)	15 (100)	14 (100)	13 (100)	16 (100)	5 (100)	90 (100)		

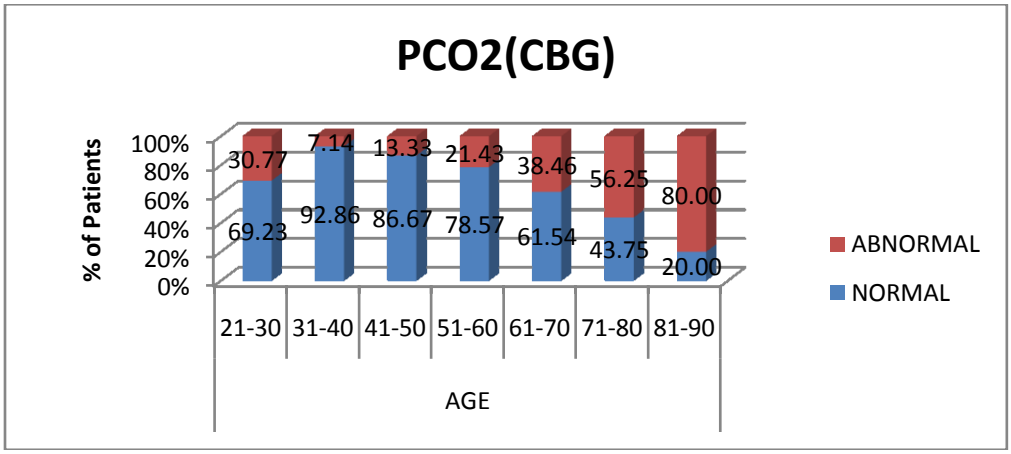

Figure 4:- Bar diagram depicting age wise distribution of % normal values of pCO2 in CBG.

The above bar diagram shows that maximum normal level of pCO2 of 92.8% in CBG was seen in the age group of 31-40 years and minimum normal value of 20% was seen in the age group of 81-90 years.

Table 6:- Age wise % of normal values of pCO2 in ABG.

PCO2 (ABG)	AGE							TOTAL	P VALUE	SIGNIFICANCE
	21-30	31-40	41-50	51-60	61-70	71-80	81-90			
NORMAL	8 (61.54)	12 (85.71)	10 (66.67)	13 (92.86)	9 (69.23)	8 (50)	3 (60)	63(70)	0.147	Not Significant
ABNORMAL	5 (38.46)	2 (14.29)	5 (33.33)	1 (7.14)	4 (30.77)	8 (50)	2 (40)	27(30)		
TOTAL	13 (100)	14 (100)	15 (100)	14 (100)	13 (100)	16 (100)	5 (100)	90 (100)		

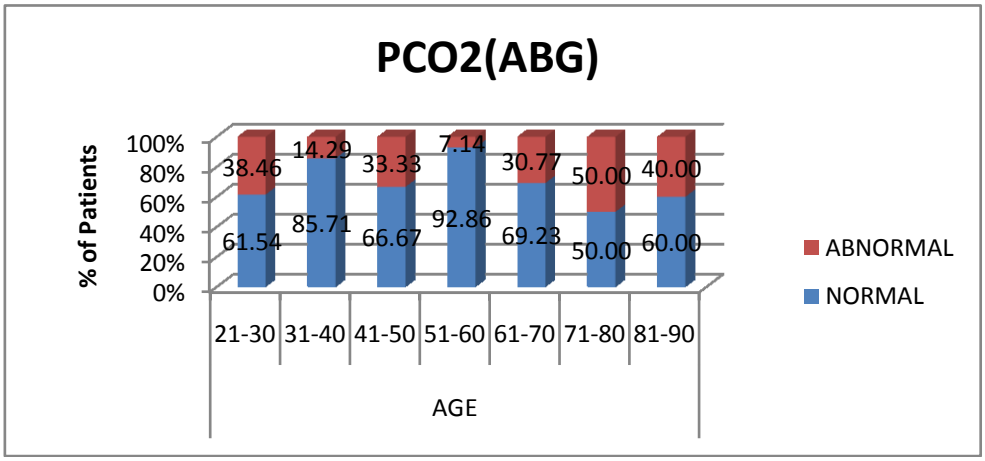

Figure 5:- Bar diagram depicting age wise distribution of % normal values of pCO2 in ABG.

The above bar diagram shows maximum normal level of pCO2 of 92.8% in ABG in age group of 51-60 years and minimum normal value of 50% was seen in the age group of 71-80 years.

Gender

Table 7:- Gender wise pCO2 comparison of patients.

GENDER		PCO2 (CBG)	PCO2 (ABG)	P VALUE
MALE	Mean	44.19	43.35	0.062
	SD	5.09	4.18	
FEMALE	Mean	43.11	43.11	1.000
	SD	4.58	3.53	

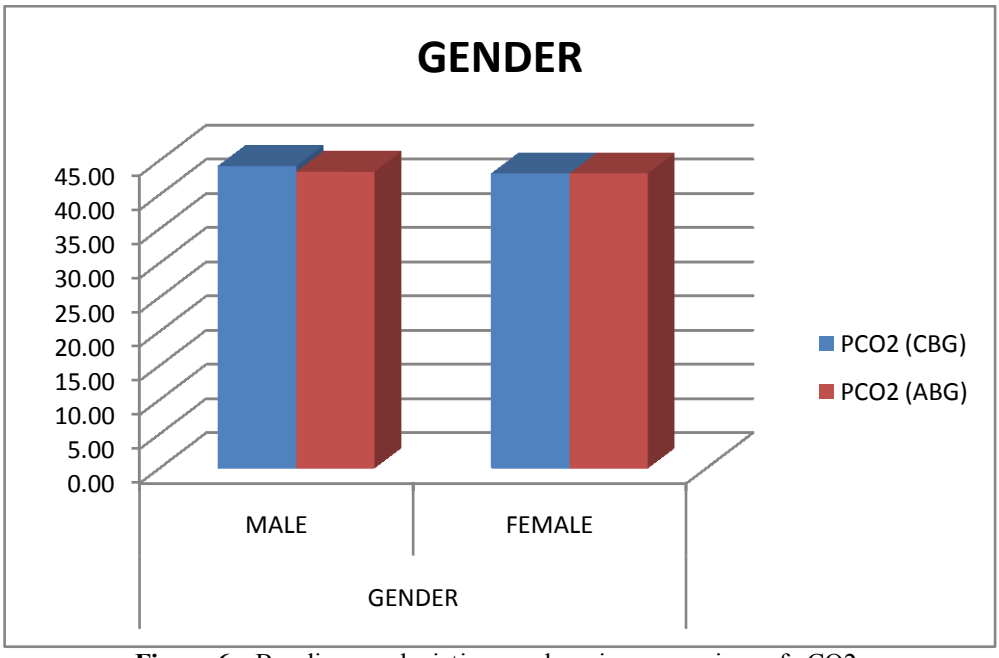

Figure 6:- Bar diagram depicting gender wise comparison of pCO2.

Table 8:- p value and significance of gender wise comparison of pCO2.

GENDER		Paired Differences				P VALUE	SIGNIFICANCE
		Mean	Std. Deviation	95% Confidence Interval of the Difference			
				Lower	Upper		
MALE	PCO2(CBG) - PCO2(ABG)	0.83	3.21	-0.04	1.71	0.062	Not Significant
FEMALE	PCO2(CBG) - PCO2(ABG)	0.00	3.05	-1.03	1.03	1.000	Not Significant

The above bar diagram and the tables show average pCO2 values of ABG and CBG in females were 43.1 and 43.1 respectively , which was similar and average pCO2 values of ABG and CBG in males were 43.3 and 44.2 respectively. The p values in both genders were insignificant.

Table 9:- Gender wise % normal values of pCO2 in CBG.

PCO2(CBG)	GENDER		Total	p Value	Significance
	MALE	FEMALE			
NORMAL	36(66.67)	26(72.22)	62(68.89)	0.577	Not Significant
ABNORMAL	18(33.33)	10(27.78)	28(31.11)		
TOTAL	54(100)	36(100)	90(100)		

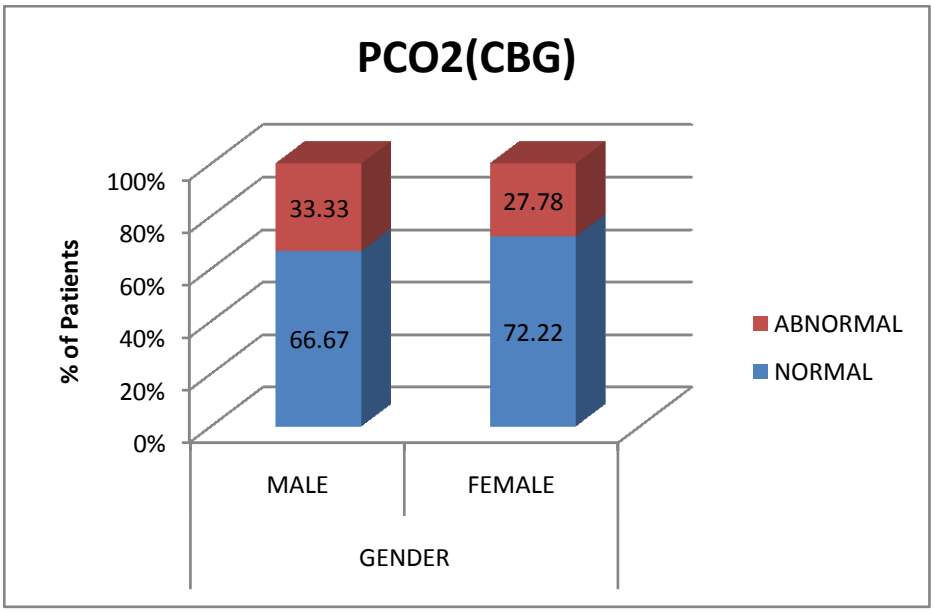

Figure 7:- Bar diagram depicting gender wise distribution of %normal values of pCO2 in CBG.

The above graph shows 72.2% of females had normal pCO2 values in CBG, and 66.6% males had normal pCO2 values in CBG.

Table 10:- Gender wise % normal values of pCO2 in ABG.

PCO2(ABG)	GENDER		Total	p Value	Significance
	MALE	FEMALE			
NORMAL	36(66.67)	27(75)	63(70)	0.398	Not Significant
ABNORMAL	18(33.33)	9(25)	27(30)		
Total	54(100)	36(100)	90(100)		

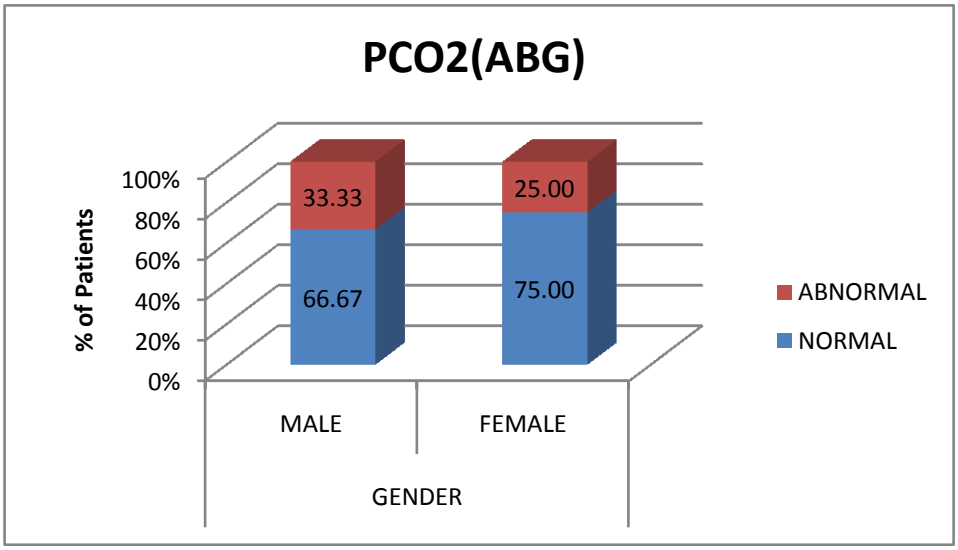

Figure 8:- Bar diagram depicting gender wise distribution of %normal values of pCO2 in ABG.

The above graph shows 75% of females had normal pCO2 values in ABG, and 66.6% males had normal pCO2 values in ABG, which is similar to the percentage in CBG for males.

Table 11:- Overall pCO2 distribution.

	MEAN	STD.DEV	P VAL	SIGNIFICANCE
PCO2(ABG)	43.26	3.91		
PCO2(CBG)	43.76	4.90	0.136	NOT SIGNIFICANT

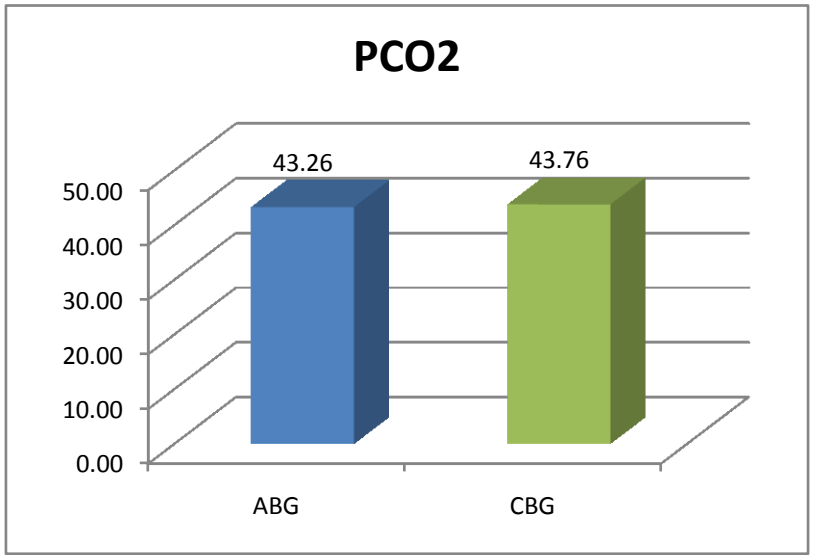

Figure 9:- Bar diagram depicting overall pCO2 distribution.

The above bar diagram shows overall average pCO2 value in ABG was 43.26 and overall average pCO2 value in CBG was 43.76.

Table 12:- p value and significance of overall pCO2 comparison.

	Paired differences				P value	Significance
	Mean	Std. Deviation	95% confidence interval of the difference			
			Lower	Upper		
PCO2(CBG) - PCO2(ABG)	0.50	3.16	-0.16	1.16	0.136	Not Significant

Spearmans rank correlation is 0.764.

The overall comparison of pCO2 values between CBG and ABG yielded a p value of 0.136, which means the difference is insignificant. With the above results, we can safely consider ABG and CBG as consistent predictor for pCO2 value.

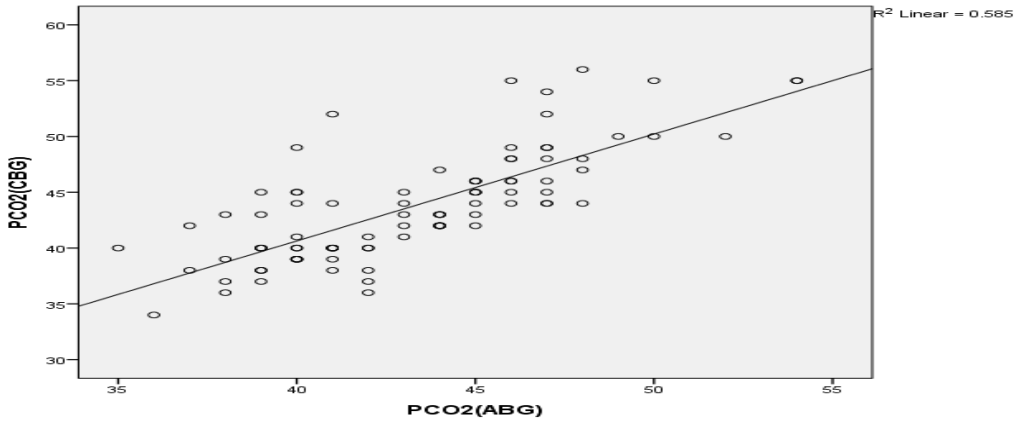

Figure 10:- Diagrammatic representation of correlation co-efficient of pCO2 values.

Table 13:- Agreement and disagreement between pCo2 values in ABG and CBG.

PCO2	Frequency	Percent
DISAGREEMENT	13	14.4
AGREEMENT	77	85.6
Total	90	100.0

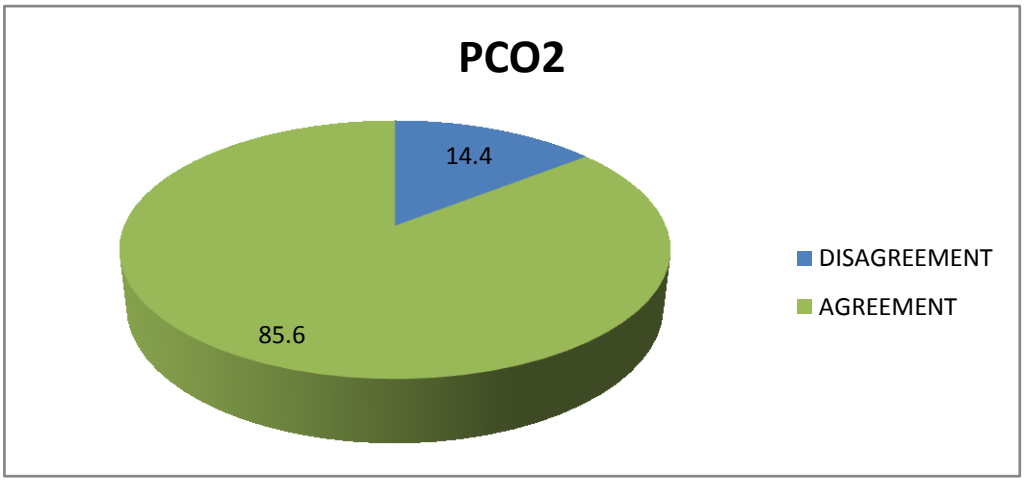

Figure 11:- Pie chart depicting comparison of agreement and disagreement between pCO2 values in ABG and CBG.

In 85% cases, both the methods measure abnormal and normal PCO2 in similar direction.
In 14% cases, both the methods measure abnormal and normal PCO2 is opposite direction.
There is a fair association between ABG and CBG in terms of predicting "normal vs abnormal "PCO2 level.

Results And Observation:-

for HCO3 values in ABG and CBG:-

Age

Table 14:- Age wise HCO3 comparison of patients.

AGE		HCO3 (CBG)	HCO3 (ABG)	p Value
21-30	Mean	23.46	21.54	0.004
	SD	1.51	2.03	
31-40	Mean	23.50	23.79	0.725
	SD	1.83	2.72	
41-50	Mean	24.40	25.13	0.334
	SD	2.41	2.61	
51-60	Mean	22.64	24.14	0.073
	SD	2.17	2.54	
61-70	Mean	22.77	21.15	0.040
	SD	2.01	2.70	
71-80	Mean	20.88	19.56	0.069
	SD	2.60	2.34	
81-90	Mean	22.60	21.00	0.374
	SD	3.05	2.00	

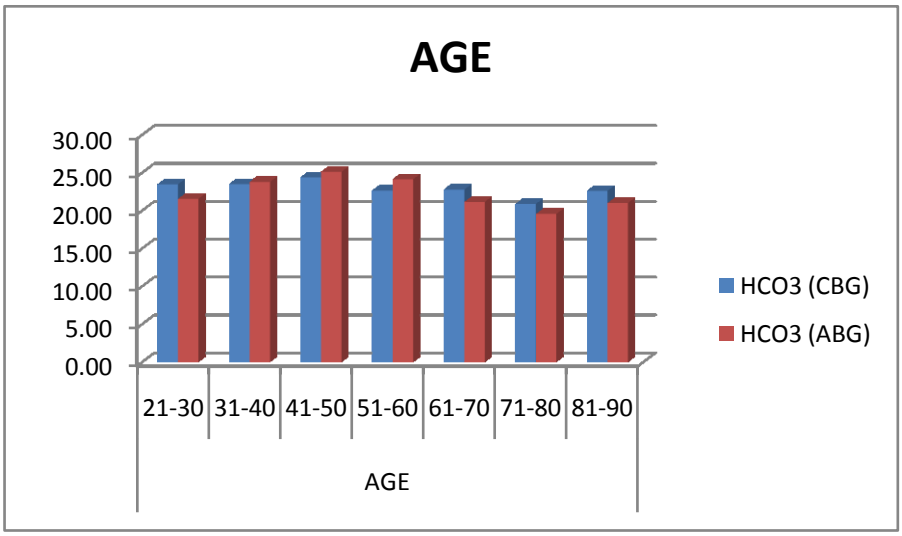

Figure 12:- Bar diagram depicting age wise comparison of HCO3.

Table 15:- p value and significance of age wise comparison of HCO3.

AGE		Paired Differences				p Value	Significance
		Mean	Std. Deviation	95% Confidence Interval of the Difference			
				Lower	Upper		
21-30	HCO3(CBG) - HCO3(ABG)	1.92	1.98	0.73	3.12	0.004	Significant
31-40	HCO3(CBG) - HCO3(ABG)	-0.29	2.97	-2.00	1.43	0.725	Not Significant
41-50	HCO3(CBG) - HCO3(ABG)	-0.73	2.84	-2.31	0.84	0.334	Not Significant
51-60	HCO3(CBG) - HCO3(ABG)	-1.50	2.88	-3.16	0.16	0.073	Not Significant
61-70	HCO3(CBG) - HCO3(ABG)	1.62	2.53	0.08	3.15	0.040	Significant
71-80	HCO3(CBG) - HCO3(ABG)	1.31	2.68	-0.11	2.74	0.069	Not Significant
81-90	HCO3(CBG) - HCO3(ABG)	1.60	3.58	-2.84	6.04	0.374	Not Significant

The above bar diagram and the tables show that the maximum HCO3 of 24.4 in CBG is seen in the age group 41-50 years and the maximum HCO3 of 25.13 in ABG is also seen in the age group 41-50 years. The minimum HCO3 values of 20.88 in CBG and 19.56 in ABG were seen in the age group 71-80 years. The p values were insignificant in all age groups except in 21-30years and 61-70 years.

Table 16:- Age wise % normal values of HCO3 in CBG.

HCO3 (CBG)	AGE							TOTAL	P VALUE	SIGNIFICANCE
	21-30	31-40	41-50	51-60	61-70	71-80	81-90			
NORMAL	12 (92.31)	11 (78.57)	11 (73.33)	8 (57.14)	9 (69.23)	6 (37.5)	3 (60)	60 (66.67)	0.061	Not Significant
ABNORMAL	1 (7.69)	3 (21.43)	4 (26.67)	6 (42.86)	4 (30.77)	10 (62.5)	2 (40)	30 (33.33)		

Total	13 (100)	14 (100)	15 (100)	14 (100)	13 (100)	16 (100)	5 (100)	90 (100)		

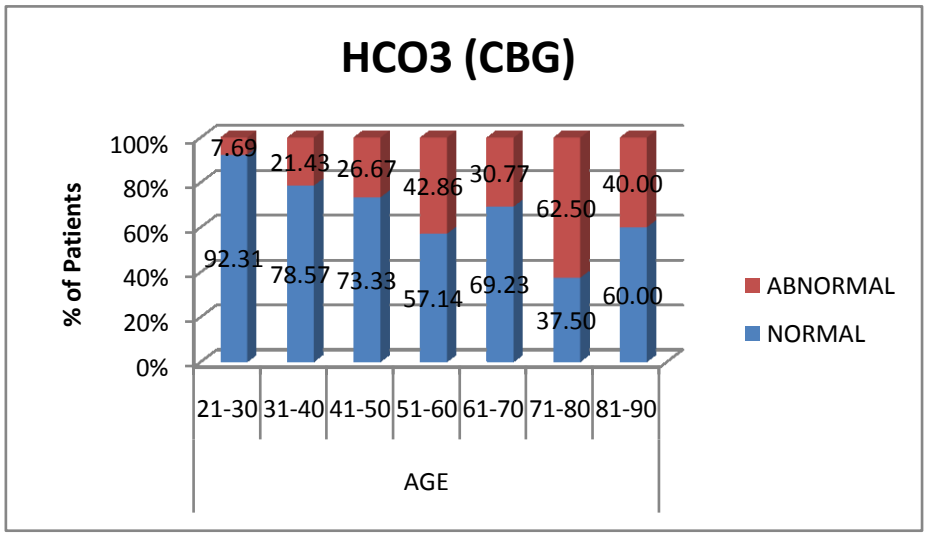

Figure 13:- Bar diagram depicting age wise distribution of % of normal values of HCO3 in CBG.

The above bar diagram shows maximum normal level of HCO3 of 92.3% seen in CBG in the age group of 21-30 years and minimum normal level of 37.5% seen in the age group of 71-80 years.

Table 17:- Age wise % of normal values of HCO3 in ABG.

HCO3 (ABG)	**AGE**							**Total**	**p value**	**significance**
	21-30	31-40	41-50	51-60	61-70	71-80	81-90			
NORMAL	7 (53.85)	10 (71.43)	10 (66.67)	8 (57.14)	6 (46.15)	4(25)	2(40)	47 (52.22)	0.190	Not Significant
ABNORMAL	6 (46.15)	4 (28.57)	5 (33.33)	6 (42.86)	7 (53.85)	12 (75)	3(60)	43 (47.78)		
Total	13(100)	14 (100)	15 (100)	14 (100)	13 (100)	16 (100)	5 (100)	90 (100)		

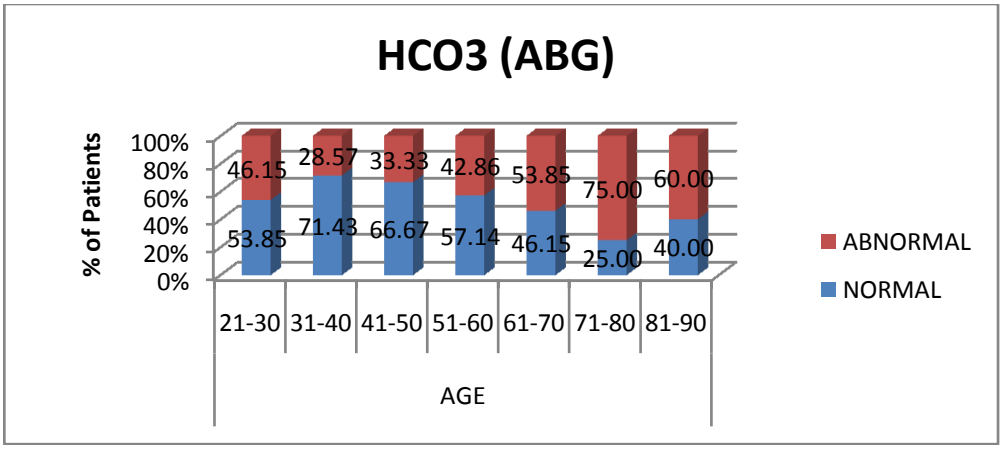

Figure 14:- Bar diagram depicting age wise distribution of % of normal values of HCO3 in ABG.

The above bar diagram shows maximum normal level of HCO3 of 71.4% in ABG in the age group of 31-40 years and minimum normal level of 25% in the age group of 71-80 years.

Gender

Table 18:- Gender wise HCO3 comparison of patients.

GENDER		HCO3 (CBG)	HCO3 (ABG)	P VALUE
MALE	Mean	22.98	22.30	0.088
	SD	2.45	3.49	
FEMALE	Mean	22.75	22.69	0.912
	SD	2.35	2.45	

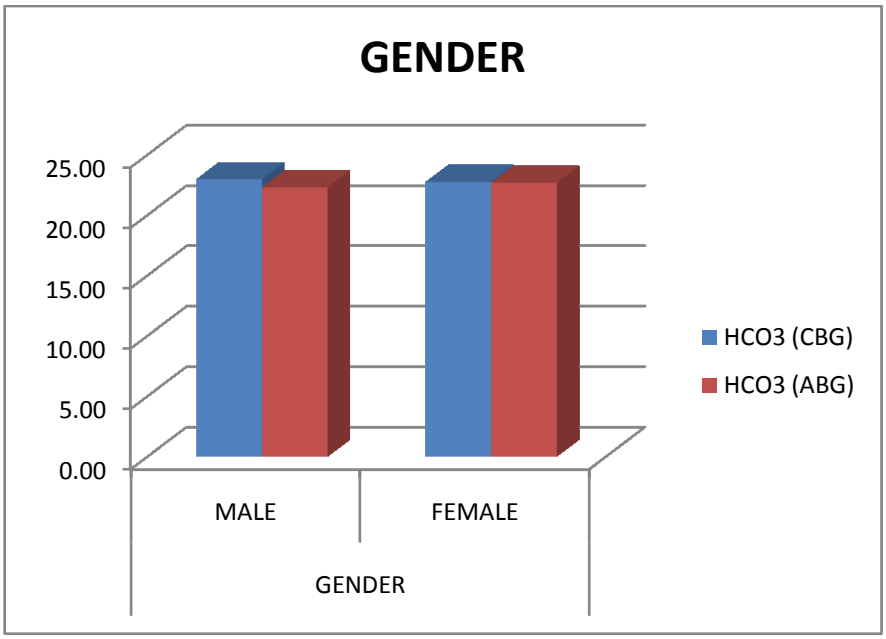

Figure 15:- Bar diagram depicting gender wise comparison of HCO3 values.

Table 19:- p value and significance of gender wise comparison of HCO3.

GENDER		PAIRED DIFFERENCES				P VALUE	SIGNIFICANCE
		MEAN	STD. DEVIATION	95% CONFIDENCE INTERVAL OF THE DIFFERENCE			
				LOWER	UPPER		
MALE	HCO3 (CBG) - HCO3 (ABG)	0.69	2.89	-0.10	1.47	0.088	Not Significant
FEMALE	HCO3 (CBG) - HCO3 (ABG)	0.06	2.99	-0.95	1.07	0.912	Not Significant

The above bar diagram and the tables show average HCO3 values of ABG and CBG in females were 22.69 and 22.75 respectively and average HCO3 values of ABG and CBG in males were 22.30 and 22.98 respectively. The p values in both genders were insignificant.

Table 20:- Gender wise % of normal values of HCO3 in CBG.

HCO3(CBG)	GENDER		TOTAL	P VALUE	SIGNIFICANCE
	MALE	FEMALE			
NORMAL	33(61.11)	27(75)	60(66.67)	0.171	Not Significant

ABNORMAL	21(38.89)	9(25)	30(33.33)		
Total	54(100)	36(100)	90(100)		

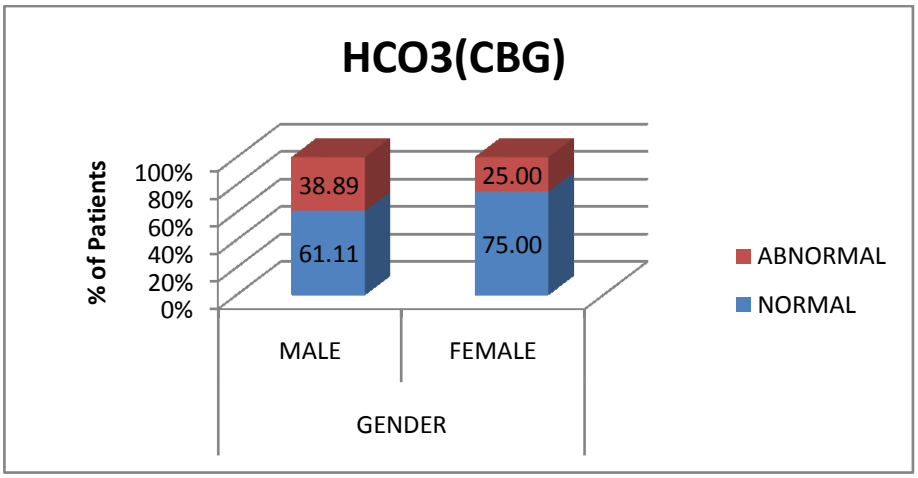

Figure 16:- Bar diagram depicting gender wise distribution of % of normal values of HCO3 in CBG.

The graph shows 75% of females had normal HCO3 values in CBG and 61% of males had normal HCO3 values in CBG.

Table 21:- Gender wise % of normal values of HCO3 in ABG.

HCO3(ABG)	GENDER		TOTAL	P VALUE	SIGNIFICANCE
	MALE	FEMALE			
NORMAL	24(44.44)	23(63.89)	47(52.22)	0.070	Not Significant
ABNORMAL	30(55.56)	13(36.11)	43(47.78)		
Total	54(100)	36(100)	90(100)		

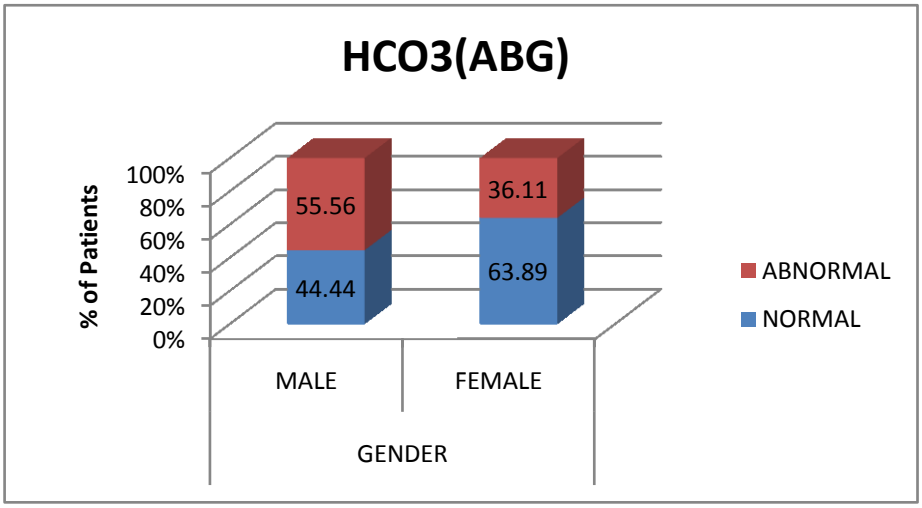

Figure 17:- Bar diagram depicting gender wise distribution of % of normal values of HCO3 in ABG.

The above graph shows 63.8% of females had normal HCO3 values in ABG, and 44.4% males had normal HCO3 values in ABG.

Table 22:- Overall HCO3 distribution.

	MEAN	STD. DEVIATION	P VALUE	SIGNIFICANCE
HCO3(CBG)	22.89	2.40	0.164	NOT SIGNIFICANT
HCO3(ABG)	22.46	3.11		

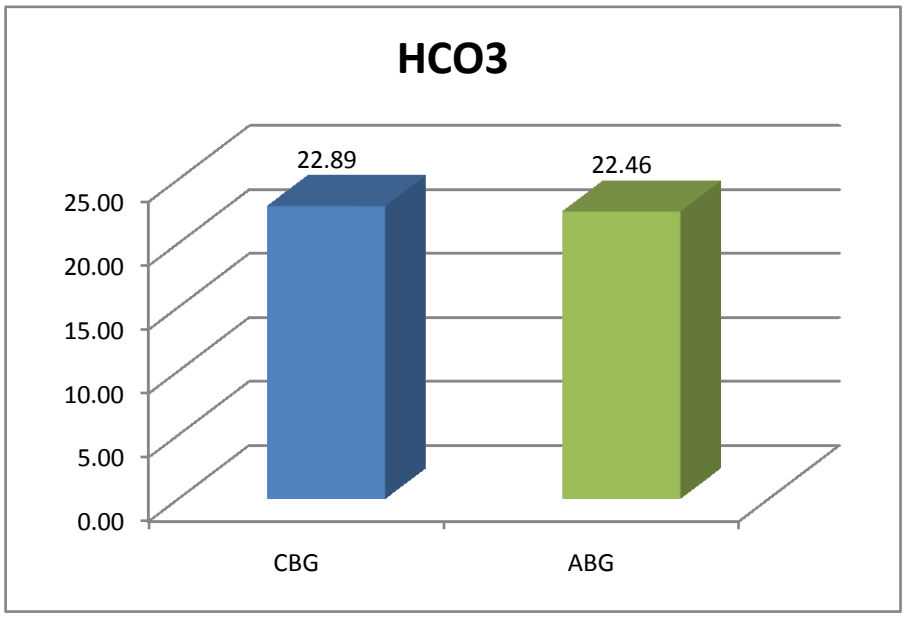

Figure 18:- Bar diagram depicting overall HCO3 distribution.

The above bar diagram shows overall average HCO3 value in ABG was 22.46 and overall average HCO3 value in CBG was 22.89.

Table 23:- p value and significance of overall comparison of HCO3.

	Paired Differences				p Value	Significance
	Mean	Std. Deviation	95% Confidence Interval of the Difference			
			Lower	Upper		
HCO3(CBG) - HCO3(ABG)	0.43	2.93	-0.18	1.05	0.164	Not Significant

Spearman's Rho Correlation – 0.415

The overall comparison of HCO3 values between CBG and ABG yielded a p value of 0.164, which means the difference is insignificant. With the above results, we can safely consider ABG and CBG as consistent predictor for HCO3 value.

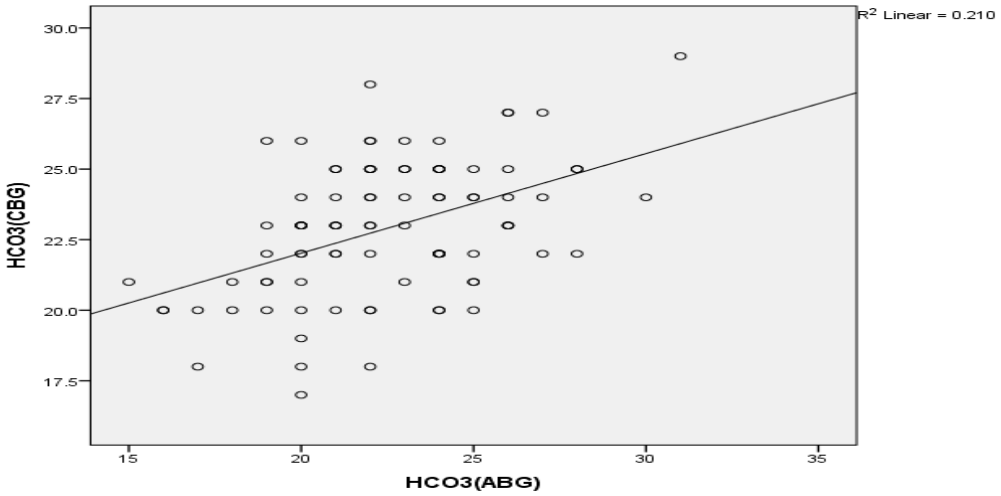

Figure 19:- Diagrammatic representation of correlation co-efficient of HCO3 values.

Table 24: Agreement and disagreement between HCO3 values in ABG and CBG

HCO3	FREQUENCY	PERCENT
DISAGREEMENT	37	41.1
AGREEMENT	53	58.9
Total	90	100.0

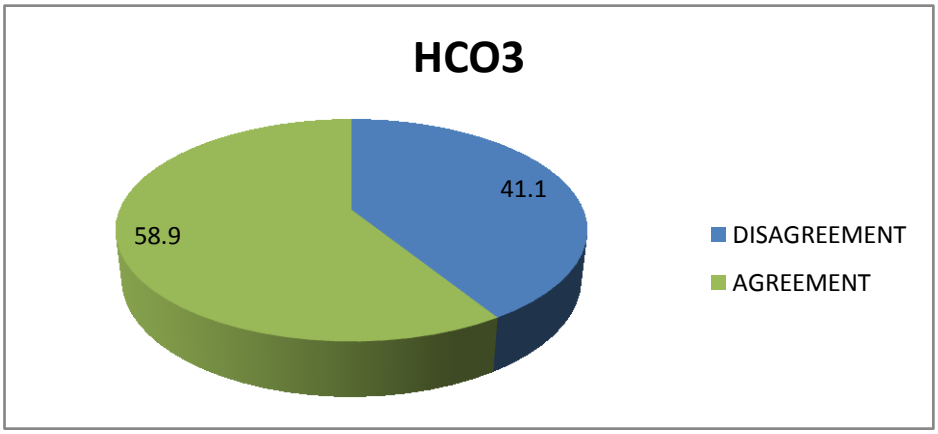

Figure 20: Pie chart depicting comparison of agreement and disagreement of HCO3 values in ABG and CBG

In 58.9% cases, both the methods measure abnormal and normal HCO3 in similar direction.
In 41.1% cases, both the methods measure abnormal and normal HCO3 in opposite direction.
Hence, within normal range or within abnormal range HCO3 comparison is not making any sense.

Results and observation for pH values in ABG and CBG:-

- **AGE**

Table 25: Age wise pH comparison of patients

AGE	PH (CBG)	PH (ABG)	P VALUE

21-30	Mean	7.40	7.40	0.598
	SD	0.02	0.02	
31-40	Mean	7.42	7.42	1.000
	SD	0.02	0.02	
41-50	Mean	7.39	7.39	0.055
	SD	0.03	0.02	
51-60	Mean	7.39	7.39	0.895
	SD	0.03	0.02	
61-70	Mean	7.36	7.36	0.102
	SD	0.04	0.04	
71-80	Mean	7.32	7.32	0.637
	SD	0.06	0.05	
81-90	Mean	7.32	7.33	0.413
	SD	0.05	0.03	

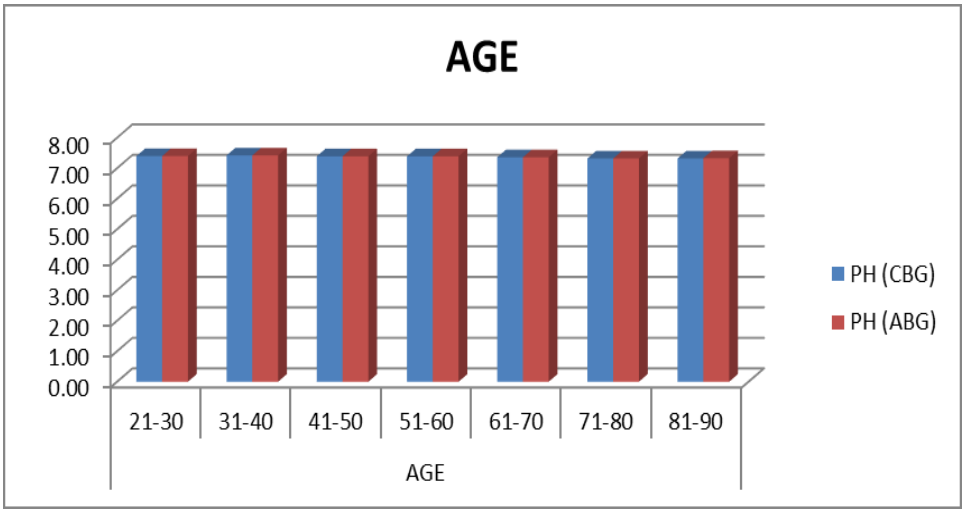

Figure 21: Bar diagram depicting age wise comparison of pH values

Table 26: p value and significance of age wise comparison of pH

AGE		PAIRED DIFFERENCES				p value	significance
		Mean	Std. Deviation	95% Confidence Interval of the Difference			
				Lower	Upper		
21-30	PH(CBG) - PH(ABG)	0.00	0.02	-0.01	0.01	0.598	Not Significant
31-40	PH(CBG) - PH(ABG)	0.00	0.02	-0.01	0.01	1.000	Not Significant
41-50	PH(CBG) - PH(ABG)	0.01	0.01	0.00	0.01	0.055	Not Significant
51-60	PH(CBG) - PH(ABG)	0.00	0.02	-0.01	0.01	0.895	Not Significant
61-70	PH(CBG) - PH(ABG)	0.01	0.02	0.00	0.02	0.102	Not Significant

71-80	PH(CBG) - PH(ABG)	0.00	0.02	-0.01	0.01	0.637	Not Significant
81-90	PH(CBG) - PH(ABG)	-0.01	0.02	-0.04	0.02	0.413	Not Significant

The above bar diagram and the tables show that the maximum pH of 7.42 in CBG and ABG were seen in the age group 31-40 years. The minimum HCO3 values of 7.32 in CBG is seen in age groups 71-80 years and 81-90 years and 7.32 in ABG was seen in the age group 71-80 years. The p values were insignificant in all age groups.

Table 27: Age wise % normal values of pH in CBG

PH (CBG)	AGE							TOTAL	P VALUE	SIGNIFICANCE
	21-30	31-40	41-50	51-60	61-70	71-80	81-90			
NORMAL	13 (100)	14(100)	14 (93.33)	13 (92.86)	8 (61.54)	6(37.5)	1(20)	69 (76.67)	<0.001	Significant
ABNORMAL	0 (0)	0(0)	1(6.67)	1(7.14)	5 (38.46)	10 (62.5)	4(80)	21 (23.33)		
Total	13 (100)	14 (100)	15 (100)	14 (100)	13 (100)	16 (100)	5 (100)	90(100)		

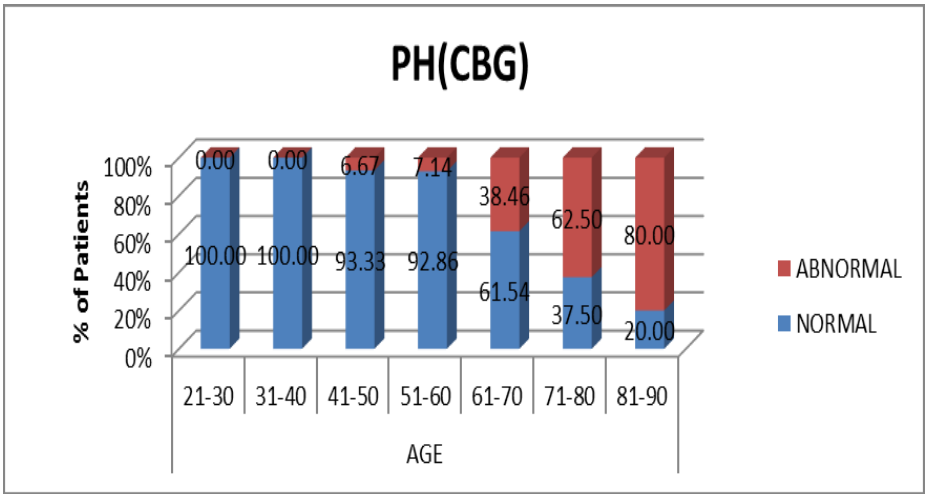

Figure 22: Bar diagram depicting age wise distribution of % of normal values of pH in CBG

The above bar diagram shows 100% normal level of pH in CBG in the age group of 21-30 years and 31-40 years and minimum normal value of 20% was seen in the age group of 81-90 years.

Table 28: Age wise % of normal values of pH in ABG

PH (ABG)	AGE							TOTAL	P VALUE	SIGNIFICANCE
	21-30	31-40	41-50	51-60	61-70	71-80	81-90			

NORMAL	13 (100)	14 (100)	15 (100)	13 (92.86)	7 (53.85)	6 (37.5)	2(40)	70 (77.78)	<0.001	Significant
ABNORMAL	0(0)	0(0)	0(0)	1 (7.14)	6 (46.15)	10 (62.5)	3(60)	20 (22.22)		
Total	13 (100)	14 (100)	15 (100)	14 (100)	13 (100)	16 (100)	5 (100)	90 (100)		

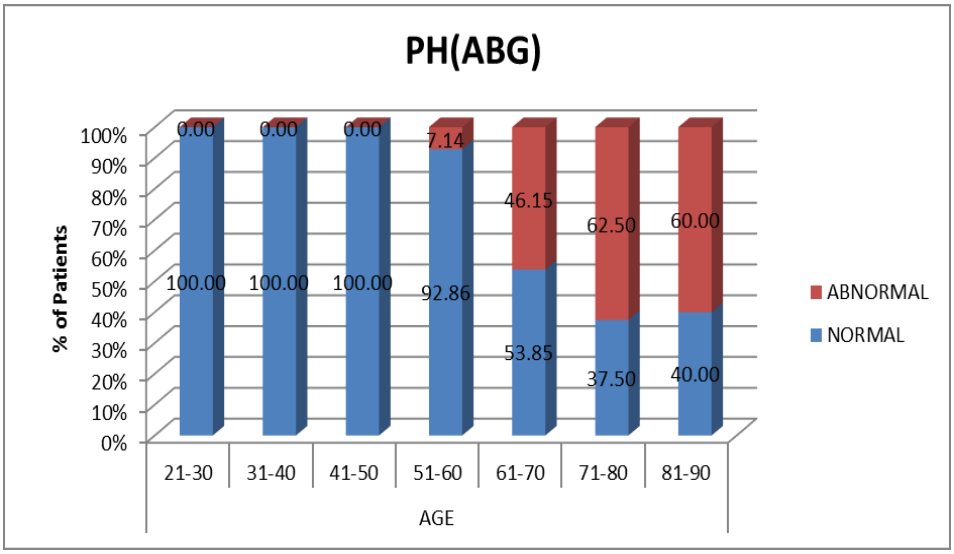

Figure 23: Bar diagram depicting age wise distribution of % of normal values of pH in ABG

The above bar diagram shows 100% of normal limits of pH in ABG in the age group of 21-30 years, 31-40 years and 41-50 years and minimum normal level of 37.5% in the age group of 71-80 years.

- **GENDER**

Table 29: Gender wise pH comparison of patients

GENDER		**PH (CBG)**	**PH (ABG)**	**p Value**
MALE	Mean	7.38	7.38	0.114
	SD	0.05	0.05	
FEMALE	Mean	7.37	7.37	0.742
	SD	0.05	0.05	

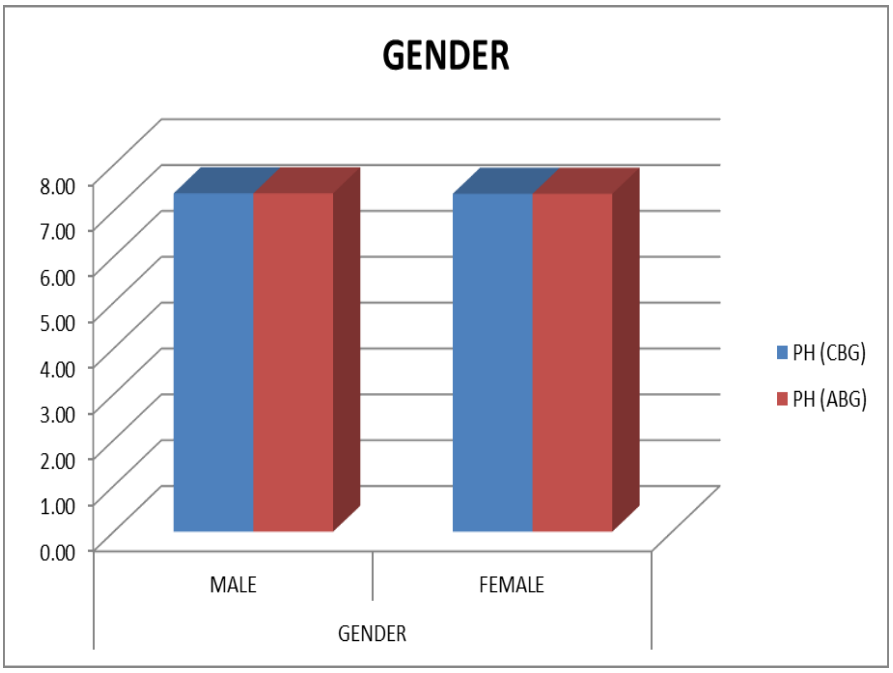

Figure 24:- Bar diagram depicting gender wise comparison of pH values.

Table 30:- p value and significance of gender wise comparison of pH.

GENDER		PAIRED DIFFERENCES				p value	significance
		Mean	Std. Deviation	95% confidence interval of the difference			
				lower	upper		
MALE	PH(CBG) - PH(ABG)	0.00	0.01	0.00	0.01	0.114	Not Significant
FEMALE	PH(CBG) - PH(ABG)	0.00	0.02	-0.01	0.01	0.742	Not Significant

The above bar diagram and the tables show average pH values of ABG and CBG in females were 7.37 and average pH values of ABG and CBG in males were 7.38. The p values in both genders were insignificant.

Table 31:- Gender wise % of normal values of pH in CBG.

PH(CBG)	GENDER		TOTAL	P VALUE	SIGNIFICANCE
	MALE	FEMALE			
NORMAL	42(77.78)	27(75)	69(76.67)	0.760	Not Significant
ABNORMAL	12(22.22)	9(25)	21(23.33)		
Total	54(100)	36(100)	90(100)		

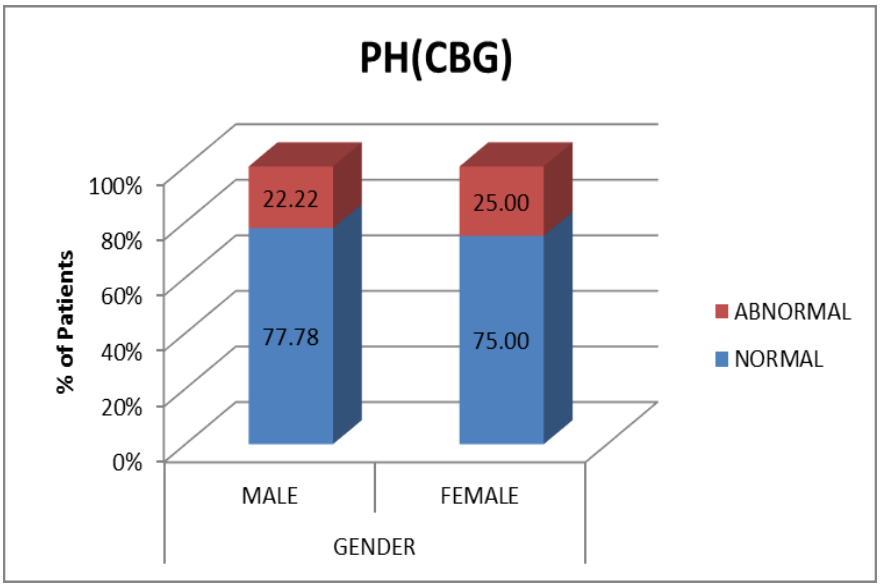

Figure 25:- Bar diagram depicting gender wise distribution of % of normal values of pH in CBG.

The graph shows 75% of females had normal pH values in CBG and 77.7% of males had normal pH values in CBG.

Table 32:- Gender wise % of normal values of pH in ABG.

PH(ABG)	GENDER		TOTAL	P VALUE	SIGNIFICANCE
	MALE	FEMALE			
NORMAL	43(79.63)	27(75)	70(77.78)	0.605	Not Significant
ABNORMAL	11(20.37)	9(25)	20(22.22)		
Total	54(100)	36(100)	90(100)		

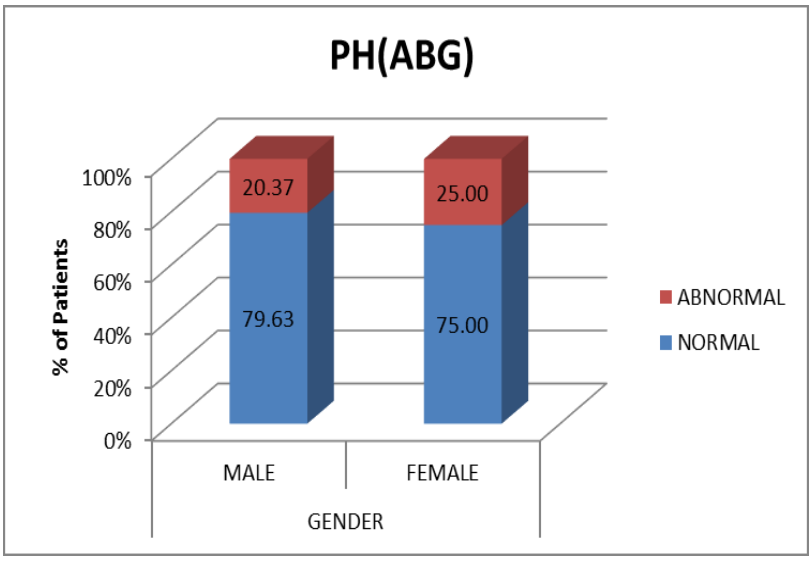

Figure 26:- Bar diagram depicting gender wise distribution of % of normal values of pH in ABG.

The graph shows 75% of females had normal pH values in ABG and 79.6% of males had normal pH values in ABG.

Table 33:- Overall pH distribution.

	MEAN	STD. DEVIATION	P VALUE
PH(CBG)	7.38	0.05	0.192
PH(ABG)	7.37	0.05	

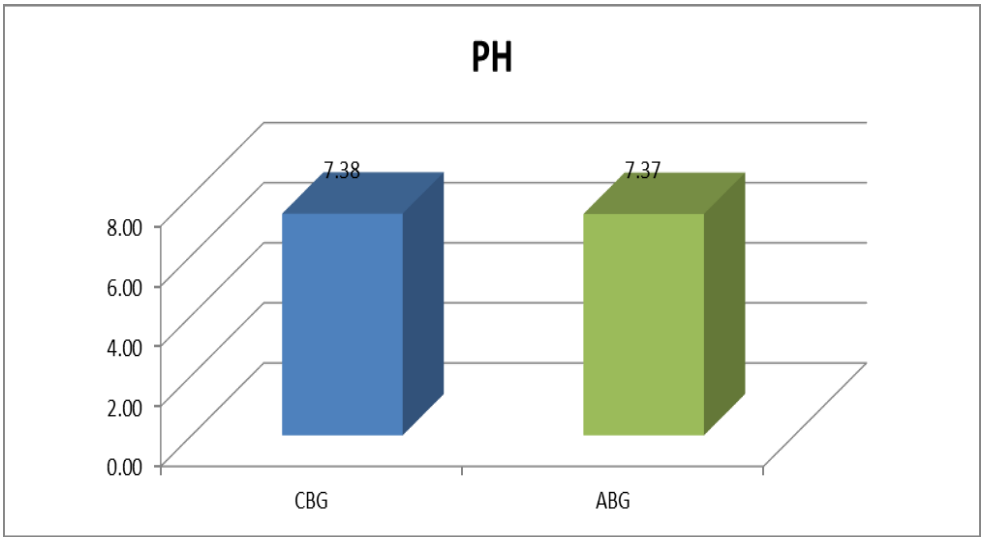

Figure 27:- Bar diagram depicting overall pH distribution.

The above bar diagram shows overall average pH value in ABG was 7.37 and overall average pH value in CBG was 7.38.

Table 34:- p value and significance of overall comparison of pH.

	Paired Differences				p Value	Significance
	Mean	Std. Deviation	95% Confidence Interval of the Difference			
			Lower	Upper		
PH(CBG) - PH(ABG)	0.00	0.02	0.00	0.01	0.192	Not Significant

Spearman Rho's Correlation IS 0.886

The overall comparison of pH values between CBG and ABG yielded a p value of 0.164, which means the difference is insignificant. With the above results, we can safely consider ABG and CBG as consistent predictor for pH value.

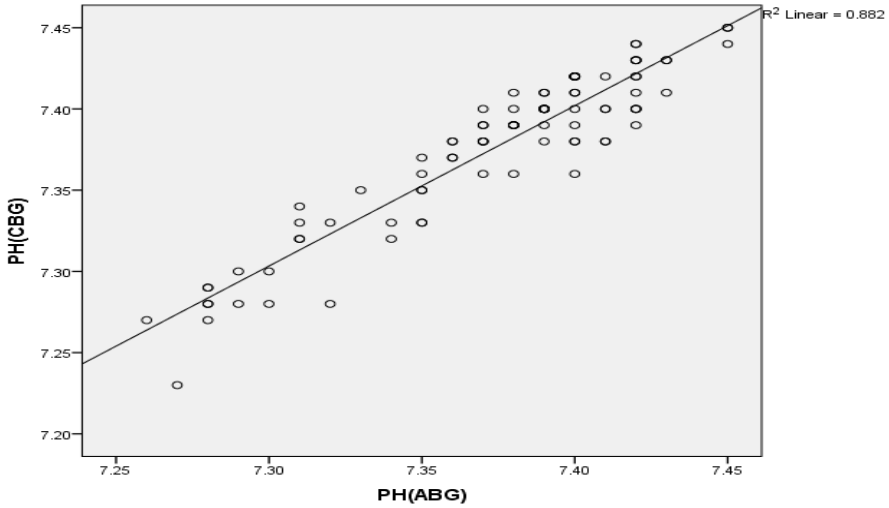

Figure 28: Diagrammatic representation of correlation co-efficient of pH values

Table 35:- Agreement and disagreement between pH values in ABG and CBG.

PH	Frequency	Percent
DISAGREEMENT	3	3.3
AGREEMENT	87	96.7
Total	90	100.0

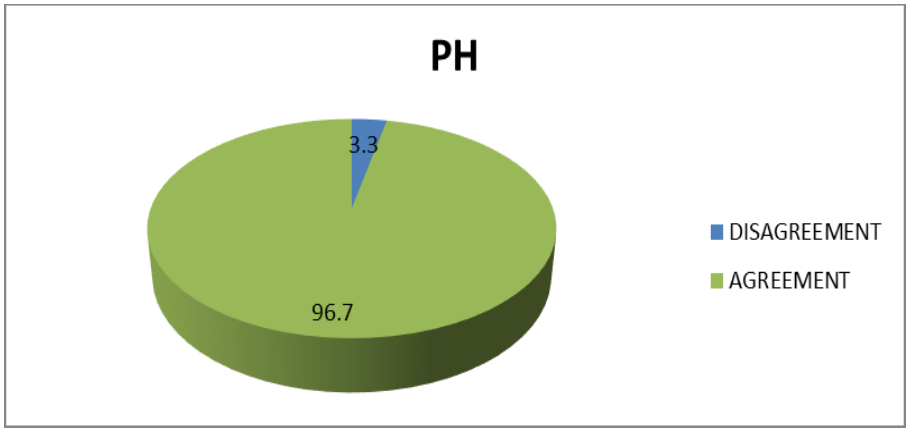

Figure 29:- Pie chart depicting comparison of agreement and disagreement of pH values in ABG and CBG.
In 96% cases, both the methods measure abnormal and normal pH in similar direction.
In 3.3% cases, both the methods measure abnormal and normal pH is opposite direction.
There is a fair association between ABG and CBG in terms of predicting "normal vs abnormal "pH value.

Results and observation for pO2 values in ABG and CBG:-

- **AGE**

Table 36:- Age wise pO2 comparison of patients.

AGE		PO2 (CBG)	PO2 (ABG)	p Value
21-30	Mean	68.92	89.23	<0.001
	SD	8.11	8.89	
31-40	Mean	65.79	85.57	<0.001
	SD	10.69	10.60	
41-50	Mean	64.40	85.33	<0.001
	SD	9.95	5.79	
51-60	Mean	67.00	79.21	0.001

	SD	9.97	6.40	
61-70	Mean	63.77	84.08	<0.001
	SD	10.03	9.09	
71-80	Mean	60.75	82.25	<0.001
	SD	9.53	7.65	
81-90	Mean	66.40	74.80	<0.001
	SD	16.89	2.59	

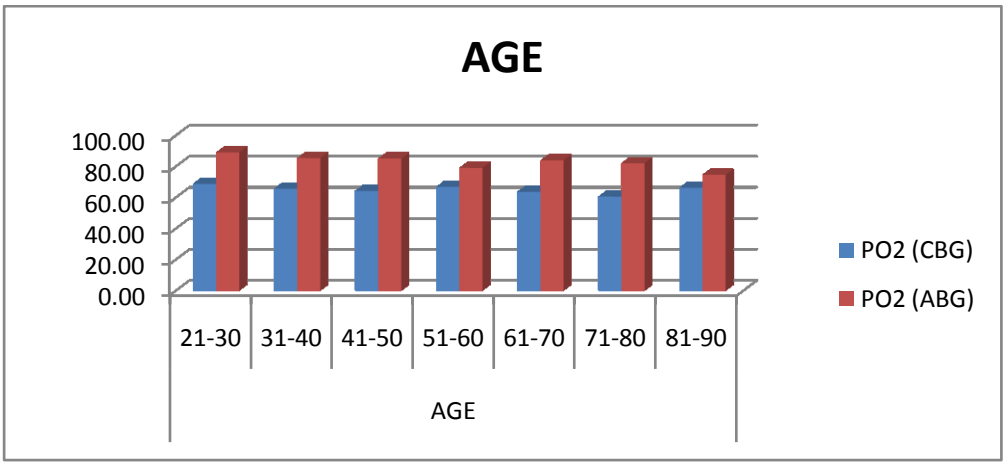

Table 30:- Bar diagram depicting age wise comparison of pO2 values.

Table 37:- p value and significance of age wise comparison of pO2.

AGE		Paired Differences				P value	Significance
		Mean	Std. Deviation	95% Confidence Interval of the Difference			
				Lower	Upper		
21-30	PO2(CBG) - PO2(ABG)	-20.31	10.55	-26.69	-13.93	<0.001	Significant
31-40	PO2(CBG) - PO2(ABG)	-19.79	11.13	-26.21	-13.36	<0.001	Significant
41-50	PO2(CBG) - PO2(ABG)	-20.93	12.46	-27.83	-14.03	<0.001	Significant
51-60	PO2(CBG) - PO2(ABG)	-12.21	10.21	-18.11	-6.32	0.001	Significant
61-70	PO2(CBG) - PO2(ABG)	-20.31	13.12	-28.24	-12.38	<0.001	Significant
71-80	PO2(CBG) - PO2(ABG)	-21.50	8.64	-26.10	-16.90	<0.001	Significant
81-90	PO2(CBG) - PO2(ABG)	-8.40	16.01	-28.28	11.48	<0.001	Significant

The above bar diagram and the tables show that the maximum pO2 of 68.92 in CBG and 89.23 in ABG were seen in the age group of 21-30 years. The minimum pO2 value in CBG was 60.7, seen in age group 71-80 years and in ABG was 74.80, was seen in the age group 81-90 years. The p values in all age groups were significant (<0.05).

Table 38:- Age wise % normal values of pO2 in CBG.

pO2 (CBG)	AGE	Total	p	Significa

	21-30	31-40	41-50	51-60	61-70	71-80	81-90		Value	nce
NORMAL	3 (23.08)	3 (21.43)	3(20)	2 (14.29)	2 (15.38)	2 (12.5)	2 (40)	17 (18.89)	0.880	Not Significant
ABNORMAL	10 (76.92)	11 (78.57)	12 (80)	12 (85.71)	11 (84.62)	14 (87.5)	3 (60)	73 (81.11)		
Total	13(100)	14(100)	15 (100)	14(100)	13(100)	16 (100)	5 (100)	90(100)		

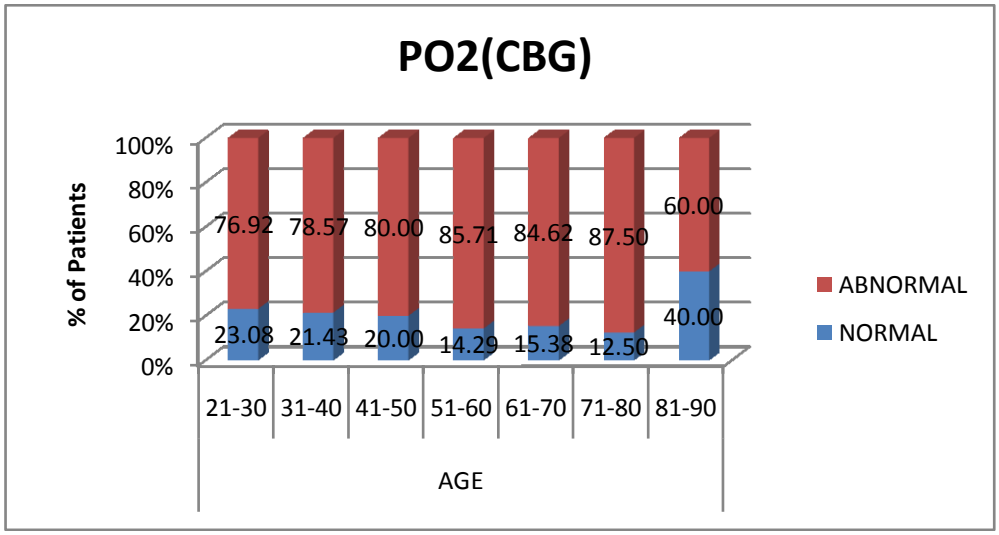

Figure 31:- Bar diagram depicting age wise distribution of % of normal values of pO2 in CBG.

The above bar diagram shows maximum normal level of pO2 of 40% seen in CBG in the age group of 81-90 years .

Table 39:- Age wise % of normal values of pO2 in ABG.

pO2 (ABG)	AGE							Total	p Value	Significance
	21-30	31-40	41-50	51-60	61-70	71-80	81-90			
NORMAL	10 (76.92)	10 (71.43)	11 (73.33)	11 (78.57)	9 (69.23)	11 (68.75)	0(0)	62 (68.89)	0.084	Not Significant
ABNORMAL	3 (23.08)	4 (28.57)	4 (26.67)	3 (21.43)	4 (30.77)	5 (31.25)	5 (100)	28 (31.11)		
Total	13 (100)	14 (100)	15 (100)	14 (100)	13 (100)	16 (100)	5 (100)	90 (100)		

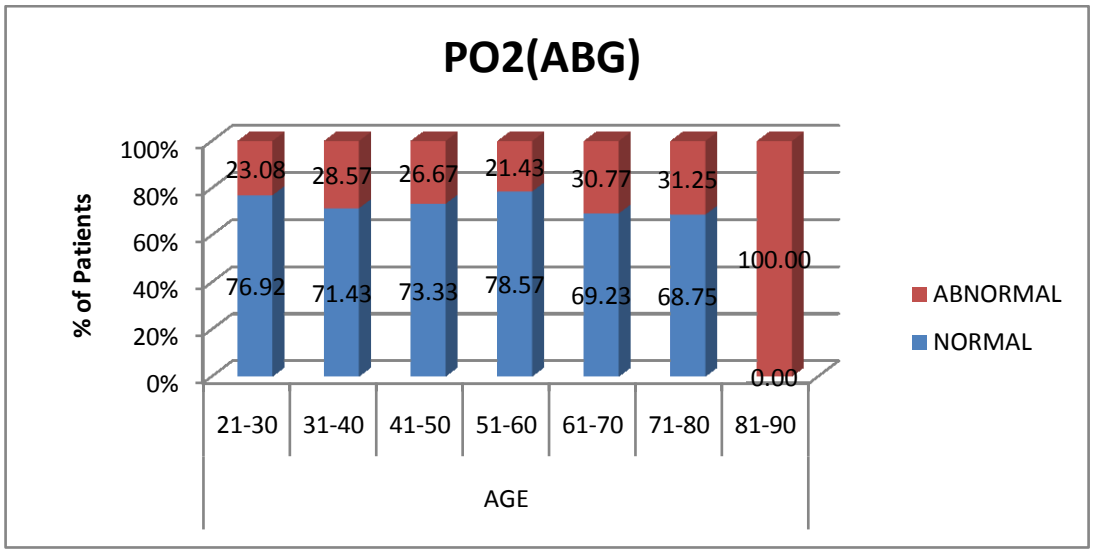

Figure 32:- Bar diagram depicting age wise distribution of % of normal values of pO2 in ABG.

The above bar diagram shows maximum normal level of pO2 of 78.5% in ABG in the age group of 51-60 years.

- **GENDER**

Table 40:- Gender wise pO2 comparison of patients.

GENDER		PO2 (CBG)	PO2 (ABG)	p Value
MALE	Mean	64.78	84.02	<0.001
	SD	9.15	8.83	
FEMALE	Mean	65.44	83.14	<0.001
	SD	11.71	8.21	

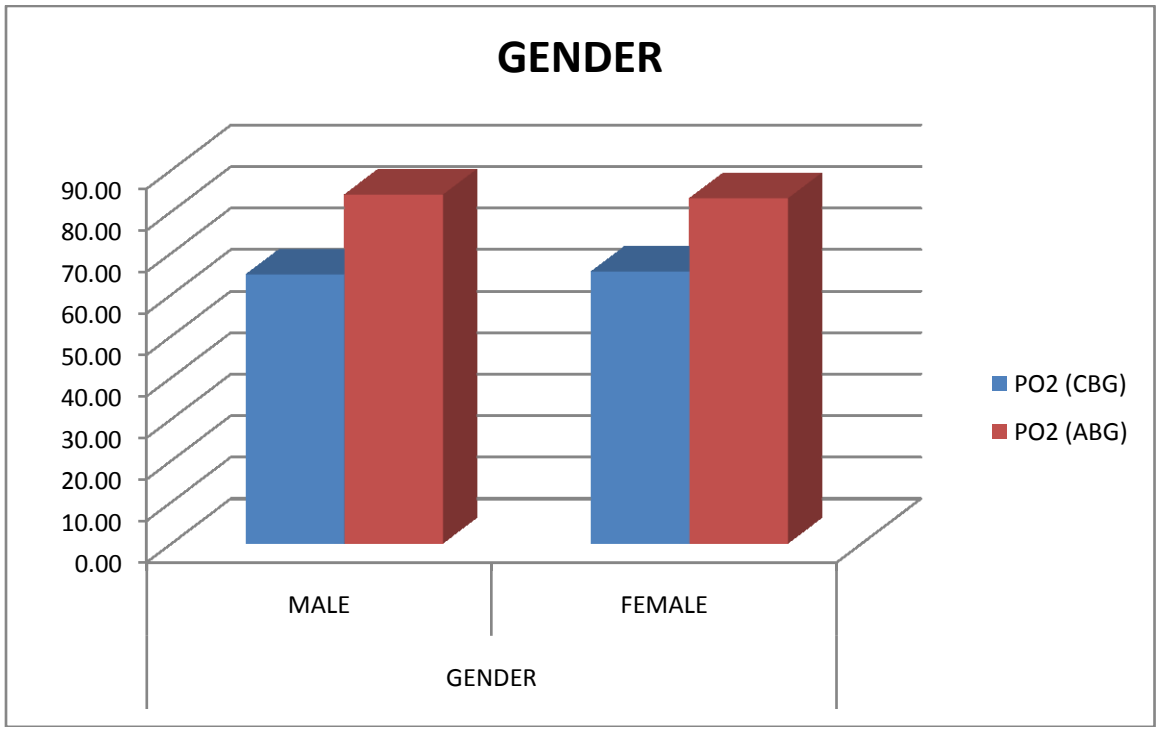

Figure 33:- Bar diagram depicting gender wise comparison of pO2 values.

Table 41:- p value and significance of gender wise comparison of pO2.

GENDER		Paired Differences				P VALUE	Significance
		Mean	Std. Deviation	95% Confidence Interval of the Difference			
				Lower	Upper		
MALE	PO2(CBG) - PO2(ABG)	-19.24	11.50	-22.38	-16.10	<0.001	Significant
FEMALE	PO2(CBG) - PO2(ABG)	-17.69	11.99	-21.75	-13.64	<0.001	Significant

The above bar diagram and the tables show average pO2 values of CBG and ABG in males were 64.78 and 84.02 respectively and average pO2 values of CBG and ABG in females were 65.44 and 83.14 respectively. The p values in both genders were significant.

Table 42:- Gender wise % of normal values of pO2 in CBG.

PO2(CBG)	GENDER		Total	p Value	Significance
	MALE	FEMALE			
NORMAL	8(14.81)	9(25)	17(18.89)	0.227	Not Significant
ABNORMAL	46(85.19)	27(75)	73(81.11)		
Total	54(100)	36(100)	90(100)		

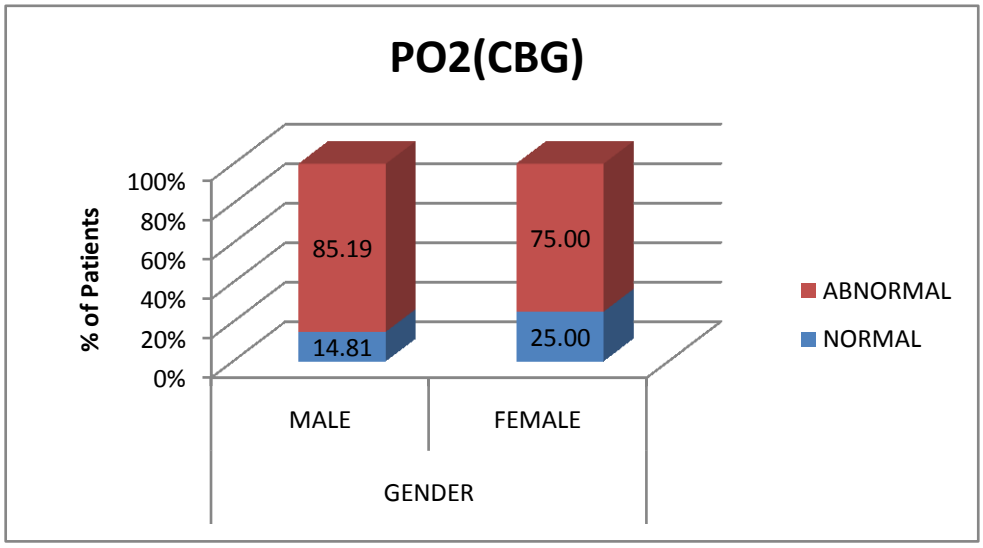

Figure 34:- Bar diagram depicting gender wise distribution of % of normal values of pO2 in CBG.

The graph shows 25% of females had normal pH values in CBG and 14.8% of males had normal pH values in CBG.

Table 43:- Gender wise % of normal values of pO2 in ABG.

PO2(ABG)	GENDER		Total	p Value	Significance
	MALE	FEMALE			
NORMAL	37(68.52)	25(69.44)	62(68.89)	0.926	Not Significant
ABNORMAL	17(31.48)	11(30.56)	28(31.11)		
Total	54(100)	36(100)	90(100)		

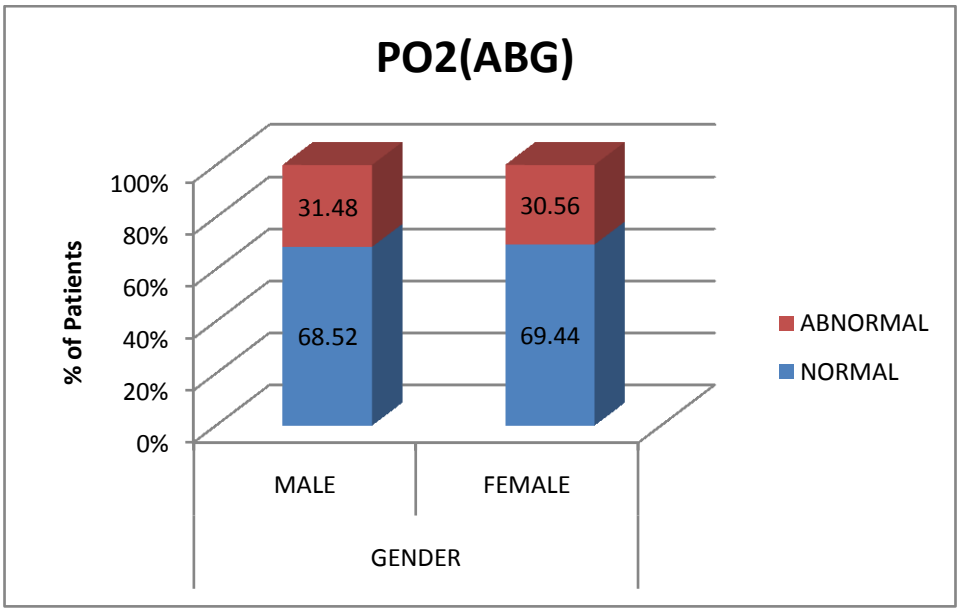

Figure 35:- Bar diagram depicting gender wise distribution of % of normal values of pO2 in ABG.

The graph shows 69.4% of females had normal pO2 values in ABG and 68.5% of males had normal pO2 values in ABG.

Table 44:- Overall pO2 distribution.

	MEAN	STD. DEVIATION	P VALUE
PO2(CBG)	65.04	10.20	<0.001
PO2(ABG)	83.67	8.55	

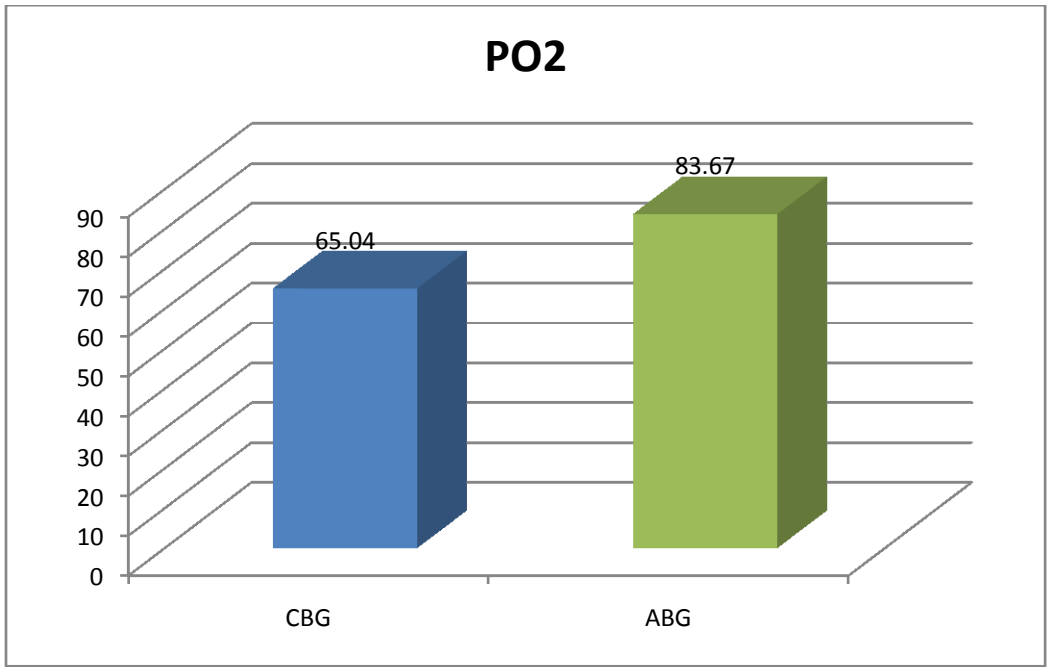

Table 36:- Bar diagram depicting overall pO2 distribution.

The above bar diagram shows overall average pO2 value in ABG was 83.67 and overall average pO2 value in CBG was 65.04.

Table 45:- p value and significance of overall comparison of pO2.

	PAIRED DIFFERENCES				P VALUE	SIGNIFICANCE
	MEAN	STD. DEVIATION	95% CONFIDENCE INTERVAL OF THE DIFFERENCE			
			Lower	Upper		
PO2(CBG) - PO2(ABG)	-18.62	11.65	-21.06	-16.18	<0.001	Significant

Spearman Rho's Correlation IS 0.217

The overall comparison of pO2 values between CBG and ABG yielded a p value of <0.001, which means the difference is significant. With the above results, we can safely conclude that further investigations are required in order to accept that ABG and CBG as consistent predictor for PO2 value.

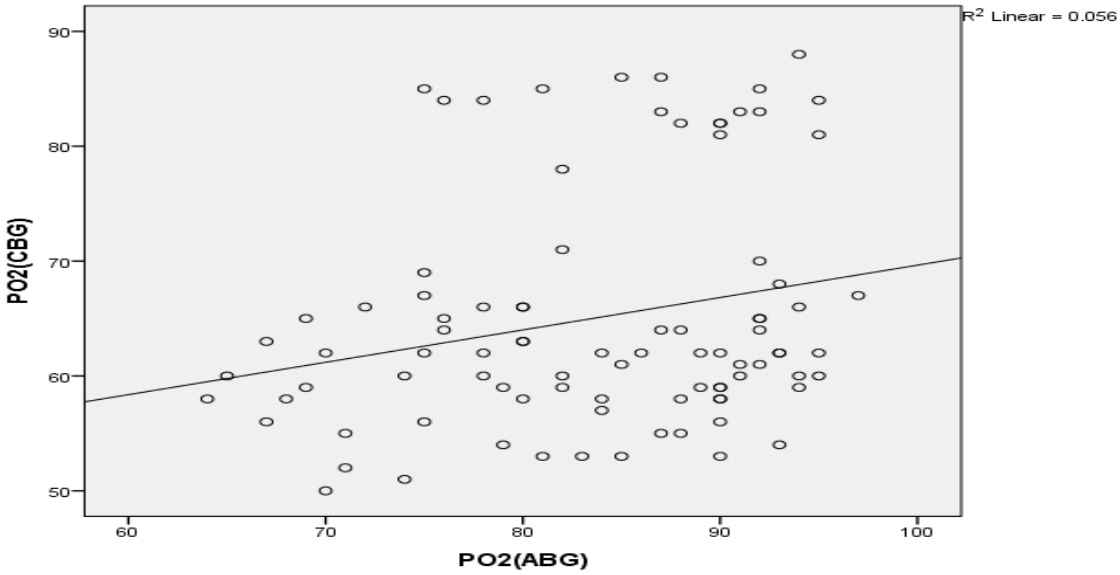

Figure 37:- Diagrammatic representation of correlation co-efficient of pO2 values.

Table 46:- Agreement and disagreement between pO2 values in ABG and CBG.

PO2	Frequency	Percent
DISAGREEMENT	51	56.7
AGREEMENT	39	43.3
Total	90	100.0

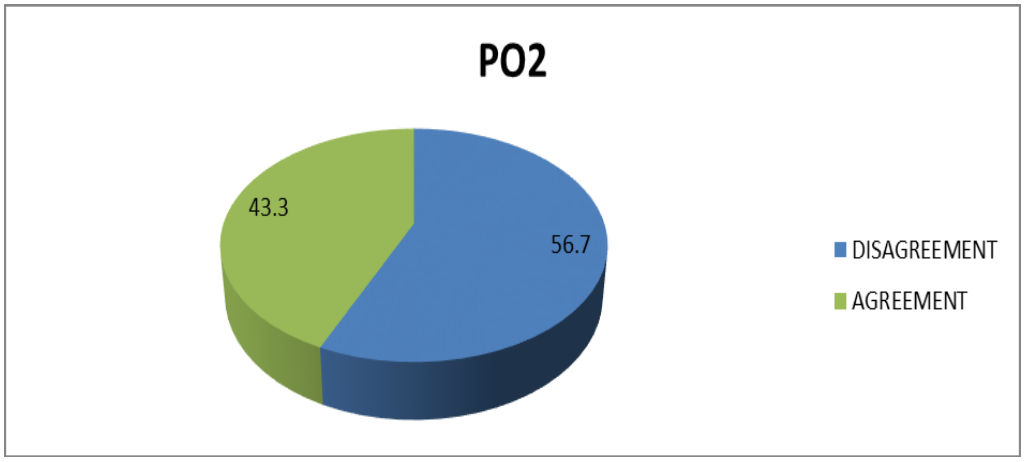

Figure 38:- Pie chart depicting comparison of agreement and disagreement of pO2 values in ABG and CBG

In 43% cases, both the methods measure abnormal and normal pO2 in same direction.
In 56.7% case, both the methods measure abnormal and normal pO2 is opposite direction.
Hence, within normal range or within abnormal range PO2 comparison is not making any sense because % of disagreement is moderately high.

Discussion:-

Morbidity and mortality from COPD are considerable and increasing. By the year 2020, COPD is predicted to become the third leading cause of death worldwide (exceeded only by heart disease and stroke.(40)(43)(29).
In the present study, we took a total of 90 patients with acute exacerbation of COPD, who came to the emergency department of Peerless Hospital and B.K.Roy Research Centre, Kolkata. This was a prospective observational study.

To our knowledge this study was to evaluate and compare the applicability and reliability of fingertip capillary blood gas analysis technique with arterial blood gas analysis. Capillary blood gas measurement from fingertip has been extensively evaluated in various physiological and pathological situations. Nevertheless, contradictory results as to its accuracy have been reported, especially for PO2 measures.

This can be explained by the physiological changes in the body as the oxygen levels in the arteries differ from that of capillaries, as capillaries are the small blood vessels which connect arteries to veins.

In a recent analysis reported that, although agreement was not high, fingertip capillary estimations could be used for clinical management since they followed arterial values (50), (45). The main sources of variability were attributed to different collection techniques and procedures.

As per the study conducted and the calculations done by pearson's chi square test method, the mean of the ABG and CBG values of pH, PCO2 and HCO3 showed that they can be safely considered as consistent predictors whereas Po2 showed significant difference between CBG and ABG values and also wide limits of agreement, which was similar to few studies done by Heidi.K.Kongstad et al(1), A Sauty et al(42) and D.Yildizdas et al(33). Also, when the normal and abnormal values of pH and pCO2 were correlated, there was a fair agreement between CBG and ABG values.

By the similar test performed for the pH, the mean of ABG and CBG values showed p value>0.05 and insignificant difference, and they also showed good agreement for predicting normal and abnormal values. Hence we conclude that CBG can be used as a consistent predictor for ABG in estimating pH values.

On the other hand, for PO2 both the methods ABG and CBG, yield significant difference in PO2 values. Further comparison of normal and abnormal values also showed significantly high differences. Hence, there is high disagreement in values of CBG over ABG and CBG cannot be used as an alternate to ABG for assessing oxygenation status of the patient, which was similar to the few previous study results. (1)(42)(25)(33).

In view of bicarbonate comparison between CBG and ABG , the mean values had p value>0.05 and there was insignificant difference, so CBG and ABG were consistent predictors of HCO3 values, but when normal and abnormal values were correlated there was quite high % of disagreement , the comparison is making no sense, which is similar to a study done by Rath et al(4).

By the similar test performed for pCO2, ABG and CBG were consistent predictors for pCO2 values with insignificant difference, and they also showed good agreement for predicting normal and abnormal values. Hence we conclude that CBG can be used as a consistent predictor for ABG in estimating pCO2 values.

Another important finding of the study was high capillary sampling failure rate. Total sample size was 110, but 15 patients were eliminated due to sample failure. High sampling failure ratios were associated with insufficient blood flow delivery to the collecting system. This was attributed to a reduced capillary blood flow in the fingertip , which was noticed mainly in old age patients and patients in shock.

Conclusion:-

Chronic Obstructive Pulmonary Disease (COPD) represents an important public health challenge and is a major cause of chronic morbidity and mortality throughout the world.

In our study a total of 90 patients of COPD with acute exacerbation were included in the study from Peerless Hospital & B.K.Roy Research Centre, Kolkata for a period of 1 year. We concluded that CBG can be used as a reliable predictor for ABG in assessing pH, pCO2 and bicarbonate values, but pO2 showed significant difference between the two and CBG cannot be used as an alternate to ABG to assess oxygenation.

With the above discussion we also conclude that at this level it is difficult to prove if CBG can replace ABG. We recommend a greater sample size for the analysis of the same and more studies to be conducted for concluding if CBG can replace ABG.
We also recommend that since CBG is frequently used in the paediatric and neonate age group and as per our study there has been a significant difference in the data so more studies to be conducted for reliability of CBG in all age groups.

Limitations Of The Study

1. The reduced number of successful blood collections may be considered as a limitation and could reduce validity of presented results.
2. Relatively smaller sample size
3. Refusal by the patients
4. Did not take the co morbidities of the patient into account
5. Did not mention whether the patient was receiving oxygen, and if patient was on oxygen supply then the percentage of oxygen supply was not mentioned.
6. Hemodynamic stability/instability of the patient was not mentioned.

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(APPENDIX I) Participant Information Sheet
Thesis Title: "Comparative evaluation of capillary blood gases as with arterial blood gases in patients of COPD with acute exacerbation presenting to emergency department: a prospective observational study"

You are being invited to take part in a research study. Before you decide, you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information. Take time to decide whether or not to take part. Thank you.

What is the purpose of the study ?: The purpose of this study is purely educational and is being conducted as part of dissertation for a post graduate trainee in an academic course namely Diplomate in National Board in Emergency Medicine under the National Board of Examination, New Delhi. The purpose of this study is : To determine the reliability of capillary blood gas in comparison to arterial blood gas in measuring the levels of pO2, pCO2, H+, and HCO3- in patients with acute exacerbation of COPD.

Why am I being invited to participate?: Your participation would greatly assist in improving our knowledge and understanding so that we will be able to offer improved and better care to patients.

Do I have to take part ?: Participation is entirely voluntary. We will describe the study and go through the information sheet, which will be given to you. We will then ask you to sign a consent form to show you agreed to take part. You are free to withdraw at any time, without giving a reason.

What are the possible benefits of taking part?: We cannot promise the study will help you but the information we get from the study will help in knowing the reliability of capillary blood gas in comparison to arterial blood gas.

What if there is a problem?: If you have a concern about any aspect of this study, you should ask to speak to the researcher who will do their best to answer your questions. Contact information of researcher: Name: Dr.B.Sathindra Sasmita; Location: Dept. of Emergency, Peerless Hospital and B.K.Roy Research Institute; Contact No: +919944913048.

Will my taking part in the study be kept confidential?: All information which is collected about you during the course of the research will be kept strictly confidential and none shall be disclosed or discussed.

What will happen if I don't carry on with the study?: Participation is voluntary and you can withdraw from the study at any point of time. All the data collected from you will then be removed from the research files.

APPENDIX II (INFORMED CONSENT FORM)
Title of the Project -
"COMPARATIVE EVALUATION OF CAPILLARY BLOOD GASES AS WITH ARTERIAL BLOOD GASES IN PATIENTS OF COPD WITH ACUTE EXACERBATION PRESENTING TO EMERGENCY DEPARTMENT: A PROSPECTIVE OBSERVATIONAL STUDY"

I have received the information sheet on the above study and have read and / or understood the written information.
I have been given the chance to discuss the study and ask questions.
I consent to take part in the study and I am aware that my participation is voluntary.
I understand that I may withdraw at any time and this will not affect my future care.
I understand that the information collected about me from my participation in this research may be looked at by responsible persons (ethics committee members / regulatory authorities). I give access to these individuals to have access to my records.

I understand I will receive a copy of the informed consent form.

Signature of doctor Date of signature

Name and signature of the participant / family member