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Research Article

Comparison of Serum Sodium and Potassium Levels; Based On Two Methods Arterial Blood Gas and Automatic Laboratory Analyzers

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ABSTRACT*:*
Background: Electrolytes are substances carrying electric charge and are crucial for proper cellular function in most of body tissues. Concerning the importance of quick measurement of electrolytes in emergency cases, this study was designed to compare results from Arterial Blood Gas (ABG) analysis and laboratory Automatic Analyzers (AA) test for determination of electrolytes in the patients.
Patients and Methods: In this cross-sectional study, 88 files from Sayyad Shirazi Hospital in Gorgan (Iran) during 2015 were chosen using simple random sampling (44 for each group). Results from both AA and ABG analyses for blood Na and K were recorded in these files. The results of AA and ABG tests for sodium and potassium determination were compared.
Results: The mean sodium levels measured in the samples were 136.35±5.25 mmol/L by AA and 140.89±6.37 mmol/L by ABG test. The determined sodium levels were significantly correlated in the two methods (Pearson correlation coefficient= 0.55 and P<0.001). Mean levels of potassium in the samples were 4.52±0.71 mmol/L in AA test and 3.52±0.75 mmol/L in ABG test. The determined potassium levels were significantly correlated in the two methods (Pearson correlation coefficient= 0.53 & P<0.001).
Conclusion: In general, there is a significant correlation between the arterial blood gas analysis and the laboratory auto-analysis in determination of sodium and potassium.

Keywords: Arterial Blood Gas, Analyzer, Laboratory Auto-Analyzer, Sodium, Potassium.

INTRODUCTION

Electrolytes are substances carrying electric charge; and they're crucial for proper cellular function in most of body tissues (1). Electrolyte disorders may cause serious risks for man's life. Levels of electrolytes are measured for every critically ill emergency patient and also for patients hospitalized in the intensive care unit (ICU) (2) .Generally there are two methods for

determination of serum electrolytes; direct and indirect. In both methods ion-selective electrodes are utilized. In the indirect method, which is the gold standard method for determination of sodium and potassium, the samples usually get diluted and the procedure is done by the auto-analyzer (**AA**).(3-5) In the direct method, the electrodes are fully in contact with no diluted blood sample. Arterial blood gas (**ABG**) analyzer or points of care testing (POCT) are mostly used in this method (2). AA method is carried out in a hospital central laboratory which may lead to long delay (several hours in some cases) between the time of test application and receiving results (2). However, ABG and POCT methods help doctors do the initial clinical treatments; and these methods are also clinically and economically cost-effective for the patients (6). Earlier studies that evaluated the accuracy of ABG analyzers in measuring electrolytes came to this conclusion that the results of these two separate measurement technologies are meaningfully different for serum sodium and chlorine concentration. This difference was notably calculated as anion gap (**AG**) and influenced ion levels (7-9). Other studies have found significant differences between ABG analyzers and more advanced analyzers measuring pH, potassium and hematocrit (10-15). Also some studies have mentioned a high degree of accordance between the results of these two methods for determining blood gases and pH (16, 17). Therefore, considering the importance of rapid analysis of electrolytes in emergency cases and the potential value of ABG analyses for sodium and potassium in critical conditions, and the necessity of time and expense saving, for the first time in north of Iran, this study was designed to compare the results from AA and ABG methods for sodium and potassium determination in the patients admitted to Sayyad Shirazi Hospital in Gorgan (Iran).

MATERIALS AND METHODS

The study population included all the patients admitted to Sayyad Shirazi Hospital in Gorgan (Iran) during 2015. In the beginning, the files of patients, hospitalized in different departments of hospital, were assessed. The inclusion criteria were if the results of both AA and ABG methods were recorded in the file and the exclusion criteria were patients which had undergone interventions for treatment of fluid and electrolytes imbalance. The data including age, sex and other variables were separately recorded in data forms for every patient. After checking 826 files, 88 samples were extracted and registered randomly.

The patients were divided into two groups based on the median age; middle-aged (< 50yrs) and old (≥50yrs). They were divided into three groups according to their blood pH indicated by ABG analysis; normal pH (7.35≤pH≤ 7.45), acidosis (pH< 7.35) and alkalosis (pH> 7.45). Mean serum sodium and potassium levels, by AA and ABG methods, were assessed both generally and individually in different groups based on pH, age, sodium and potassium levels.

In the laboratory of hospital, a device named *OPTI CCA-TS* was used for ABG analysis, which measured serum sodium and potassium level by photometry; and there was a *Biolyte 2000* auto-analyzer too, that was only utilized for determination of serum sodium and potassium.

STATISTICAL ANALYSIS

The obtained data were analyzed by SPSS-18 software. Frequency, percentage, mean level and standard deviation were used to describe the data; and to determine the correlation between the results from the two methods, *Pearson correlation coefficient* was used.

To measure the mean difference between the two methods in terms of sodium and potassium levels in different groups, the independent *t-test* and *ANOVA test* were used. Differences were considered significant at $P<0.05$.

RESULTS :

Among the 88 patients who participated in this study, demographic data was according to table 1.

Table 1. Demographic data of patients

Variable		Patients
Age (yrs)		53.77±12.3
Gender (Male N-%)		48 (54.5)
Group	Middle aged (%)	43 (48.9%)
	Old (%)	45 (51.1%)
Blood acidity	acidosis	16 (18.2%)
	normal range	56 (63.6%)
	alkalosis	16 (18.2%)

The mean sodium levels determined by AA and ABG methods were significantly correlated. (P<0.001) Another significant correlation was seen in mean potassium levels indicated by these two methods (table 2).

Table 2: Comparison of mean levels of sodium and potassium, in the entire sample and their correlation coefficient (N=88).

Electrolyte	Analysis method	Mean level	Pearson's correlation coefficient	Mean difference in results of the two methods	SD	P value
Sodium(mmol/L)	AA	136.35±5.2	0.55	5.4	2.7	0.001 P<
	ABG	140.89±6.3				
Potassium(mmol/L)	AA	4.52±0.7	0.53	1.7	0.61	0.001 P<
	ABG	3.52±0.7				

The mean differences in sodium and potassium levels determined by AA and ABG analyses, also was evaluated. In groups of normal pH, acidosis and alkalosis, mean sodium levels, measured by AA and ABG methods, were significantly correlated (P<0.001); however, in terms of potassium level, the correlation was significant for normal pH and alkalosis groups but not significant in acidosis group.(P>0.05)(table 3)

Table 3: Evaluation of correlation coefficients in sodium and potassium levels, determined by the two methods, in different pH groups

Acidity	Analysis method	Mean	Correlation coefficient	P value
Sodium				
Normal acidity	AA	136.32±5.4	0.53	P< 0.001
	ABG	141.61±7.2		
Acidosis	AA	135.25±6.2	0.78	P< 0.001
	ABG	139.19±4.5		
Alkalosis	AA	137.5±2.7	0.62	P = 0.01
	ABG	140±3.7		
Potassium				
Normal Acidity	AA	4.44±0.7	0.54	P< 0.001
	ABG	3.37±0.6		
Acidosis	AA	4.88±0.6	0.23	P = 0.39
	ABG	4.18±0.9		
Alkalosis	AA	4.44±0.5	0.72	P = 0.001
	ABG	3.37±0.6		

DISCUSSION

Electrolyte abnormalities are one of the common reversible causes of morbidity and mortality in patients admitted in hospitals. The levels of electrolytes need to be monitored on regular basis in the patients which are ordered in ABG or serum sample as per the convenience of sampling and requirement. The results of both types of measurement are used in inter exchangeable manner with the assumption that they are equivalent. There are a lot many controversies in the reports of the estimation of electrolytes of serum and ABG from different hospitals. The Research Gate Discussion on correlation between

electrolytes in blood gases and serum electrolytes ensued that the serum electrolytes are more reliable, while some argue accuracy depends on the machines.

In present study we suggest that ABG method shows higher results in sodium level and lower results in potassium level. In the study of *Quinn et al (2013),* conducted on 100 patients, serum sodium and potassium levels did not show any significant difference in the physiological range; however, in terms of hyperkalemia range (potassium > 5 mmol/L), the results of ABG analyses were noticeably different from the standard venous tests (difference = 0.44 mmol/L and P<0.0013). In our study, sodium levels reported by the two methods, had the least correlation coefficient (P=0.105). Potassium levels reported by the two methods represent the most correlation coefficient (P=0.002) in hyperkalemia cases unlike the above-mentioned study. In hypokalemia cases there was not any significant correlation (P=0.505) while showing the least mean difference in measurement by the two methods. The study of *Chhapola et al.(2013),* conducted on 59 patients, evaluated mean level of sodium in both methods and found meaningful data comparing the results of ABG analyzers to AA. however, of the potassium level, this difference was meaningful in hyperkalemia and normokalemia subgroups. This difference was not significant in hypokalemia cases. In our study, mean sodium levels of the entire sample were 136.35 mmol/L and 140.89 mmol/L calculated by auto-analyzer and ABG analyzer, respectively. The difference of the mean levels was 4.54; and these values were significantly correlated (P<0.001). This correlation was minor in normonatremia group comparing to hyponatremia. Mean levels of potassium determined for the entire sample were 4.52 and 3.52 by auto-analyzer and ABG analyzer, respectively. The difference of the numbers was 1, and a significant correlation was seen in these values (P<0.001). This correlation was less in hypokalemia cases comparing to normokalemia and hyperkalemia groups. However as well as the mentioned study, in hypokalemia cases the difference between the results of the two methods was 0.45 and non-significant.

About the study of *Budak et al*.(2012) on 84 patients, results indicated that sodium and potassium levels, measured by ABG an AA methods, are not equal. The results of our study are confirmed concerning the inequality of AA an ABG test results.

The study of *Jain et al*., which was done on 200 patients, indicated that there is a statistical difference between the two devices measuring sodium; however, there was no meaningful difference in potassium levels determined by the two devices. In our study, significant differences were observed between the two methods for measurement of both sodium and potassium.

CONCLUSION

According to our findings, there is a significant correlation between the results of auto-analyzers and arterial blood gas analyzers in determination of serum sodium and potassium levels. Acidosis, hypokalemia, hyperkalemia and alkalosis groups had the highest sodium levels measured by both methods; and in terms of potassium level, hyperkalemia and alkalosis groups were the highest.

Conflict of interest

The authors declare that they have no conflict of interests.

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