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USE OF CAUTION WHILE INTERPRETATION OF ELECTROLYTE RESULTS (SODIUM AND POTASSIUM) WHEN PROCESSED ON ELECTROLYTE ANALYZER OR ON ARTERIAL BLOOD GAS ANALYZER

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ABSTRACT

Objectives

Accurate electrolyte results are important for management of critically ill patients hence this retrospective study was planned to compare these results processed on different instruments using the same direct ion-selective electrode technology.

Material and Methods

This was a retrospective study conducted in the Central Biochemistry Laboratory (CBL) of Punjab Institute of Medical Sciences, Jalandhar, from March 2017 to September 2017. Paired samples of whole blood and serum were analyzed from 500 patients. ABG samples received in heparinized syringes were processed Medical Easy Stat ABG analyzer (Medica Corporation, Bedford, USA) and serum electrolytes were analyzed on Aciculate electrolyte analyzer (AEA) by Compact diagnostics India Pvt. Ltd. The data were compared and analyzed using Microsoft Excel 2010. The inter-instrument comparison was also done using Bland-Altman plots.

Results

There was a total of 500 patients for comparative analysis 284 males and 216 females with a mean age of 54 years. The values for electrolytes were higher on electrolyte analyzer as compared to ABG analyzer for sodium they were 136.70±9.28 mEq/L and135.30±11.66 mEq/L, ($p<0.01$) and for potassium they were 4.26 ±1.10 mEq/L and 3.50±1.03 mEq/L respectively ($p<0.05$). the difference observed in the two instruments was statistically significant.

Conclusions

The results of the ABG analyzer can be used as a guideline to initiate primary treatment for critically ill patients but decide on definitive treatment only after the availability of serum electrolyte results.

KEYWORDS: *Critically Ill Patients, Paired Samples, Medica Easy Stat ABG Analyzer, Acculite Electrolyte Analyzer (AEA).*

Article History

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INTRODUCTION

Background

Electrolytes are one of the most commonly requested critical biochemical marker in the clinical laboratory. They are essential components of the tissues and helps in maintenance of various cellular functions like cell membrane potential, neurohormonal pathways, energy transformation, fluid and acid base balance of the body (1-4). The electrolytes levels (sodium and potassium) are important for predicting the patient outcome in critically ill or ICU patients, hence the availability of early results helps in the correction of electrolyte imbalance promptly and improves the patient outcome (5, 6, 7).

In Clinical biochemistry laboratory sodium and potassium levels can be analyzed both in whole blood and serum, but if the prompt report is required the electrolytes sodium and potassium are processed on arterial blood gas analyzer because the electrolyte analyzer requires a serum sample which takes time to separate(8).

In a laboratory, the most common and fast method of estimating is by the ion selective electrode (ISE). It is of two types of direct ISE which processes the undiluted sample and indirect ISE which processes the sample after dilution. These analyzers could range from a POCT device to a benchtop analyzer or a fully automated Biochemistry analyzer (8, 9, 10).

Various studies that have been performed for assessing the efficacy of electrolyte analyzers have reported variable results. There is a significant difference in electrolyte concentration processed on POCT devices compared to central laboratory analyzer(11-13) but many other studies observed comparable values and thus, can be used interchangeably for reporting the electrolytes with equivalent significance(14, 15).

The aim of our study was to evaluate if sodium and potassium values of paired arterial and serum samples, processed on two different analyzers i.e. ABG analyzer and electrolyte analyzer are equivalent and if they can be used interchangeably for reporting.

MATERIAL AND METHODS

This was a retrospective study conducted in the Central Biochemistry Laboratory (CBL) of Punjab Institute of Medical Sciences, Jalandhar, from March 2017 to September 2017. The data was collected from Inpatients mainly from emergency and Intensive care unit (ICU). A total of 500 patients whose paired venous and heparinized arterial samples were received simultaneously within 30 minutes, were included in the study. NICU patients and haemolysed samples were excluded from the study group. The ABG samples were received in heparinized syringes and processed within 15 minutes on Medica Easy Stat ABG analyzer (Medica Corporation, Bedford, USA). The serum electrolytes were analyzed on Acculite electrolyte analyzer (AEA) by Compact diagnostics India Pvt. Ltd. Both the machines were standardized daily by ensuring strict maintenance protocols and running daily internal quality controls. EQAS sample was also processed monthly as a part of external quality assurance.

The biological reference ranges used for reporting for sodium and potassium were 135-150 mEq/L and 2.5-5.0 mEq/L.

Statistical Analysis

The data were compared and analyzed using Microsoft Excel 2010. Mean, standard deviation and two-tailed P value were calculated. Any P value <0.05 was considered statistically significant. The inter-instrument comparison was also done using Bland-Altman plots.

RESULTS

After exclusion of haemolysed and paediatric (<10years of age) samples, a total of 500 patients were taken for this retrospective comparative study. In our study, we compared the electrolyte analyzer values with the ABG analyzer values for both Sodium and Potassium. 284 males with a mean age of 53.9 yrs and 216 females with mean age of 54.1 yrs were included in the study. The overall mean age of the study group was 54yrs.

The mean Sodium values on Electrolyte analyzer and ABG analyzer were 136.70±9.28 mEq/L and135.30±11.66 mEq/L, respectively ($p<0.01$) as shown in Table 1. A comparative difference mean between electrolyte analyzer samples and ABG analyzer samples for sodium was 1.39 mEq/L with SD ±7.56 mEq/L. (Table 2) The 95% confidence interval of the difference was 0.725- 2.05 mEq/L. (Table 3)

The mean potassium values on ABG analyzer was 3.50±1.03 mEq/L as compared to 4.26 ±1.10 mEq/L on Electrolyte analyzer ($p<0.05$). (Table 1)The mean difference for potassium was 0.70 mEq/L with SD ±0.65 mEq/L (Table 5). The 95% confidence interval of the difference for potassium was 0.644-0.756 mEq/L. (Table 6)

Table 1: Comparison of Mean Values of Na+ and K+ from ABG Analyzer and Electrolyte Analyzer

Analyte	ABG Analyzer Mean±SD	Electrolyte Analyzer Mean±SD	P
Sodium (mEq/L)	135.30±11.66	136.70±9.28	0.01
Potassium (mEq/L)	3.5±1.03	4.26 ±1.10	0.05

Table 2: Sodium Mean Difference with SD

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Na_difference	500	1.3900	7.56706	.33841

Table3: Mean of Difference for Sodium between Electrolyte and ABG Analyzer Results with 95% Confidence Interval

One-Sample Test						
	Test Value = 0					
	T	Df	Sig. (2-Tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Na_difference	4.107	499	.000	1.39000	.7251	2.0549

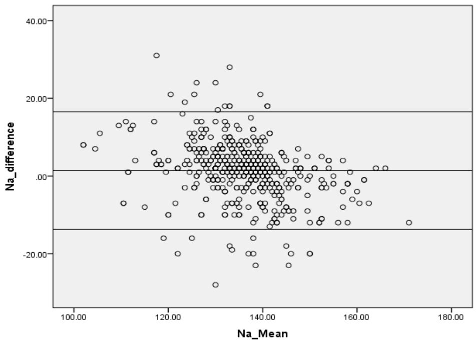

Figure 1: Bland-Altman Plot of Sodium Showing Sodium Difference (Serum Sodium – Arterial Sodium) with a Bias of 1.39meq/L and A 95% Confidence Interval Difference Of 0.725to 2.05 Meq/L

Table 4: For Sodium there is a Proportionate Bias the Values on Two Test Showed a Constant Disproportion.

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	36.419	4.430		8.221	<0.01	27.715	45.123
	Na_Mean	-.258	.032	-.335	-7.928	<0.01	-.321	-.194
A Dependent Variable: Na difference								

Table 5: K Difference and SD

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
K_difference	500	.7015	.64996	.02907

Table 6: Mean of Difference for Potassium between Electrolyte and ABG Analyzer Results with 95% Confidence Interval

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.396	.115		3.452	.001	.170	.621
	K_Mean	.078	.028	.123	2.759	.006	.023	.134
A Dependent Variable: K difference								

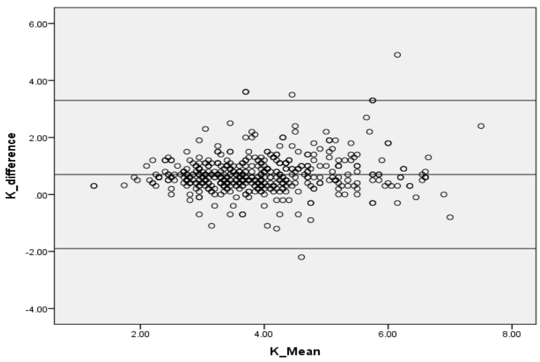

Figure 2: Bland-Altman Plot Showing Potassium Difference (Serum Potassium– Arterial Potassium) with a Bias of 0.701meq/L and A 95% Confidence Interval Difference of 0.644to 0.758 Meq/L

For Potassium too, there is a proportionate Bias The values on two test showed a constant disproportion.

For Sodium and potassium, there is a positive proportionate Bias. The values reported by electrolyte analyzer were higher as compared to the ABG analyzer. The values on the two test showed a constant disproportion.

DISCUSSIONS

In the present study, we investigated whether sodium and potassium values measured on two different instruments working on the same principle were equivalent, and if so, the data can be employed interchangeably in routine practice. The US CLIA 1988 rules accept a difference of 4.0 mmol/L in sodium levels and 0.5 mmol/L in potassium levels. In our study, the difference in sodium and potassium levels was 1.39 mmol/l and 0.7 mmol/l. The values showed a positive bias for electrolyte values as compared to the ABG values.

Previous studies by Yasemin et al 2012, Jain A & Chow E 2008 (16) also showed similar results as that sodium values analyzed on two different instruments differed significantly to an extent that it affects therapeutic choice.

In another study undertaken by Morimatsu et al,21 it was seen that that results of electrolyte analyzer and ABG analyzer were significantly different for sodium and chloride levels. The differences in the electrolyte values significantly affect the true calculation of the anion gap and hence delay the timely correction of the deficit if any present. Another study by Chacko et al(22) also showed that the values obtained by the two analyzers were different.

Similarly, potassium values obtained on ABG analyzer and Electrolyte analyzer differ significantly ($p<0.1$). The observed variations in K^+ values of paired samples may be due to differences in sample type i.e. serum and the whole blood. It is well-known fact that during clotting potassium is released from platelets, contributing to higher serum potassium levels than in whole blood. Whereas in whole blood sample various preanalytical factors affect the integrity of the sample e.g. inadequate mixing of heparin with the sample leading to clot formation, excess usage of heparin or incomplete flushing of heparin from the syringe leading to dilution of sample (17,18). The heparin has the ability to bind to the positively charged ions in the blood creating a negative effect on the electrolyte level which could be the reason for the negative bias in the ABG analyzer results. (19,20)

The observed differences between electrolyte levels measured on ABG analyzer and Electrolyte analyzer may be explained by a combination of factors like sample type, sample transport, variations in instrument calibration, use heparin, different manufacturer. (1)

CONCLUSIONS

The mean value of electrolytes (sodium and potassium) as measured by electrolyte analyzer were higher than the ABG analyzer values showing a positive proportionate bias more for the sodium result and lesser for the potassium results, hence these cannot be used interchangeably but at the same time the bias is positive and constant indicating that the values of ABG analyzer can be used as a guideline for to initiate the primary treatment for a critically ill patient but the clinician must decide on definitive treatment only after the serum electrolyte results are available The clinician must carefully interpret the electrolyte results in case of emergency. Another aspect for comparing the two results which need to be investigated is the use of conventional syringes flushed with liquid heparin which could possibly lead to some dilution of the sample and hence leading to low results for electrolytes on ABG analyzers.

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