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CORRELATION OF ARTERIAL VERSUS VENOUS BLOOD GAS MEASUREMENTS IN TRAUMA PATIENTS PRESENTING IN THE EMERGENCY DEPARTMENT OF A TERTIARY CARE CENTRE IN CHENNAI

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Abstract
Background: An arterial blood gas (ABG) provides important information for critically ill patients. This study aimed to assess if venous blood gas (VBG) results are numerically similar to arterial blood gas (ABG) in acutely ill trauma patients. **Materials and Methods:** We prospectively correlated ABG and VBG results [pH, pCO2, HCO3 and base excess (BE)] in adult trauma patients when ABG was clinically indicated. We hypothesised that VBG results could predict ABG results using a derived regression equation from 103 patients. Patient details, clinical condition and relevant blood gas results were recorded. **Result:** One hundred three patients were enrolled with male predominance with a mean age of 43.0± 15.65 years. Nearly three-fourths 76(73.8%) of the subjects were victims of Road traffic accidents. Seven of our cases developed hematoma as a complication while doing ABG analysis. 26 (25.2%) patients required multiple attempts for arterial sample collection. There was a significant difference between the ABG and VBG pH values, pCO2, HCO3 and Base excess. The correlation between the ABG and VBG values of these parameters is strong. However, there is no significant correlation between the ABG and VBG values for pO2 and sO2. Our results derived regression equations to predict arterial values from venous values (pH: 7.3019, 7.4056; pCO2: 38.813, 53.672; HCO3: 18.884, 24.732). **Conclusion:** From this, it can be considered that the VBG values of these parameters cannot be used to replace the ABG values. However, the correlation between these parameters' ABG and VBG values was strong.

INTRODUCTION

An acid-base analysis is an essential investigatory tool in Emergency medicine, giving valuable information about various disease processes. Blood gas analysis is routinely requested for point-of-care testing, especially for emergency or critical care patients with metabolic or respiratory illnesses.[1] Arterial blood gas (ABG) analysis is important in determining sick patients' acid-base balance and blood-gas status. Arterial base excess is an already established shock marker and a good predictor of survival in patients with trauma.[2]

Despite its high efficacy in evaluating patients' response to treatment regimens, arterial blood gas analysis test has some complications. The most common complications associated with arterial puncture are pain, hematoma, infection, thrombosis with distal digit ischemia, haemorrhage, and aneurysm formation.[3] The procedure can be technically difficult, particularly in elderly patients, children and infants; several attempts may be required. Peripheral venous blood sampling may be a useful alternative to arterial blood gas analysis sampling, obviating the need for arterial puncture. Venous blood is easier to get, the procedure is less painful, and the venous sample may be drawn simultaneously with samples for other laboratory investigations. Venous blood is very easily obtained during the line establishment for venous access.[4]

Therefore, using venous base excess as a good marker prevents the number of procedures performed in busy trauma resuscitation. Venous blood gas (VBG) analysis is a comparatively safer procedure as fewer punctures are required, thus minimising the risk of needle stick injury to the health care personnel. The relationship between the numerical values derived from ABG and VBG has been correlated several times for over half a century. Venous base excess has been shown to correlate well with arterial base excess in critically ill, mechanically ventilated trauma and acute trauma patients.[5] It also suggested that venous BE (base excess) better reveals overall tissue perfusion and is a good predictor of shock severity and mortality.[6] Although several studies have demonstrated that a venous sample is relatively precise for acid-base assessment, VBG analysis has not gained much acceptance as a substitute for ABG analysis.[7] The present study aimed to investigate the correlation of ABG and VBG measurements in trauma patients presenting in the Emergency department of a tertiary care Centre in Chennai.

MATERIALS AND METHODS

This prospective correlation study was done at Rajiv Gandhi Government General Hospital, Madras Medical College, Chennai, from February 2020 to January 2021 on 103 trauma patients.

Inclusion Criteria

All trauma patients of either gender with ≥ 18 years of age, patients having fractures with severe complications like massive bleeding, vessel injury etc., patients with systolic BP < 90 mmHg in the ED and SpO2 < 93%, patients requiring advanced airway and transfusion of blood products, all patients older than 60 years with any trauma or SBP <100 mm Hg or pulse < 60 beats per minute or > 100 beats per minute, and patients admitted in hospital due to fall from height and major road traffic accidents were included.

Exclusion Criteria

Patients with age group below 18 years, ABG and VBG 1 hour apart and if any samples were taken after any intervention were excluded.

Methodology

After obtaining permission from the Ethical committee, a study was conducted in the Emergency Department of Rajiv Gandhi Government General Hospital, Chennai. During the study period, samples were obtained from patients satisfying inclusion criteria after taking informed consent from the patient or caretaker (depending on the patient's clinical condition).

After performing the Modified Allens test confirming the patency of the ulnar artery, paired arterial and peripheral venous samples were collected in a pre-heparinised syringe under strict aseptic precautions following the WHO guidelines and analysed using an ABG analyser.8 Patient details, clinical condition and relevant blood gas results were recorded. Descriptive and appropriate inferential statistical analysis tests were done using an appropriate statistical tool.

Statistical Analysis

Data was entered in MS Excel, and statistical analysis was done using SPSS version 20.0. Categorical data are presented in percentages, and continuous data in Mean and Standard deviation. Pearson's correlation, paired t-test, and Bland Altman analysis were used to study the relationship between numerical variables in ABG and VBG. Regression equations to predict ABG parameters based on VBG parameters were constructed. Simple linear regression was applied for this purpose. Appropriate charts such as Scatter plots, Box and Whiskers plots, ROC Curves, and Bland Altman plots represent data distribution and relationships between variables.

RESULTS

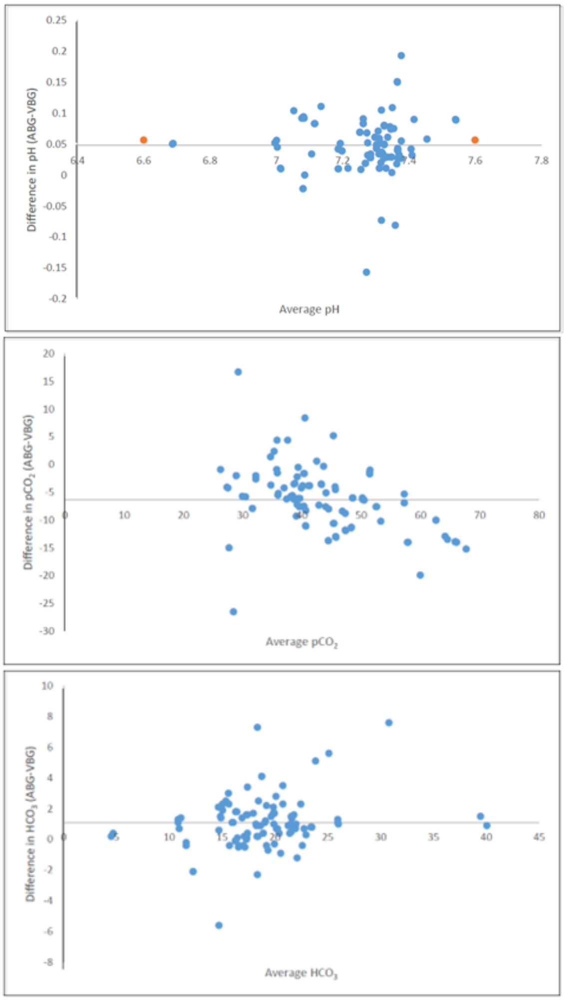

Figure 1: Bland Altman plot of agreement of (A) pH (B) pCO3 (C) HCO3 between ABG and VBG

Male predominance was reported, with a mean age of 43.0 ± 15.65 years. Nearly three-fourths 76 (73.8%) of the subjects were victims of road traffic accidents. About 77 (74.8%) patients were intubated, whereas 26 (25.2%) were non-intubated. The extremity was cool in patient 12 (11.7%) and warm in patient 91 (88.3%). In the majority of our cases, 60 (58.3%), the sample for ABG analysis was taken from the radial artery. Other arteries chosen were brachial artery 36 (34.9%) and femoral artery 7 (6.8%). Seven of our cases developed hematoma as a complication while doing ABG analysis. 26 (25.2%) patients required multiple attempts for arterial sample collection. Only 77 (74.8%) patients could get the arterial sample in a single attempt [Table 1].

The majority of the venous sample for VBG analysis was taken from the median cubital vein 59 (57.3%). Only seven patients required multiple attempts (2 attempts). The rest of the patients, 96 (93.2%), got their venous samples in a single attempt. No complications recorded were recorded while doing VBG [Table 1].

There was a significant difference between the ABG and VBG pH values, pCO2, HCO3 and Base excess. The correlation between the ABG and VBG values of these parameters is strong. The VBG values of these parameters cannot be used to replace the ABG values. However, the VBG values may be used to predict the corresponding ABG value [Table 2, 3]. However, there is no significant correlation between the ABG and VBG values for pO2 and sO2. Bland Altman plot of agreement of pH, pCO2, HCO3 and Base excess between ABG and VBG showed that the mean difference of these parameters was within the limits of agreement (±2SD) [Figure 1].

The normal range for pH on ABG is 7.35-7.45. ABG pH below 7.35 is considered Acidosis, and above 7.45 is Alkalosis. Based on the Regression equation, the corresponding VBG values are 7.3019 and 7.4056, respectively. The pCO2 is considered normal within the range of 35 to 45 in ABG. The corresponding values of pCO2 on VBG are 38.813 and 53.672. HCO3 is considered normal within the range of 20 to 26 in ABG. The corresponding values of HCO3 on VBG are 18.884 and 24.732 [Table 3].

Table 1: Observation of demographic and other evaluation parameters of patients

Parameters		**Frequency (%)**
Gender	Male	80 (77.7%)
	Female	23 (22.3%)
Age group	< 20	3 (2.9%)
	20-29	20 (19.4%)
	30-39	23 (22.3%)
	40-49	20 (19.4%)
	50-59	20 (19.4%)
	60-69	10 (9.7%)
	70-79	5 (4.9%)
	≥ 80	2 (1.9%)
Type of Injury	Road Traffic Accident	76 (73.8%)
	Assault	14 (13.6%)
	Fall from height	13 (12.6%)
Condition of Patient on Arrival		
Airway	Intubated	77 (74.8%)
	Non intubated	26 (25.2%)
Extremity	Cool	12 (11.7%)
	Warm	91 (88.3%)
GCS	E1 VT M1	8 (7.8%)
	E1 VT M2	10 (9.7%)
	E1 VT M3	20 (19.4%)
	E1 VT M4	23 (22.3%)
	E2 V3 M5	3 (2.9%)
	E2 VT M4	16 (15.5%)
	E3 V3 M5	9 (8.7%)
	E3 V4 M5	13 (12.6%)
	E4 V3 M5	1 (1.0%)
Heart rate (beats/min)		101.9 ±17.18
Mean arterial pressure (MAP) (mmHg)		92.9±17.58
Artery chosen	Brachial artery	36 (34.9%)
	Femoral artery	7 (6.8%)
	Radial artery	60 (58.3%)
Vein Chosen	Basilic vein	12 (11.7%)
	Cephalic vein	26 (25.2%)
	Femoral vein	5 (4.9%)
	Greater Saphenous vein	1 (1.0%)
	Median cubital vein	59 (57. 3%)
Any complications while doing ABG	Hematoma	7 (6.8%)
	Nil	96 (93.2%)
No of attempts for Arterial sample	1	77 (74.8%)
	2	23 (22.3%)
	3	3 (2.9%)
Number of attempts for venous sample	1	96 (93.2%)
	2	7 (6.8%)

Table 2: Mean Difference of various parameters in ABG and VBG

Parameters	Mean Difference (ABG – VBG)	Std. Deviation	95% CI of the Difference		p-value
			Lower	Upper	
pH	0.048	0.0440	0.0394	0.0566	0.000
CO2	-6.39	5.819	-7.528	-5.253	0.000
HCO3	1.10	1.711	0.766	1.435	0.000
Base Excess	0.31	2.246	-0.130	0.748	0.166
pO2	69.39	26.490	64.217	74.571	0.000
sO2	28.99	14.391	26.178	31.803	0.000

Table 3: Mean values of parameters on ABG and VBG

Parameters	ABG		VBG	
	Mean (SD)	Range	Mean (SD)	Range
pH	7.286 (0.142)	6.712 – 7.587	7.238 (0.141)	6.662 – 7.498
CO2	40.34 (8.82)	15.2 – 60.1	46.73 (11.26)	20.9 – 75.3
HCO3	19.32 (5.32)	4.6 – 40.5	18.22 (4.91)	4.4 – 39.6
Base Excess	-6.35 (6.22)	-27.0 – 16.8	-6.66 (6.14)	-27.0 – 16.3
pO2	115.43 (23.94)	64.7 – 197.0	46.04 (11.45)	25.50 – 76.00
sO2	98.18 (1.43)	91.0 – 99.8	69.19 (14.15)	39.6 – 93.5

DISCUSSION

The study subjects ranged from 19 to 89 years, with a mean age of 43.0. Among the 103 patients in our study, 80 were males, and 23 were females. Bilan et al. in their study also reported similar findings in their investigations.[9] In our study, nearly three-fourths (73.8%) of the subjects were victims of Road traffic accidents, while 14 (13.6%) were victims of assault. Comparison of peripheral VBG values with ABG values has been made in patients with other conditions like Diabetic ketoacidosis in a study by Balaji et al.[10] In the study by Awasthi et al., a group of ICU and critically ill patients like postoperative cases admitted to ICU from emergency surgical/gynaecology/obstetric ward, respiratory discomfort, and potential metabolic problems such as diabetic ketoacidosis, renal failure, and seizure disorders were considered.[11]

About 75% of patients in our study were intubated, whereas 25% were non-intubated. The extremity was cool in 12 patients (11.7%) and warm in 91 patients (88.3%). The heart rate of the study population ranged from 58-156, with a mean heart rate of 101.9. The mean MAP was 92.9. These observations in our study follow earlier reported studies.[9,11] In most of our cases (58.3%), the sample for ABG analysis was taken from the radial artery. The majority of the venous sample for VBG analysis was taken from a median cubital vein (57.3%). In a similar study on the correlation of arterial vs venous blood gas measurements in trauma patients by Rudkin et al., femoral and radial arteries were taken for arterial sampling. In contrast, the median cubital vein was taken for venous sampling.[12] Investigators who have reported high complication rates when considering arterial entry at a variety of sites have commented upon the relative safety of the radial artery approach.[13]

Seven of our cases (6.8%) developed hematoma as a complication while doing ABG analysis. No other complication was found in our study population. No complication developed while doing sampling for VBG. In a study by Gillies et al., minor complications, mainly bruising and tenderness, occurred at 39% of sites while sampling for ABG. At 2% of sites there occurred significant pain and tenderness. There was a small incidence of pulse diminution, particularly at the radial site, but no arterial occlusion. They reported that using a smaller needle (23 gauzes) significantly reduced the overall incidence of complications.[14] An unusual but dramatic complication of embolisation complicating radial artery puncture has been reported by Matthews et al.[15]

In our study, twenty-six patients required multiple attempts for arterial sample collection (23 underwent two attempts, and 3 underwent three attempts). Only the remaining 77 patients could get the arterial sample in one attempt. In a study by Gillies et al. on the nature and incidence of complications of peripheral arterial puncture, 39% of patients required multiple attempts. They reported that the overall incidence of complications could not be related to the number of punctures. Only seven patients required multiple attempts (2) for venous sampling, and the remaining 96 (93.2%) required only one attempt.[14]

Our study showed a significant difference between the ABG and VBG pH values, and the correlation between the ABG and VBG values was strong. The VBG pH values cannot be used to replace the ABG value. However, the VBG pH value may be used to predict the corresponding ABG value. Many studies in the literature have shown similar observations. Malatesha et al. found that peripheral VBG correlated well with ABG to pH.[16] A study by Chung et al. suggested that VBG would be a good screening tool for identifying acidemia in the general population. VBG should not replace clinical judgment if the patient is clinically deteriorating or clinical suspicion for acidemia is high, and an ABG should be obtained regardless of the VBG result. Moreover, they reiterated that a VBG pH should not be used if exact values are needed given a wide LOA, especially at pH <7.35.[17]

In our study, there was a significant difference between the ABG and VBG values of pCO2, and the correlation between the ABG and VBG values was strong. A study by Paine et al. compared PCO2 levels obtained from arterial and venous blood samples and demonstrated a significant correlation.[18] In a study by Elborn et al. conducted on COPD patients, no significant difference was observed between the arterial and venous CO2 tensions, which were closely correlated.[19]

Our study showed a significant difference between the ABG and VBG value of HCO3, and the correlation between the ABG and VBG value was strong. VBG values may be used to predict the corresponding ABG value. The study by Kelly et al. on an agreement between bicarbonate (HCO3) measured on arterial and venous blood gases in patients with respiratory or metabolic illness found a good correlation between arterial and venous bicarbonate values.[20] Another study by Mohan et al. on whether VBG may be used as an alternative to ABG in the initial management of metabolic acidosis secondary to diabetic ketoacidosis/ renal failure, arterial and venous blood gas values showed significant correlation coefficient for pH, HCO3, pCO2 and lactate.[21]

Our study showed a significant difference between the ABG and VBG values of base Excess (BE) and a strong correlation between these parameters' ABG and VBG values. A study by Wijaya et al. stated that venous base excess could replace arterial base excess in trauma patients to identify and predict early shock.[22]

Our study showed no significant correlation between the ABG and VBG values for pO2 and sO2. VBG values of pO2 and sO2 cannot be used to predict the corresponding ABG values. A similar observation was seen in a study by Malatesha et al.[16] Based on our results, regression equations were derived to predict arterial values from venous values: pH (ABG) = 0.311 + 0.964 x pH (VBG), pCO2 (ABG) = 8.879 + 0.673 x pCO2 (VBG), HCO3 (ABG) = 0.625 + 1.026 x HCO3 (VBG), and BE (ABG) = – 0.047 + 0.947 x BE (VBG). In literature, very few studies have derived regression equations to predict arterial from venous values.[18,20]

CONCLUSION

Our study in this population of acutely ill trauma patients showed a significant difference between the ABG and VBG values of pH, HCO3, pCO2 and base excess. From this, it can be considered that the VBG values of these parameters cannot be used to replace the ABG values. However, the correlation between these parameters' ABG and VBG values was strong. Hence, the VBG values may be used by a mathematical regression equation to predict the corresponding ABG value. There were more complications related to arterial blood sampling than venous sampling for blood gas analysis. The number of attempts was fewer for venous sampling. There was no significant correlation between the ABG and VBG values for pO2 and sO2; hence, VBG values of pO2 and sO2 cannot be used to predict the corresponding ABG values.

Limitations of the Study

Only one paired sample was taken and analysed. Further studies involving serial paired samples may give better results.

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