# Correlation between the Measurements of Serum and Arterial Blood Gas (ABG) Electrolytes in Patients Admitted to the Intensive Care Unit at King Abdul-Aziz Medical City, Riyadh, Saudi Arabia

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**Abstract**  **Background:** The values of electrolytes are measured by both the arterial blood gas analyzer and the auto-analyzers, in arterial and venous blood respectively. Literature reports suggest controversies in comparisons between the results. Concerns have been increased about the precision of the instrument due to difference in results of laboratories, in addition to the time consumed. **Materials and Methods:** This is a prospective observational study on serum and ABG electrolytes in samples from 53 (34 Male and 19 Female) patients admitted to ICU at King Abdul-Aziz Medical City (KAMC). The analysis was done in Central Laboratory. The results from patients' file were uploaded to SPSS from excel sheets and statistical analysis was done. **Results and Conclusion:** The age of patients varied between 14 years and 87 years in both the sexes. The sex wise frequency was 64.151% (males) and 35.85% (females). The pathological reports showed highest incidence of post-Motor Vehicular Accidents (MVA) followed by Community Acquired Pneumonia (CAP) and Respiratory Failure (RF). Comorbidities were infrequent. However; the highest incidence was related to Diabetes (DM) + Hypertension (HTN), followed by HTN alone and subsequently DM alone. SPSS analysis showed correlation between serum electrolytes and ABG electrolytes was significant at 0.01 levels. Correlation between serum and arterial electrolytes was significant, however; related to time it was weakly negative. We conclude that critical decisions can be made by trusting the values obtained through both ABG and Serum levels of the electrolytes.

*Keywords: correlation, ABG, serum, electrolytes, prospective, observational, SPSS*

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## 1. Introduction

Electrolyte disturbances can lead to serious and critical events, hence; quick and accurate assessment of these disturbances warrants emergent medical attention. The quickness of that assessment, especially in developing countries, is frequently restricted by the postponement in transporting samples to laboratory, either because of deficiency of adequate couriers or the nonappearance of quick transport systems. This frequently lead to a lengthy time (regularly over 15 minutes) for the estimation of electrolytes in laboratory [1]. These postponements could negatively affect consequences.

Arterial blood gas analyzer is progressively used in emergency Units (ER) and the intensive care units (ICU) to allow the quick assessment of electrolytes and ABG disturbances. Although there is an advantage of fast processing time with ABG analyzer, concerns have been increased about the precision and nicety of the instrument. There appears to be enormous controversy in the results of different laboratories, possibly because of the use of dissimilar devices, whereas previous studies determined that consequences varied meaningfully for plasma sodium and chloride concentrations, others as well discovered

major variances in potassium results [2,3]. Hence, it is not unfamiliar to see health care givers operating the ABG analyzer to see the results to proceed in an urgent condition, especially where maximum of electrolyte results value are gained. Serum electrolytes analyze the electrolytes in serum and it is affected by protein level in the blood [4].

It is well known that rapid provision of blood measurements, particularly blood gases and electrolytes may translate into improved clinical outcomes. Studies have shown that point of care testing carries advantages of providing reduced therapeutic turnaround time, shorter clinical decision time, rapid availability of data and minimized pre- and post- analytic testing errors [5]. Nevertheless, there is a lot of debate on analyzer inaccuracy, imprecision and performance. Hence, it was found imperative to investigate the comparative analysis of Electrolyte estimated by ABG analyzer and serum electrolyte estimated at the laboratory, since these procedures imitate practice approximately in all hospitals [6,7].

## 2. Materials and Methods

We conducted a prospective observational study at the medical ICU of KAMC. This ICU is a 29 bedded level 3 critical care unit managed by intensivists with the support of respiratory therapist and critical nursing. The present study is approved by the Ethics Committee of King Abdul-Aziz medical city. All procedures were in accordance with the Second Declaration of Helsinki of 1975, as revised in 2000. [7]We included Adult patients (both sexes), 18 years or older admitted to the intensive care unit and Patients who have arterial and central venous access in situ (under normal and pathological conditions) for clinical management purposes.

The Normal individuals and pediatric patients were excluded. The study blood samples drawn from all patients who needed the estimation of arterial and serum electrolytes during a period of two weeks of the study were included. The target population constituted the total number of patients attending for estimation of arterial and serum electrolytes. Hence sample size depended on the total number of patients who are admitted in ICU.

The blood drawn was routinely taken. The arterial sample was analyzed in the ABG analyzer and then results were printed and these results were entered in data collection form. The serum samples was transported through a rapid pneumatic system to the central laboratory for analysis of electrolytes and the results was transferred to patient file through computer and then we entered these results in the data collection form [8, 9].The data obtained was uploaded into SPSS software through excel. A backup soft copy version as well as a hard copy was dated, saved and secured after each data entry update. A designated study binder and a dedicated USB flash memory were kept in the laboratory records. The data analysis was done using SPSS software.

## 3. Results

The age of patients whose blood samples were taken for estimation of serum and ABG electrolytes varied between 14 years and 87 years in male and females. The age in the male patients ranged between 14 years and 87 years and in female patients, it varied between 28 years and 81 years. The sex wise frequency was 64.151% and 35.85% in males and females respectively. The patients with different pathological conditions showed highest frequency in the post MVA, followed by CAP and RF. The frequency of de compensated heart failure (DHF), pancreatic cancer (PC) and prostate cancer (P+ CA) was similar. The other conditions with equal frequencies were ST segment elevation myocardial infarction (STEM I), intra-cerebral hemorrhage (ICH), shock, hemoglobin SS disease (SS), Pnuemosepsis and Pulmonary embolism (PE), other conditions (embryonic carcinoma (EC), mitral stenosis (MS), systemic sclerosis (SS), end stage renal disease (ESRD), intracebral hemorrhage (ICH), DM and HTN, spinal cord injury (SCI), internal carotid stenosis (ICS), keto acidosis (KA), systemic lupus erythematosus (SLE) and others were all equal. Majority of the patients had no comorbidities, followed by HTN and DM. HTN alone was followed by DM alone. The frequencies of BA; HTN, DM and congestive heart failure (CHF); HTN, DM and BA; HTN, End stage renal disease (ESRD), Chronic obstructive pulmonary disease (COPD); HTN and BA; HTN, DM and BA were all similar and showed lower tendency.

**Table 1. Correlation observed between Serum Sodium and ABG Sodium**

| Correlations | | SNa | ABGNa |
|---|---|---|---|
| SNa | Pearson Correlation | 1 | .944** |
| | Sig. (2-tailed) | | .000 |
| | N | 53 | 53 |
| ABGNa | Pearson Correlation | .944** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 53 | 53 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Table 2. Correlation observed between Serum Potassium and ABG Potassium**

| Correlations | | SK | ABGK |
|---|---|---|---|
| SK | Pearson Correlation | 1 | .679** |
| | Sig. (2-tailed) | | .000 |
| | N | 53 | 53 |
| ABGK | Pearson Correlation | .679** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 53 | 53 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Table 3. Correlation observed between Serum Calcium and ABG Calcium**

| Correlations | | SCa | ABGCa |
|---|---|---|---|
| SCa | Pearson Correlation | 1 | .399** |
| | Sig. (2-tailed) | | .003 |
| | N | 53 | 53 |
| ABGCa | Pearson Correlation | .399** | 1 |
| | Sig. (2-tailed) | .003 | |
| | N | 53 | 53 |

**. Correlation is significant at the 0.01 level (2-tailed).

The correlations between Serum sodium, potassium and calcium and ABG sodium, potassium and calcium were statistically significant at the 0.01 level (Table 1-Table 3 and Figure 1, Figure 2 and Figure 3). The correlation of these groups with time was statistically insignificant.
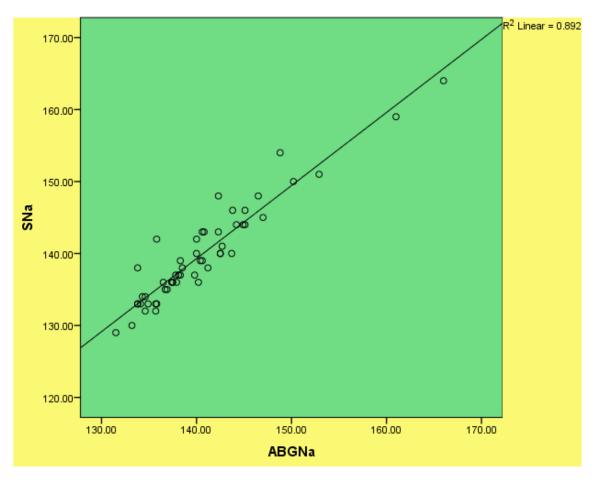
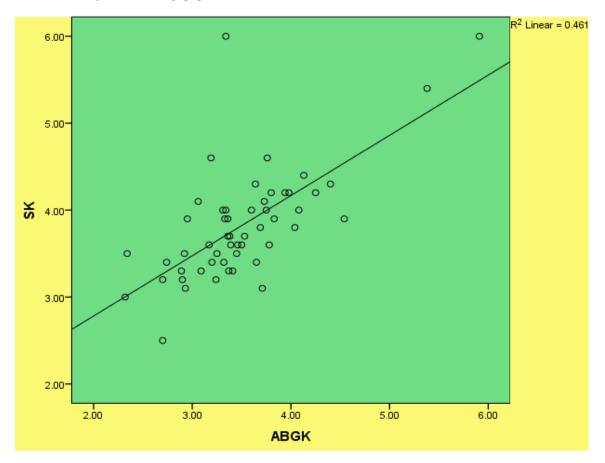**Figure 1**. Scattered graph plotted to show the correlation between Serum Sodium and ABG Sodium



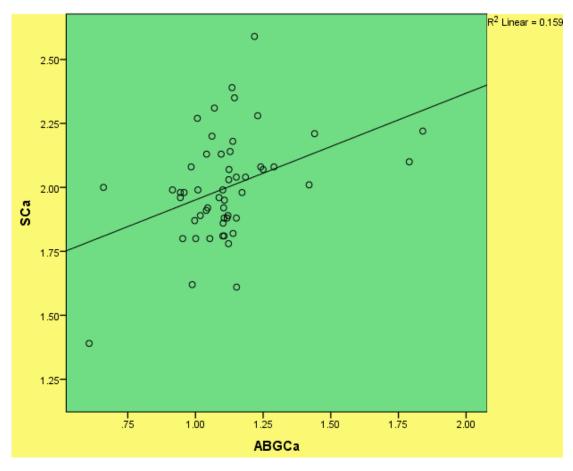**Figure 2.** Scattered graph plotted to show the correlation between Serum Potassium and ABG Potassium

**Figure 3.** Scattered graph plotted to show the correlation between Serum Calcium and ABG Calcium

## 4. Discussion

Electrolyte abnormalities are reported as one of the common causes of morbidity and mortality in critically ill patients [10]. Studies in the past reported Hypercalcemia is linked to neoplasia, hyperparathyroidism, nonparathyroid endocrinopathies, and pharmacological agents [11]. Diabetic patients often develop electrolyte disorders. These disturbances are particularly common in decompensated diabetics, especially in the context of diabetic ketoacidosis or nonketotic hyperglycemic hyperosmolar syndrome. These patients are markedly potassium-, magnesium and phosphate-depleted. The Diabetes mellitus is linked to both hypo- and hyper-natremia reflecting the coexistence of hyperglycemia- related mechanisms [12]. Maurice et al., [13] reported hyponatremia is associated with increased morbidity, length of hospital stay and hospital resource use, but it has also been shown to be associated with increased mortality. Hence, the target population included in the study of the patients attending for estimation of arterial and serum electrolytes were based on the following pathological conditions post MVA, CAP, RF, DHF, PC, P+CA, STEM I, ICH, shock, SS, PE, EC, MS, SS, ESRD, ICH, DM, HTN, SCI, ICS, KA, SLE, BA, CHF, COPD, as recorded in their medical records. Severe hyperkalemia leads to significant morbidity and mortality [14].

There are a lot many controversies in the reports of the estimation of electrolytes of serum and ABG from different hospitals. The Research Gate Discussion on correlation between electrolytes in blood gases and serum electrolytes ensued that the serum electrolytes are more reliable, while some argue accuracy depends on the machines. The lab results were discussed to be more accurate, but they are very much delayed and to start immediate treatment, hence; one has to rely on Blood Gas Machine [15].

Jain et al., [16] found no significant difference between the potassium values measured by blood gas machine and auto-analyzer, however; the difference between the measured sodium was significant. Nanda et al., [10] also found that arterial sodium and arterial potassium can be used instead of venous sodium and venous potassium levels in the management of critically ill patients.

In the current study we examined whether the Na, K and Ca in Serum samples and Na, K and Ca in arterial samples are correlated. So that the data obtained through the two sources can be used alternately in the practice depending on the efficiency. Data obtained from arterial samples are found to be significantly correlated with serum samples results (Na correlation = 0.944, K correlation = 0.679 and Ca= 0.399). Based on the above analysis, we found a positively significant correlation between Na, K and Calcium measured both in the ABG and serum. We therefore conclude that critical decisions can be made by trusting the Na, K and Ca values obtained from both the arterial blood gas analysis and the serum. Furthermore, the time difference between the different electrolytes and the two protocols was statistically insignificant. Our results on correlation between the ABG and Serum electrolytes are similar to the earlier results [10,16,17].

## 5. Limitations

Some of the limitations of our study are narrowed to the use of machines for serum and ABG, while previous

studies conducted their research in more than one ABG machine brands. Another limitation was that the arterial samples were taken with heparinized syringes which will affect the accuracy of the results by reducing the dilutions.

# 6. Conclusion

In view of the positive correlation between the values of sodium, potassium and calcium in both the ABG and Serum samples and the time difference, being insignificant, we conclude that critical decisions can be made for clinical decision-making in trusting the values obtained through both ABG and Serum levels of the electrolytes. Further research is needed to establish their accuracy in other parameters.

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