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Original Research Article

Comparative Study on ABG Analyzer Versus Electrolyte Analyzer for Estimation of Electrolyte in Whole Blood: Cross-sectional Observational Study

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Abstract:

Background: Electrolyte imbalance is a common and potentially life-threatening condition in critically ill patients. Rapid assessment of electrolytes is essential for timely clinical decision-making. ABG analyzers are increasingly used as POCT devices due to their short turnaround time; however, concerns remain regarding their comparability with conventional electrolyte analyzers. This study aimed to compare electrolyte measurements obtained from an ABG analyzer and an electrolyte analyzer using the same heparinized whole blood samples.

Methods: A total of 100 arterial blood samples were collected from adult patients admitted to the emergency department and ICU. Samples were collected in lithium-heparinized ABG syringes and analyzed immediately using a Radiometer ABL 90 FLEX ABG analyzer and a Roche 9180 electrolyte analyzer, both based on direct ISE technology. Data were collected and analyzed with the help of Microsoft Excel.

Results: The study included 100 participants with a mean age of 53.6 years; 59% were males and 41% were females. The mean sodium concentration measured by the ABG analyzer was significantly higher than that measured by the electrolyte analyzer (133.56 ± 8.91 mmol/L vs. 129.72 ± 8.44 mmol/L; mean difference 3.84 mmol/L, $p = 0.002$). The maximum observed difference for sodium was 8 mmol/L. Potassium levels showed excellent agreement between the two analyzers (4.13 ± 1.12 mmol/L vs. 4.14 ± 1.16 mmol/L; mean difference 0.01 mmol/L, $p = 0.951$). Similarly, chloride levels were comparable (96.87 ± 10.38 mmol/L vs. 96.58 ± 8.19 mmol/L; mean difference 0.24 mmol/L, $p = 0.827$). Most observed differences were within the acceptable limits recommended by the CLIA.

Conclusion: Potassium and chloride measurements obtained from the ABG analyzer and electrolyte analyzer demonstrated excellent agreement and can be used interchangeably in clinical practice. Although sodium measurements showed a statistically significant difference, the variation was clinically acceptable in most cases. Therefore, ABG analyzers can serve as reliable point-of-care instruments for rapid electrolyte assessment in emergency and critical care settings. The use of dried heparin syringes may further improve analytical accuracy.

Keywords: Electrolytes, ABGanalyzer, Electrolyte analyzer, POCT, Direct ISE.

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Introduction

Electrolytes are essential for life. They are charged elements that required for normal functioning of each and every cell of the body. Electrolytes have role in membrane potential, neuro-hormonal pathways, acid-base balance and energy transformation. Electrolyte imbalance can be life-threatening. The incidence of electrolyte disorders is nearly 25% in ICU patients.[1] Recent studies are suggestive of increase mortality with electrolyte imbalance in ICU patients. [2-4] That's why prompt correction of electrolyte disorders is vitally important. The most common practice is to measure electrolytes in serum. This practice requires serum separation and needs extra time. Nowadays, critical care physicians prefer Point-of-care testing (POCT) for measurement of electrolytes. Arterial blood gas

(ABG) analysis is now the first choice of physicians due to short turnaround time. The quicker diagnosis is vitally important for timely management of patients. Despite the advantage, accuracy and reliability of POCT devices were always questioned. Conflicting results from various studies made it serious concern. The differences among electrolyte levels measured in whole blood using an ABG analyzer and in serum using an electrolyte analyzer may be explained by a combination of factors, including sample transport, dilution of serum samples prior to testing (in indirect ISE method), and variations in instrument calibration, pre-analytical variables such as hemolysis (especially K^+ level), clots within the specimen, inproper mixing of the specimen with anticoagulant and varying ratio of blood sample to anticoagulant. [5,6] Recent studies reported that the use of different types of heparin in blood gas syringes can introduce negative biases when the levels of positively charged ions are measured. The extent of bias differs among syringe types. [7,8] There were many studies conducted comparing electrolyte estimation in heparinized whole blood using ABG analyzer and serum using conventional electrolyte analyzer, but a comparison of electrolyte in heparinized whole blood using ABG analyzer and electrolyte analyzer was not done so far. So, we planned to analyse that whether electrolyte levels assessed in heparinized whole blood, using ABG analyzer and Electrolyte analyzer were equivalent or not.

Materials and Methods

This was a cross-sectional observational study conducted between February2022andMay 2022 in the clinical biochemistry laboratory at RNT Medical College, Udaipur. The priorapproval from Institutional Ethical Committee was obtained. The samples received from emergency and ICU were included in the study. Patients with positive informed consent and aged between 18-65years were included in the study. Only participants whose ABG samples could be collected from an artery were included in our study. Negative informed consent rendering, aged below 18 or above 65 years were excluded from our study. These sampleswere collected only when there was an indication. Arterial blood samples from 100 patients were collected. 0.6 ml blood was collected in commercially available plastic ABG syringes (BD A-LINE ABG collection syringe of 1.0 ml volume, 0.6 ml recommended draw volume, coated with lithium-heparin) under a sterile environment using standard sampling protocol. Quality control was ensured by collecting samples through trained staff of emergency and ICU in the hospital and analyzed immediately on two analyzers located in the clinical biochemistry laboratory under similar environmental conditions. Both instruments Radiometer ABL 90 FLEX analyzer as well as Roche 9180, work on the principle of direct ISE technology. The internal quality control of BIORAD was run daily on both instruments during the study period. The mean Na^+ was 125.7mmol/L and 142.7mmol/L for the concentration of 126.0 mmol/L (122.01-129.99mmol/L) and 143.1 mmol/L (139.86-146.34mmol/L) respectively on Roche 9180 analyzer and 126.4 mmol/L and 143.5mmol/L on ABG analyzer. The mean K^+ was 3.96mmol/L and 6.15mmol/L for concentrations of 3.91 mmol/L (3.76-4.06 mmol/L) and 6.11 (5.93-6.29) mmol/L, respectively, on Roche 9180 analyzer and 3.88mmol/L and 6.06mmol/L on ABG analyzer. The mean Cl^- was 103.5 mmol/L and 83.99mmol/L for concentrations of 104.3 mmol/L (100.58-108.02 mmol/L) and 85.04 (81.56-88.52) mmol/L, respectively, on Roche 9180 analyzer and 104.9 mmol/L and 86.23mmol/L on ABG analyzer. Our laboratory also participates in the external quality assessment scheme (EQAS) for clinical chemistry (monthly) Program - Cycle 21ran during the study interval. Z-scores for electrolytes were between -1 to +1 in all months when we did the present study.

Statistical Analysis: A total of 100 Arterial blood samples were collected from the emergency and ICU. The data were collected and arranged in tables using Microsoft Excel version 2010. The Mean, standard deviation and pvalue was calculated. pvalue< 0.05 was considered statistically significant.

Results

The mean age of the participants was 53.6 years. There were 59 male and 41 female patients. The mean level of Na^+in ABG analyzer was 133.56±8.91mmol/L compared to 129.72±8.44mmol/L in electrolyte analyzer [Table-1]. We founda significant difference when the mean (±SD) of sodium levels was compared between ABG and electrolyte analyzer ($p < 0.05$). The maximum difference in sodium level was 8mmol/L and the minimum 0 mmol/L[Table-2]. The mean difference among the results was 3.84mmol/L showing a negative bias in electrolyte analyzer. There were 68 samples with variation up to 4 mmol/L which is an acceptablelimit for Na^+ as per Clinical Laboratories Improvement Amendment (CLIA) guidelines. [9]

The mean K^+ in ABG analyzerwas 4.13±1.12mmol/L as compared to 4.14±1.16mmol/L in electrolyte analyzer ($p> 0.05$) [Table-1]. The results are comparable when the mean (±SD) of potassium levels was compared between ABG and electrolyte analyzer. The maximum difference in measurement was 0.6mmol/L, and the minimum 0 mmol/L[Table-2]. The mean difference among the results was 0.01mmol/L. There were 99 samples with variation up to 0.5 mmol/L which is an acceptablelimit for K^+

as per Clinical Laboratories Improvement Amendment (CLIA) guidelines. [9]

The mean Chloride in ABG analyzer was 96.87±10.38mmol/L as compared to 96.58±8.19mmol/L in electrolyte analyzer (P > 0.05) [Table-1]. The results are comparable when the mean (±SD) of potassium levels was compared between ABG and electrolyte analyzer. The maximum difference in measurement was 6mmol/L, and the minimum 0 mmol/L[Table-2]. The mean difference among the results was 0.24mmol/L. There were 94 samples with variation within±5 % which is an acceptable limit for Chloride as per Clinical Laboratories Improvement Amendment (CLIA) guidelines. [9]

Table 1: Comparison of mean results in ABG and electrolyte analyzer

Electrolyte	ABG analyzer	Electrolyte analyzer	Mean difference	p value
Sodium level	133.56	129.72	3.84	0.002
Potassium level	4.13	4.14	0.01	0.951
Chloride level	96.87	96.58	0.24	0.827

Table-2: Comparison of range and difference in ABG and electrolyte analyzer

Electrolyte	Rangein ABG analyzer	Rangein Electrolyte analyzer	Minimum difference	Maximum difference
Sodium level	113-152	108-145	0	8
Potassium level	1.8-7.6	1.7-7.7	0	0.6
Chloride level	71-116	76-112	0	6

Discussion

It's already known that ISE-based instruments from different manufacturers yield sodium- potassium values that differ by 2-5% but calibration of an analyzer using a NIST (National Institute of Standards and Technology) standard lowers the differences. [10] Recent studies reported that the use of different types of heparin in blood gas syringes can introduce a pre-analytical bias. Heparin binds with positively charged ions and might introduce different negative biases when the levels of electrolytes are measured. [7-8,11-13] The extent of bias differs among syringe types. [7,8] Chhapola V et al. observed that ABG analyzers underestimate sodium and potassium levels if arterial samples are collected in liquid heparinized containers. [12] The underestimation of electrolytes due to liquid heparin can be avoided by use of lyophilized heparinized syringes. Jain A et al. observed negative bias in electrolytes values in arterial blood because of binding of heparin to electrolytes. [13]

Story et al. have reported that indirect ISE leads to overestimation of Na^+ in hypoalbuminemia. [14] They concluded that difference between direct and indirect ISE results was due to interference of serum albumin and total protein concentrations. [15] The use of different techniques was not a limitation in our present study as we compared results of two instruments using direct ISE method.

In our study, we tried to minimize these external contributing factors by considering other study limitations. For the standardization of sampling and to edge out all affecting factors, as mentioned above, we used BD A-LINE ABG syringes (coated with lithium-heparin) for sampling. To prevent sampling errors only trained and selected staff of the ICU performed the sampling.

The use of different analyzer and difference in use of calibrators could also be responsible for the observed difference in electrolytes. [16] It is known that ISE based analyzer from different manufactures gave Na^+ and K^+ results that differ by 2-5%. Since we are unable to correlate the results with the clinical condition of patient and so we cannot comment that results of which analyzer represent better.

Conclusions

We conclude that the results of electrolytes on ABG and electrolyte analyzer can be utilized in inter-exchangeable manner. A statistically significant difference was observed in sodium measurements while potassium and chloride measurements showed no statistically significant differences between the two analyzers and demonstrated excellent agreement. However, most of the observed variations were within the allowable limits recommended by Clinical Laboratory Improvement Amendments (CLIA), indicating good comparability between the two analyzer. The differences noted in sodium estimation may be attributed to analyzer-specific calibration characteristics and pre-analytical factors associated with heparinized samples.

Although sodium measurements showed a statistically significant difference, the variation was clinically acceptable in most cases. Therefore, ABG analyzers can serve as a reliable point-of-care tool for rapid electrolyte assessment in emergency and critical care settings, facilitating timely clinical decision-making. For better results of electrolyte, the use of dried heparin syringes may be encouraged. Further studies with larger sample sizes and correlation with clinical outcomes are recommended to validate these findings.

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