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Investigating pre and post-operative blood gases and serum electrolyte in patients undergoing coronary artery bypass surgery (CABG)

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Abstract

Background: Arterial blood gas analysis is a common investigation exercised in emergency room and ICU. In post-operative CABG patients, acid base alterations is the commonest problem encountered. Thus, constant check on these parameters is necessary to minimize post-operative mortality.

Aim and Objectives: To document the pre-operative and post-operative ABG, hemoglobin and serum potassium in patients undergoing CABG.

Materials and Method: Present observational study was conducted on 27 patients (Male=12 & Female=15) in the department of clinical biochemistry and cardiovascular thoracic unit at GMC-SSH, Nagpur. Fresh Arterial blood Samples were collected in dept. of biochemistry for ABG, hemoglobin and serum potassium pre-operatively and post operatively. Data were expressed in mean and standard deviation. Level of significance was expressed in P value applying student paired "t" tests.

Results: Findings suggested significant decrease in PaO2, in post-operative 5th & 9th day (P=0.0001) as compared to pre-operative Pa02.Raised PH observed on 5th and 9th day following CABG. Non-significant PaC02 changes in pre and 1st day following CABG.

However, significant drop observed in PaCO2 on 5th and slight improved PaC02 on 9thday but still significant changes as compared to pre-operative values (P=0.001). Extremely Significant (P=0.0001) decrease in Serum potassium (K+) and Hemoglobin (Hb) and hematocrit observed on 1st and 5th post-operatively as compared to pre-operative, However, improved serum K+ (p=0.03) and Hb (p=0.02)demonstrated on 9th day following CABG but still quite significantly decreased.

However, when compared in female and male patients in pre and post-operative state, non-significant PH, alterations in PaO2,PaCo2, potassium (K^{+}) and hemoglobin was significant between male and females.

Conclusion: Pre and post-operative serial ABG analysis is most important parameters to know status of acid base imbalance amongst CABG patients. By knowledge of ABG, one can manage post-operative CABG complications, provided ABG should be interpreted properly by physician.

Keywords: Coronary Arteries Bypass Graft, Pre and Post-operative ABG, Serum Potassium.

Introduction

Measurement of the arterial blood gases (ABG), before, during and after cardiac surgery has an extreme significance. This even has an importance in controlling clinically ill patients admitted in ICU.(1)

Monitoring arterial blood gas (ABG) is an essential part in the management of high risk patients and in ICU especially in cardiac patients and patients undergoing bypass graft (CABG). CABG surgery helps people whose coronary arteries have become narrowed or blocked by fatty material called plaque. The word bypass means by-way, since it allows more blood and oxygen to flow to the heart muscle. The doctor will take a blood vessel from chest or leg. One end is attached to aorta (the large artery that comes out of the heart), and the other end is attached to the coronary artery below the point where it's blocked. Blood can now flow through the new channel to the heart.(2)

Electrolyte abnormalities are common disorders during coronary artery bypass surgery, so that the potassium disorders are seen in more than 20% of hospitalized patients. Although potassium (K^{+}) disorders are usually well tolerated in healthy people, it can be life-threatening in severity. Even mild and moderate hypokalemia also increases the risk of morbidity and mortality in cardiovascular patients. In patients with various heart problems, mild to moderate disorders of potassium can also increase the probability of cardiac arrhythmias and causes systolic and diastolic pressure increase.(3)

Arterial blood gas analysis is a common investigation in emergency departments and intensive care units for monitoring patients with Coronary artery diseases. The automated ABG analyzer measured the pH, the partial pressures of oxygen (PaO2), carbon dioxide (PaCO2) and bicarbonate level in arterial blood.(4) According to American Heart Association CABG is indicated in Stable Angina, Unstable Angina/ Non–Q Wave MI, ST-Segment Elevation (Q-Wave), Poor LV Function, Life-Threatening Ventricular Arrhythmias, CABG after Failed PTCA, Patients with Previous CABG etc.(5)

Disorders of acid base balance can complicate many disease states and occasionally the abnormality may be so severe as to be life threatening. Monitoring of ABGs is an essential part in the anaesthetic management of the high-risk patients as well as in the care of critically ill patients in the ICU. Since both areas manifest sudden and life threatening changes in all systems concerned, a

thorough understanding of acid base balance is mandatory for any physician and anesthesiologist.[6]

Acute myocardial infarction is characterized by tissue hypoxia, metabolic acidosis and falls in plasma bicarbonate level due to rise in lactic acid. Metabolic acidosis is compensated by hyperventilation. Those who are not able to compensate the metabolic disturbances by respiration are at risk of higher mortality. Increase in carbon dioxide increases the acidosis as well as decreases the arterial oxygen tension that is more dangerous. Corrections of metabolic acidosis and respiratory compensation have showed different effect on prognosis of patient in different studies. Various rhythm disturbances which are even refractory to electrical cardio version are found to be spontaneously responding to correction of metabolic acidosis.[7]

Pre-operative evaluation is strongly recommended in patients with Cardio circulatory diseases such as unstable angina, coronary artery disease, myocardial infarction, symptomatic arrhythmias, poorly controlled hypertension (diastolic >110, systolic >160), history of congestive heart failure. ABG analysis is most important to know the status of the patient with cardiac diseases to know about pH, the partial pressures of oxygen (PaO2), carbon dioxide (PaCO2) and bicarbonate (HCO3), Hematocrit (Hct) level in arterial blood. If we know about ABG parameter we can treat the patient accordingly or can manage the various vital parameters.[8]

The purpose of this study was primarily to document the serial pre and post-operative changes in arterial blood gases, serum potassium (K+) and hemoglobin (Hb) in patient undergoing CABG and secondarily to identify gender factors that may affect these changes.

Materials and Method

After ethical clearance from Institutional ethical committee and informed consent of the concerned departments and patients, the present evaluation study was conducted at GMC-SSH Nagpur in department of Clinical Biochemistry. Population comprised of 27 patients who were candidates for CABG (coronary artery bypass grafting) surgery during one year was selected. Entry criteria included patients undergoing CABG, no pre-operative electrolyte disorder, no operation of aortic balloon pump before surgery, no risk of coagulation disorder, no requirement of emergency surgery and patients operated before and with left ventricular function less than 30. All selected patients had normal hemoglobin concentration.

All 27 (Male=12; Female=15) patients who had undergone CABG surgery, were recorded for serum potassium values, Hb and ABG, pre-operatively. Same patients sample were analyzed followed by CABG for ABG & serum potassium, Hb values 10 minutes after pump removal, on 1st, 5th, and 9th day. These values were extracted and recorded again. Arterial Blood gas sample collected after CABG after the patient is separated from the ventilator, provided when he was fully conscious, hemo-dynamically stable, has no active bleeding, saturation of O2 was above

95%. Recorded data entered into computer and analyzed by using online Graph pad software and by applying paired Student *t* test, two tailed p value was as level of significance was calculated. Data was expressed as mean ± Standard deviation. P value less than 0.05 was considered as levels of significance. ABG parameters, serum potassium were measured using COBAS, ABG analyzer from Roche. Hemoglobin done by cell counter.[9,10,11]

Observations and Results

In this study, 27 patients (M=12 and F=15) undergoing coronary artery bypass surgery were selected with hemoglobin level of all within normal range. The average age of these patients were aged between 38-60 years.

Gender wise distribution shows (Table 1) 55.56% female whereas, male were 44.44% indicating slightly higher inclination towards female. The mean ± SD age in years for men and women were 59.16±5.99 and 58.13±7.14 respectively which is statistically insignificant (P=0.7007, CI= -6.4859 to 4.4259 and SED= 2.649).

Table 1: Age and sex wise distribution

Sex	Number of cases & %	Age in Years (Mean ±Standard deviation)
Female	15 (44.56%)	58.13 ± 7.14
Male	12(55.44%)	59.16 ± 5.99
Total	27 (100%)	

Table 2: Pre and post-operative arterial blood gas (ABG) analysis in patients undergoing CABG

Parameters Studied	Pre-operative condition (N=27) (Mean ± Standard Deviation)	1st day Post-operative (N=27) (Mean ± Standard Deviation)	5th day Post-operative (N=27) (Mean ± Standard Deviation)	9th day Post-operative N=27 (Mean ± Standard Deviation)
PH	7.404 ± 0.047	7.418 ± 0.036#	7.431 ±0.0288** P=0.0139	7.480 ± 0.06*** p=0.006
PaO2 mm of Hg	88.08 ± 15.82	56.11 ± 13.96*** p=0.0001	61.08 ± 16.0*** p=0.0001	74.13 ± 14.54** p=0.001

PaCO2 mm of Hg	34.60 ± 3.650	32.93 ± 2.997#	30.02 ± 3.131*** p=0.0001	31.87± 2.920** p=0.003
HCO3	21.94 ± 2.878	22.68 ± 3.499#	23.65 ± 3.251* p=0.045	23.99 ± 2.990* p=0.013
HCt	38.44 ± 4.047	34.32 ± 4.031** p=0.0001	31.11±4.482*** p=0.0001	32.32± 4.061*** p=0.0001
BE	-1.948 ± 2.407	-2.419 ± 2.550#	-2.873 ± 2.432#	-2.634± 2.322#
Potassium (K^+)mmol/L	3.655 ± 0.424	3.125 ± 0.336*** p=0.0001	3.012±0.311*** p=0.0001	3.411± 0.303* p=0.03
Hb gm%	13.0 ±1.1	10.9±0.9*** p=0.0001	11.5±0.83*** p=0.0001	12.33 ± 0.98* p=0.02

#Non-significant= (P >0.05); * Significant (P< 0.05);
** Highly significant (P< 0.001) *** Extremely Significant (P<0.0001).

Table 3: Comparison of Pre-operative and Post-operative ABG parameters in female patients

Parameters Studied	Pre-operative condition (N=15) (Mean ±Standard Deviation)	1st Post-operative condition (N=15) (Mean ± Standard Deviation)	5th day Post-operative (N=15) (Mean ± Standard Deviation)	9th day Post-operative N=15 (Mean ± Standard Deviation)
PH	7.408±0.058	7.419±0.066#	7.421 ±0.041#	7.427 ± 0.046#
PaO2 mm of Hg	82.98±13.31	68.4±14.97*** p=0.008	74.08 ± 14.01	79.00 ± 13.61#
PaCO2 mm of Hg	34.68±3.840	31.80±2.445* p=0.03	30.02 ± 2.980** p=0.002	32.17± 3.120#
HCO3	21.97±3.230	20.96±2.854#	22.65 ± 3.051#	23.99 ± 2.990#
HCt	36.78±4.024	34.43±4.008#	31.11±4.642** p=0.001	31.33± 4.010** p=0.009
BE	-1.826±3.259	-2.108±2.845#	-2.673 ± 3.132#	-2.434± 3.422#
Potassium(K^+ mmol/L)	3.584±0.480	3.124±0.424*** p= 0.009	3.242±0.398* p=0.042	3.415± 0.434#
Hb gm%	12.8 ±0.98	11.0±1.01*** p=0.0001	11.8±1.15 p=0.016	12.22 ± 0.98#

#Non-significant= (P >0.05); * Significant (P< 0.05);
** Highly significant (P< 0.001) *** Extremely Significant (P<0.0001).

Table 4: Comparison of Pre and Post ABG parameters in male patients (N=12)

Parameters Studied	Pre-operative condition (N=12) (Mean ±Standard Deviation)	Post-operative condition (N=12) (Mean ± Standard Deviation)	5th day Post-operative (N=12) (Mean ± Standard Deviation)	9th day Post-operative N=12 (Mean ± Standard Deviation)
PH	7.400±0.064	7.417±0.054#	7.411 ±0.0488#	7.44 ± 0.061#
PaO2 mm of Hg	88.46±14.25	68.40±13.55**] p=0.001	76.08 ± 12.65* p=0.04	83.93 ± 13.60#
PaCO2 mm of Hg	34.50±4.459	33.01± 4.105#	31.11 ± 3.863#	32.07± 3.982#
HCO3	21.97±3.328	23.84±3.403	22.97 ± 3.502	23.99 ± 2.809
HCt	38.52±4.620	34.20±4.318 P=0.02	31.41±4.442*** P=0.0009	31.38± 4.210*** P=0.0007
BE	-2.100± 1.162#	-2.933±3.003#	-2.873 ± 2.853#	-2.582± 2.202#
Potassium (K^+) mmol/L	3.715±0.423	3.251±0.385 P=0.01	3.158±0.435** P=0.004	3.382± 0.411* P=0.063
Hb gm%	12.87±1.31	10.9±1.06** P=0.0005	11.6±0.96** P=0.01	12.01 ± 0.95#

#Non-significant= (P >0.05); * Significant (P< 0.05);

** Highly significant (P< 0.001) *** Extremely Significant (P<0.0001).

Discussion

Arterial blood gas analysis is commonly indicated to evaluate oxygen and CO2 blood gas exchange and acid base status to optimize the quality of patients care; In general, severely ill patients usually include patho-physiological abnormalities that can affect gas exchange or acid base disturbances. Occurrence of serious acid base alterations is not only more likely during open heart surgery, but its correction and the continued maintenance of good acid base status is crucial. Electrolyte disorders following CABG is common and patients are at risk often for development of ventricular and supraventricular arrhythmias.

In Present study, Pre-operative ABG and serum potassium and hemoglobin recorded pre-operatively and on 1st, 5th & 9th day following CABG and levels were recorded and statistically analyzed. Thus, the purpose of the study was to investigate the serial changes in ABG following CABG.

Present study conducted on 27 patients undergoing CABG was included, comprised of 12 male and 15 female. Blood for ABG analysis (PH, PaCO2, PaO2, HCO3), hemoglobin, hematocrit, serum potassium was obtained in all patients pre-operatively and on day 1st, 5th, 9th post-operatively and recorded.

Table 1 Showed- Gender wise distribution shows (Table 1) 55.56% female whereas, male were 44.44% indicating slightly higher inclination towards female. The mean ± SD age in years for men and women were 59.16±5.99 and 58.13± 7.14 respectively which is statistically insignificant.

Table 2 demonstrates different parameters studied in pre and on day 1st, 5th and 9th post CABG. Following CABG, significant variation in PH on 5th (P=0.0139) and 9th day. (P=0.006), However on day 1st non-significant change seen as compared to pre-operative state. Pa02 shows significant altered values. The changes were most pronounced on the first post-operative day (p=0.0001) and then showed gradual improvement (Table 2). However on 9th post-operative day also, there were still significant abnormalities (p=0.001).

The PaCO2 tended to decrease on day 1st, 5th, 9th after surgery than pre-operative value. Changes in PO2 and PCO2 demonstrate mild respiratory alkalosis followed by CABG, the reason being might be due to compensatory mechanisms in response to an important decrease in O2 levels observed by Braun and coworkers.[12,13] Results here indeed demonstrate that alveolar hypoventilation was not responsible for hypoxemia since the post-operative values for PaCO2 were less than the pre-operative values which is in accordance with the study carried out by NP Singh et al.[12]

In Present study, impressive decrease in hemoglobin and hematocrit was observed after CABG. On the 1st, 5th, 9th post-operative day, p value observed was (P=0.0001), respectively for hematocrit. For hemoglobin, P=0.0001, 0.0001 and P=0.0211 respectively was observed on 1st, 5th, and 9th post-operative day. Our results correlated well with earlier study carried out where decreased Hb, Hct, Paco2 and Paco2 was observed in CABG candidates using saphenous vein grafting.[12,13,14]

During first day after surgery, patients experience a clinically important reduction in oxygen content of arterial blood .This can compromise the supply of O2 to tissues.[12]

Even though ABG is considered to be as primary parameter but still it is questionable by many workers who demonstrated that the duration of CABG is more crucial and contributes and influences on post-operative ABG alterations.

Electrolyte balance disorders after cardiac surgery are not widely investigated. There are only few studies that show depletion of serum electrolytes,[15,16] the common cause of ventricular and supraventricular arrhythmias complication followed CABG observed in ICU. Present study observed significant low serum potassium levels on 1st, 5th, and 9th post-operative day as compared to pre-operative values Table 2. Our results correlated well with earlier study conducted.[17] It has been demonstrated that the hypokalemia <3.5 mmol/L is suggested to be associated with higher risk of atrial fibrillation. Thus, low levels can have adverse effects on clinical outcome of patients. Hence, preventing electrolyte disorders is an important goal of therapy in this category of patients.[17]

Study conducted by Kees H Polderman et al,[18] postulated that patients undergoing cardiac surgery with extracorporeal circulation are at risk for electrolyte depletion despite of supplementation of some electrolytes such as potassium. The probable mechanism might be due to combination of increased urinary excretion and intracellular shift induced by extracorporeal circulation and decreased body temperature during surgery.

Most of the studies, designed to evaluate the changes in electrolyte depletion and balance disorders. Hemodilution and the use of diuretics are considered to be the main causes of enhanced electrolyte depletion.[15] Chuah et al studied ABG and electrolyte changes indicates potassium levels 4.03 in pre, 4.81 in post-operative and 4.70 mmol/L in next morning samples when performed on pump and for off pump CABG samples, potassium levels 4.18, 4.25 & 4.66 mmol/L respectively was observed in pre-operative, Post CABG and next morning following surgery.[14]

Presents study also studied variation in pre-operative and 1st, 5th, 9th post-operative ABG, Hb, serum potassium changes among female and male subjects. We found Significant drop in PaO2 (Table 3 & 4) with P=0.008 on day 1st, Non-Significant change on 5th & 9th day respectively in female. Whereas, p=0.001 and 0.04

on 1th, 5th day NS on 9th post-operative CABG in male patients respectively. PaCO2 showed significant variation (Table 3) in females on 1st (p=0.03), and 5th (p=0.02) post-operative day and NS on 9th day of Post CABG. However, in male, pre and post-operative PaCO2 no significant alterations were demonstrated. Serum potassium and hemoglobin levels shows significant decrease in both male and female (Table 3,4) in post CABG on 1st, and 5th day but after a week, as the period progresses, conditions improved and non-significant p value was obtained on 9th post-operative day male and female.

Conclusion

Arterial blood gas analysis is used to measure the PH, PaCO2, and PaCO2 in blood. Our findings suggested low serum potassium explain might risk of tachyarrhythmia in patients undergoing cardiac surgery and should be monitored frequently for such high risk patients. Altered PaO2, PaCO2, Hct, Hb were observed in our study. Investigation is relatively easy and yields information that can guide the management of post CABG acid base and electrolyte alterations corrections and monitoring. Thus, By knowledge of ABG, one can able to manage post-operative CABG complications, provided ABG should be interpreted properly by physician.

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