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Original Research Article

Comparison of Arterial and Venous Blood Gas Measurements in Non-Respiratory Diseases Patients Admitted in Intensive Care Unit (ICU)

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Abstract: The aim is to study the relationship between arterial and venous blood gas measurements of pH, $HCO3^-$& pCO_2 in patients of non-respiratory diseases admitted in ICU in PCMS&RC, Bhopal.Enrollment of non-respiratory disease patients admitted in ICU reporting in our hospital to evaluate the relationship between arterial and venous blood gas parameters through Cross-sectional Study.The data we reviewed revealed us that venous blood gas analysis has the potential to be of great importance in the ICU setting in general as well as for patients presenting with different diagnosis. The association between Arterial and venous pH in which p-value of 0.85 which is not significant.The association between Arterial and venous pO_2 in which the p-value of 0.001 which is highly significant.The association between Arterial and venous pCO_2 in which p-value of 0.001 which is highly significant.The association between Arterial and venous HCO_3^- in which p-value of 0.056 which is not significant.Correlation between arterial and venous parameters reveals all the correlation coefficient (r) is positive and only pH, pCO_2 and HCO_3^- are highly significant.The use of venous blood gas values has shown to be cost-effective and implementation of this procedure in the routine venous blood sampling will prove to be time and money saving as well, as it will reduce the risk factors for the patient and the health care worker. The venous blood gas values for pH and HCO_3^- showed excellent association and correlation and can be considered clinically interchangeable with arterial values.
Keywords: Arterial blood gas (ABG), venous blood gas (VBG), pH, pCO_2 and HCO_3^-

INTRODUCTION

Blood is a connective tissue. The primary function of blood is to transport oxygen from lungs to the body tissues and CO_2 from the tissues to the lungs. This function is essential in order to prevent the death of the tissues due to hypoxia. If body tissues are not getting adequate supply of oxygen, acid-base imbalance will occur. The term 'blood gas' strictly refers to the measurement of tension or partial pressure of O_2 and CO_2 in blood but the determination of acid-base imbalance is an integral part of blood gas measurement which occurs due to improper oxidation of carbohydrates and fats. The result is there is an increased production of lactic acids and ketoacids. Estimation of H^+ ion concentration or pH is an integral part of blood gas measurement [1]. 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, the anaesthesiologist and the nurse is no exception [1]

The modern approach to acid±base disorders was initially proposed by Stewart in the early 1980s [2, 3].Stewart used the fundamental principles of physical chemistry to elucidate factors that must determine $[H^+]$ in biological solutions. Using this mechanistic

approach, he derived three independent variables that ought to be the sole final determinants of pH and explained how other factors, including the bicarbonate concentration [HCO_3^-], would be dependent on these three independent variables.

In emergency departments and other non-intensive care departments where arterial blood gas analysis still is an important part of daily monitoring, i.e. pulmonary, nephrology, endocrinology (diabetes) and neonatal departments, patients do not routinely have arterial catheters. In other medical and surgical wards arterial blood sampling are not routine and are usually only taken when a patient has deteriorated or the clinician needs further information.

As arterial puncture bears risks of bleeding, haematoma, emboli/thrombosis or nerve damage and is associated with substantial pain [4] and in contrast, large numbers of peripheral venous blood samples are taken easily and safely in almost every hospital department. In fact a peripheral venous blood sample is often one of the first diagnostic tests performed on admission to the hospital, and on in-patients whose status deteriorates. The information obtained from the peripheral venous blood does not normally include values relevant to the acid-base status except typically the standard bicarbonate (SBC) and the haemoglobin (Hb).

In general Peripheral Venous Blood Gas (pVBG) sampling may be an acceptable alternative for the initial assessment of a patient presenting to the emergency department with diabetic ketoacidosis, [5] or uremic acidosis [6].

METHOD

Study Population: Patients with non- respiratory disease admitted in ICU.

Study Design: Cross-sectional Study

Duration of study: Nov, 2013 to July, 2015

- A total of 50 patients will be analyzed.
- The pO_2, pCO_2, pH and HCO_3^-, will be recorded from the ABG/VBG report for the study.
- Additional data recorded will be: the Diagnosis of the disease, Heart rate, mean arterial pressure (MAP), arterial oxygen saturation (SpO_2), temperature, haemogram, and renal profile.
- We will obtain ABG samples from radial artery with 23 G hypobaric needle in heparinised 2 ml syringe.
- VBG samples will also be obtained from vein in heparinised 2 ml syringe.
- All patients will be sampled for arterial and venous blood under strict aseptic precautions and with minimum delay (always <2 minutes) between the samples.
- The samples will be analyzed using the blood gas analyzer.

INCLUSION CRITERIA

- All adult patients (>13 yrs) who will be admitted in the ICU will be enrolled in the study.
- When an ABG seems to be necessary as part of ICU management, a venous sample will also be obtained within 2 minutes.
- Patients suffering from non-respiratory diseases will be enrolled.
- 50 adult patients including both sexes, age ranging between 13 and 65 yrs will be enrolled in the study.

EXCLUSION CRITERIA

- Patients suffering from respiratory disease will be excluded.
- Patient age less than 13 yrs and more than 65 years.
- Patient with abnormal coagulation profile.
- Refusal to consent.
- Samples will be excluded, if after analysis, the sample thought to be arterial in origin proved to be venous.

STATISTICAL ANALYSIS

The data obtained was subjected to statistical analysis with the consult of a statistician. The data so obtained was compiled systematically. A master table was prepared and the total data was subdivided and distributed meaningfully and presented as individual tables along with graphs.

Statistical procedures were carried out in 2 steps:

1. Data compilation and presentation
2. Statistical analysis

Statistical analysis was done using Statistical Package of Social Science (SPSS Version 20; Chicago Inc., USA). Data comparison was done by applying specific statistical tests to find out the statistical significance of the comparisons. Quantitative variables were compared using mean values and qualitative variables using proportions. Significance level was fixed at $P < 0.05$.

RESULTS

A total of 50 paired samples were analysed (50 ABG and 50 VBG). The pO_2, pCO_2, HCO_3^-, and pH were recorded from ABG and VBG report and evaluated for the study. Additional data recorded were diagnosis, MAP and haemoglobin. All samples were drawn less than 2 min apart.

In our study no patient was repeated. This was done to avoid bias of disease and patient specifics. The

study populations was made up of 35 male (70 %) and 15 female (30 %) with a mean age of 47.86. the study population was made 46 whose MAP was more than or equal to 65 mm of Hg and the rest 4 patients had MAP less than 65 mm of Hg. As for haemoglobin, 7 patients was in normal range, 7 patients were between 11-11.9 gm/dl, 20 patients were in 10-8.9 gm/dl and 16 patients were less than 8 gm/dl. So the mean haemoglobin was 9.54 gm/dl. Only the age group is correlating significantly with P value of 0.039 (FIGURE 1).

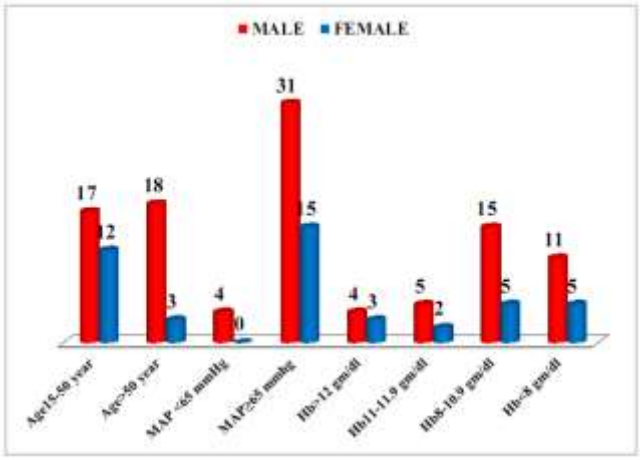

Fig-1: Demographic Distribution of study subjects according to gender, age, Hb, MAP

Figure 2 reveals the association between Arterial and venous pH in which Arterial pH levels are more than venous pH levels with the S.D. of 0.146 and p-value of 0.85 which is not significant.

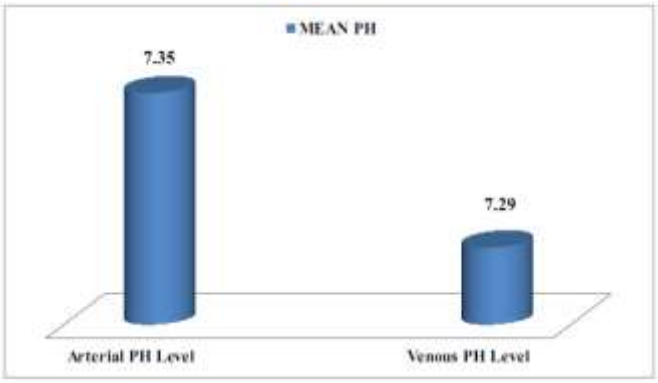

Fig-2: Association between arterial & venous pH Level

Figure 3 reveals the association between Arterial and venous pO_2 in which Arterial pO_2 (113.78) levels are more than venous pO_2 (42.27) levels with the p-value of 0.001 which is highly significant.

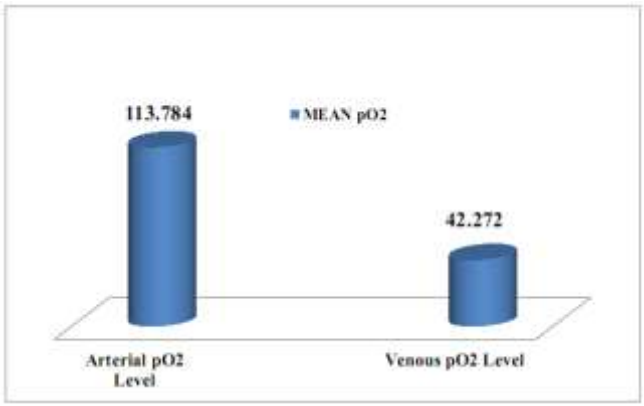

Fig-3: Association between arterial & venous pO_2 Level

Figure 4 reveals the association between Arterial and venous pCO_2 in which Arterial pCO_2(23.19) levels are less than venous pCO_2 (30.39) levels with the p-value of 0.001 which is highly significant.

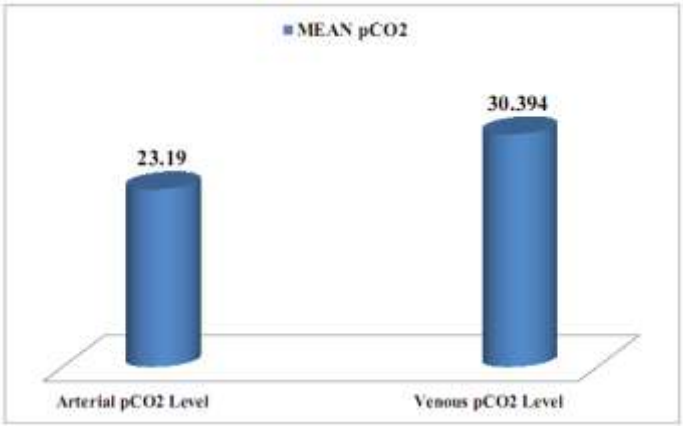

Fig-4: Association between arterial & venous pCO_2 Level

Figure 5 reveals the association between Arterial and venous HCO_3^- in which Arterial HCO_3^- (13.10) levels are less than venous HCO_3^- levels with the p-value of 0.056 which is not significant.

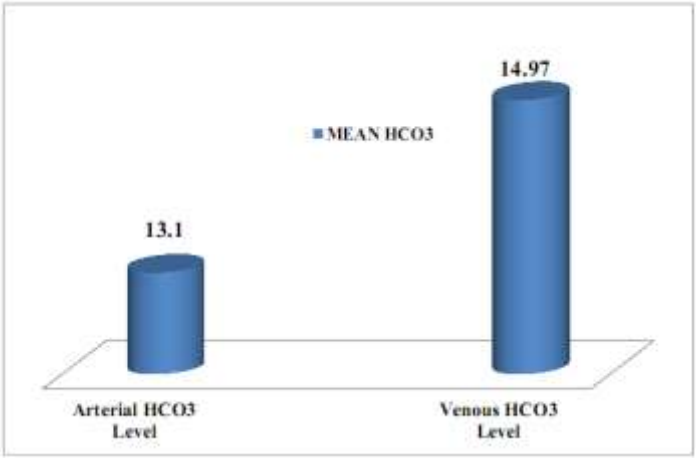

Fig-5: Association between arterial & venous HCO_3 Level

Figure 6 which reveals correlation between arterial and venous parameters reveals all the correlation coefficient (r) are positive and only pH, pCO_2 and HCO_3^- are highly significant.

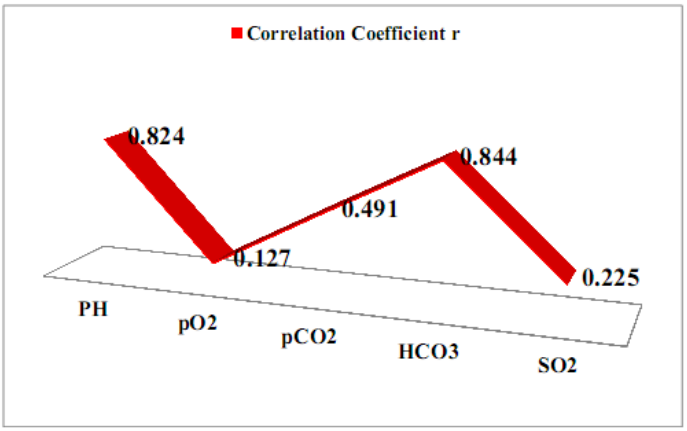

Fig-6:Pearson Correlation between various arterial & venous parameter

DISCUSSION

VBG analysis clearly does not replace ABG analysis but may be a safer alternative to ABG analysis for determining acid-base status, reducing the need for frequent invasive arterial sampling. A number of studies have suggested that there is agreement between ABG and VBG values, although most of the previous studies 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) [2, 5, 7, 8]. A few authors even expressed doubts about the use of VBG values in lieu of arterial values [9, 10]. The aim of this study was to investigate the agreement between ABG and VBG samples for all commonly used parameters (pH, pCO_2, pO_2 and bicarbonate) in a pathologically diverse ICU patient population.

Peripheral as well as central venous samples have acceptable agreement with ABG values whose results were obtained by Tregger *et al*[11].

No previous study has assessed whether all patients share a common relationship between arterial and venous pH, pCO_2, pO_2 and bicarbonate. Factors that are intrinsic to each individual patient, as well as their differing pathophysiologic states, could result in differential CO_2 unloading at the tissue level; therefore, it cannot be presumed that all patients have a common relationship between ABG and VBG values. Obtaining paired arterial and venous samples from each patient allowed us to perform homogeneity tests, which revealed that arterial *versus* venous intercept and slope for pH, pCO_2, pO_2 and bicarbonate had *P* values of 0.085, 0.001, 0.001 and 0.051, respectively; therefore, there is a association between arterial and venous pH, and bicarbonate for all patients, but not for pCO_2 and pO_2 allowing all 50 observations to be pooled for the remainder of the analysis

There is excellent agreement between arterial and central venous values for pH and bicarbonate, which is consistent with the results of other studies in the literature [7, 9,12, 13]. In regard to pH, the mean arterial minus venous difference was 0.051 (SD 1.742) and P value of 0.085 (Figure 2). This probably indicated poor limits of agreement with significant correlation between pH of arterial and venous blood gases which was in accordance to previous authors. Like Malinoski *et al* in 2005 evaluated poor limits of agreement between pH of arterial and central venous blood gases although correlation was statistically significant.

With respect to bicarbonate, Figure 5 reveals the association between Arterial and venous HCO_3^- in which Arterial HCO_3^- (13.10) levels are less than venous HCO_3^- levels with the p-value of 0.056 which is not significant (Figure 5). Previous studies which determined the extent of agreement between arterial and central venous blood gases of bicarbonate by Middleton et al showed acceptable limits of agreement and concluded that bicarbonate of central venous blood gases could replace bicarbonate of arterial blood gases in many clinical contexts in ICU.

Figure 4 reveals the association between Arterial and venous pCO_2 in which Arterial pCO_2 (23.19) levels are less than venous pCO_2 (30.39) levels with the p-value of 0.001 which is highly significant (Figure 6). Previous literature showed 95% limits of agreement between the arterial and central venous values for pCO_2 like our study. Kelly *et al.*[14], which demonstrated a mean arterial minus venous difference of 5.8 with a 95% limits of agreement of 8.8 to 20.5. Study by Malinoski *etal.*[9], which showed a mean arterial minus venous differenceof 4.36 with 95% limits of agreement of 2.20 to 10.90 and Malatesha *et al.*[7], which revealed a mean arterial minus venous difference of 3.0 with 95% limits of agreement of 7.6 to 6.8. Overall, the results of our study in regard to pCO_2 are consistent with the existing literature. Given that blood gas values should be interpreted in the context of the individual patient's clinical status and that frequently serial blood gases are obtained to help assess a patient's course, venous pCO_2 largely should be able to replace arterial pCO_2 in most clinical circumstances.

Figure 3 reveals the association between Arterial and venous pO_2 in which Arterial pO_2 (113.78) levels are more than venous pO_2 (42.27) levels with the p-value of 0.001 which is highly significant. The widespread availability of pulse oximetry has encouraged the interpretation of oxygen saturation as a crude estimate of the pO_2 without the need for blood sampling and has resulted in fewer ABG analyses being performed [15].

This high level of correlation between arterial and venous parameters reveals that all the correlation coefficient (r) are positive and only pH, pCO_2 and HCO_3^- are highly significant as an acceptable substitute for an arterial estimation.

CONCLUSIONS

The data we reviewed revealed us that venous blood gas analysis has the potential to be of great importance in the ICU setting in general as well as for patients presenting with different diagnosis. The blood gas values for pH and HCO_3^- showed excellent association and correlation and can be considered clinically interchangeable with arterial values. On venous pCO_2 we found differing results and therefore suggest the possible implementation of arterialization of venous blood gas which will make all these values even

more accurate and will allow the use of venous pCO2 in the clinical setting. The use of venous blood gas values has shown to be cost-effective and implementation of this procedure in the routine venous blood sampling will prove to be time and money saving, as it as well will reduce the risk factors for the patient and the health care worker. In presentations were pO2 values have to be determined there were not enough data to say that venous can be used in place of arterial values.

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Conflicts of interest -There are no conflicts of interest.

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