

Correlation Between Sodium and Potassium Levels in Arterial Blood Gas Samples and Serum

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Abstract

Background and Objective:

Electrolyte disturbances, particularly involving sodium and potassium, are among the most frequent and clinically important abnormalities observed in hospitalized patients, especially in intensive care units (ICUs) and emergency departments. Although arterial blood gas (ABG) analysis is widely utilized in clinical practice, potential discrepancies between electrolyte values obtained from ABG samples and those measured in serum may affect clinical decision-making. This study aimed to assess the correlation between sodium and potassium levels measured in arterial blood gas samples and corresponding serum concentrations in patients admitted to Shohadaye Kargar Hospital, Yazd, during 2024–2025.

Methods

This cross-sectional analytical study was conducted on 102 patients admitted to the ICU and emergency departments. A census sampling approach was employed for participant selection. Sodium and potassium levels were measured in both arterial blood gas and serum samples. In addition, demographic characteristics and selected laboratory parameters were collected and analyzed. Patients who did not meet standardized sampling criteria or who had received medications influencing electrolyte balance were excluded. Data analysis was performed using SPSS software, version 26.

Results

The mean sodium concentration measured in ABG samples was significantly higher than that in serum samples ($P < 0.001$), whereas potassium levels in ABG were significantly lower compared to serum measurements ($P < 0.001$). A strong positive correlation was observed between ABG and serum measurements for both sodium ($r = 0.627$) and potassium ($r = 0.892$), with statistical significance ($P < 0.001$). Gender-based differences were significant for potassium levels but not for sodium. Furthermore, significant associations were identified between certain laboratory parameters, including pH and bicarbonate levels, and potassium concentrations measured in ABG samples.

Conclusion

Despite significant differences in mean electrolyte values between ABG and serum measurements, the strong correlations observed indicate that arterial blood gas analysis may serve as a reliable method for estimating electrolyte status, particularly potassium levels, in critically ill patients.

Introduction

Acid–base disturbances and electrolyte imbalances are among the most frequent and clinically significant abnormalities encountered in hospitalized patients, particularly in emergency departments and intensive care units (ICUs)(1), where they substantially influence prognosis, therapeutic decision-making, and mortality outcomes. In this context, blood gas analysis especially arterial blood gas (ABG) analysis serves as a fundamental diagnostic modality, providing essential information regarding patients' respiratory and metabolic status(2). Its interpretation, however, should always be integrated with clinical findings to ensure accurate clinical assessment. ABG analysis is particularly valuable for the rapid evaluation of acid–base disorders in acute and life-threatening conditions(3).

In addition to acid base parameters, modern blood gas analyzers allow for the concurrent measurement of selected electrolytes, including sodium and potassium(4). This capability is particularly advantageous in emergency settings, where time-sensitive decision-making is critical to patient outcomes. By contrast, electrolyte measurement using standard laboratory autoanalyzers remains the reference method; however, it is associated with inherent processing delays, which may limit its utility in urgent clinical scenarios(5).

Despite these advantages, the accuracy and reliability of electrolyte measurements obtained from ABG samples compared with serum-based laboratory measurements remain a subject of ongoing debate(6). Although several studies have demonstrated acceptable correlations between sodium and potassium values derived from the two methods, clinically significant discrepancies particularly in critically ill patients may still occur and potentially lead to divergent interpretations and inconsistent therapeutic decisions. These variations may be attributable to multiple factors, including differences in analyzer technology, calibration procedures, sampling timing, and patients' hemodynamic and metabolic status(7, 8). It is important to note that many previous investigations have been conducted in heterogeneous populations with varying clinical conditions or have utilized different analyzers with non-comparable methodological settings. As a result, the generalizability of their findings to specific clinical environments is limited. Furthermore, most studies have primarily focused on correlation analyses, whereas assessment of clinical agreement which is crucial for decision-making in practice has received comparatively less attention. This gap underscores the need for more context-specific evaluations based on local clinical data, particularly in healthcare settings with distinct patient populations and operational conditions.

In critically ill patients, who often experience rapid physiological fluctuations, even minor deviations in electrolyte measurements may have significant clinical implications(1). Inaccurate estimation of potassium levels may increase the risk of life-threatening cardiac arrhythmias, while errors in sodium measurement may result in inappropriate fluid management and serious osmotic complications(9).

Therefore, determining whether electrolyte values obtained from ABG analysis can reliably substitute serum measurements in clinical decision-making is of considerable clinical importance. Establishing such evidence may contribute to more rapid therapeutic decisions, reduction of diagnostic delays, optimization of laboratory resource utilization, and ultimately improvement in patient outcomes in critical

care settings. The present study was conducted to evaluate the correlation and level of agreement between sodium and potassium concentrations measured in arterial blood gas samples and those obtained from serum in patients admitted to the emergency and intensive care units of the hospital.

Method

Study Design and Setting

This study employed an analytical cross-sectional design to assess the correlation and level of agreement between sodium and potassium concentrations measured in arterial blood gas (ABG) samples and serum. The study was conducted in the intensive care units (ICUs) and the emergency department of Shohadaye Kargar Hospital, Yazd, Iran, during the period 2024–2025. This study was approved by the Ethics Committee of Islamic Azad University, Yazd Branch, Iran (Ethics Code: IR.IAU.YAZD.REC.1404.007).

Study Population and Sampling Method

The study population comprised all hospitalized patients admitted to the ICU and emergency department for whom simultaneous arterial blood gas analysis and serum electrolyte testing were clinically indicated. A census sampling approach was adopted, and 50 eligible patients were included. To improve the generalizability of the findings, supplementary data were also obtained from patients admitted to Seyed al-Shohada Hospital, Yazd, Iran.

Inclusion and Exclusion Criteria

Patients were included if simultaneous electrolyte measurements from ABG and serum samples were available, the time interval between the two sampling procedures did not exceed 30 minutes, and no interventions known to affect electrolyte balance (e.g., intravenous fluids or electrolyte-modifying medications) were administered during this period. Written informed consent was obtained from either the patient or their legal representative.

Patients were excluded if the time interval between sample collections exceeded 30 minutes, if any intervention affecting electrolyte status was performed between sampling, or if technical issues such as hemolysis or incomplete data were present. In addition, cases involving sampling from different anatomical sites or incomplete clinical records were excluded from the final analysis.

Data Collection

Data were collected using a structured data extraction form. The variables included age, sex, underlying comorbidities, sodium and potassium concentrations in serum and ABG samples, blood pH, and

bicarbonate levels. Information was retrieved from patients' medical records and systematically recorded.

Measurement Tools and Quality Control

Serum electrolyte concentrations were measured using a standard laboratory autoanalyzer, while ABG electrolyte values were obtained using a calibrated blood gas analyzer. To ensure data reliability and minimize measurement bias, only samples meeting predefined quality criteria including absence of hemolysis, accurate documentation, and verified device calibration were included in the final analysis.

Statistical Analysis

All data were entered into SPSS software (version 26) and analyzed using appropriate statistical methods. The normality of data distribution was assessed using the Shapiro–Wilk test, along with descriptive statistics. Quantitative variables were expressed as mean $\pm$ standard deviation, while categorical variables were reported as frequencies and percentages. The relationship between sodium and potassium levels in ABG and serum samples was evaluated using Pearson's correlation coefficient. Independent samples t-tests were used to compare mean electrolyte levels across subgroups defined by age, sex, comorbidities, and acid–base status. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

This study was approved by the Ethics Committee of Islamic Azad University, Yazd Branch. All patient information was handled with strict confidentiality and used exclusively for research purposes. The study involved no therapeutic intervention and imposed no financial burden or clinical risk on participants.

Result

In the present study, 102 patients (53 females, 51.9%, and 49 males, 48.1%) were included. The mean age of the participants was 54.75 ± 22.05 years (range: 1–92 years), with the highest frequency observed in the age group over 65 years (41.2%).

Among the studied patients, cardiovascular diseases were the most prevalent comorbidity (35.3%), followed by diabetes mellitus (31.4%), pulmonary diseases (13.7%), and renal disorders (9.8%). Regarding comorbidity burden, 37.3% of patients had no underlying comorbid condition, while 42.2% had one comorbidity. In addition, 14.7% had two comorbidities, 4.9% had three comorbid conditions, and 1% had four comorbidities. A total of 75 patients (73.5%) were not receiving any medications known to affect electrolyte balance. Among the medications used, angiotensin-converting enzyme (ACE) inhibitors and loop/thiazide diuretics were each administered to 15 patients (14.7%), corticosteroids to 6 patients

(5.9%), and potassium-sparing diuretics to 4 patients (3.9%). In terms of medication burden, 73.5% of patients were not receiving any medications, 14.7% were taking one medication, 10.8% were receiving two medications, and 1% were on three medications.

The mean sodium concentration in ABG samples was 144.75 ± 5.48 mEq/L, which was significantly higher than the corresponding serum value (138.3 ± 4.8 mEq/L) ($P < 0.001$). The mean potassium level in ABG samples was 3.75 ± 0.66 mEq/L, which was significantly lower than that measured in serum (4.17 ± 0.66 mEq/L) ($P < 0.001$). These findings indicate a systematic difference between the two measurement methods for both electrolytes.

Regarding the range of values, ABG sodium levels varied from 132.1 to 160.9 mEq/L, while potassium levels ranged from 2.29 to 7.30 mEq/L, indicating considerable variability among hospitalized patients. Overall, the results suggest that although ABG analysis may serve as a rapid tool for electrolyte assessment in emergency settings, the significant differences observed compared with serum values should be carefully considered in clinical interpretation (Table 1).

Table 1

Comparison of sodium and potassium levels between serum and ABG samples in hospitalized patients

Variable	Serum Mean $\pm$ SD	ABG Mean $\pm$ SD	Min (ABG)	Max (ABG)	P-value
Sodium (mEq/L)	138.3 ± 4.8	144.75 ± 5.48	132.1	160.9	< 0.001
Potassium (mEq/L)	4.17 ± 0.66	3.75 ± 0.66	2.29	7.30	< 0.001

In subgroup analyses based on age, no statistically significant differences were observed in sodium and potassium levels measured in ABG and serum across different age groups (≤ 18 to ≥ 65 years) ($P > 0.05$). This finding suggests relative stability of electrolyte measurements across age categories and indicates that age does not significantly influence the discrepancy between ABG and serum values.

In the gender-based analysis, a statistically significant difference in potassium levels was observed between the two groups. Specifically, potassium concentrations in both ABG and serum samples were significantly higher in males compared with females ($P = 0.022$), whereas no significant difference was found for sodium levels ($P > 0.05$).

Table 2

Comparison of sodium and potassium levels between serum and ABG samples in hospitalized patients

Factor	Group	n (%)	Na ABG (mean ± SD)	Na Serum (mean ± SD)	P- value (Na)	K ABG (mean ± SD)	K Serum (mean ± SD)	P- value (K)
Sex	Female	53 (51.9)	145.6 ± 6.35	139.0 ± 4.64	0.175	3.60 ± 0.49	4.03 ± 0.51	0.022
	Male	49 (48.1)	144.3 ± 6.04	137.7 ± 4.89		3.90 ± 0.78	4.33 ± 0.81	
Age group	≤ 18	5 (4.9)	145.3 ± 6.82	140.2 ± 5.54	0.593	4.00 ± 0.74	4.56 ± 1.05	0.789
	19–44	30 (29.4)	144.7 ± 4.14	139.1 ± 4.72		3.73 ± 0.49	4.09 ± 0.53	
	45–64	25 (24.5)	144.8 ± 6.12	138.2 ± 4.95		3.68 ± 0.59	4.11 ± 0.56	
	≥ 65	42 (41.2)	145.4 ± 7.50	137.9 ± 4.71		3.78 ± 0.81	4.24 ± 0.80	
Pulmonary disease	Yes	14 (13.7)	148.84 ± 6.5	—	0.029	3.56 ± 0.56	—	0.214
	No	88 (86.3)	144.41 ± 5.9	—		3.77 ± 0.67	—	
Cardiac disease	Yes	36 (35.3)	144.14 ± 6.7	—	0.313	3.84 ± 0.81	—	0.353
	No	66 (64.7)	145.50 ± 5.8	—		3.70 ± 0.56	—	
Diabetes	Yes	32 (31.4)	144.74 ± 7.9	—	0.795	3.76 ± 0.82	—	0.881
	No	70 (68.6)	145.15 ± 5.2	—		3.74 ± 0.58	—	
Renal disease	Yes	10 (9.8)	142.85 ± 5.5	—	0.223	4.30 ± 1.30	—	0.189
	No	92 (90.2)	145.26 ± 6.2	—		3.69 ± 0.52	—	
ACE inhibitors	Yes	15 (14.7)	142.79 ± 3.7	—	0.034	3.68 ± 0.39	—	0.522
	No	87 (85.3)	145.40 ± 6.4	—		3.76 ± 0.70	—	
Loop/Thiazide diuretics	Yes	15 (14.7)	144.84 ± 6.4	—	0.909	3.75 ± 1.08	—	0.993

Factor	Group	n (%)	Na ABG (mean ± SD)	Na Serum (mean ± SD)	P- value (Na)	K ABG (mean ± SD)	K Serum (mean ± SD)	P- value (K)
Potassium-sparing diuretics	No	87 (85.3)	145.05 ± 6.2	—	0.558	3.75 ± 0.57	—	0.342
	Yes	4 (3.9)	143.72 ± 4.0	—		3.52 ± 0.41	—	
	No	98 (96.1)	145.07 ± 6.2	—		3.75 ± 0.67	—	
Corticosteroids	Yes	6 (5.9)	149.46 ± 8.0	—	0.216	3.48 ± 0.56	—	0.290
	No	96 (94.1)	144.74 ± 6.0	—		3.76 ± 0.66	—	

Regarding underlying comorbidities, a statistically significant difference in ABG sodium levels was observed only in patients with pulmonary disease compared with those without this condition ($P = 0.029$). However, no statistically significant differences were identified for other comorbidities, including cardiovascular disease, diabetes mellitus, and renal disease, for either electrolyte ($P > 0.05$) (Table 2). Among the medications evaluated, only the use of angiotensin-converting enzyme (ACE) inhibitors was associated with a significant reduction in ABG sodium levels ($P = 0.034$). This finding is consistent with the established mechanism of ACE inhibition, which suppresses the renin–angiotensin–aldosterone system, leading to decreased aldosterone secretion from the adrenal cortex and consequently increased renal sodium excretion, potentially resulting in hyponatremia (Table 2).

In the analysis of the relationship between pH and arterial blood gas electrolytes, the mean ABG sodium level was 144.75 ± 5.48 mEq/L and showed no significant association with pH variations ($P = 0.656$). In contrast, the mean ABG potassium level was 3.75 ± 0.66 mEq/L and demonstrated a highly significant association with pH ($P = 0.001$), such that lower pH values were associated with higher potassium concentrations. This pattern is consistent with the well-established physiological mechanism of intracellular-to-extracellular potassium shift in acidotic conditions. In the analysis based on bicarbonate (HCO_3^-) levels, the mean ABG sodium concentration remained 144.75 ± 5.48 mEq/L, and the mean potassium concentration was 3.75 ± 0.66 mEq/L. The results indicated a statistically significant association between ABG sodium and bicarbonate levels ($P = 0.045$), with relatively higher sodium values observed in conditions of reduced bicarbonate. Furthermore, ABG potassium showed a highly significant association with bicarbonate levels ($P < 0.001$), such that decreased bicarbonate was accompanied by increased potassium concentrations. These findings highlight the important role of acid–base status in influencing potassium fluctuations compared with sodium in ABG measurements.

A positive and highly significant correlation was observed between arterial blood gas (ABG) sodium levels and serum sodium concentrations ($r = 0.627$, $P < 0.001$). Similarly, a very strong and statistically

significant correlation was found between ABG potassium levels and serum potassium concentrations ($r = 0.892$, $P < 0.001$) (Table 3). The correlation coefficient for potassium indicates a very strong, near-perfect association, whereas the correlation for sodium reflects a moderate-to-strong relationship. These findings suggest that inter-individual variations in potassium levels measured by ABG closely parallel those observed in serum measurements, whereas the association for sodium, although slightly weaker, remains strong and clinically meaningful.

Table 3
Correlation between ABG and serum sodium and potassium levels

Variable	Correlation coefficient (r)	P-value
ABG Sodium vs Serum Sodium	0.627	< 0.001
ABG Potassium vs Serum Potassium	0.892	< 0.001

Discussion

The present study aimed to evaluate the correlation between sodium and potassium levels in arterial blood gas (ABG) samples and serum in 102 hospitalized patients admitted to Shahid Kargar and Seyed al-Shohada Hospitals. The mean sodium concentration in ABG samples (144.75 ± 5.48 mEq/L) was significantly higher than the corresponding serum level (138.3 ± 4.8 mEq/L) ($P < 0.001$). This statistically significant difference in sodium values may be partly attributable to the use of sodium heparin in ABG sampling in Iran instead of lithium heparin, which has been suggested as a potential source of sodium overestimation.

In contrast, the mean potassium concentration in ABG samples (3.75 ± 0.66 mEq/L) was significantly lower than that in serum (4.17 ± 0.66 mEq/L) ($P < 0.001$). This consistent difference in mean values aligns with previous studies(10), and may reflect physiological factors, including differences in water and electrolyte distribution between plasma and the intracellular compartment under critical illness conditions.

Despite these systematic differences in mean values, a strong positive correlation was observed between paired measurements ($r = 0.627$ for sodium and $r = 0.892$ for potassium, both $P < 0.001$). In comparable studies, such as that by Anjana et al., correlation coefficients of 0.78 for sodium and 0.76 for potassium were reported(11). These findings indicate that the correlation for potassium in the present study was stronger than that reported in some previous studies ($r = 0.892$ vs. 0.76), whereas the correlation for sodium was somewhat weaker ($r = 0.627$ vs. 0.78). Similarly, Kaya et al. reported correlation coefficients of 0.78 for sodium and 0.88 for potassium, demonstrating a stronger correlation for sodium but a slightly weaker association for potassium compared with the present findings(12). Overall, these results suggest that individual variations in electrolyte levels in ABG and serum occur in a parallel manner. Accordingly, ABG may serve as a reliable tool for estimating serum electrolyte status, particularly potassium, in critically ill patients.

No significant differences in ABG electrolyte levels were observed across different age groups, including patients aged ≤ 18 , 19–44, 45–64, and ≥ 65 years ($P > 0.05$). Similarly, no statistically significant differences in sodium levels were found between males and females in either serum or ABG measurements ($P = 0.175$ and $P = 0.291$, respectively), findings that are consistent with those reported by Key et al. (37, 38). However, potassium levels showed a statistically significant difference by sex ($P = 0.022$ in ABG and $P = 0.025$ in serum), with higher values observed in males than in females, consistent with previous studies(12, 13).

Acid–base disturbances, particularly reductions in pH and bicarbonate (HCO_3^-), were associated with a significant increase in ABG potassium levels, a finding that is physiologically consistent with the well-established shift of potassium from the intracellular to the extracellular space in acidotic states. This observation is in agreement with prior research, including the study by Haskaya et al., which emphasized that in conditions with marked pH alterations, reliance solely on ABG-derived electrolyte values may lead to misinterpretation and inappropriate clinical decision-making(14).

Regarding comorbidities, a statistically significant difference in serum sodium levels was observed only in patients with pulmonary disease compared with those without this condition ($P = 0.029$). No significant differences in sodium or potassium levels were observed in patients with cardiovascular disease, renal disease, or diabetes mellitus. Furthermore, none of the underlying comorbidities were associated with significant differences in ABG electrolyte values. These findings indicate that the systematic differences observed between ABG and serum measurements (higher sodium and lower potassium in ABG) remain consistent across different patient subgroups and are not significantly influenced by underlying diseases. Among the medications evaluated, only the use of ACE inhibitors was associated with a significant reduction in ABG sodium levels ($P = 0.034$). This effect may be explained by inhibition of the renin–angiotensin–aldosterone system, leading to reduced aldosterone secretion and increased renal sodium excretion, ultimately resulting in hyponatremia. Although no studies were identified that specifically examined the effect of ACE inhibitors on ABG sodium values, the strong correlation between ABG and serum sodium reported in this and previous studies suggests that reductions in serum sodium are likely reflected in ABG measurements as well. Findings from Anjana et al. and Kaya et al. further support this assumption(11, 12).

This study has several limitations that should be considered when interpreting the results. The relatively small sample size and the inclusion of patients from a limited number of centers may restrict the generalizability of the findings. In addition, potential confounding factors such as fluid intake, nutritional status, and detailed hemodynamic parameters were not simultaneously controlled. The absence of long-term follow-up is another limitation.

Despite these limitations, ABG analysis may be considered a rapid and useful method for the initial assessment of electrolyte status in critically ill patients. However, confirmation with serum measurements remains recommended in clinically critical decision-making scenarios. Future studies with larger sample sizes and multicenter designs are warranted to enhance the external validity of the

findings. Further investigation into specific patient subgroups, particularly those with renal failure, hepatic dysfunction, or severe acid–base disturbances, may provide a more comprehensive understanding of electrolyte behavior in different clinical contexts.

Conclusion

The findings of this study demonstrate that although sodium levels are systematically higher and potassium levels are lower in ABG samples compared with serum measurements, there is a significant positive correlation between the two methods. This correlation is particularly strong for potassium and moderate-to-strong for sodium. Accordingly, ABG analysis may serve as a rapid and readily available tool for the initial estimation of electrolyte status, especially in emergency and critically ill patients, while the presence of systematic differences between the two methods should be carefully considered in clinical interpretation.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Islamic Azad University, Yazd Branch, Iran (Ethics Code: IR.IAU.YAZD.REC.1404.007). The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment in the study.

Competing interests

The authors declare no competing interests.

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Author Contribution

A.H. conceptualized and supervised the study and contributed to the clinical interpretation of the findings. M.H.S. participated in data collection, patient recruitment, and manuscript drafting. M.P. contributed to study design, literature review, manuscript writing, and critical revision of the manuscript for important intellectual content. M.Z. contributed to the clinical evaluation of patients, interpretation of laboratory findings, and manuscript revision. H.F. performed the statistical analysis, interpreted the data, and contributed to the methodology section. All authors reviewed and approved the final version of the manuscript.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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