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Original Research Article

Central Venous Gas Analysis: An Alternative to Arterial Blood Gas Analysis for Ph, Pco2, Bicarbonate, Sodium, Potassium and Chloride in the Intensive Care Unit Patients

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Abstract

Aim: This study was aimed to investigate the correlation of pH, PCO2, bicarbonate, sodium, potassium, and chloride (electrolytes) between ABG and central VBG in ICU patients.

Material & methods: A randomized controlled comparative study conducted in the department of Anaesthesiology, at Indira Gandhi institute of Medical Sciences, Patna within duration of 12 months. 100 patients were randomly selected.

Results: We have found, maximum number of the ICU patients were belongs to 51-70 years of age group i.e. 33(33%), next commonest age group was 31-50 years, it consisted 31% cases. 14% & 22% cases were belongs to 18-30 & >70 years of age group respectively. Male cases were predominantly higher than Female cases. Male was 62.0% and female was 38.0% respectively. Male & Female ratio was 1.63:1. We have found Mean and SD value of arterials Blood Gas Analysis among study population pH value was 7.41±0.03, PCO2 (mmHg) was 40.99±2.80, HCO3 (mEq/L) was 25.17±2.40, Na+ (mEq/L) was 130.19±6.66, K+ (mEq/L) was 3.06±0.40 & Cl- (mg/dl) was 93.74±2.59 respectively. We have found Mean and SD value of Central Venous Blood Gas Analysis among study population pH value was 7.35±0.04, PCO2 (mmHg) was 46.98±2.78, HCO3 (mEq/L) was 26.32±2.52, Na+ (mEq/L) was 128.91±6.65, K+ (mEq/L) was 2.99±0.40 & Cl- (mg/dl) was 92.47±3.89 respectively. We have found significant correlation between ABG pH & VBG pH. r factor was .290 and p value was 0.003. We have found positive correlation between arterial blood gas PCO2 & Central Venous Blood Gas PCO2 r factor was .961 and p value was <0.0001.

Conclusion: Central venous pH, PCO2, and bicarbonate may be an acceptable substitute for ABG in patients admitted in the ICU. However caution should be exercised while applying electrolyte measurements.

Keywords: Agreement; Arterial blood gas analysis; Central venous blood; Correlation; Electrolytes.

Introduction

Arterial blood gas (ABG) has been demonstrated to be the most frequently ordered test in intensive care unit (ICU) [1] and has become so essential in management of critically ill that recent critical care guidelines [2] recommend 24 hr. ABG availability. Though ABG analysis is rapid and reliable, the arterial puncture carries a risk of hemorrhage and other vascular complications, [3] which is painful and no longer necessary for diagnosing respiratory failure because of widespread use of pulse oximetry for measuring oxygen saturations. Sodium, potassium, and chloride (electrolytes) abnormalities [4] are also one of the common causes of morbidity and mortality in ICU patients and are conventionally measured by auto analyzers available in hospital's central laboratories.

Typically, an average turn-around time of 20–30 minutes is noted in acute care laboratories of most tertiary care hospitals. Earlier studies have shown good correlation between ABG and VBG values with respect to pH, PCO2, and bicarbonate in adult patients presented to the emergency department and ICU. [5,6] Central venous catheter (CVC) is inserted for central venous pressure measurement, sampling of blood for investigation, VBG analysis, and drug administration. Studies involving ICU

patients have shown good correlation for potassium measured between ABG machine and point of care analyzers. [7,8]

Peripheral, mixed, and central venous blood can also be sampled. Venous blood gas (VBG) measurements obtained from peripheral, mixed, or central venous blood can be used interchangeably with ABGs to assess acid–base status in hemodynamically stable critically ill patients. [9] Adrogue and Weil concluded in their study that in the presence of severe circulatory failure, there is a worse agreement between arterial and central or mixed venous values, with central or mixed venous blood having a higher CO2 concentration and lower pH than arterial blood because of impaired removal of generated CO2 from the tissues. This increase in the venous–arterial PCO2 difference occurs in states of decreased flow irrespective of the reason for the circulatory failure and has an inverse relationship with cardiac output. [10] The main complications of arterial blood gas measurements include arterial injury, thrombosis, air or clotted blood embolism, arterial occlusion, hematoma, aneurysm formation, and reflex sympathetic dystrophy. [11] Turner et al. evaluated recall of patients' collective experience in their ICU stay. He found that ABG sampling was rated by 48% of the patients as the most unpleasant experience during admission, followed by tracheal suction in 44% of the patients. [12]

Hence, the aim of the study was to analysize central Venous Blood Gas as an alternative to Arterial Blood Gas Analysis for pH, PCO2, Bicarbonate, Sodium, Potassium and Chloride in the Intensive Care Unit Patients.

Material & Methods

A randomized controlled comparative study conducted in the department of Anaesthesiology, at Indira Gandhi institute of Medical Sciences, Patna within duration of 12 months. 100 patients were randomly selected.

Inclusion Criterias:

- Patient requiring respiratory and acid –base status in critically ill patients admitted in Intensive Care Unit.

Exclusion Criterias:

- Pregnant patients.
- Patients having CVP line with single port.

Methodology:

Age, sex, presenting complaint, vital signs, and indication for testing. Arterial and peripheral venous samples were drawn simultaneously in a preheparinized syringe to prevent coagulation. Arterial blood was taken from radial/dorsalis pedis artery/any other easily accessible artery (either brachial/femoral in difficult condition). Peripheral venous blood was taken from any easily accessible peripheral vein.

Analysis was done on Nova biomedical blood gas analysis machine, commonly known as blood gas, electrolyte, and metabolite measuring system. Measuring capabilities of analyzer were pH, PCO_2 (partial pressure of carbon dioxide), PO_2 (partial pressure of oxygen), electrolytes (sodium, potassium, chloride, bicarbonate), base excess/base deficit, anion gap. Arterial and peripheral samples were recorded for the above values.

Statistical Analysis

The results were entered into a specifically designed database and analyzed the data using computation of Pearson's product − moment correlation coefficient. 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

Table 1: Demographic data

Age in Year	No of Cases	Percentage
18-30	14	4.0
31-50	31	31.0
51-70	33	3.0
>70	22	22.0
Sex		
Male	62	2.0
Female	38	38.0

We have found, maximum number of the ICU patients were belongs to 51-70 years of age group i.e. 33(33%), next commonest age group was 31-50 years, it consisted 31% cases. 14% & 22% cases were belongs to 18-30 & >70 years of age group respectively. Male cases were predominantly higher than Female cases. Male was 62.0% and female was 38.0% respectively. Male & Female ratio was 1.63:1.

Table 2: Mean & SD value of arterial blood gas Analysis and Central Venous Blood Gas Analysis

Arterial blood gas Analysis	Mean	SD
pH	7.41	±0.03
PCO_2 (mmHg)	40.99	±2.80
HCO_3 (mEq/L)	25.17	±2.40
Na+ (mEq/L)	130.19	±6.66
K+ (mEq/L)	3.06	±0.40
Cl- (mg/dl)	93.74	±2.59
Central Venous Blood Gas Analysis		
pH	7.35	±0.04
PCO2 (mmHg)	46.98	±2.78
HCO3 (mEq/L)	26.32	±2.52
Na+ (mEq/L)	128.91	±6.65
K+ (mEq/L)	2.99	±0.40
Cl- (mg/dl)	92.47	±3.89

We have found Mean and SD value of arterials Blood Gas Analysis among study population pH value was 7.41±0.03, PCO2 (mmHg) was 40.99±2.80, HCO3 (mEq/L) was 25.17±2.40, Na+ (mEq/L) was 130.19±6.66, K+ (mEq/L) was 3.06±0.40 & Cl- (mg/dl) was 93.74±2.59 respectively. We have found Mean and SD value of Central Venous Blood Gas Analysis among study population pH value was 7.35±0.04, PCO2 (mmHg) was 46.98±2.78, HCO3 (mEq/L) was 26.32±2.52, Na+ (mEq/L) was 128.91±6.65, K+ (mEq/L) was 2.99±0.40 & Cl- (mg/dl) was 92.47±3.89 respectively.

Table 3: Correlation between arterial blood gas pH & Central Venous Blood Gas pH and Correlation between arterial blood gas PCO2 & Central Venous Blood Gas PCO2

Correlation between arterial blood gas pH & Central Venous Blood Gas pH			
		ABG pH	VBG pH
ABG pH vs VBG pH	Pearson Correlation (r)	1	.290**
	p Vlaue		.003
	No of cases	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			
Correlation between arterial blood gas PCO2 & Central Venous Blood Gas PCO2			
		ABG **PCO_2**	VBG **PCO_2**
ABG **PCO_2** vs VBG **PCO_2**	Pearson Correlation (r)	1	.988**
	p Vlaue		.000
	No of cases	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			

We have found significant correlation between ABG pH & VBG pH. r factor was .290 and p value was 0.003. We have found positive correlation between arterial blood gas PCO2 & Central Venous Blood Gas PCO2 r factor was .961 and p value was <0.0001.

Table 4: Correlation between arterial blood gas HCO3 & Central Venous Blood Gas HCO3 and Correlation between arterial blood gas Na+& Central Venous Blood Gas Na+

Correlation between arterial blood gas HCO3 & Central Venous Blood Gas HCO3			
		ABG **HCO_3**	VBG **HCO_3**
ABG **HCO_3** vs VBG **HCO_3**	Pearson Correlation (r)	1	.961**
	p Vlaue		.000
	No of cases	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			
Correlation between arterial blood gas Na+& Central Venous Blood Gas Na+			
		ABG **Na+**	VBG **Na+**
ABG **Na+** vs VBG **Na+**	Pearson Correlation (r)	1	.991**
	p Vlaue		.000
	No of cases	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			

We have found positive correlation between arterial blood gas HCO3 & Central Venous Blood Gas HCO3 r factor was .961 and p value was <0.0001. We have found positive correlation between arterial blood gas Na+ & Central Venous Blood Gas Na+r factor was .991 and p value was <0.0001.

Table 5: Correlation between arterial blood gas K+& Central Venous Blood Gas K+ and Correlation between arterial blood gas Cl-& Central Venous Blood Gas Cl-

Correlation between arterial blood gas K+& Central Venous Blood Gas K+			
		ABG **K+**	VBG **K+**
ABG **K+**vs VBG **K+**	Pearson Correlation (r)	1	.448**
	p Vlaue		.000
	No of cases	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			
Correlation between arterial blood gas Cl-& Central Venous Blood Gas Cl-			
		ABG **Cl^-**	VBG **Cl^-**
ABG **Cl^-** vs VBG **Cl^-**	Pearson Correlation (r)	1	.496**
	p Vlaue		.000
	No of cases	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			

We have found positive correlation between arterial blood gas K+ & Central Venous Blood Gas K+ r factor was .448 and p value was <0.0001. We have found positive correlation between arterial blood gas Cl- & Central Venous Blood Gas Cl- r factor was .496 and p value was <0.0001.

Discussion

Arterial blood gas is a vital component in determining the clinical status and progress of critically ill patients with suspected blood gas and acid base imbalance. However, arterial samples may not always be easy to obtain. A small but significant risk of complications exists with arterial punctures and long-term in situ arterial catheters. [13] Electrolyte abnormalities are another significant cause of morbidity and mortality in critically sick patients [4] and are typically assessed from venous blood serum using a central laboratory analyzer, which takes 20–30 minutes. Patients in the intensive care unit (ICU) frequently have in situ central venous catheters, and central VBG analysis may be a safer alternative to ABG analysis for determining acid-base status and electrolytes levels, reducing the need for frequent invasive arterial sampling and electrolytes estimation turnaround time.

For pH, PCO2, and bicarbonate, there was a substantial association between arterial and central venous readings, while sodium, potassium, and chloride had a moderate correlation. We discovered a strong link between ABG pH and VBG pH. The r factor was.290, with a p value of 0.003. This is in line with the findings of Tregger et al [5], Awasthi et al [6], Middleton et al [14] and Bo Ra kim et al [15] who found a mean A-V difference for pH ranging from –0.04 to 0.053 in their research. The r factor was.961 and the p value was 0.0001. We found a significant positive association between arterial blood gas PCO2 and central venous blood gas PCO2. However, their 95 percent LOAs (-25–13.1) were too broad to allow substitution. Given that blood gas values should be interpreted in the context of the individual patient's clinical status and that arterial blood gases are frequently obtained to aid in the assessment of a patient's course, central venous PCO2 should be able to largely replace arterial PCO2 in the vast majority of clinical situations.

The r factor was.961 and the p value was 0.0001. We found a significant positive association between arterial blood gas HCO3 and central venous blood gas HCO3. According to Tregger et al5 and Rang et al [16] this was within clinically acceptable limits. The LOA in this investigation was wide (-4.7–6.5), which was similar to Tregger et al [5] (-4–2.4), who concluded that this limit represents excellent agreement between arterial and venous HCO3-. Because venous pH is lower than arterial pH and venous PCO2 is greater than arterial PCO2, mean venous HCO3- was unexpectedly higher than mean arterial HCO3-. We infer that the CO2 level on which the calculation is based, rather than the pH, affects the value of HCO3-.

The correlation between arterial blood gas Na+ and central venous blood gas Na+r factor was.991, with a p value of 0.0001. The r factor for arterial blood gas K+ and central venous blood gas K+ was.448 and the p value was 0.0001. We also discovered a positive correlation between arterial blood gas Cl- and central venous blood gas Cl-, with a r factor of.496 and a p value of 0.0001, which is consistent with the findings of Awasthi et al[6] who found a good correlation between both samples and low arterial versus venous differences for pH, bicarbonate, and electrolytes in a group of ICU and critically ill patients. In patients with cardiac arrest, Johnston5 looked examined the concordance between arterial and venous blood potassium levels. The average difference between arterial and

venous potassium was determined to be 0.106 mmol/L. A mean difference of 0.04 mmol/L was found to be comparable in our study to the author's findings. Nanda et al [17] discovered that arterial sodium and potassium were lower than venous sodium and potassium, which is consistent with the current study's findings. Wongyingsinn et al. found a strong association between arterial and venous potassium and concluded that arterial potassium can be used to substitute venous potassium measurement. [18] Electrolytes assessed in whole blood by a point-of-care analyzer were equivalent to electrolytes measured in plasma or venous serum samples, according to Flegar Mestric et al [19] There was no significant difference between potassium measured in an ABG analyzer and potassium measured using a regular chemical auto analyzer, according to Jain et al. [20]

With the current study's excellent correlation for acid-base status and moderate correlation for electrolytes, it may be possible to use VBG analysis electrolytes, along with pH, PCO2, and bicarbonate, in place of ABG and serum electrolytes in emergency department and ICU patients in the early stages of resuscitation. This can help to lessen the risks of long-term arterial catheterization as well as the time necessary for electrolyte analysis. The current study can show that changes in venous values reflect changes in the equivalent arterial values, and so can be used for trending purposes, due to good correlation and acceptable mean differences.

Patients with a variety of clinical diseases, as well as abnormal blood gas and electrolyte readings, were excluded from the study. Before proposing widespread use of an aberrant VBG, more research into the variations in clinical decision making based on VBG analysis for acid base status and electrolyte levels from a specific patient population with a likelihood of abnormal blood gases and electrolytes is needed.

The laboratory auto-analyzer test results are generally time consuming. In contrast, the blood gas measurement devices usually can produce results in as little as 90 seconds. So, the calculation of the value measured with a laboratory auto analyzer from the value measured with a blood gas analyzer can save time for the physicians. In a study comparing arterial blood gases and central laboratory measurements in critically ill patients, the researchers found the Na, Cl, Hb, bicarbonate and glucose values are correlated and calculated formulas for laboratory autoanalyzer values from venous blood gas analyzer values. [21] In a similar study, Kozaci et al. calculated the laboratory blood sample values (measured by laboratory auto-analyzer) from venous blood gas sample values (measured by blood gas analyzer) by using linear regression equations. [22]

Conclusion

These findings suggest that venous values can replace arterial measurements in many ICU clinical settings, eliminating the need for repeated arterial sampling. Although electrolyte measurements save time and money, they should be used with caution. The findings of laboratory auto-analyzer tests can take a long time. Blood gas measurement instruments, on the other hand, may usually deliver results in as little as 90 seconds. As a result, physicians can save time by calculating the value measured with a laboratory auto analyzer from the value measured with a blood gas analyzer. The researchers discovered that the Na, Cl, bicarbonate, and pH & PCO2 values are correlated in a study comparing arterial blood gases and central laboratory measurements in critically ill patients, and they calculated formulas for laboratory autoanalyzer values from venous blood gas analyzer values. More research is needed to verify their electrolyte value accuracy.

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