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# Plasma and Serum Electrolyte Levels Correlation in the Pediatric ICU

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## ABSTRACT

**Background:** Patients in the intensive care unit (ICU) are susceptible to develop electrolyte imbalance resulting in increased mortality rate. Electrolyte measurements especially for sodium and potassium are frequently required in critically ill patients. The purpose of the present study was to compare sodium and potassium concentrations between serum from venous blood and plasma from arterial blood in order to decrease the number of needle punctures required in children admitted to the ICU.

**Materials and Methods:** Thirty-five patients admitted to the pediatric intensive care unit (PICU) were enrolled in this study; hypotensive patients were excluded. Two cc venous and 1cc arterial blood samples were taken for serum and plasma measurement of sodium and potassium. Venous samples were analyzed within 15 minutes in the hospital laboratory and arterial samples were immediately auto-analyzed in the PICU for sodium and potassium concentrations.

**Results:** Mean serum concentrations of sodium ( $NaV=137.1\pm5.5$ ) and potassium ( $KV=4.1\pm0.7$ ) were higher than plasma concentrations of sodium ( $NaA=133.1\pm11.1$ ) and potassium ( $KV=3.1\pm0.7$ ); ( $p<0.02$  and  $p<0.001$  respectively). Linear regression showed  $NaV=106+0.23 Na A$  for sodium; ( $p=0.005$ ), and  $KV=1.96+0.69 KA$ ; ( $p<0.001$ ) for potassium.

**Conclusion:** Serum concentrations of sodium and potassium were higher than their plasma levels and could be calculated using the plasma sample and the formula given above. (Tanaffos2010; 9(4): 34-38)

**Key words:** Sodium, Potassium, Electrolyte, Pediatric, Intensive care.

## INTRODUCTION

Numerous factors, including the serious nature of underlying diseases, incapacitation, inability to express thirst and inappropriate intravenous fluid administration, put ICU hospitalized patients at a high risk for developing sodium imbalance which

may be associated with increased morbidity or mortality (1-3). Similarly, potassium abnormalities have been recognized as a preventable cause of cardiac arrest. Serial measurements of arterial blood gases (ABG) and electrolytes are therefore essential for monitoring ICU patients (4-6).

Hazards of frequent blood sampling for ABG, electrolyte and other laboratory investigations include increased infection rate, pain, stress response, patient's discomfort and anemia in newborns. In a multicenter study, anemia was an almost universal

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finding in ICU patients in the United States (7). Although anemia in critically ill patients is multifactorial, phlebotomy accounts for greater blood loss than pathologic bleeding and is associated with a higher mortality rate in these patients (8-10).

Furthermore, specific conditions like severe underlying disease, patient's critical condition, and frequent previous blood samplings, make repeated venepunctures difficult and uncomfortable for children.

In order to decrease the number of phlebotomies, it is preferable to check blood electrolytes on the one single sample collected for ABGs rather than performing additional venepunctures to collect venous blood in order to check serum levels of sodium and potassium.

The purpose of the present study was to compare sodium and potassium concentrations between serum and plasma and to establish if a meaningful relationship could be determined between plasma and serum sodium and potassium concentrations to spare the patient additional venepunctures.

## MATERIALS AND METHODS

After obtaining an approval from the ethical and research committees of the University and taking informed consent from parents, 35 patients admitted to the pediatric intensive care unit of our hospital were enrolled in this study.

Hypotensive patients like those older than 2 yrs. with a systolic blood pressure <75 mmHg or infants younger than 2 yrs. with systolic BP <65 mmHg were excluded from the study (11-12).

After aseptic cleaning, a 2cc venous blood sample was obtained using a tourniquet and 1cc arterial blood sample was obtained from radial or brachial artery (preferably radial), using a 22 gauge needle.

Heparinized arterial samples were analyzed immediately in an automatic blood gas system

Techno Media, (GASTAT-603ie) located in the

PICU after calibration and venous samples were analyzed in the hospital lab using standard sodium and potassium kit (Eppendorf) through Essel machine.

The decision to take an arterial sample was always made by the attending physician. All samples were obtained by the researchers. All venous samples were immediately delivered to the clinical chemistry laboratory for analysis within 15 minutes of collection. The measurements for each patient were entered into a database for statistical analysis using SPSS ver.16 software, paired t-test, Pearson correlation coefficient and linear regression analysis.

## RESULTS

Thirty-five patients admitted to the PICU were enrolled in this study. Diagnosis upon admission included respiratory distress syndrome, sepsis, status epilepticus, pneumonia and croup. The mean age of patients was  $48.6 \pm 14.4$  months (range 3 to 72 months). Nineteen patients (54.3%) were males and 16 (45.7%) were females. Mean serum concentrations of sodium ( $\text{NaV} = 137.1 \pm 5.5$ ) and potassium ( $\text{KV} = 4.1 \pm 0.7$ ) were higher than plasma concentrations of sodium ( $\text{NaA} = 133.1 \pm 11.1$ ) and potassium ( $\text{KV} = 3.1 \pm 0.7$ ); ( $p < 0.02$  and  $p < 0.001$  respectively) (Table 1).

Table1. Comparison of sodium and potassium concentrations between serum and plasma

	Plasma	Serum	P value
$\text{Na}^+$	$133.1 \pm 11.1 \text{ meq/l}$ (118-171 meq/l)	$137.1 \pm 5.5 \text{ meq/l}$ (127-153 meq/l)	$P < 0.02$
$\text{K}^+$	$3.1 \pm 0.7 \text{ (meq/l)}$ (1-4.6 meq/l)	$4.1 \pm 0.7 \text{ (meq/l)}$ (2.8-5.3 meq/l)	$P < 0.001$

Linear relationships were observed between the serum concentrations of sodium and potassium and their plasma concentrations and the following equations were obtained.

$\text{NaV} = 106 + 0.23 \text{ NaA}$   $p = 0.005$ ,  $r = 0.46$   
(Figure 1)

NaV=venous sodium, NaA=arterial sodium

$\text{KV} = 1.96 + 0.69 \text{ KA}$   $p < 0.001$ ,  $r = 0.72$   
(Figure 2)

KV=venous potassium

KA=arterial potassium

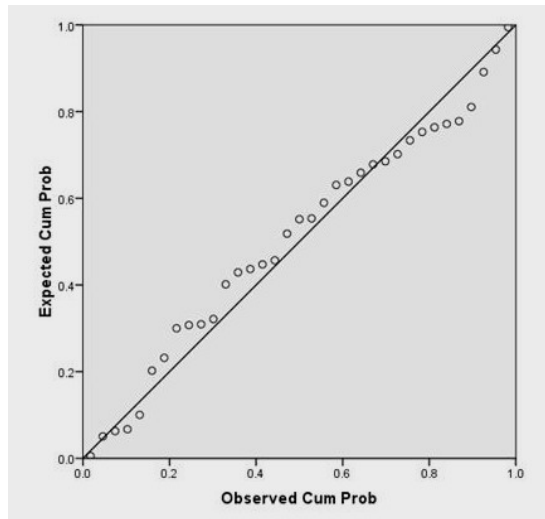


Figure 1. Normal P-Plot of regression standardized residual dependent variable: venous sodium

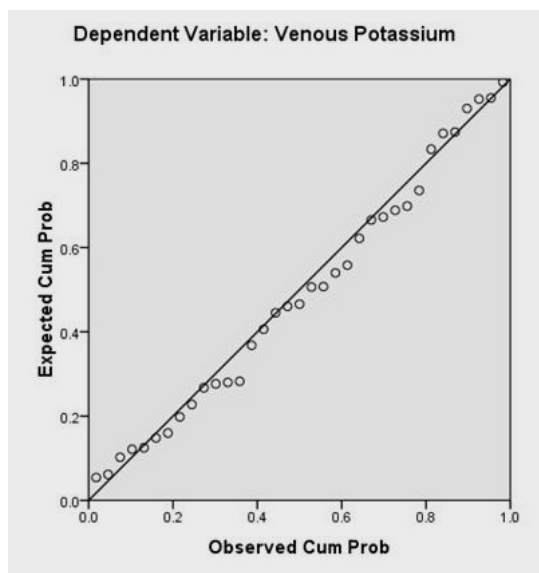


Figure 2. Normal P-Plot of regression standardized residual.

## DISCUSSION

Our study showed significant differences between serum and plasma concentrations of both sodium and

potassium; clearly, serum concentrations were higher than plasma values.

Conventionally, electrolyte analysis is performed on serum i.e. the portion of blood without cells or clotting factors. Serum is used to eliminate any ionic contribution that hemolyzed cells might make to the sample. Potassium, particularly, is stored primarily within the cell; this presents a problem in analyzing whole-blood samples that have undergone hemolysis, resulting in potassium release from the cell into the serum which can cause a falsely elevated value.

Factors that could cause hemolysis in a sample include small needle size, rough handling, incorrect temperature, and time delay. Obtaining the sample and performing analysis without delay can minimize hemolysis (13).

Costello et al. reported equality of sodium concentrations in arterial and venous samples (14).

Higher venous sodium concentration in our study may be due to the dilutional effect of heparin in the arterial sample.

The effect of the addition of sodium heparin, passage of time and cooling can result in alterations of electrolyte concentrations. Delay of more than 30 minutes between drawing blood and performing the test renders plasma potassium measurements unreliable (15).

There is still controversy on potassium concentration in arterial (plasma) and venous (serum) samples.

Johnston and Murphy reported higher levels of arterial potassium compared with venous samples in patients with cardiac arrest (16).

Fu et al. found that potassium concentration reported from blood gas analysis could not be reliable for serum potassium concentration in diabetic ketoacidosis especially when serum glucose concentrations were higher (17).

Wongyingsinn and Suksuriyayothin found a correlation between arterial blood gas and venous

potassium and suggested using arterial potassium concentration instead of venous levels as a guideline for treatment (18).

Our results were similar to those of the above mentioned study and also studies of Mehta and Lum who reported higher levels of potassium in venous samples (19, 20).

Lower arterial potassium level may be due to immediate auto-analysis of the arterial sample and delayed analysis of venous blood with consequent hemolysis.

We found a strong correlation through linear regression between arterial and venous concentrations of sodium and potassium; therefore, venous levels of these electrolytes could be calculated on the basis of arterial levels.

Based on this significant correlation, sodium and potassium concentrations based on arterial sampling could be used in treatment and therefore, there would be no need for frequent sampling in the PICU.

However, it is advised to collect the first sample from both routes followed by arterial sampling only.

In summary, we showed a good correlation between plasma and serum concentrations of sodium and potassium. Serum concentration of these electrolytes could be calculated based on plasma values and it is advocated to use arterial sampling in PICU for sodium and potassium measurements in order to avoid frequent sampling.

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