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Agreement of Arterial Sodium and Arterial Potassium Levels with Venous Sodium and Venous Potassium in Patients Admitted to Intensive Care Unit

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ABSTRACT

Introduction: Electrolyte abnormalities are one of the common causes of morbidity and mortality in critically ill patients. The turnaround time for electrolyte reporting should be as low as possible. Electrolytes are measured conventionally in serum obtained from venous blood by electrolyte analyser which takes 20 to 30 min. Point of care analysers are now available where in electrolytes can be measured in arterial blood within 5 min. This study was done to study the agreement of arterial sodium and arterial potassium with venous sodium and venous potassium levels.

Materials and Methods: Venous sodium and venous potassium levels and arterial sodium and arterial potassium levels were analysed on 206 patient samples admitted to Intensive Care Unit (ICU). The venous values were compared with the arterial values for correlation. Venous sodium was compared with arterial sodium by spearman correlation. Venous potassium was compared with arterial potassium by pearson correlation.

Results: The mean value of arterial sodium was 134 and venous sodium was 137. The mean value of arterial potassium was 3.6 and venous potassium was 4.1. The correlation coefficient obtained for sodium was 0.787 and correlation coefficient obtained for potassium was 0.701. There was positive correlation of arterial sodium and arterial potassium with venous sodium and venous potassium indicating agreement between the parameters.

Conclusion: Arterial sodium and arterial potassium can be used instead of venous sodium and venous potassium levels in management of critically ill patients.

Keywords: Critical Illness, Electrolytes, Potassium, Sodium

INTRODUCTION

Electrolytes are measured in all the patients admitted to intensive care unit conventionally. Electrolyte abnormalities are one of the common reversible causes of morbidity and mortality in intensive care unit (ICU) patients [1].

Inaccurate sodium results can lead to inappropriate fluid administration which can result in hypernatremia. One of the reversible causes of cardiac arrest is abnormalities in potassium concentrations. Bradycardia and asystole can be caused by hyperkalemia and cardiac arrhythmias can be caused by hypokalemia. Fluctuation in potassium levels is also well-documented during the course of cardiac resuscitation [2]. Accurate estimation of electrolytes has gained additional importance in diagnosis of etiology of various diseases as it is used to calculate anion gap. The turnaround time (TAT) for electrolytes should be kept as low as possible, so that early management of electrolyte abnormalities can be initiated. Conventionally, electrolytes are measured in serum obtained from venous blood which is analysed by an electrolyte analyser [2].

The limitation of electrolyte measurement in serum is delayed turnaround time which is around 20 to 30 min. To overcome this limitation of serum electrolyte measurement in electrolyte analyser, Point of care Arterial blood gas analysers can be used to measure electrolytes in arterial blood where in results are available within 5 min thus decreasing the turnaround time. The differences between arterial blood gas (ABG) machines and electrolyte analyser are listed in [Table/Fig-1]. Previous studies that measured the accuracy of electrolyte values obtained by ABG analysers concluded that the results obtained from point of care ABG analyser differed significantly for sodium and potassium concentrations which affected the calculated anion gap and strong ion difference values. Thus the reliability of electrolytes measured in point of care testing ABG analyser is still questionable [3,4]. Some authors in their study have observed electrolytes measured in point of care analysers showed acceptable accuracy [5].

There are very few published data regarding the comparison of venous electrolytes and arterial electrolytes. In this study, we aimed to study the agreement between sodium and potassium measurements in venous and arterial samples.

MATERIALS AND METHODS

The study was a retrospective study. The study was conducted from April to June 2014. Two hundred and six samples obtained from intensive care unit patients of Pondicherry Institute of Medical Sciences were included in the study. Out of the 206 samples, 126 were from male patients and 80 were from female patients. Only those patient samples were included in the study where the arterial and venous electrolytes results were available. The arterial and venous electrolyte values were obtained from the laboratory records. The time of receiving the samples by the laboratory was noted. The time was matched for both venous and arterial samples of patients and only those patients were included where the difference between receiving of venous and arterial electrolytes did not exceed 20 min. The arterial and venous samples of patients which were received by the laboratory beyond 20 min interval were excluded from the study. The venous electrolytes were measured by Easylyte electrolyte analyser from transasia. The electrolytes in arterial sample were measured by Cobas B121 ABG analyser from Roche diagnostics.

STATISTICAL ANALYSIS

The statistics in the study were descriptive statistics which included mean, standard deviation, minimum and maximum values. The data of sodium and potassium was entered in Microsoft excel for windows. Arterial sodium was correlated with venous sodium by spearman's correlation. Arterial potassium was correlated with venous potassium by Pearson correlation. Scatter plot was employed to represent arterial and venous sodium and potassium. Scatter plot was used to derive the formula for predicting venous electrolyte values from arterial electrolytes.

RESULTS

The results of the study are illustrated in [Table/Fig-2,3].

S. No	Blood gas analyser	Electrolyte analyser
1	Whole blood analysed	Serum sample analysed
2	Heparinized sample used	Serum sample used without anticoagulant
3	TAT is short – within 5 mins	TAT is long – within 30mins
4	Urine electrolytes cannot be measured	Urine electrolytes can be measured

[Table/Fig-1]: Differences between the blood gas analyser and electrolyte analyser

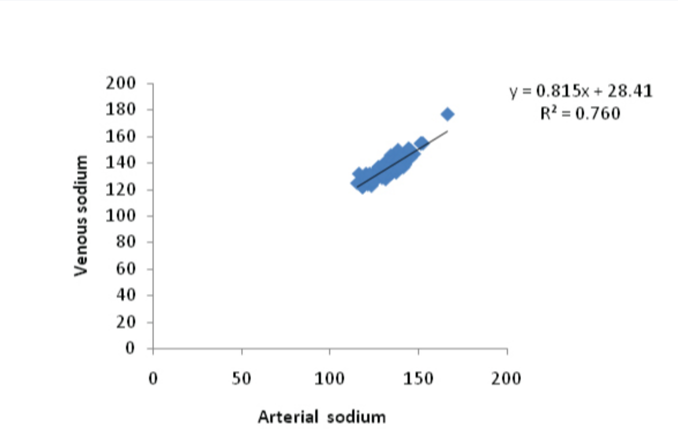
Parameter	Mean value	Minimum value	Maximum value
Arterial Sodium	134	115	166
Venous Sodium	137	122	177
Arterial Potassium	3.6	2.3	5.8
Venous Potassium	4.1	2.3	5.9

[Table/Fig-2]: Mean value, minimum value, maximum value of the parameters studied

Parameter	Correlation coefficient
Sodium	0.787
Potassium	0.701

[Table/Fig-3]: Correlation coefficients for the parameters studied

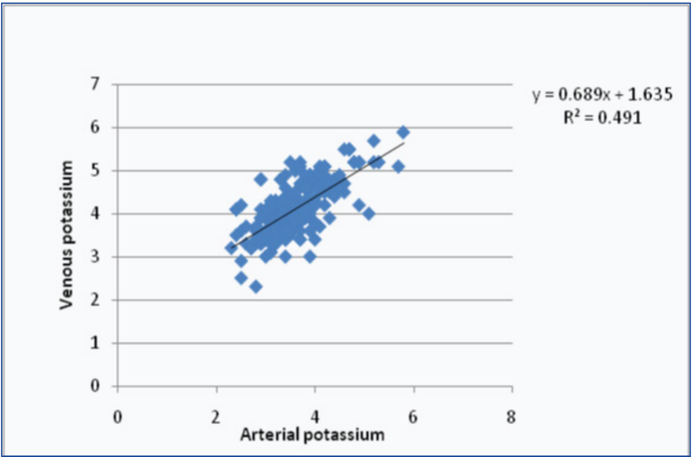
The mean arterial sodium was 134 and the mean venous sodium was 137. The mean arterial potassium was 3.6 and the mean venous potassium was 4.1. The correlation coefficient for sodium was 0.787 and the correlation coefficient for potassium was 0.701. There was positive correlation of arterial sodium and arterial potassium with venous sodium and venous potassium. The arterial and venous sodium are illustrated through scatter plot in [Table/Fig-4]. The arterial and venous potassium are illustrated through scatter plot in [Table/Fig-5]. Scatter plot for sodium illustrates that venous sodium can be derived from arterial sodium by the formula, Venous sodium = 0.81 x arterial sodium + 28.4. Scatter plot for potassium is illustrated in [Table/Fig-5]. Scatter plot for potassium illustrates that venous potassium can be derived from arterial potassium by the formula, Venous potassium = 0.68 x arterial potassium + 1.6.



[Table/Fig-4]: The venous sodium values (in mEq/L) are plotted in y axis and arterial sodium values are plotted in X axis

DISCUSSION

Development in technology in point of care analysers has led to measurements of multiple parameters in whole blood. Point of care testing analysers has gained lot of importance because of low TAT which is desirable in management of critically ill patients [2]. In the present study, the mean values of arterial sodium and arterial potassium values were found to be lower than venous sodium and venous potassium. Johnston and Murphy observed higher levels of potassium in arterial sample when compared to venous sample which was not comparable to the findings of the present study [2]. Mehta V et al., observed that venous values of potassium were higher than arterial levels which was comparable with the findings of the present study [6].



[Table/Fig-5]: The venous potassium values (in mEq/L) are plotted in y axis and arterial potassium values are plotted in X axis

S Rajavi et al., observed higher levels of sodium and potassium in serum when compared to sodium and potassium in arterial blood. According to S Rajavi et al., the lower arterial values could be explained by dilutional effect of heparin since arterial samples are collected in heparinized containers [7]. In the present study, the value of venous sodium could be calculated from arterial sodium by the formula, venous sodium = 28.4 $\pm$ 0.81 x arterial sodium. The value of venous potassium in the present study could be calculated by the formula, venous potassium = 1.6 $\pm$ 0.68 x arterial potassium. S Rajavi et al., observed in their study that venous sodium could be calculated by the formula 106 + 0.23 x arterial sodium and venous potassium could be calculated by the formula 1.96 + 0.69 x arterial potassium [7].

Wongyingsinn M et al., observed a good correlation between arterial and venous potassium and they stated that arterial potassium can replace measurement of venous potassium [8]. Chhapola V et al., observed that arterial blood gas analysers underestimate sodium and potassium levels if arterial samples are collected in liquid heparinized containers [9]. The underestimation of electrolytes due to liquid heparin can be avoided by use of lyophilized heparinized containers for collection of arterial blood. Fu P et al., studied on potassium levels in patients with diabetic ketoacidosis and concluded that arterial potassium cannot be used as a substitute to serum potassium in patients with diabetic ketoacidosis [10]. Flegar Mestric Z et al., observed that electrolytes measured in whole blood by point of care analyser were comparable to electrolytes measured in plasma or venous serum samples [5].

Anunya Jain et al., observed that there was no significant difference between potassium measured in ABG analyser and potassium measured by routine chemistry auto analyser but they observed significant difference between sodium measured by ABG analyser and sodium measured by chemistry autoanalyser. According to Jain A et al., the cause for lower values of electrolytes in arterial blood is because of binding of heparin to electrolytes [11]. R King et al., observed that there was good agreement between the sodium and potassium values measured by ABG analyser and chemistry autoanalyser [12]. Binila Chacko et al., observed that there was significant difference between arterial and venous sodium levels and arterial and venous potassium levels which was not comparable with the findings of the present study. Binila Chacko et al., suggested such studies to be conducted in each center and a correction factor need to be established which needs to be added to the arterial electrolyte values to derive the accurate electrolyte values [13]. According to Chacko B et al., the reasons for such differences between the arterial and serum electrolytes could be attributed to difference in sample, whole blood and serum, difference in the type of electrode used and difference in the use of calibrators [13]. Herrington WG et al., observed that potassium values of arterial samples were in agreement with the potassium values measured in serum [14]. Shilpi Awasthi, et al., observed that there was a strong correlation between the arterial sodium and potassium and venous sodium and potassium which were similar to the findings of the present study [15].

In the present study, the bias for sodium was 0.9 and for potassium was 0.3 which is within the acceptable bias as per Clinical Laboratory Improvement Amendment (CLIA) guidelines. As per CLIA guidelines, the acceptable bias for sodium is target value + 4 mEq/L and for potassium, the acceptable bias is target value $\pm$ 0.5 mEq/L. Budak YU et al., observed a bias of 4.9 for sodium and a bias of 0.25 for potassium. According to Budak YU et al., one of the causes for high serum potassium levels when compared to arterial potassium levels was the release of potassium from platelets during the clotting process [16].

CONCLUSION

Sodium and potassium analysed in point of care ABG analyser is comparable to the sodium and potassium levels measured in electrolyte analyser and ABG electrolytes can be used as a replacement to electrolytes measured in electrolyte analyser.

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