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Cross-sectional Study

Measuring serum sodium levels using blood gas analyzer and auto analyzer in heart and lung disease patients: A cross-sectional study

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ABSTRACT

Objective: Emergency services require precise and rapid measurement of electrolytes to initiate treatment. Blood gas analyzers (BGA) analyzes blood samples in seconds however, its accuracy is still debatable. The aim of this study was to compare the level of serum sodium measured through BGA and auto analyzer in the laboratory analyzers.
Methods: This cross-sectional study was performed on 79 patients with heart and lung disease in the intensive care unit of the center. Patient information was recorded along with serum sodium levels measured through BGA and auto analyzer in the laboratory.
Results: The mean sodium level measured by BGA was 138.38 mEq/L and by auto analyzer was 137.42 mEq/L. The difference was statistically significant, $p = 0.007$. Among lung disease patients, the mean sodium levels from BGA and autoanalyzer did not differ significantly $p = 0.052$ where in patients with heart disease, these levels were 138.54 mEq/L and 137.23 mEq/L, respectively. The difference was significantly different, $p = 0.015$. Acidic pH measured using BGA and autoanalyzer also differed significantly, $p = 0.006$.
Conclusion: Blood gas analyzer method has a high correlation with laboratory analyzer, but in cases of hypernatremia, the accuracy of blood gas analyzer method decreases and especially in acidosis and in patients with pulmonary problems, the difference with laboratory method increases.

1. Introduction

Electrolytes are charged elements in the body that are crucial for proper functioning of body tissues and organs. Dysfunction in the levels of electrolytes is associated with several morbidities and present life-threatening risk [1–3]. In these cases, rapid measurement of electrolytes is required to provide immediate treatment. Additional delay in transport of samples due to insufficient human resources, labs and transit system is reported in developing country, leading to turnaround time of more than 15 min [4].

Commonly, auto analyzer in laboratories is used for the analysis of electrolytes however, it is a time-consuming procedure and in certain circumstance, this delay can hinder quick decisions depending on electrolytes [5]. Some decisions are made blindly because of this delay. Electrolytes measured with arterial blood gas analyzer (BGA) are not trusted for clinical decision-making since the data might not be reliable [6]. The United States Clinical Laboratory Improvement Amendment (US CLIA) 2006 accepts a deviation of 4 mmol/l in sodium levels relative to the gold standard measure of standard calibration solutions [7]. Previous studies have shown that sodium and chloride values of BGA can vary significantly compared to automatic laboratory analyzer. This difference was associated with calculated anion gap and strong ion difference [8]. Such differences have reported in other studies too [9, 10].

The aim of this study is to evaluate the levels of sodium measured through blood gas analyzer and auto analyzer in heart and lung disease patients in intensive care unit.

2. Methods

In this cross-sectional study, sample reported for sodium analysis in blood at (XXX) from 2019 to 2020 were analyzed using ABL555 gas analyzer and auto-laboratory analyzer (Dimension RxL Max Integrated Chemistry System, Siemens). In this study, patients with

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cardiopulmonary diseases aged between 18 and 80 years were included. Pregnant women, deceased patients, and those with bleeding disorders were excluded from the study.

Research tool included a checklist form for all the samples were data was recorded. Venous blood samples were collected for auto-analyzer and arterial blood samples were collected for blood gas analyzer. The samples were collected at the same time and operators wore latex gloves and used disinfectants before the collection. The collection was performed by a single trained and experienced staff and both the analyzers were located in the same laboratory under same environmental condition. Sample of the study was determined using following formula:

For statistical analysis, SPSS v22 (IBM, Chicago, IL, USA) was used. Descriptive representation of the data was achieved through frequency and percentage. For normally distributed data, Kolmogorov–Smirnov test was performed. Student T test was used to confirm the normality of the data. In case of abnormal distribution, Wallis's Kruskal test and Mann-Whitney test were used. Chi-square test and Fisher's exact test were used to evaluate the qualitative data. $P < 0.05$ was considered to be statistically significant.

The methods are stated in accordance with STROCSS 2021 guidelines [11].

This study was approved by the Research Ethics Board of (XXX).

Unique identifying number is: researchregistry7629.

3. Results

Samples from 79 patients were included in this study where mean age of the patients was 61.55 ± 10.34 years. 47 patients (59.5%) were male and 32 patients (40.5%) were female. 44 patients (55.6%) had heart disease whereas 35 patients (44.3%) had lung disease (Fig. 1).

The mean sodium level from blood gas analyzer was 138.38 ± 6.026 mEq/L and laboratory analyzer was 137.42 ± 4.413 mEq/L. The mean difference in sodium levels was significantly different from these two methods, $p = 0.007$.

In both age and gender groups, the mean sodium level measured by blood gas analyzer method was significantly higher than that of the laboratory analyzer method ($P < 0.05$) (Tables s1 and 2).

Among patients with lung disease, mean sodium level from gas and laboratory analyzer was 138.25 mEq/L and 137.57 mEq/L, respectively. The difference was not statistically significant, $p = 0.052$ (Table 3). Among patients with heart disease, these levels were 138.54 mEq/L and 137.23 mEq/L, respectively. The difference was significantly different, $p = 0.015$ (Table 4).

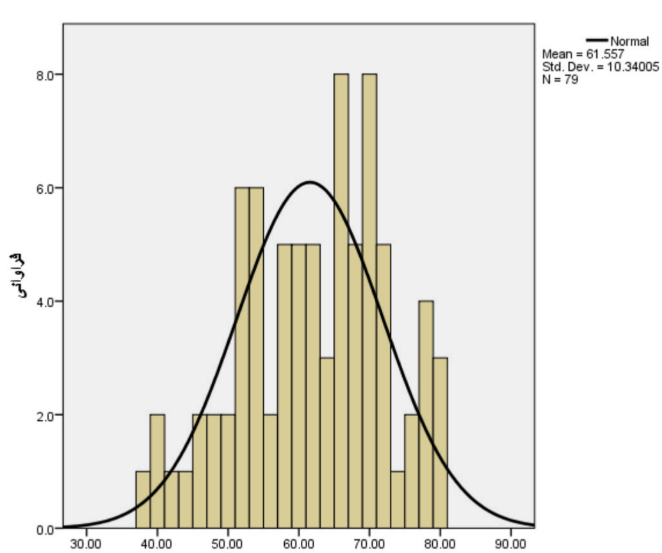

Fig. 1. Frequency of age in the studied patients.

Based on pH of the patients, the mean sodium levels among patients with acidic blood pH ($n = 15$) was 138.25 with gas analyzer and 137.25 with laboratory analyzer (Table 5).

The difference was significant in the two groups, $p = 0.006$. In patients with normal pH ($n = 55$), the mean sodium level with gas and laboratory analyzer was 138.40 mEq/L and 137.69 mEq/L, respectively. The difference was not significant in the two groups, $p = 0.063$. In 9 patients with basic pH, mean sodium level from gas analyzer was 137 mEq/L and 136.2 mEq/L from laboratory analyzer. The mean difference in these two groups was also not significantly different, $p = 0.244$.

4. Discussion

Point-of-care analyzers are important for prompt clinical decision compared to routine biochemical analysis. These are helpful in emergency department, ambulance and cardiac surgery however, is associated with financial burden [12–17]. The findings of our study showed that among heart and lung disease patient, sodium levels were significantly higher when measured through BGA, compared to autoanalyzer. However, difference in sodium levels were not correlated with blood pH in case of normal and basic pH but was significantly correlated with acidic pH.

Jain et al. [18] conducted an observational cohort study to compare electrolyte values from point-of-care blood gas analyzer and automatic analyzer among 200 intensive care unit patients. The results of the study showed that sodium levels from BGA were significantly lower than automatic analyzer whereas no significant difference in terms of potassium levels were seen. A retrospective study by Solak [19] compared 2557 samples with BGA and auto analyzer to evaluate levels of sodium. The outcomes of the study showed that sodium levels measured by BGA are significantly higher than autoanalyzer. These findings are not in line with our study. Similarly, Pouryahya, Tan [20] conducted an observational study on three Monash Health emergency department and showed that in case of acid-base analysis, sodium, potassium and creatinine values showed significant variations through BGA system. However, they concluded that these variations were minor and can be fixed by precise calibration of the instrument. These differences are significantly large in preterm infants [21]. In a cross-sectional study, Rezaei Shahmirzadi, Mostafavi Toroghi [22] showed that sodium levels measured using BGA systems are significantly more than autoanalyzer system in 88 patients, whereas, in 200 patients Zhang, Lin [23] showed that BGA showed significantly lower values of serum sodium levels. However, the later study concluded that these biases did not surpass US Clinical Laboratory Improvement Amendment-determined limits and in terms of these limits, the difference was not statistically significant. Difference in sample size, sampling methods and making of BGA and autoanalyzer could be the reasons of these discrepancies.

Our study has small sample size, includes data regarding sodium analysis only and does not provide correlation with other variables including demographic of the patients. We recommend further comparative studies, taking in account these short comings and comparison should be made with the instruments of same manufacturer. These studies can help clinicians to decide between the use of auto-analyzer (time and accuracy) and blood gas analyzer (quick yet inaccurate) for the measurement of electrolytes.

5. Conclusion

In general, the difference in the sodium levels with two methods differed significantly. This difference was maintained in patients with heart disease and acidic pH. Since the difference in values are minute, we recommend precise calibration of the instrument and study with greater sample size to verify these outcomes. However, in heart disease patients, BGA may not produce accurate results.

Table 1
Mean and standard deviation of sodium measured two methods studied by age grouping.

Age	Method	Number	Mean (m/Eq/L)	SD	Coefficient of variation	SD	P-value
60>	Blood gas analyzer	33	138.18	7.256	1.091	2.909	0.02
	Laboratory Analyzer	33	137.09	5.405			
60≤	Blood gas analyzer	46	138.52	5.405	0.870	2.446	0.039
	Laboratory Analyzer	46	3.585	3.585			

Table 2
Mean and standard deviation of sodium measured by the two studied methods by gender grouping.

Age	Method	Number	Mean (m/Eq/L)	SD	Coefficient of variation	SD	P-value
Male	Blood gas analyzer	47	137.96	6.430	0.915	2.709	0.025
	Laboratory Analyzer	47	137.04	4.699			
Female	Blood gas analyzer	32	139.00	5.418	1.031	2.559	0.03
	Laboratory Analyzer	32	137.97	3.963			

Table 3
Mean and standard deviation of sodium measured two methods studied by grouping lung disease.

Age	Method	Number	Mean (m/Eq/L)	SD	Coefficient of variation	SD	P-value
No	Blood gas analyzer	44	138.25	5.815	0.682	2.260	0.037
	Laboratory Analyzer	44	137.57	4.464			
Yes	Blood gas analyzer	35	138.54	6.363	1.314	0.037	0.021
	Laboratory Analyzer	35	137.23	4.406			

Table 4
Mean and standard deviation of sodium measured by the two studied methods by grouping heart disease.

Age	Method	Number	Mean (m/Eq/L)	SD	Coefficient of variation	SD	P-value
No	Blood gas analyzer	29	138.24	6.306	1.207	2.969	0.037
	Laboratory Analyzer	20	137.03	4.428			
Yes	Blood gas analyzer	50	138.46	5.922	0.820	2.439	0.021
	Laboratory Analyzer	50	137.64	4.434			

Table 5
The frequency of sodium disturbance was measured in two ways.

Blood gas analyzer		Laboratory Analyzer				
		hyponatremia	Normal	Hypernatremia	Total	p-value
hyponatremia	N	9	1	0	10	<0.001
	%	90%	10%	0%	100%	
Normal	N	5	58	0	63	
	%	7.9%	92.1%	0%	100%	
Hypernatremia	N	0	3	3	6	
	%	0%	50%	50%	100%	
Total	N	14	62	3	79	
	%	17.7%	78.5	3.8%	100%	

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No funding was secured for this study.

Ethical approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent

Not applicable.

Author contributions

Dr. Mahnaz Narimani Zamanabadi: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr.Reza Alizadeh: Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr. Tina Narimani Zamanabadi: Coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

Registration of research studies

Name of the registry: Unique Identifying number or registration ID: IR.IAU.TMU.REC.1399.352.

Hyperlink to the registration (must be publicly accessible): https://ethics.research.ac.ir/ProposalCertificateEn.php?id=173313&Print=true&NoPrintHeader=true&NoPrintFooter=true&NoPrintPageBorder=true&LetterPrint=true.

Guarantor

Dr. Mahnaz Narimani Zamanabadi.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Declaration of competing interest

The authors deny any conflict of interest in any terms or by any means during the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2022.103713.

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