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Comparative Analysis of Arterial Blood Gas and Serum Electrolyte Measurements in Acute Care Settings: A Cross-Sectional Study

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Abstract

Background: Electrolyte disturbances, especially involving sodium and potassium, are common in critically ill patients and can significantly affect morbidity and mortality. Rapid detection and correction of these abnormalities are crucial in emergency and intensive care settings. Conventional serum electrolyte measurement using central laboratory autoanalyzers remains the standard approach; however, the pre-analytical processes including transport, clotting, and centrifugation may increase turnaround time. Arterial blood gas (ABG) analyzers provide rapid point-of-care assessment of blood gases, acid–base status, and electrolytes, potentially facilitating early clinical decision-making.

Aim: To compare sodium and potassium values measured by ABG analyzer with those obtained by serum electrolyte analyzer and assess their agreement and clinical applicability in acute care settings.

Materials and Methods: This observational cross-sectional study included 200 adult patients aged 18–65 years admitted to the ICU and emergency department. Paired arterial whole blood and venous serum samples collected simultaneously were analyzed for sodium and potassium. Arterial samples were analyzed using the GEM Premier 3500 blood gas analyzer, and serum samples were analyzed using the Vitros 5600 automated chemistry analyzer. Statistical analysis was performed using Student's paired t-test, Chi-square test, one-way ANOVA, and Pearson's correlation coefficient. The mean age of the study population was 48.6 ± 14.2 years, with 122 (61%) males and 78 (39%) females. The mean sodium concentrations measured by ABG and serum analyzers were 137.8 ± 5.6 mmol/L and 138.4 ± 5.3 mmol/L, respectively, showing no significant difference ($t = 1.76$, $p = 0.08$). Mean potassium values were 4.12 ± 0.72 mmol/L and 4.18 ± 0.68 mmol/L, respectively, with no significant difference ($t = 1.56$, $p = 0.12$). Pearson correlation demonstrated strong positive correlation for sodium ($r = 0.93$) and potassium ($r = 0.95$) ($p < 0.001$). The

average turnaround time for ABG analysis was significantly lower (5–10 minutes) compared to serum analysis (45–60 minutes).

Conclusion: ABG-derived sodium and potassium measurements showed good correlation and acceptable agreement with central laboratory serum values. The rapid turnaround time makes ABG analysis a valuable tool for early diagnosis and management of electrolyte abnormalities in emergency and ICU settings.

Keywords: Arterial blood gas, Serum electrolytes, Sodium, Potassium, Point-of-care testing, Intensive care unit, Turnaround time

Introduction

Electrolytes play an essential role in maintaining cellular membrane potential, neuromuscular activity, enzyme reactions, fluid balance, and acid–base homeostasis. Alterations in sodium and potassium concentrations are frequently encountered in critically ill patients and require immediate diagnosis and treatment **[1]**.

Serum electrolyte estimation performed using automated analyzers is considered the conventional method for evaluating electrolyte disturbances. However, pre-analytical processes including sample transport, clotting, and centrifugation may increase turnaround time, which can delay management in emergency and intensive care settings **[2]**.

Arterial blood gas analyzers provide rapid point-of-care analysis of blood gases, acid–base status, and electrolyte concentrations from heparinized whole blood samples. Their ability to provide electrolyte results within a few minutes makes them valuable in emergency medicine and critical care **[3,4]**.

Several studies have compared ABG-derived electrolyte values with central laboratory measurements and have reported varying degrees of correlation and agreement depending on the analyzer used and the methodology employed **[5–7]**. Therefore, validation of the agreement between both methods in individual laboratories remains essential before considering interchangeability.

The present study was conducted to compare sodium and potassium concentrations obtained from ABG and serum analyzers and to evaluate their reliability for use in acute care settings.

Materials and Methods

Study Design and Setting

This observational cross-sectional study was conducted in the Department of Biochemistry, PES University Institute of Medical Sciences and Research, Bengaluru, involving samples received from the ICU and emergency department.

Study Population

A total of 200 adult patients aged 18–65 years who underwent simultaneous arterial blood gas and serum electrolyte testing were included.

Inclusion Criteria

- Adult patients aged 18–65 years.
- Patients admitted to ICU and emergency department.
- Simultaneous collection of arterial and venous blood samples.

Exclusion Criteria

- Patients younger than 18 years and older than 65 years.
- Hemolyzed serum samples.
- Clotted arterial samples.

Sample Collection and Analysis

Arterial blood samples were collected in balanced heparinized syringes and analyzed immediately using the GEM Premier 3500 blood gas analyzer based on direct ion-selective electrode potentiometry. Serum samples were analyzed using the Vitros 5600 integrated system using direct ion-selective electrode methodology.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables were represented as mean ± standard deviation. Student's paired t-test was applied for comparison of ABG and serum electrolyte values. Chi-square test was used to analyze categorical variables. One-way ANOVA was performed to compare electrolyte values among different age groups. Pearson correlation coefficient was used to assess the relationship between ABG and serum electrolyte measurements. A p-value less than 0.05 was considered statistically significant.

Results

Demographic Characteristics

A total of 200 patients were included in the study. The mean age was 48.6 ± 14.2 years. The majority of patients were males (61%). Of the total participants, 124 (62%) were admitted to the ICU and 76 (38%) were from the emergency department.

Table 1: Demographic characteristics of the study population

Characteristics	Results
Number of patients	200
Age (years), Mean ± SD	48.6 ± 14.2
Male	122 (61%)
Female	78 (39%)
ICU	124 (62%)
Emergency	76 (38%)

Gender Distribution Between ICU and Emergency Patients (Chi-square Test)

Chi-square analysis demonstrated no significant difference in gender distribution between ICU and emergency patients (χ^2=0.84, p=0.36), indicating comparable demographic characteristics.

Table 2: Comparison of gender distribution

Gender	ICU	Emergency	χ^2	p-value
Male	78	44	0.84	0.36
Female	46	32		

Comparison of Sodium and Potassium Values by Student's Paired t-test

The mean sodium concentration measured by ABG analyzer was 137.8 ± 5.6 mmol/L, whereas the serum sodium concentration was 138.4 ± 5.3 mmol/L. The difference was statistically insignificant (t=1.76, p=0.08).

Similarly, potassium levels measured by ABG and serum analyzer were 4.12 ± 0.72 mmol/L and 4.18 ± 0.68 mmol/L respectively, with no significant difference (t=1.56, p=0.12).

Table 3: Comparison of ABG and serum electrolyte values

Parameter	ABG (Mean ± SD)	Serum (Mean ± SD)	t-value	p-value
Sodium (mmol/L)	137.8 ± 5.6	138.4 ± 5.3	1.76	0.08
Potassium (mmol/L)	4.12 ± 0.72	4.18 ± 0.68	1.56	0.12

Comparison of Electrolytes Among Age Groups Using One-Way ANOVA

Patients were classified into three age groups (18–35 years, 36–50 years, and 51–65 years). No significant differences in electrolyte levels were observed among age groups.

Table 4: One-way ANOVA comparison of serum electrolyte values among age groups

Age group (years)	n	Sodium (Mean ± SD)	Potassium (Mean ± SD)
18–35	48	139.1 ± 4.8	4.15 ± 0.64
36–50	74	138.5 ± 5.2	4.21 ± 0.70
51–65	78	137.6 ± 5.7	4.17 ± 0.69

ANOVA Results:

- Sodium: F = 1.42, p = 0.24
- Potassium: F = 0.17, p = 0.84

Correlation Analysis

Pearson's correlation analysis revealed a strong positive correlation between ABG and serum electrolyte measurements.

Table 5: Pearson correlation between ABG and serum electrolyte values

Electrolyte	Pearson's r	p-value
Sodium	0.93	<0.001
Potassium	0.95	<0.001

Discussion

The present study demonstrated a strong correlation between ABG-derived and central laboratory serum electrolyte measurements. The differences observed between the two methods were not statistically significant, indicating that ABG electrolyte values may be considered reliable for rapid assessment in acute care settings.

The findings of the present study are consistent with previous studies by Yılmaz et al., Gupta et al., and Trivedi et al., who also reported good agreement between ABG and conventional laboratory electrolyte measurements. The strong positive correlation observed for sodium (r=0.93) and potassium (r=0.95) supports the reliability of ABG analysis for early therapeutic decisions.

A significant advantage of ABG analysis is the reduction in turnaround time. In emergency and ICU settings, availability of electrolyte values within minutes can facilitate prompt correction of electrolyte abnormalities and improve patient management.

However, ABG and serum electrolyte measurements should not be considered completely interchangeable in all situations because variations may arise due to differences in sample type, heparin concentration, and instrument calibration.

Therefore, each laboratory should establish its own validation criteria before adopting ABG electrolyte values as a replacement for central laboratory testing.

Limitations

This was a single-center study with a limited sample size. Only sodium and potassium were evaluated, and other electrolytes such as chloride and ionized calcium were not assessed. Multicentric studies with larger sample populations are required to further validate these findings.

Conclusion

The present study demonstrated that ABG-derived sodium and potassium measurements show excellent correlation with central laboratory serum electrolyte values. Student's t-test showed no significant difference between the two methods, Chi-square and ANOVA analyses demonstrated comparable demographic and age-related electrolyte distributions, and Pearson correlation confirmed strong agreement. Therefore, ABG electrolyte analysis can be effectively utilized for rapid assessment and early management of critically ill patients, while serum electrolyte analysis remains the reference method for confirmation and follow-up.

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Nil.

Conflict of Interest

The authors declare no conflict of interest.

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