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RESEARCH ARTICLE

To Study the Comparison Between Point of Care Testing Vs Autoanalyzer for Electrolyte Level in Critical Patients Of ICU

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Abstract: ***Background and Objectives***: Electrolyte levels in critically ill patients must be reported accurately and quickly; hence, POCT instruments are used in ICUs, though their values may differ from those of the autoanalyzer within CLIA's acceptable limits (4 mmol/L for Na^+, 0.5 mmol/L for K^+). Considering the frequent hypoalbuminemia in these patients, we have selected the most accurate estimation method. ***Methodology***: This was a comparative cross-sectional study and was conducted in the department of medicine from September 2024 to December 2024. The sodium and potassium levels of 55 ICU patients were determined on arterial blood gas and an Auto analyzer. 2ml of arterial blood (heparinized syringe) processed on GEM3500, as well as 2ml venous blood measured on Beckman Coulter, was collected for electrolyte and protein albumin estimation. ***Result***: When employing lithium heparinized syringes for hyponatremic individuals, there was a significant difference (p=0.0236) in sodium readings between the autoanalyzer and ABG, which were consistently lower in 55 ICU patients. There was little variance in potassium levels and no discernible variation across methods. Across all approaches, stratified analysis showed that hypoalbuminemic individuals had considerably greater potassium and decreased sodium (p<0.0001). On ABG using self-made syringes, albumin and sodium showed a small but significant link (p=0.026), while all other correlations were negligible. Overall, the potassium estimate stayed mostly constant, but the sodium measurement varied depending on the albumin and the technique. ***Interpretation and Conclusion***- Our findings suggest that the autoanalyzer may be a more reliable choice for sodium measurement, with no significant difference in potassium level. In the comparison of our results, we interpreted that adding Na+ and K+ using lithium vials, the ABG tool can give accurate results for critically ill patients

Keywords: -Arterial Blood Gas, Analyzer, Laboratory Auto-Analyzer, Sodium, Potassium, Intensive care unit, Albumin.

INTRODUCTION

Point-of-Care Testing (POCT) is a rapidly evolving discipline in laboratory medicine, expanding in both its analytical scope and clinical applications. It is characterized by testing performed in proximity to the patient, facilitating immediate care or treatment administration(1). Arterial blood gas (ABG) analyzers are a prime example of POCT, widely utilized in intensive care units (ICUs) and emergency rooms. They offer direct electrolyte estimation with minimal processing, significantly reducing turnaround time and enabling prompt patient treatment (2).

POCT devices extend beyond the ICU, offering ease of operation with premade reagents and operating under the supervision of clinical laboratories (3). In contrast, automated analyzers are sophisticated devices designed for intricate chemical examinations of analytes (4). Electrolyte estimation on an autoanalyzer typically employs ion-selective electrode (ISE) technology, which can be either direct or indirect. Direct ISEs allow the serum sample to interact directly with the ion-selective membrane, while indirect ISEs measure a pre-diluted sample. For instance, the Beckman Coulter Au480 Autoanalyzer uses an integrated indirect ISE method for measuring electrolytes in serum drawn from venous blood (5). A key area of investigation involves comparing electrolyte levels estimated by direct ISEs (used in POCT) and indirect ISEs (used in autoanalyzer) (6). This comparison often focuses on serum sodium (Na+) and potassium (K+) levels, also exploring their correlation with serum albumin levels. Direct ISEs in POCT typically utilize whole blood samples, whereas indirect ISEs in clinical laboratories (autoanalyzer) use serum samples. Understanding the differences and correlations between these methodologies is crucial for optimizing their clinical applications and ultimately enhancing patient care.

Electrolytes, including sodium, potassium, chloride, calcium, phosphate, and bicarbonates, are fundamental for various physiological functions. These include maintaining electrical neutrality within cells and facilitating the generation and conduction of action potentials in nerves and muscles (7). Imbalances, whether high or low levels, can disrupt normal body functions and lead to life-threatening complications (8). Consequently, electrolyte levels are routinely assessed in all critically ill emergency patients and those admitted to the ICU (9)

Given that POCT is user-friendly and minimizes pre-analytical errors, leading to faster results, its value in electrolyte estimation is significant. A particular focus is on critically ill patients with low albumin. Heparin is a

commonly used anticoagulant, and lithium heparin, often available in ready-to-use forms, is relatively expensive but does not interfere with sodium levels. The aim is to optimize testing efficiency and maintain accuracy, thereby ensuring better patient care without unnecessary delays. This approach seeks to leverage the benefits of POCT, particularly its speed and reduced error potential, for critical electrolyte measurements in vulnerable patient populations.

MATERIAL AND METHODOLOGY.

A comparison study was conducted in the Medicine Department during a study period of six months from September 2024 to March 2024.

Selection of cases: - The study population included 55 ICU patients. The electrolyte level was estimated on an arterial blood gas analyzer as well as an auto analyzer. 2ml of arterial blood (heparinized syringe) from self-prepared sodium heparinized and pre-prepared lithium heparinized taken for estimation of Arterial blood gas processed on GEM3500 as well as 2ml venous blood (yellow vacutainer) measured for Na+, K+, and serum albumin estimation analyzed within 2hrs, to our central laboratory, via indirect ISE on Beckman Coulter AU480 model.

The sample for the Arterial blood gas analyzer in a prepared lithium heparinized syringe (commercially ready to use), as well as a self-prepared sodium heparinized syringe (0.1ml), will be taken along with a serum sample for the estimation of ionized electrolytes sodium and potassium of ICU patients. The patients who do not give consent are excluded from the study. These samples were collected only when clinically indicated. All samples were collected by the specially trained staff. All the Patients (above 18 years old) who give consent and are subjected to arterial blood gas are admitted to the ICU.

Statistical method employed: - Data were evaluated using "GraphPad." Prism 10.4.1 Means, standard deviations (SDs), and coefficients of variation were calculated. Karl Pearson's correlation coefficients were found. Deming regression analysis was performed to compare the results of the two methods. $P < 0.0001$ was considered statistically significant. Microsoft Word and excel and GraphPad used to generate graphs and tables. Comparison between two groups was analyzed by student t-test was performed.

RESULT.

The research was conducted on intensive care unit patients. From October 2024 to March 2025, with a total 55 sample size. The characteristics of the research subject can be seen in the table below.

The comparison of sodium (Na^+) and potassium (K^+) values between the ABG analyzer and the autoanalyzer, using both self-prepared sodium heparinized syringes and ready-to-use lithium heparinized syringes, is shown in Table 1. For sodium, the autoanalyzer consistently reported higher values than the ABG analyzer. When self-prepared sodium heparinized syringes were used, sodium levels averaged 127.3 mmol/L (SD-10.42) on the ABG analyzer compared to 129.7 mmol/L (SD-10.59) on the autoanalyzer. This difference of 2.4 mmol/L reached statistical significance ($p = 0.035$). A similar pattern was observed with the ready-to-use lithium heparinized syringes, where sodium values were 126.5 mmol/L (SD-10.76) on the ABG analyzer and 129.2 mmol/L (SD-10.09) on the autoanalyzer, showing a larger and statistically significant difference of 3.2 mmol/L ($p < 0.05$).

In contrast, potassium levels were broadly comparable between the two analyzers. With self-prepared sodium heparinized syringes, potassium values were 4.52 mmol/L (SD-1.44) on the ABG analyzer and 4.73 mmol/L (SD-1.40) on the autoanalyzer, a non-significant difference ($p = 0.305$). Similarly, with the ready-to-use lithium heparinized syringes, potassium levels were 4.06 mmol/L (SD- 0.96) on the ABG analyzer and 4.49 mmol/L (SD-1.56) on the autoanalyzer, with a mean difference of 0.4 mmol/L, which was also not statistically significant ($p = 0.08$).

Taken together, these findings suggest that while sodium values showed a significant upward shift when measured by the autoanalyzer, potassium values remained relatively stable across both methods and instruments.

Table 1. Sodium and potassium mean ± SEM using a self-prepared heparin syringe and Ready-to-use Lithium heparinized in ABG analyzer and autoanalyzer.

Sodium (Na+) and Potassium (K+) value	ABG analyzer Mean ± SEM (mmol/L)	Autoanalyzer Mean ± SEM (mmol/L)	Mean difference (mmol/L)	p-value
Sodium (Na+) value-Self-prepared sodium heparinized method	127.3 ± 1.406 (SD-10.42)	129.7 ± 1.42 (SD-10.59)	2.4	p=0.035

Sodium (Na+) value-Ready to use Lithium heparinized	126.5 ± 1.45 (SD-10.76)	129.2 ± 1.36 (SD-10.09)	3.2	p <0.05
Potassium (K+) value-Self-prepared sodium heparinized method	4.52 ± 0.194 (SD-1.44)	4.73 ± 0.189 (SD-1.40)	0.2	p=0.305
Potassium (K+) value-Ready-to-use lithium heparinized method	4.06 ± 0.130 (SD- 0.96)	4.49 ± 0.155 (SD-1.56)	0.4	p=0.08

Sodium analysis was stratified based upon the standard laboratory values, and 135–145 mmol/L was considered normal serum sodium. Anything above was considered hypernatremia. Patients with serum sodium 120–135 mmol/L were considered as borderline hyponatremic, and patients with serum sodium less than 120 mmol/L were diagnosed as hyponatremic (Figures 1 and 2)

In Figure 1. The maximum mean difference obtained in estimating sodium levels was observed in the range of (135–145 mmol/L) and was borderline significant (p<0.05).

In Figure 2. A significant difference was observed in the hyponatremic range (>145 mmol/L), where sodium levels measured by ABG analyzer and autoanalyzer differed notably when using ready-to-use lithium heparinized syringes. Other sodium ranges showed no statistically significant discrepancies. Sodium levels measured by the ABG analyzer were lower than those from the Autoanalyzer. An important difference occurred in hyponatremic patients using ready-to-use lithium heparin samples (p = 0.0236), while other groups showed no significant difference. Self-prepared sodium heparin samples showed a borderline difference in the normal range (p = 0.05), indicating slight variation.

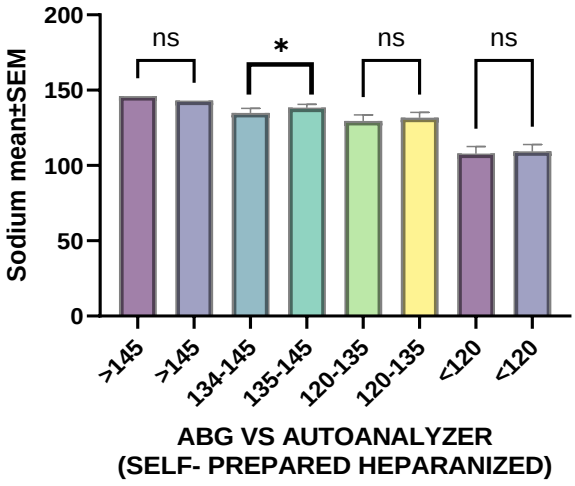

Fig.1

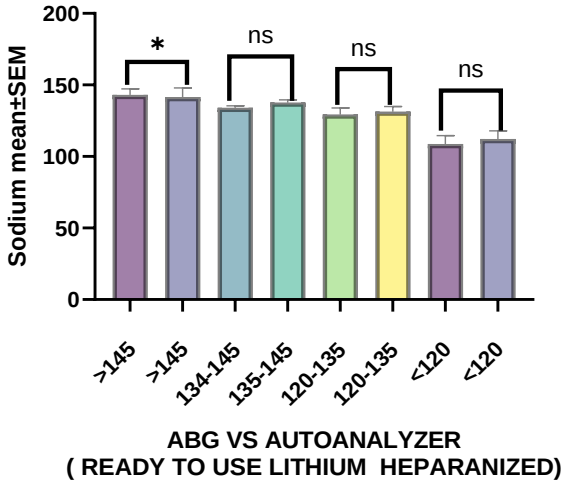

Fig.2

Potassium values were stratified in Figures 3 and 4 based on standard laboratory values. Patients with K+ 3.5– 5.0 mmol/L were normokalemic, values above 5.0 mmol/L were considered hyperkalemia, and those below 3.5 mmol/L were considered hypokalemia. There was no significant difference between ABG and autoanalyzer potassium values across potassium ranges. Potassium levels showed no significant differences between the ABG analyzer and Autoanalyzer, indicating strong agreement. Unlike sodium, both self-prepared sodium heparin and ready-to-use lithium heparin samples gave comparable potassium results.

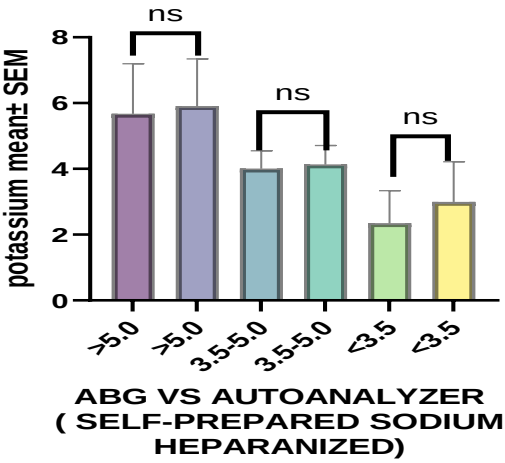

Fig.3

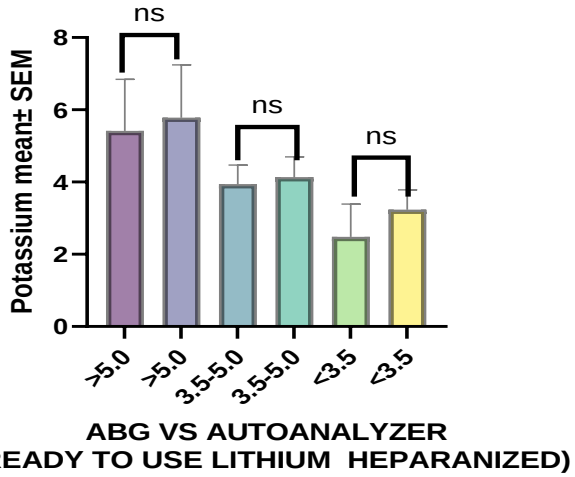

Fig.4

Table 2 Correlation between albumin level, sodium and potassium level measured using ABG analyzer and Autoanalyzer.

ABG analyzer Sodium (mmol/L) Mean ± SEM			p-value	r value
Albumin (g/dl) Mean ± SEM 3.122 ± 0.087 SD (0.645)	Self-prepared sodium heparinized syringe	127.3 ± 1.406	p=0.026	r=0.089
	Ready to use lithium heparinized syringe	126.1 ± 1.45	p=0.151	r=0.038
ABG analyzer Potassium (mmol/L) Mean ± SEM				
Albumin (g/dl) Mean ± SEM 3.122 ± 0.087 SD (0.645)	Self-prepared sodium heparinized syringe	4.52 ± 0.194	p=0.669	r=0.0032
	Ready to use lithium heparinized syringe	4.06 ± 0.130	p=0.679	r=0.0034
Autoanalyzer Sodium (mmol/L) Mean ± SEM				
Albumin (g/dl) Mean ± SEM 3.122 ± 0.087 SD (0.645)	Self-prepared sodium heparinized syringe	129.7 ± 1.428	p=0.078	r=0.057
	Ready to use lithium heparinized syringe	129.2 ± 1.36	p=0.249	r=0.024
Autoanalyzer Potassium (mmol/L) Mean ± SEM				
Albumin (g/dl) Mean ± SEM 3.122 ± 0.087	Self-prepared sodium heparinized syringe	4.73 ± 0.189	p=0.375	r=0.014

SD (0.645)	Ready to use lithium heparinized syringe	4.49 ± 0.155	p=0.345	r=0.0168

In Table 2 with the ABG analyzer, sodium showed a weak but significant positive correlation with albumin using self-prepared sodium heparin syringes (p = 0.026, r = 0.089), while other sodium and all potassium measurements showed no significant correlation. With the Autoanalyzer, sodium or potassium levels showed no significant correlation with albumin. Overall, a statistically significant but weak correlation was observed only between albumin and sodium levels using the ABG analyzer with self-prepared heparinized syringes. All other correlations across devices and electrolytes were not statistically significant, indicating minimal or no relationship between albumin levels and electrolyte (Na^+ or K^+) values in these contexts.

Table 3 shows that individuals with normal albumin levels (3.4–5.4 g/dL) had consistently higher sodium (Na^+) concentrations compared to those with hypoalbuminemia (<3.5 g/dL) across both the ABG analyzer and Autoanalyzer methods. For example, with self-prepared syringes, sodium levels were 127.7 mmol/L in the normal albumin group versus 122.1 mmol/L in the hypoalbuminemic group using the ABG analyzer ($p < 0.0001$), and 128.0 vs 125.3 mmol/L using the autoanalyzer ($p < 0.0001$). Similarly, with ready-to-use syringes, sodium levels were 126.9 vs 121.1 mmol/L (ABG, $p < 0.0001$) and 128.8 vs 124.5 mmol/L (autoanalyzer, $p < 0.0001$). In contrast, potassium (K^+) values showed smaller differences in participants with normal albumin (ranging from 0.21 to 1.14 mmol/L), with some not statistically significant (e.g., ABG with ready-to-use syringes, p = 0.7756). However, in hypoalbuminemic individuals, potassium levels were consistently higher (1.31–1.84 mmol/L) and all comparisons were statistically significant ($p < 0.0001$). Overall, these findings indicate that hypoalbuminemia is associated with lower sodium and higher potassium differences, with the discrepancies being more pronounced for potassium, and that ABG-based measurements—particularly with ready-to-use syringes—tend to give lower values than autoanalyzer, highlighting the greater reliability of autoanalyzer-based results in low-albumin patients.

Table 3. Comparison of Sodium and Potassium Measurements by ABG and Autoanalyzer Using Different Heparinized Syringes in Relation to Albumin Levels

Analyte	Method / Sample	Albumin Group (g/dL)	n	Mean Diff (mmol/L)	SE Diff	Max Diff	Min Diff	p-value
Na^+	ABG – Self-prepared sodium heparinized	3.4–5.4	19	127.7	2.36	1.86	0.05	<0.0001
		<3.5	36	122.1	1.71	1.82	0.07	<0.0001
	Autoanalyzer – Self-prepared sodium heparinized	3.4–5.4	19	128.0	2.38	2.4	1.9	<0.0001
		<3.5	36	125.3	1.25	2.3	1.6	<0.0001
	ABG – Ready-to-use lithium heparinized	3.4–5.4	19	126.9	2.36	3.7	2.5	<0.0001
		<3.5	36	121.1	1.71	1.8	0.02	<0.0001
	Autoanalyzer – Ready-to-use lithium heparinized	3.4–5.4	19	128.8	2.27	1.82	1.97	<0.0001
K^+	ABG – Self-prepared sodium heparinized	3.4–5.4	19	0.757	0.347	0.40	0.36	0.0632
		<3.5	36	1.664	0.252	0.30	0.33	<0.0001
	Autoanalyzer – Self-prepared sodium heparinized	3.4–5.4	19	1.137	0.339	0.37	0.36	0.0022

		<3.5	36	1.842	0.246	0.33	0.34	<0.0001
	ABG – Ready-to-use lithium heparinized	3.4–5.4	19	0.210	0.242	0.20	0.29	0.7756
		<3.5	36	1.317	0.176	0.10	0.27	<0.0001
	Autoanalyzer – Ready-to-use lithium heparinized	3.4–5.4	19	0.736	0.282	0.28	0.32	0.0209
		<3.5	36	1.647	0.205	0.25	0.30	<0.0001

DISCUSSION

Two methods are commonly used for electrolyte testing: the central laboratory Autoanalyzer (AA), which measures electrolytes from serum (10), and the ABG analyzer, widely used in ICUs and emergency rooms for rapid results with minimal pre-analytical steps, enabling prompt treatment (2). Point-of-care testing (POCT) is a growing field offering quick bedside results, reducing turnaround time and overall costs compared to central lab testing (11–13). This study compared sodium (Na^+) and potassium (K^+) measurements from ABG analyzers and autoanalyzers using both self-prepared sodium heparinized and ready-to-use Lithium heparin syringes in 55 ICU patients, and examined their correlation with albumin. The mean differences using self-prepared syringes were 2.4 mmol/L (Na^+) and 0.2 mmol/L (K^+), and using lithium heparin syringes were 3.2 mmol/L (Na^+) and 0.4 mmol/L (K^+), all within USCLIA 2006 permissible limits ($Na^+ \leq 4$ mmol/L, $K^+ \leq 0.5$ mmol/L). Prior studies also noted significant sodium and chloride variations in ABG readings affecting strong ion difference and anion gap calculations (14). Sodium showed a significant difference between the two analyzers with self-prepared syringes ($p = 0.035$), with the autoanalyzer giving higher values, consistent with earlier reports of system-related variability (15,16). With lithium heparin syringes, the difference was not significant ($p = 0.051$), except in hypernatremic patients, where it was significant ($p = 0.0236$). Lithium heparin is preferred as sodium heparin can falsely elevate sodium levels (17). Potassium showed no significant differences between methods, with a mean difference of 0.4 mmol/L, also within USCLIA 2006 limits. A weak but significant positive correlation was seen between albumin and sodium using ABG with self-prepared syringes ($p = 0.026$, $r = 0.089$), while potassium and lithium heparin samples showed no correlation. Hypoalbuminemic patients had significantly lower sodium ($p < 0.0001$), likely due to altered plasma water distribution (18), which can cause pseudohyponatremia, and low albumin is linked to poor outcomes in critically ill patients (19). As albumin binds sodium, low albumin can cause falsely low sodium values, and ABG—which measures sodium directly—is more accurate than central lab assays (20). Potassium was higher in hypoalbuminemic patients, especially with the autoanalyzer, possibly due to altered potassium homeostasis or other confounding factors.

Conclusion

Self-prepared sodium (Na^+) syringes can introduce preparation errors, and sodium heparin may falsely elevate Na^+ levels. In contrast, Lithium heparin causes no electrolyte interference, with values aligning closely to USCLIA guidelines, which also recommend lithium heparin syringes for ABG analyzer use. In hypoalbuminemia, lower Na^+ levels were observed, and ABG readings appeared more reliable. Lithium heparinized syringes showed deviations of up to 3.2 mmol/L for sodium and 0.4 mmol/L for potassium, staying within USCLIA limits, making them preferable to self-prepared heparinized syringes.

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