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ARTERIAL BLOOD GAS VERSUS VENOUS SAMPLING FOR ELECTROLYTE AND GLUCOSE ESTIMATION IN HOSPITALISED PATIENTS: A COMPARATIVE STUDY

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ABSTRACT Background: Arterial blood gas (ABG) analysis is widely used for rapid assessment of glucose and electrolyte levels in hospitalised patients. However, arterial sampling is invasive and associated with patient discomfort. This study aimed to evaluate the agreement between arterial and venous measurements and assess whether venous sampling can serve as a reliable alternative. Methods: This cross-sectional study included 210 hospitalised patients. Paired arterial and venous blood samples were collected simultaneously. Arterial samples were analysed using blood gas analysers, while venous samples were processed in the central laboratory. Parameters analysed included glucose, sodium, potassium, chloride, and ionised calcium. Paired t-test and Pearson correlation were used for statistical analysis. Results: No significant differences were observed between arterial and venous measurements for glucose ($p = 0.762$), sodium ($p = 0.502$), potassium ($p = 0.559$), and chloride ($p = 0.59$). Ionised calcium showed a small but statistically significant difference ($p = 0.0421$). All parameters demonstrated strong positive correlation, with correlation coefficients ranging from 0.981 to 0.998 ($p < 0.001$). Conclusions: Venous sampling shows excellent agreement with arterial measurements for glucose and major electrolytes and can be used as a reliable, less invasive alternative in routine clinical practice. Although ionised calcium differed significantly, the clinical impact appears minimal, supporting the broader use of venous sampling in hospital settings.

KEYWORDS : Arterial Blood Gas; Venous Sampling; Electrolytes; Glucose; Ionised Calcium; Correlation

INTRODUCTION

Accurate and rapid assessment of electrolyte and glucose levels is a cornerstone in the management of hospitalised patients, particularly in emergency and critical care settings. Arterial blood gas (ABG) analysis has become an indispensable bedside tool for evaluating acid–base status, oxygenation, and ventilation. In addition to these parameters, modern ABG analysers provide simultaneous measurements of electrolytes and glucose, offering clinicians immediate biochemical data that can facilitate early therapeutic decisions [1].

Despite its clinical utility, arterial sampling is technically more challenging, associated with increased patient discomfort, and carries a higher risk of complications like arterial injury, thrombosis, and hematoma formation. In contrast, venous sampling remains the standard method for biochemical analysis, being less invasive, easier to perform, and widely accepted for routine laboratory investigations. However, reliance on central laboratory autoanalysers often results in longer turnaround times, which may delay timely clinical interventions, especially in critically ill patients [2].

With the increasing availability and use of point-of-care testing (POCT), ABG analysers are frequently utilised not only for blood gas analysis but also for rapid estimation of electrolytes and glucose. This has raised an important clinical question regarding the reliability and interchangeability of arterial measurements with conventional venous values. Several studies have explored this comparison, yielding heterogeneous results. While strong correlations between arterial and venous electrolyte levels have been reported in some studies, statistically significant differences in absolute values have also been observed, potentially limiting their interchangeability [3,4].

Recent evidence suggests that although parameters such as sodium and potassium measured via ABG may demonstrate acceptable agreement within clinically allowable error limits, discrepancies still exist depending on analytical methods and patient conditions. Similarly, glucose measurements obtained from arterial samples may differ significantly from venous values, sometimes exceeding acceptable error thresholds, thereby raising concerns about their direct substitution in clinical decision-making [1]. Factors such as heparin dilution, differences in sample type (whole blood vs serum), analyser technology, and physiological variations between arterial and venous compartments contribute to these inconsistencies [6].

Given these considerations, it is essential to evaluate whether ABG-derived electrolyte and glucose measurements can reliably substitute venous values in hospitalised patients. Establishing such comparability would not only enhance clinical efficiency by reducing turnaround time but also minimise patient discomfort due to repeated sampling. Therefore, the present study aims to compare arterial and venous blood levels of electrolytes and glucose in hospitalised patients and to assess the degree of agreement between these two sampling methods, thereby determining their potential interchangeability in routine clinical practice.

MATERIALS AND METHODS

This cross-sectional observational study was conducted at Sawai Man Singh Hospital, Jaipur, a tertiary care teaching hospital in Rajasthan, India. The study included hospitalised patients admitted to various departments over the study period. Institutional ethics committee approval was obtained before commencement, and written informed consent was obtained from all participants or their legally authorised representatives. A total of 210 hospitalised patients aged between 18 and 60 years were included in the study. Patients requiring arterial blood gas (ABG) analysis as part of routine clinical care were eligible. Patients with known haematological disorders affecting sample integrity, those with inadequate samples, or those in whom paired sampling could not be obtained were excluded.

For each participant, paired arterial and venous blood samples were collected simultaneously under aseptic conditions to minimise temporal variation. Arterial samples were obtained from the radial artery using pre-heparinised syringes. Venous samples were collected from peripheral veins using standard phlebotomy techniques. All samples were collected by trained personnel, ensuring minimal pre-analytical error. Arterial samples were analysed immediately at the point of care, while venous samples were transported promptly to the central laboratory under appropriate conditions. Arterial blood samples were analysed using the GEM Premier 3000 blood gas analyser (Instrumentation Laboratory, USA), which provides rapid measurement of electrolytes and glucose using direct ion-selective electrode (ISE) methodology.

Venous blood samples were processed in the central laboratory using the Randox RX Imola autoanalyser (Randox Laboratories, UK), based on indirect ISE and standard photometric methods. The following

parameters were measured in both arterial and venous samples: Glucose, Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), and Calcium (Ca^{2+}). Quality control procedures were routinely performed for both analysers in accordance with manufacturer guidelines. Demographic data, including age and gender, were recorded. Clinical variables and relevant diagnoses were noted where applicable. All biochemical parameters were documented separately for arterial and venous samples for each participant. Data were entered into Microsoft Excel and analysed using standard statistical software (GraphPad Prism Ver. 6.0). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The agreement and correlation between arterial and venous values were assessed using Pearson's correlation coefficient (r). Differences between paired arterial and venous measurements were evaluated using the paired Student's t-test. For subgroup analyses, categorical variables were compared using the Chi-square test. A p-value of < 0.05 was considered statistically significant.

RESULTS

A total of 210 hospitalised patients were included in this cross-sectional study. Paired arterial and venous samples were analysed for glucose and electrolyte parameters. The study population included both male and female patients, with a comparable distribution across groups (Figure 1A). The mean values of glucose and electrolytes in arterial and venous samples are presented in Table 1. There was no statistically significant difference between arterial and venous measurements for glucose (136.25 ± 67.91 vs 136.34 ± 67.65 mg/dL, p = 0.762), sodium (139.33 ± 2.96 vs 139.39 ± 3.12 mmol/L, p = 0.502), potassium (4.89 ± 0.91 vs 4.90 ± 0.89 mmol/L, p = 0.559), and chloride (101.85 ± 2.69 vs 101.90 ± 2.87 mmol/L, p = 0.59). However, ionised calcium levels showed a small but statistically significant difference between arterial and venous samples (4.72 ± 0.27 vs 4.69 ± 0.27 mg/dL, p = 0.0421).

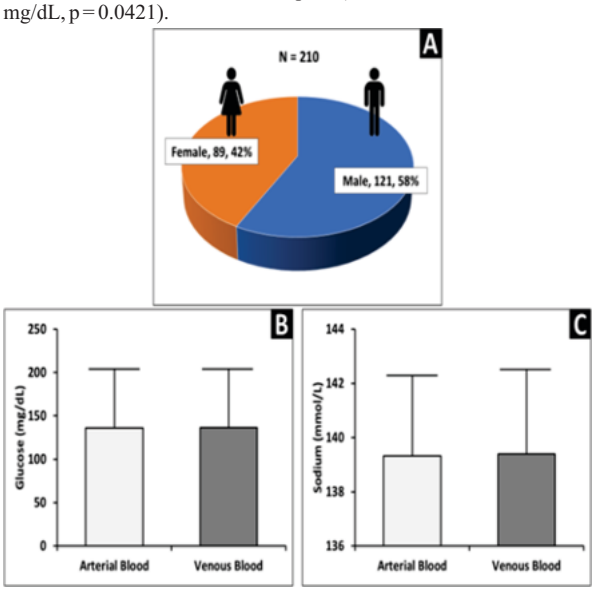

Figure 1: (A) Distribution of Male and Female Patients in the Study. Comparison of (B) Glucose and (C) Sodium Levels in Arterial and Venous Blood.

Correlation analysis demonstrated a very strong positive correlation between arterial and venous values for all measured parameters (Table 2). Glucose showed near-perfect correlation (r = 0.998, p < 0.001), while sodium (r = 0.99), potassium (r = 0.981), chloride (r = 0.983), and ionised calcium (r = 0.994) also exhibited excellent correlation (all p < 0.001).

Table 1: Comparison of different parameters in arterial and venous samples.

	Arterial Blood	Venous Blood	p-value
Glucose (mg/dL)	136.25 ± 67.91	136.34 ± 67.65	0.762 (NS)
Sodium (mmol/L)	139.33 ± 2.96	139.39 ± 3.12	0.502 (NS)
Potassium (mmol/L)	4.89 ± 0.91	4.90 ± 0.89	0.559 (NS)
Chloride (mmol/L)	101.85 ± 2.69	101.90 ± 2.87	0.59 (NS)
Ionised Calcium (mg/dL)	4.72 ± 0.27	4.69 ± 0.27	0.0421 (S)*

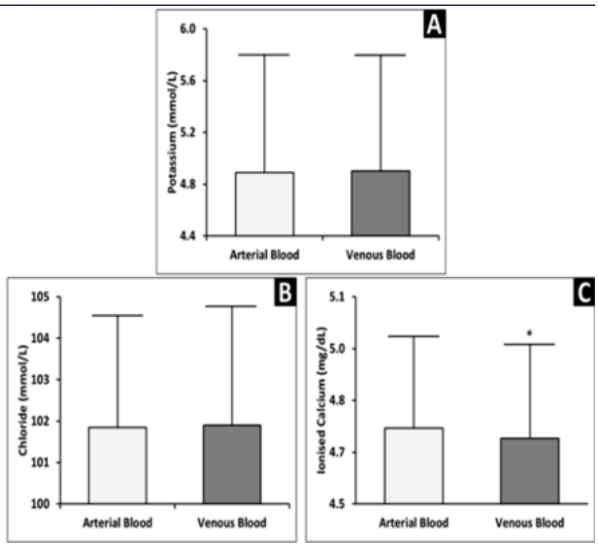

Figure 2: (A) Distribution of Male and Female Patients in the Study. Comparison of (B) Glucose and (C) Sodium Levels in Arterial and Venous Blood. Paired t-test. *<0.05.

Table 2: Correlation between different parameters in arterial and venous samples.

Arterial Vs Venous Sample	Correlation (r)	p-value
Glucose	0.998	<0.001
Sodium	0.99	<0.001
Potassium	0.981	<0.001
Chloride	0.983	<0.001
Ionized Calcium	0.994	<0.001

DISCUSSION

The present cross-sectional study evaluated the comparability of arterial and venous measurements of glucose and selected electrolytes in 210 hospitalised patients. Our findings indicate that arterial and venous values for glucose, sodium, potassium, and chloride are statistically comparable, with no significant differences observed between the two sampling methods. Furthermore, all parameters demonstrated a strong positive correlation, suggesting a high degree of agreement.

Glucose measurements showed no significant difference between arterial and venous samples (p = 0.762), with an almost perfect correlation (r = 0.998). These findings are consistent with previous studies that have reported minimal variation between arterial and venous glucose levels, supporting the reliability of venous sampling in routine clinical practice [4, 6, 7]. Similarly, sodium, potassium, and chloride levels did not differ significantly between the two sample types, corroborating earlier reports that demonstrated strong agreement between arterial blood gas analysers and central laboratory measurements [8,9]. Systematic reviews have also suggested that venous sampling can adequately substitute arterial measurements in most emergency settings, particularly when rapid decision-making is required [10].

The correlation coefficients for all measured parameters were notably high (r = 0.981–0.998, p < 0.001), indicating excellent linear relationships between arterial and venous values. These results are in agreement with prior studies conducted in both adult and paediatric populations, which have consistently shown that venous samples can serve as reliable substitutes for arterial samples for most biochemical parameters [7, 8].

In contrast, ionised calcium levels showed a statistically significant difference between arterial and venous samples (p = 0.0421). Although the absolute difference was small, this finding is consistent with previous literature indicating that ionised calcium is influenced by pre-analytical factors such as pH, sample handling, and delays in analysis [11, 12]. Arterial samples, which are typically analysed immediately using blood gas analysers, may better reflect in vivo physiological conditions compared to venous samples processed in central laboratories. From a clinical perspective, the findings of this study suggest that venous sampling may be used as a less invasive and more practical alternative to arterial sampling for the estimation of glucose and major electrolytes. This is particularly relevant in emergency and

critical care settings, where arterial sampling may be associated with discomfort and potential complications. However, caution should be exercised when interpreting ionised calcium values, especially in critically ill patients where precise measurement is essential [13, 14, 15].

The strengths of this study include the relatively large sample size and the use of simultaneously collected paired arterial and venous samples, which minimise temporal variability. Additionally, the evaluation of multiple biochemical parameters enhances the clinical applicability of the findings. However, certain limitations should be acknowledged. The study was conducted at a single centre, which may limit generalisability. Differences in analytical techniques between blood gas analysers and central laboratory instruments may also contribute to minor variability.

CONCLUSIONS

In conclusion, arterial and venous measurements of glucose and major electrolytes demonstrate strong agreement and correlation, supporting the use of venous samples as a reliable alternative in routine clinical practice. While ionised calcium showed a minor, yet statistically significant difference, major electrolytes did not show any significant difference. Hence, for the assessment of sodium, potassium and chloride in ill patients, both arterial and venous samples can be used.

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Conflict of Interests

The authors declare that they have no known competing financial or personal relationships that could have appeared to influence the work reported in this paper.

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