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Original Research Article

Can Venous blood gas be a reliable substitute for Arterial blood gas in modern clinical practice?

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ABSTRACT

Background: It is clearly mentioned in the medicine books that blood gas analysis from arterial puncture is the gold standard. But in the past few years it is commonly seen that clinicians have started trusting on venous blood gas analysis as well as started advising VBG (Venous blood gas) in the initial diagnosis of critical patients in emergency setting. Keeping this fact in mind, we designed a study to determine whether VBG could be a better replacement of ABG (Arterial blood gas) in the emergency where diverse pathological conditions are encountered.
Methods: This prospective cross-sectional study comprised of 50 patients of 20-60 yrs age with a variety of diagnoses admitted in the emergency department. 50 paired samples (ABG+VBG) were obtained from them under strict aseptic precautions after obtaining their verbal consent. With a minimum delay of less than 2 min blood gas analysis was performed on blood gas analyzer. Parameters (pH, PCO_2, PO_2, HCO_3, Base Excess and O_2 saturation) from ABG and VBG were recorded and compared using Student's Unpaired 't' test.
Results: pH and HCO_3 showed statistical significant (p value <0.05) differences between ABG and VBG, while BE showed statistical non-significant (p value >0.05) difference between them. Contrary to this, PCO_2, PO_2 and O_2 saturation from ABG and VBG showed statistical highly significant (p value <0.0001) differences.
Conclusions: VBG should not be interchangeably considered in place of ABG with regard to pH, HCO_3, PCO_2, PO_2 and O_2 saturation in conditions where actual oxygenation status of patient is required (e.g.; hypovolemic shock, respiratory disorders, mechanically ventilated patients, etc.)

Keywords: Arterial blood gas, Diabetic ketoacidosis, Hypovolemic shock, Venous blood gas

INTRODUCTION

Blood gas analysis provides critical information to healthcare providers that assists in the diagnosis and treatment of a variety of metabolic and respiratory disorders. Percutaneous arterial puncture or arterial sampling from an indwelling catheter with measurement by a point of care or blood gas analyzer remains the "gold standard" for blood gas analysis.[1] The most common complications associated with arterial puncture are pain, arterial injury, local hematoma, infection, thrombosis with distal ischemia, emboli, haemorrhage, aneurysm formation, technical difficulties and potential hazards for sampler.[2] Venous Blood Gas (VBG) samplings may be useful alternatives as it is easier to obtain and a less invasive way of evaluating acid-base status, avoiding the risks of arterial punctures.[3-5] Venous specimens may be suitable if pH, pCO_2, and HCO_3 values are needed. Results from venous specimens are affected by metabolism and peripheral circulation. Although various studies suggest that a venous sample is relatively accurate for acid–base assessment,[6-12] VBG analysis has not gained much acceptance as a substitute for ABG analysis because ABG is still gold standard test for determining the arterial metabolic milieu (pH, PCO_2, HCO_3) as well as actual PO_2.ABG may also be necessary to accurately

determine PCO_2 in severe shock , in hypercapnic conditions (i.e. PCO_2>45 mmHg) and to determine arterial lactate >2mM (rarely necessary). The disadvantage of VBG is that PO_2 values are poorly compared with ABG values. Also, the fact is that arterial PO_2 is typically 36.9 mm Hg greater than the venous with significant variability (95% confidence interval from 27.2 to 46.6 mm Hg).[13] This cross-sectional prospective study was designed to prove that VBG cannot be a substitution of ABG in every clinical scenario. For this, we have compared ABG with VBG to determine whether VBG could replace ABG in the initial diagnosis of patients in the emergency setting where diverse pathological conditions are encountered.

METHODS

This prospective cross-sectional study was conducted in the emergency laboratory of biochemistry department of Pt. B. D. Sharma Postgraduate Institute of Medical Sciences, Rohtak (Haryana) in Northern India from October to December 2018. The study comprised of 50 patients including both genders, age ranging between 20 years and 60 years admitted in the emergency department with presenting complications of chronic obstructive pulmonary disease, pneumonia, acute or chronic renal failure, acute coronary syndrome, diabetic ketoacidosis, systemic malignancy, acute gastroenteritis and suspected organo-phosphorus poisoning. After obtaining verbal consent of patient or patient's attendant, a couple of samples were taken from patient under strict aseptic precautions, For VBG analysis, 1ml blood was taken from the antecubital vein in heparinised syringe while for ABG analysis 1 ml blood was taken from the radial artery with 24 G hypobaric needle in heparinised syringe with a minimum delay of less than 2 minutes. Both the samples were analyzed as quickly as possible on Eschweiler Combiline Blood Gas analyser located in the emergency biochemistry laboratory. According to the hospital policy, daily internal quality control testing was performed to maintain accuracy of the results. Also, external quality control testing was performed using Bio Rad QC materials (Level 1, Level 2 and Level 3).

Results obtained from ABG and VBG analysis were recorded in tabular form in MS EXCEL Sheets. Statistical analysis was done by using student's unpaired 't' test. Level of significance was set as p value.

p >0.05-statistical non- significant
p <0.05-statistical significant
p <0.0001-statistical highly significant

There were certain limitations of our study which are as follows.

- Our sample size was limited comprising of 50 patients only. Due to which it was quite difficult to obtain highly statistical significant results.
- Most of the previous studies have been done on a specific patient group (e.g. diabetic ketoacidosis, respiratory alkalosis, mechanically ventilated patients, etc). But in this study, authors have included the patients with a variety of diagnoses. Therefore, there may be possible chances for biases.
- Out of 50 samples, 5 samples were alkalotic, 20 were acidotic and 25 samples fall under the category of normal pH. Thus, it was quite difficult to obtain statistical highly significant differences in our findings.

RESULTS

This study consisted of 50 patients (30 males and 20 females) of the age ranging from 20-60 years, having presenting complications like chronic obstructive pulmonary disease, pneumonia, acute or chronic renal failure, acute coronary syndrome, diabetic ketoacidosis, systemic malignancy ,acute gastroenteritis and suspected organo- phosphorus poisoning. We analysed 50 paired samples (ABG + VBG) on Eschweiler Combiline Blood Gas analyser. The pH,PCO_2, PO_2, HCO_3, Base excess and O_2 saturation were recorded from ABG and VBG report and compared using students unpaired 't' test. Based on a normal pH range of 7.35-7.45 pH units, 20 samples were acidotic, 5 were alkalotic and 25 fall under the normal pH range. In this study no patient was repeated.

This was done in order to avoid bias of disease and patient specifics. Table 1 shows the comparison of different parameters viz pH,PCO_2, PO_2, HCO_3,Base excess and O_2 saturation between arterial blood gas and venous blood gas. Figure 1 shows the comparison of arterial pH with venous pH. Arterial pH values (7.363±0.07) are more than venous pH values (7.323±0.07) with statistical significant difference (p value < 0.05). Figure 2 shows the comparison of arterial PCO_2 with venous PCO_2 in which arterial PCO_2 (42.96±11.7 mmHg) is less than venous PCO_2 (52.2±10.7 mmHg) with statistical highly significant difference of p value <0.0001.

Figure 3 shows the comparison of arterial PO2 with venous PO_2 in which arterial PO_2 (62.99±16.9 mmHg) is more than venous PO_2 (28.5±11.73 mmHg) with statistical highly significant difference (p value <0.0001). Figure 4 shows the comparison of arterial HCO_3 with venous HCO_3 in which arterial HCO_3 (23.79±10.2 mmol/L) is statistical significantly (p value <0.05) less than venous HCO_3 (30.5±14 mmol/L). Figure 5 shows the comparison of arterial Base Excess with venous Base Excess according to which arterial Base Excess(2.53±6.98 mmol/L) is more than venous Base Excess (2.51±7.68 mmol/L) with statistical non-significant difference of p value >0.05.Figure 6 shows the comparison of arterial O_2 saturation with venous O_2 saturation which states that arterial O_2 saturation (88.29±7.32%) is more than venous O_2 saturation (54.2±12.5%) with highly significant difference (p value <0.0001).

Table 1: Comparison of Arterial blood gas and Venous blood gas parameters.

Parameters	ABG (n=50) Mean	±SD	SEM	VBG (n=50) Mean	±SD	SEM	p value
pH	7.363	0.07	0.01	7.323	0.07	0.01	0.010** (SS)
pCO_2 (mmHg)	42.96	11.17	1.58	52.2	10.77	1.52	<0.0001*** (HS)
PO_2 (mmHg)	62.99	16.9	2.39	28.5	11.73	1.65	<0.0001*** (HS)
HCO_3 (mmol/L)	23.79	10.2	1.45	30.5	14	1.9	0.0071* (SS)
BE (mmol/L)	2.53	6.98	0.98	2.51	7.68	1.08	0.9880** (NS)
O_2 SAT (%)	88.29	7.32	1.03	54.2	12.5	1.77	<0.0001*** (HS)

Note – (*denotes statistical non- significant i.e. P value>0.05, **denotes statistical significant i.e. P value<0.05 and ***denotes statistical highly significant i.e. P value<0.0001.

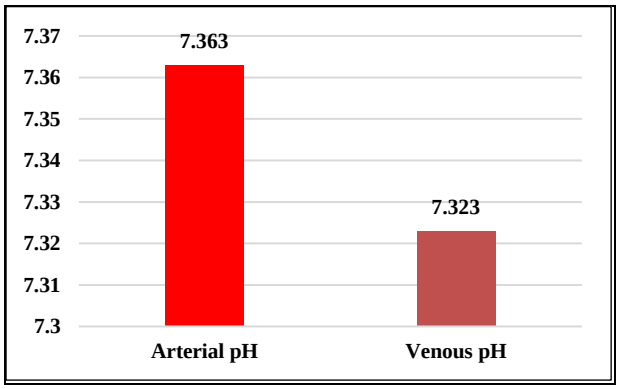

Figure 1: Comparison of Arterial pH and Venous pH.

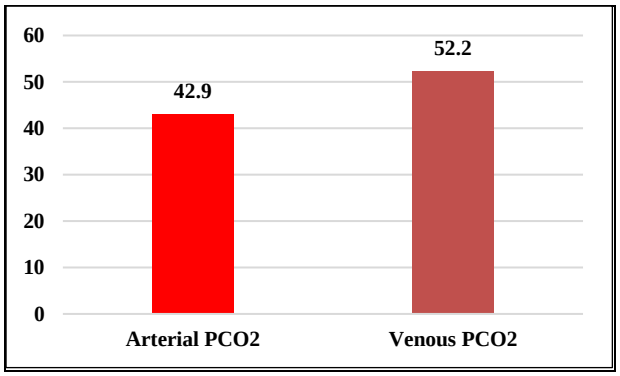

Figure 2: Comparison of arterial PCO_2 and venous PCO_2.

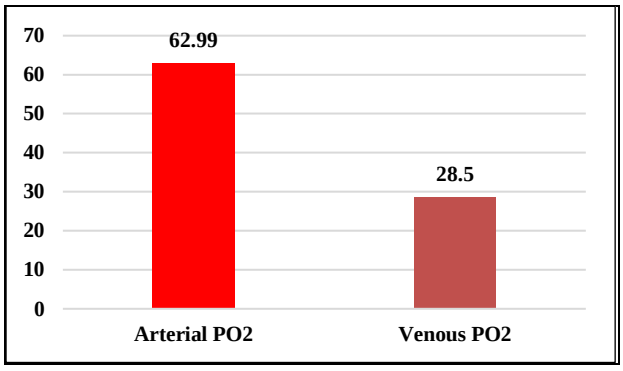

Figure 3: Comparison of arterial PO_2 and venous PO_2.

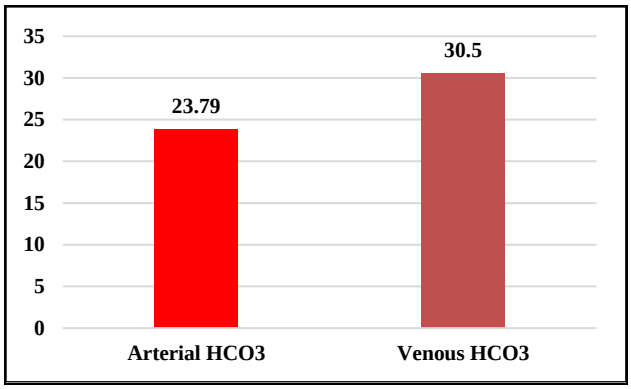

Figure 4: Comparison of arterial HCO_3 and venous HCO_3.

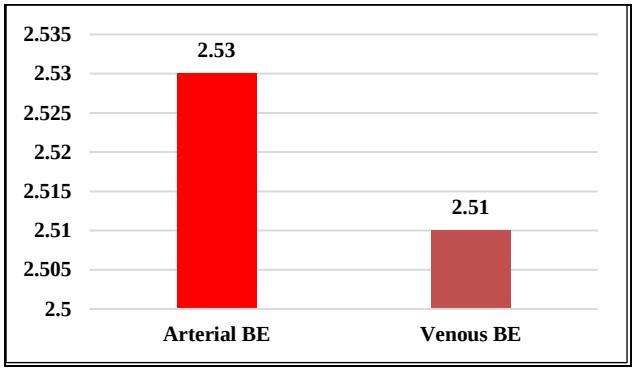

Figure 5: Comparison of arterial base excess and venous base excess.

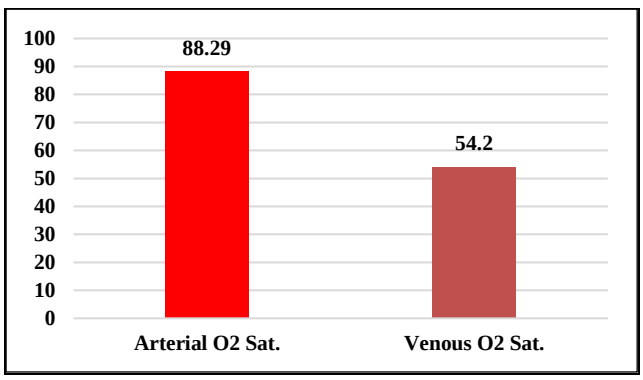

Figure 6: Comparison of arterial O_2 saturation and venous O_2 saturation.

DISCUSSION

Arterial blood gases (ABGs) are commonly used for estimating the acid-base status, oxygenation and carbon dioxide concentration of unwell patients. However, arterial blood can be difficult to obtain due to weak pulses or patient movement. Due to thicker, muscular and innervated walls, arteries are also more painful to puncture than veins. As such, venous blood gas (VBG) can be used as an alternative method of estimating pH and HCO_3.But still VBG cannot clearly replace ABG because PCO2 in venous blood is higher as compared to PCO_2 in arterial blood. Also, PO_2 and O_2 saturation in arterial blood is much higher than venous blood. So, VBG values are non-comparable with ABG values in case of PCO_2, PO_2 and O_2 saturation. A number of studies have suggested that there is agreement between ABG and VBG values, but they were limited by specific patient group samples (e.g. patients with diabetic ketoacidosis) and analysis of only one or some parameters rather than all commonly used parameters (e.g., pH, PCO_2, and bicarbonate).[9,14-16]

Treger et al, studied the agreement between ABG and central VBG samples for pH,PCO_2 and bicarbonate and found that pH for central venous blood (7.340±0.134) was less than arterial blood (7.370±0.138).PCO_2 for central venous blood was 42.3±12.6 which was more than arterial blood i.e., 38.4±12.4. Similarly ,Bicarbonate for central venous blood was 23.20±7.80 which was more than arterial blood i.e., 22.40±7.60.There was no statistical significant difference (p value >0.05) for pH, PCO_2 and Bicarbonate values between ABG and VBG.[17] Therefore, they concluded that peripheral or central venous pH, PCO_2 and bicarbonate can be replaced by their arterial equivalents in many clinical contexts that are encountered in the ICU. Malathesha et al, carried out the study to determine whether VBG values can replace ABG values (pH, bicarbonate, PCO_2 and PO_2) in the initial emergency department evaluation of patients.[15] They concluded that agreement is excellent in pH values and acceptably narrow in PCO_2 and bicarbonate values while venous PO_2 and arterial PO_2 did not showed good agreement. Kozaci et al, studied the comparison of arterial and venous blood gas parameters and the usability of VBG instead of ABG in patients with respiratory alkalosis. They found that the correlation between the results of pH, PCO2, bicarbonate and BE in arterial and venous blood gas samples were statistically significant.[18] Gupta et al, compared the arterial and venous blood gas measurements in non-respiratory diseases patients admitted in intensive care unit and found that the VBG values for pH and HCO_3 showed excellent association and correlation. Therefore, they can be considered clinically interchangeable with arterial values.[19]

Contrary to above mentioned previous findings, our study showed statistical significant differences (p value < 0.05) in the values of pH and HCO_3 and non-significant differences (p value >0.05) in BE between ABG and VBG, while PCO_2 ,PO_2 and O_2 saturation in venous blood showed poor agreement with arterial blood having highly significant differences of p value <0.0001. Hence for the assessment of PCO_2, PO_2 and O_2 saturation in the patients with respiratory disorders and artificially mechanically ventilated, VBG should not be interchangeably used, only ABG should be strictly performed.

There are large discrepancies between the PO_2 measured in arterial and venous blood. Therefore, VBG cannot be used to assess oxygenation. In conditions of hypovolemic shock, VBG does not demonstrate a higher CO_2 concentration and lower pH compared to arterial blood. Therefore, the VBG is not a surrogate for the acid-base status in hypovolemic shock, likely due to peripheral vasoconstriction and central shunting of blood to essential organs. There is also a poor agreement between PCO_2 measured in venous and arterial blood. Thus, VBG should not be used as a direct substitute for ABG in then measurement of PCO_2.[20]

We recommend that VBG should not be considered in place of ABG with regard to PCO_2,PO_2 and O_2 saturation because in our study we found statistical highly significant (p value <0.0001) differences between ABG and VBG in context to PCO_2,PO_2 and O_2 saturation, Also VBG values for pH and HCO_3 showed statistical significant differences (p<0.05) with ABG values. Therefore, they cannot be clinically interchangeable with arterial values. In modern clinical practice, VBG is nowadays deemed adequate for both the diagnosis and the monitoring of diabetic ketoacidosis according to the latest UK guidelines. However, it is also important to recognize the limitations of VBG in relation to arterial analysis. [20]

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