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Are the electrolyte values of blood gas analyzer and a laboratory auto-analyzer comparable?

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Abstract

Our aim is to determine whether the levels of blood electrolytes assessed using blood gas analyzer and central laboratory auto-analyzer are equivalent. This retrospective study was conducted over six month period (October 2012- March 2013). A total number of 60 paired blood samples were drawn from pediatric and adult patients either in the intensive care unit or in the ward with a variety of diagnoses .Analysis of blood sodium and potassium levels was carried out using a point-of-care blood gas analyzer and a central laboratory auto-analyzer. Statistical measures were employed using paired t –tests. The mean level (± standard deviation) of sodium measured by blood gas analyzer was significantly higher than in the auto-analyzer (141.4 ± 7.3 mmol/L and 137.7 ± 5.6 mmol/L respectively; $P<0.001$). Regarding the potassium levels, there was also a significant difference between the mean level (± standard deviation) measured by blood gas analyzer and central laboratory auto-analyzer (3.2 ± 0.8 mmol/L and 4.2 ± 0.7 mmol/L respectively; $p<0.001$). Our results showed that sodium and potassium levels measured by blood gas analyzer and auto-analyzer were significantly different.

Key words: blood gas analyzer, auto-analyzer, electrolytes.

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Introduction

Measurement of electrolytes in blood is a commonly performed diagnostic test as the electrolytes are of major physiological importance for numerous functions of the body. Electrolyte abnormalities can represent significant risks to life [1]. Analysis of electrolytes such as sodium and potassium employs ion-specific electrodes (ISE), which includes two methods, direct and indirect [2]. The Direct ISE method is utilized by ion specific electrode modules (for electrolyte analysis) and does not involve sample dilution; this approach is obtained by blood gas analyzers (ABG). The Indirect assay includes pre-analytic sample dilution and is often employed in central hospital laboratories running automated analyzers (AA) [2, 3].

Measurement of electrolytes levels and detection of abnormalities is important in the assessment of ill adults and children, especially in intensive care units. Delay in detection of electrolyte abnormality may compromise the treatment of critically ill patients and then unfavorably impact outcomes [4, 5]. Assessment of electrolytes by auto-analyzers available in central laboratories of hospitals is time-consuming , particularly in developing countries due to delay in transporting samples to the central laboratory which results in a long turnaround time (usually over 15 minutes) [5-7]. On contrary, faster assessment of electrolytes can be achieved by blood gas analyzers [6].

Despite the advantage of short processing time present with ABG, questions have been raised regarding their reliability and accuracy. In this study we compared electrolyte values obtained from AA available in central laboratories (plasma – based

assays) and ABG (whole blood– based assays) to determine whether clinically relevant discrepancies might occur if testing is performed on both plasma (central laboratory) and whole blood (blood gas analyzer) .

Methodology

This retrospective study was approved by the Ethics Committee of Jordanian Royal Medical Services. It was conducted over six month period (October 2012- March 2013). We studied patients who had been hospitalized for some time in that interval. A total number of 60 paired samples were drawn from pediatric and adult patients either in the intensive care unit or in the ward with a variety of diagnoses. The collected samples included an arterial blood sample for blood gas analysis and a venous blood sample for auto-analyzer electrolyte measurement. The arterial blood samples were collected using heparin flushes in the syringes. Each paired blood samples were taken simultaneously and then analyzed for sodium (Na^+) and potassium (K^+) by blood gas analyzer present in intensive care unit and auto-analyzer present in the hospital central laboratory.

According to the hospital policy, daily calibration was done for both analyzers to perform accurate testing. The simultaneously measured blood Na^+ and K^+ concentrations were compared using paired t –tests. P-value of <0.05 was taken as statistically significant.

Results

Analysis of the sodium results revealed a significant difference in the mean level (± standard deviation) between whole blood samples measured by the ABG and serum samples measured by the auto analyzer (141.4 ± 7.3 mmol/L vs. 137.7 ± 5.6 mmol/L respectively ; P<0.001) as seen in table 1 and figure 1.

While the minimum difference in sodium level was zero mmol/L, the maximum difference was high reaching up to 16.7 mmol/L as table 2 showed. As the probability of the sodium results (P- value) is less than 0.001, the null hypothesis was rejected. Pearson correlation coefficient(r) was 0.41. Although it was a positive correlation, the relationship between sodium levels measured by the two methods was weak. Regarding the potassium levels, there was also a significant difference between the mean level (± standard deviation) measured by blood gas analyzer and central laboratory auto-analyzer (3.2 ± 0.8 mmol/L and 4.2± 0.7 mmol/L respectively; p<0.001), as showed in table 1 and figure 2. As a significant difference was detected, the null hypothesis was rejected.

The maximum difference in potassium level was 2.53 mmol/L and the minimum was zero mmol/L as seen in table 3. Pearson correlation coefficient(r) was 0.47 (weak positive correlation).

Table 1: Statistical analysis of sodium and potassium samples

Sample	**Sodium samples (n= 60) Mean ±SD (mmol/l)**	**Potassium samples (n= 60) Mean ±SD (mmol/l)**	**P - Value**
Blood gas analyzer	141.4±7.3	3.2±0.8	<0.001
Auto analyzer	137.7±5.6	4.2±0.7	<0.001

Table 2: Statistical analysis of electrolyte difference values between ABG and auto analyzer

Electrolyte	**Mean difference mmol/l**	**Max. difference mmo/l**	**Min. difference mmol/l**	**Pearson Correlation Coefficient(r)**
Sodium	7.03	16.7	0.0	0.41
Potassium	0.86	2.53	0.0	0.47

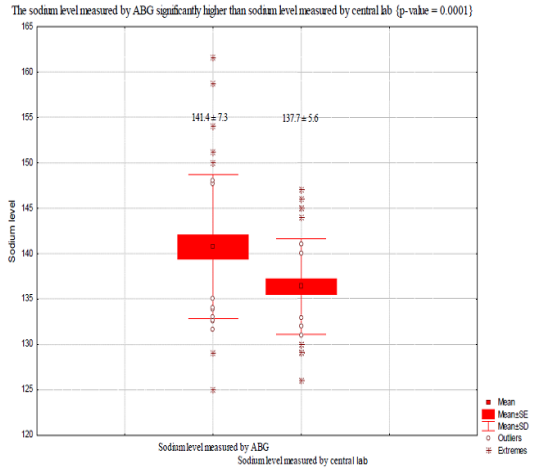

Figure 1

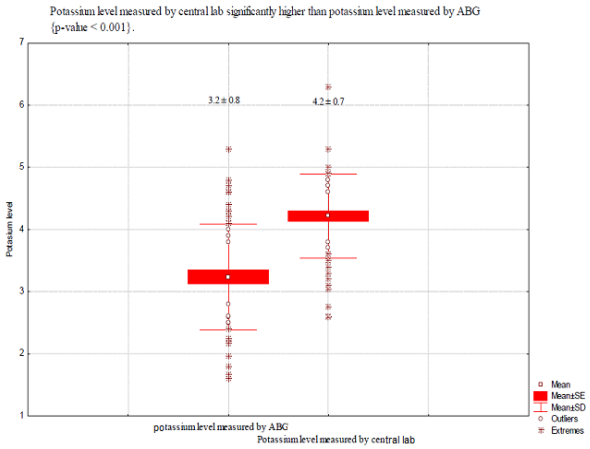

Figure 2

Discussion

Accurate and immediate results at or near the site of patient care without spending much time is helpful for physicians working in emergency medicine or areas of critical care. This is primarily needed to act in a life-threatening crisis or to provide counsel in the ongoing management of a chronic disease [8]. It can be made by point of care testing (POCT), which is supposed to give us fast, actionable electrolyte results and other information. This is especially true and beneficial in critical care departments, cardiothoracic surgical departments and inter hospital transport of critically ill patients [9-11]. In our study, we compared sodium and potassium levels done by ABG at point of care testing in intensive care unit (ICU) vs. that done in laboratory electrolyte analyzer to decide if these two methods of measurement can be employed interchangeably in practice.

Our results showed a significant difference in the mean sodium concentration between whole blood and serum samples ($P < 0.001$). Also data for sodium values from ABG appeared to be weakly correlated with AA ($r = 0.41$). The mean difference for sodium in our present study was 7.03 mmol/l. This exceeded the acceptable sodium difference of 4 mmol/l approved by The United States Clinical Laboratory Improvement Amendment (US CLIA) 2006 [12].

Our data agrees with other studies which concluded that results differed significantly for plasma chloride, sodium and also potassium values obtained using two different types of measurements [6, 13-15]. Some of the authors determined a correction factor to minimize the differences between the two analyzer machines by making an average compensation [2, 16] . In our study, we cannot accept or recommend this approach of applying a correction factor to compare sodium results because of the weak correlation between the two methods, which is not clinically acceptable nor appropriate.

Our study revealed a weak correlation between whole blood and serum potassium levels ($r = 0.47$). We also found a clinically significant difference in the potassium mean level ($p< 0.001$). The potassium mean difference of 0.86 mmol/l went beyond that level accepted by The United States Clinical Laboratory Improvement Amendment (US CLIA) 2006 which is 0.5 mmol/l [12].

Several studies demonstrated a statistically significant differences for potassium level when the above two methods of measurement were compared [2, 5, 17]. On contrary to ours, Jain et al. found no significant difference between the potassium values measured by the blood gas machine and the auto-analyzer. They therefore concluded that critical decisions can be made by trusting the potassium values obtained from the arterial blood gas analysis [6]. The significant differences and poor correlation between sodium and potassium values measured by BGA and AA may be attributed to several factors, including the type of sample used (whole blood vs. serum), preanalytic dilution of serum samples with fixed volume diluents (indirect vs. direct electrodes), and variations in calibration of the machine [2, 5]. Another contributing factor is the effect of dilution of the sample by using heparin flushes in the syringes. Experts have theoretically considered that dilution with heparin raises the volume of the sample, thereby lowering the value of the measured electrolytes on the ABG , and the high volume of heparin itself binds the electrolytes, Thereby lowering the value of measured electrolytes by the ABG [18]. Also, it has

recently been reported that the use of different types of heparin in blood gas syringes can introduce a preanalytical bias in electrolyte concentrations [19, 20].

Conclusion

Our results showed that sodium and potassium levels measured by blood gas analyzer and auto-analyzer machines were significantly different, which is not acceptable in clinical practice .We therefore, cannot build clinical decisions depending on sodium and potassium levels measured by blood gas analyzers.

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