

Original Article

Peripheral venous blood gas analysis: An alternative to arterial blood gas analysis for resuscitation and monitoring of critically ill patients.

ASM Areef Ahsan¹, Mohammad Omar Faruq², Kaniz Fatema³, Fatema Ahmed⁴, Debasish Kumar Saha⁵, Madhurima Saha⁶, Suraiya Nazneen⁷, Rozina Sultana⁸

Abstract

Objective: This study was aimed to compare between arterial and peripheral venous samples for blood gases and acid base status in critically ill patients and to evaluate if venous sample is a better alternative for initial assessment and resuscitation.

Methods: This prospective study was conducted on 50 patients of more than 18 years of age in the department of Critical Care Medicine, BIRDEM General Hospital. Arterial and peripheral venous samples were taken within five minutes of each other and analyzed immediately for blood gases and acid base status. Mean difference and Pearson's product moment correlation coefficient was used to compare the result.

Results: Mean difference and correlation coefficient between arterial and peripheral venous sample for pH, bicarbonate, base excess, PaCO₂ and TCO₂ value showed high correlation ($r > 0.9$). Comparison of electrolyte and hematocrit between arterial and peripheral venous sample also showed high correlation ($r > 0.9$).

Conclusion: Peripheral venous gas analysis for pH, bicarbonate, base excess, PCO₂ and Electrolytes (Na⁺, K⁺) show good correlation with the respective arterial values. This result suggests that venous estimations can be an acceptable alternative to arterial measurements for managing critically ill patients.

Key Words: Arterial blood, blood gas analysis, peripheral venous blood

Introduction:

Blood gas analysis is an essential investigation in intensive care unit (ICU) for initial assessment and resuscitation of critically ill patients particularly who are suffering from respiratory diseases, metabolic and acid base disorders. An

arterial blood gas (ABG) is a test that measures the oxygen tension (PaO₂), carbon dioxide tension (PaCO₂), Acid-Base status (pH), oxyhemoglobin saturation (SaO₂), and bicarbonate (HCO₃⁻) concentration in arterial blood. Some blood gas analyzers also measure Electrolytes. As a result, ABG has become so essential in management of critically ill patients that recent critical care guidelines¹ recommend 24 hour ABG availability.

Though it is a very important test, sometimes it is very difficult to obtain samples due to diminished pulses or patient movement. Diminished pulses may reflect poor peripheral circulation or low blood pressure, while patient movement is frequently caused by the pain associated with arterial puncture. Other important complication associated with arterial puncture is local hematoma; very rarely arterial dissection and thrombosis may occur.² This procedure is technically difficult, particularly in children and elderly patients and several attempts may be required.

Peripheral venous blood gas (VBG) sampling may be a useful alternative to ABG sampling, obviating the need for arterial puncture.³ Venous blood is easier to obtain, expertise is not needed to perform the procedure and can avoid the complications of arterial puncture. Additionally, venous blood sample can be obtained when drawing blood for other laboratory. Several studies have shown good correlation between arterial and peripheral venous blood gas samples.⁴⁻⁷

The aim of this study was to prospectively examine the correlations and mean differences between simultaneous arterial and peripheral venous blood gas values among

1. Dr. ASM Areef Ahsan, Associate Professor & Head, Dept of Critical Care Medicine, BIRDEM General Hospital, Dhaka.
2. Dr. Mohammad Omar Faruq, Professor, Dept of Critical Care Medicine, Ibn Sina Hospital, Dhanmondi, Dhaka.
3. Dr. Kaniz Fatema, Assistant Professor, Dept of Critical Care Medicine, BIRDEM General Hospital, Dhaka.
4. Dr. Fatema Ahmed, Assistant Professor, Dept of Critical Care Medicine, BIRDEM General Hospital, Dhaka.
5. Dr. Debasish Kumar Saha, Registrar, Dept of Critical Care Medicine, BIRDEM General Hospital, Dhaka.
6. Dr. Madhurima Saha, Registrar, Dept of Critical Care Medicine, BIRDEM General Hospital, Dhaka.
7. Dr. Suraiya Nazneen, Registrar, Dept of Critical Care Medicine, BIRDEM General Hospital, Dhaka.
8. Dr. Rozina Sultana, Medical Officer, Dept of Critical Care Medicine, BIRDEM General Hospital, Dhaka.

Corresponding Author:

Dr. ASM Areef Ahsan
FCPS (Medicine), MD (Chest), MD (Critical Care Medicine)
Associate Professor & Head, Dept of Critical Care Medicine
BIRDEM General Hospital
122, Kazi Nazrul Islam Avenue, Dhaka 1000.
E-mail: dr_asmareef@yahoo.com

critically ill patients in the department of critical care medicine and to determine whether peripheral venous blood gas values can be a good alternative to arterial blood.

Materials and Methods:

This prospective study was conducted on 50 patients of more than 18 years of age of either sex in the department of Critical Care Medicine, BIRDEM General Hospital. Consecutive sampling was done from the critically ill patients who were admitted in ICU and who required blood gas analysis. All the study patients were critically ill requiring supplemental O₂, either by non-invasive way (nasal canula, face mask, and rebreather mask) or by endotracheal tube with/without mechanical ventilator. Arterial and peripheral venous samples were taken within five minutes of each other in a pre-heparinized syringe to prevent coagulation. Arterial blood was taken from radial or any other easily accessible artery (either brachial/femoral in difficult condition). Peripheral venous blood was taken from any easily accessible peripheral vein (preferably from anti-cubital vein).

Collected samples were analyzed immediately by a blood gas analysis machine. Measuring capabilities of analyzer are pH, PaCO₂ (partial pressure of carbon dioxide), PaO₂ (partial pressure of oxygen), electrolytes like Na⁺, and K⁺, base excess/base deficit and Hematocrit (Hct).

Mean value was calculated and compared for each variable. Mean difference was calculated between the sample pair. Pearson's product moment correlation coefficient for each of measured blood gas variable was calculated by method of difference.

Results:

In this study, male and female were almost same in number (1:1.08) (Table I). Mean age of male and female were also almost same (male: 65.19 years; female: 64.69 years) (Table II).

Table I: Distribution of patients according to gender (n=50)

Gender	Frequency (n)	Percentage (%)
Male	24	48.0
Female	26	52.0
Total	50	100.0

Table II: Age distribution of patients in male and female (n=50)

Age	Male	Female	Total
Mean ± SD	65.19 ± 15.56	64.69 ± 11.84	64.93 ± 13.58
Range (Min-Max)	35 - 85	27 - 90	27 - 90

Observation of different variable: pH, bicarbonate (HCO₃), base excess, Hct, Na⁺, K⁺, PaO₂, PaCO₂, and SaO₂ were noted and recorded in table III, IV &V. Mean difference and correlation coefficient between arterial and peripheral venous sample for pH, bicarbonate, base excess shows high correlation (*r* > 0.9) (Figure 1). Comparison of electrolyte and Hct between arterial and peripheral venous sample also shows high correlation (*r* > 0.9) (Figure 2). While comparing

respiratory parameters, PaCO₂ and TCO₂ value shows high correlation (*r* > 0.9), while PaO₂ and SaO₂ show low correlation coefficient (*r* < 0.05) (Figure 3).

Table III: Mean difference and correlation of pH, HCO₃ and base excess values for arterial and peripheral venous blood (n=50)

	ABG (Mean ± SD)	VBG (Mean ± SD)	Mean difference	Correlation coefficient (r value)	p value
pH	7.44 ± 0.06	7.40 ± 0.06	0.034	0.904	0.000***
HCO ₃	26.02 ± 4.27	26.59 ± 5.14	-0.574	0.902	0.077 ^{ns}
BE	2.49 ± 3.98	2.11 ± 5.11	0.378	0.903	0.249 ^{ns}

Table IV: Comparison of electrolyte values (Na⁺ and K⁺) and hematocrit between arterial and peripheral venous samples (n=50)

	ABG (Mean ± SD)	VBG (Mean ± SD)	Mean difference	Correlation coefficient (r value)	p value
Na ⁺	135.80 ± 7.30	136.58 ± 7.02	-0.78	0.918	0.065 ^{ns}
K ⁺	3.30 ± 0.77	3.36 ± 1.05	-0.06	0.910	0.391 ^{ns}
Hct	33.59 ± 6.70	33.74 ± 7.38	-0.15	0.819	0.803 ^{ns}

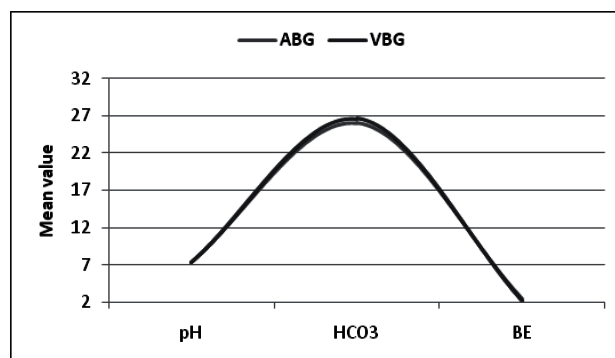


Figure 1: Mean value and correlation of pH, HCO₃ and base excess values for arterial and peripheral venous blood

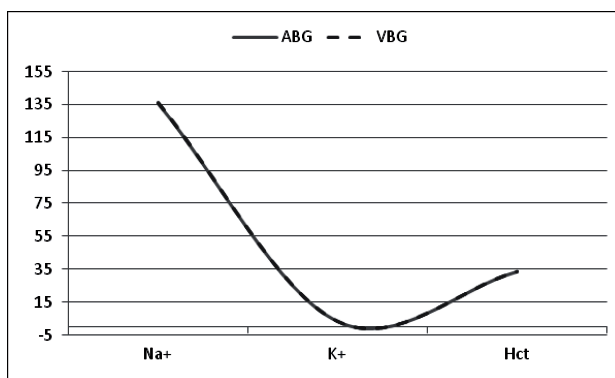
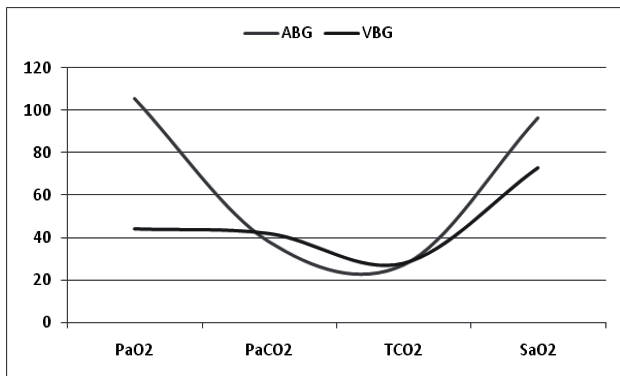


Figure 2: Mean value and correlation of electrolyte values (Na⁺ and K⁺) and hematocrit between arterial and peripheral venous samples

Table V: Mean difference between arterial and peripheral venous blood for PaO₂, PaCO₂, TCO₂ and O₂ saturation (n=50)

	ABG (Mean ± SD)	VBG (Mean ± SD)	Mean difference	Correlation coefficient (r value)	p value
PaO ₂	105.52 ± 56.49	44.06 ± 14.73	61.46	-0.027	0.000***
PaCO ₂	38.08 ± 7.95	41.88 ± 9.60	-3.80	0.916	0.000***
TCO ₂	27.16 ± 4.46	27.81 ± 5.31	-0.65	0.914	0.042*
SaO ₂	96.42 ± 3.17	72.89 ± 16.48	23.53	0.049	0.000***

**Figure 3:** Correlation of respiratory parameters between ABG and VBG**Discussion:**

ABG analysis has been playing an important role for managing acutely ill patients since automated blood analyzers first became available. It is particularly useful to adjust ventilator parameters in ICU setting and also assess the severity of illness. Although during blood gas analysis variables are measured from arterial blood, access to arterial blood may be difficult particularly in early stages of resuscitation if arterial line is yet to be established.

This study was aimed to determine the extent of correlation between ABG and VBG in critically ill patients.

In our study 50 critically ill patients who were admitted in ICU were included. According to our study peripheral blood gas sampling is an attractive alternative to arterial sampling as our data showed strong correlation and small mean difference between arterial and venous values for pH, PCO₂, HCO₃⁻, base excess, Hct and electrolytes like Na⁺ and K⁺.

Awasthiet al.,⁸ conducted a prospective study to determine whether peripheral venous blood gas analysis can be an alternative to arterial blood gas analysis for initial assessment and resuscitation in emergency and intensive care unit patients. The study showed minimal mean difference and good correlation ($r > 0.9$) between arterial and peripheral venous sample for blood gases and acid base status but correlation in PO₂ measurement was poor ($r < 0.3$). According to present study, mean difference and correlation coefficient between arterial and peripheral venous sample for pH, bicarbonate, base excess showed high correlation ($r > 0.9$) and correlation coefficient for PaO₂ is low ($r < 0.05$).

Kelly et al.,⁷ did prospective study of patients to determine their ventilatory or acid base status by comparing pH on arterial and venous sample. The values were highly correlated ($r = 0.92$) with an average difference between the samples of 0.04 units. They concluded that venous estimation is an acceptable substitute for arterial measurement and may reduce risks of complications both for patients and health care workers. In our study, we also found good correlation between arterial and venous pH. Kelly et al.,⁹ also compared arterial and venous sample for PCO₂, and found good correlation.

Malatesha et al.,¹⁰ to determine the agreement between arterial and venous samples in a pathologically diverse patient population presenting at an emergency department (ED) with a view to obviating the need for ABG analysis in initial ED evaluation. The arterial and venous values of pH, bicarbonate and PCO₂ show acceptably narrow 95% limits of agreement using the Bland–Altman method (0.13 to 20.1, 4.3 to 25.8 and 6.8 to 27.6, respectively). Agreement in PO₂ measurements was poor (95% limits of agreement 145.3 to 232.9). This study concluded that venous blood gas analysis for pH, bicarbonate and PCO₂ may be a reliable substitute for ABG analysis in the initial evaluation of an adult patient population presenting to the ED.

Rang et al.,¹¹ performed venous blood gas analysis in patients requiring ABG analysis in ED. Pearson's product moment correlation coefficients between arterial and venous values were pH (0.913), PCO₂ (0.921), and HCO₃⁻ (0.953). They concluded that the small mean difference between the sample and strong correlation might preclude using such results interchangeably.

As found by the above study, present study also shows good correlation between arterial and venous sample: pH (0.904), PCO₂ (0.916), bicarbonate (0.902).

Nanda et al., conducted a study to determine the agreement of arterial sodium and arterial potassium with venous sodium and venous potassium level. The result showed positive correlation of arterial sodium and arterial potassium with venous sodium and venous potassium indicating agreement between the parameters.¹² This study concluded that arterial sodium and arterial potassium can be used instead of venous sodium and venous potassium levels in management of critically ill patients. Comparison of electrolyte (Na⁺ and K⁺) between arterial and peripheral venous sample in our study showed high correlation.

Various studies have found a proper correlation between arterial and venous samples regarding the values of pH, PCO₂, HCO₃⁻ in conditions including diabetic ketoacidosis,¹³ trauma,³ and intoxication.¹⁴

Conclusion:

Venous blood gas analysis can be a reliable alternative to arterial blood gas analysis as the correlation coefficient of present study between arterial and peripheral venous sample for pH, bicarbonate, base excess, PaCO₂, TCO₂ and electrolytes like Na⁺ and K⁺ showed high correlation ($r > 0.9$).

Sometimes it is difficult to obtain arterial blood from critically ill patients particularly who are in shock or suffering from coagulopathy. So in critically ill patients without arterial line venous blood gas analysis can be a good alternative to arterial blood and may reduce risks of complications.

References:

1. Guidelines for standards of care of patients with acute respiratory failure on mechanical ventilator support. Task Force on Guidelines; Society of Critical Care Medicine. Crit Care Med. 1991;19:275-8.
2. Barker WJ. Arterial puncture and cannulation. In: Roberts JR, Hedges JR, editors. Clinical Procedure in Emergency Medicine. 3rd ed. Philadelphia: WB Saunders; 1998. pp. 308-22.
3. Malinoski DJ, Todd SR, Slone S, Mullins RJ, Schreiber MA. Correlation of central venous and arterial blood gas measurements in mechanically ventilated trauma patients. Arch Surg. 2005;140:1122-5.
4. Kelly AM, McAlpine R, Kyle E. Agreement between bicarbonate measured on arterial and venous blood gases. Emerg Med Australas. 2004;16:407-9.
5. Ma OJ, Rush MD, Godfrey MM, Gaddis G. Arterial blood gas results rarely influence emergency physician management of patients with suspected diabetic ketoacidosis. Acad Emerg Med. 2003;10:836-41.
6. Gokel Y, Paydas S, Koseoglu Z, Alparslan N, Seydaoglu G. Comparison of blood gas and acid-base measurements in arterial and venous blood samples in patients with uremic acidosis and diabetic ketoacidosis in the emergency room. Am J Nephrol. 2000;20:319-23.
7. Kelly AM, McAlpine R, Kyle E. Venous pH can safely replace arterial pH in the initial evaluation of patients in the emergency department. Emerg Med J. 2001;18:340-2.
8. Awasthi S, Rani R, Malviya D. Peripheral venous blood gas analysis: An alternative to arterial blood gas analysis for initial assessment and resuscitation in emergency and intensive care unit patients. Anesth Essays Res. 2013 Sep-Dec; 7(3): 355-358.
9. Kelly AM, Kyle E, McAlpine R. Venous pCO₂ and pH can be used to screen for significant hypercarbia in emergency patients with acute respiratory disease. J Emerg Med. 2002;22:15-9.
10. G Malatesha, Nishith K Singh, AnkurBharija, Bhavya Rehani, Ashish Goel. Comparison of arterial and venous pH, bicarbonate, PCO₂ and PO₂ in initial emergency department assessment. Emerg Med J 2007;24:569-571.
11. Rang LC, Murray HE, Wells GA, Macgougan CK. Can peripheral venous blood gases replace arterial blood gases in emergency department patients? CJEM. 2002;4:7-15.
12. Nanda SK, Ray L, Dinakaran A. Agreement of Arterial Sodium and Arterial Potassium Levels with Venous Sodium and Venous Potassium in Patients Admitted to Intensive Care Unit. Journal of Clinical and Diagnostic Research. 2015 Feb, Vol-9(2): BC28-BC30
13. Brandenburg MA, Dire DJ. Comparison of arterial and venous blood gas values in the initial emergency department evaluation of patients with diabetic ketoacidosis. Ann Emerg Med. 1998;31:459-65.
14. Eizadi-Mood N, Moein N, Saghaei M. Evaluation of relationship between arterial and venous blood gas values in the patients with tricyclic antidepressant poisoning. Clin Toxicol (Phila) 2005;43:357-60.