2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 30 to October 5, 2007
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: 978-85-99141-02-1

RELATIONSHIPS BETWEEN NA AND K CONCENTRATION IN HUMAN BLOOD AND SERUM

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ABSTRACT

A nuclear procedure to determinate Na and K in whole blood and serum of human being, based on neutron activation analysis technique, was applied aiming its application for checking electrolyte disorders. The Na and K concentrations were analyzed in healthy group select from Paulista Blood Bank at Sao Paulo city. The serum results were compared with the conventional analysis and they are in agreement. These limits were then obtained for whole blood. These results permitted to perform a discussion about the advantages and limitations of using serum and or whole blood for biochemistry analysis in clinical practice.

1. INTRODUCTION

In the human being, the metals and ions in blood are kept inside of a narrow range of variation independently of the alimentary state and of physical activity. Particularly for Na and K, the main extracellular and intracellular electrolytes respectively, changes in these concentrations may modify the extracellular sodium/water status as well as the intracellular potassium/water status because the extracellular and intracellular osmolality must be identical. Considering the elements Na and K are interdependent, this study focus to investigate the behavior between them in serum as well as in whole blood. As consequence these relationships can be used to anticipate the development of anomalies related to electrolyte disorder, i.e., hyponatremia, hypernatremia, hypokalemia and hyperkalemia. These disturbances reflect a water balance alterations and consequent variations, i.é, increase (hyper) or loss (hypo) in the plasmatic osmolality.

In the last years we have performed several investigations in the medical area using the semi-parametric NAA technique [1-8]. The success in these medical applications has motivated us to continue these studies for the clinical practice using serum as well as whole blood. In this context, we performed a study to check electrolyte disorders.

For this investigation the neutron activation analysis, using Au as flux monitor [2], was applied to determine the concentrations of the K and Na in whole blood and serum. To perform this investigations a certified reference material from the National Institute of Public Health - Québec (ICP- 04S-06) was analyzed to verify the accuracy in this analytical method. After that, the whole blood and serum samples of healthy volunteers were analyzed. An application involving the analyses of blood in patients undergoing long-term dialysis have also performed.

2. EXPERIMENTAL PROCEDURE

In the present experiment, the whole blood and serum samples were donated by 24 healthy volunteers from Paulista Blood Bank at Sao Paulo city. Ethical approval for the study was obtained from the Ethics Committee of the Blank Blood authority. For sample preparation, about 1ml of whole blood was collected in a vacuum plastic tubing attached to the donor's arm and, immediately after the collection, exactly 100µl of blood were transferred to the filter paper, using calibrated pipette to draw up the correct amount of blood. After that, the sample was dried for few minutes using an infrared lamp. The biological material still in the plastic tubing was then centrifuged and 200µl from serum were transferred to the filter paper and dried. After that, each pair of samples (100µl of whole blood/200µl of serum) was irradiated, together with a neutron flux monitor (Au foil), for 2 minutes in the nuclear reactor at IPEN/SP (IEA-R1, 2-4MW, pool type) and gamma-counted using a Germanium Spectrometer. The concentration for each element, in whole blood and serum, was obtained using in-house software [9]. The same procedure has been done with the whole blood samples of patients with Chronic Renal Insufficiency (CRI).

3. RESULTS

The results of reference material are presented in Table 1. For the measurement of reference material 5 aliquots of serum (200µl) were analyzed and the results presented are the mean value and the associated uncertainly correspond to one standard deviation (1SD). Table 2 presents the concentration of K and Na for serum of the 24 subjects analyzed and Table 3 presents the results for whole blood. These tables include the arithmetic mean and the standard deviation. In figures 1 and 2 the results for K and Na determination in whole blood samples of six patients submitted to dialyses for long periods (more than 5 years) are presented; the intervals of reference obtained for whole blood in this study are also included for comparison.

Table 1. Analysis of reference material using NAA

Reference Material	K mEq/l	Na mEq/l
ICP04S-06 Human serum	3.94 ± 0.31	135 ± 7
Indicative Interval [10]	3.6 – 5.1	137 – 144

Table 2. Potassium and Sodium results in serum: mean value and standard deviation (SD) using Au as neutron flux monitor.

Element	Mean Value	1 SD	Indicative Reference Interval
K, mEq/l	4.1	0.7	3.4 – 4.8
Na, mEq/l	140	8	132 - 148

Table 3. Potassium and Sodium results in whole blood: mean value and standard deviation (SD) using Au as neutron flux monitor.

Element	Mean Value	1 SD	Indicative Reference Interval
K, mEq/l	42	5	37 - 47
Na, mEq/l	83	12	71 – 95

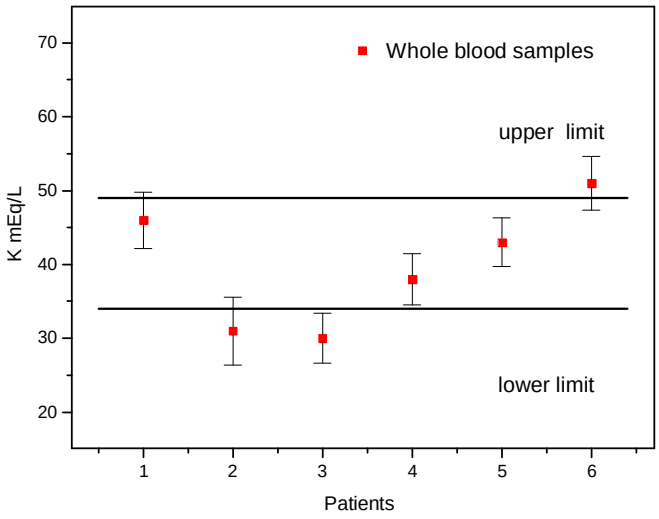

Figure 1: Potassium-concentration in whole blood of patients submitted a dialysis. The horizontal lines represent the indicative interval obtained in this work.

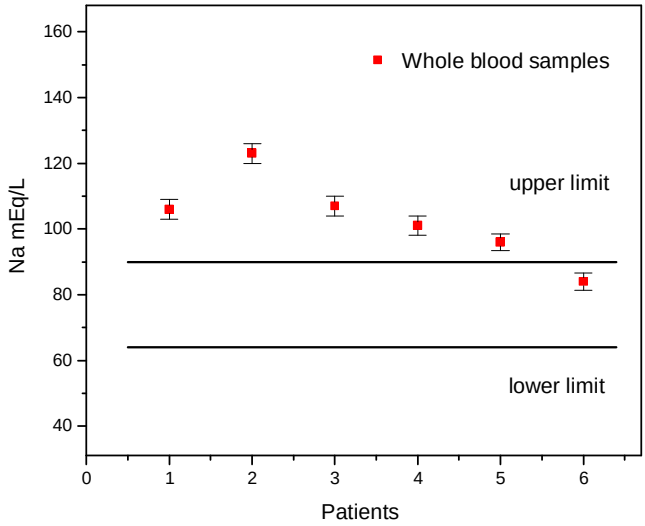

Figure 2: Sodium-concentration in whole blood of patients submitted a dialysis. The horizontal lines represent the indicative interval obtained in this work.

4. DISCUSSION

In this investigation the K and Na levels in whole blood and serum have been evaluated using a nuclear procedure (NAA) in a group of 24 individuals for the proposition of an indicative interval for reference values. The serum results for K (3.4 – 4.8 mEq/l) and Na (132 – 148 mEq/l) when compared with the adopted reference value for K (3.6 – 5.1 mEq/l) and Na (137-144 mEq/l) [10] are in agreement, providing a tool for the diagnosis and prognostic of

electrolytic diseases. Results related to reference values for whole blood have also been obtained for K (37 – 47 mEq/l) and Na (71 – 95 mEq/l). An application involving patients with CRI and with electrolytic dysfunction (specifically hypernatremia) has been done (using whole blood) and the results confirmed this diagnostic (see figure 2) suggesting this nuclear procedure using whole blood can be an alternative for clinical practice.

Relating to the use of this methodology to perform clinical investigations some advantages can be pointed, such as, simultaneous determination using small quantities, the possibility to storage the samples for a long period (directly related to durability of filter paper) without the need of refrigeration and facilities in its handling and discarding (the samples can be treated as regular biohazard or be stored for future reexamination). Furthermore, using whole blood it is not necessary to perform the serum-plasma separation making this process very fast. The limitation is the necessity to have access to a nuclear reactor but, considering the high concentration of potassium and sodium in whole blood and serum as well as the significant thermal neutron activation cross section for ^{42}K and ^{23}Na [11], using a higher amount of these body fluids (0.5ml for blood and 1ml for serum) [5] these clinical analyses can be done using neutron sources also available at IPEN facilities [13]. In addition, considering the viability of performing these laboratory analyses using a Compact Neutron Generator [12], nowadays in test, in the future they could be performed outside of the nuclear premises.

5. CONCLUSIONS

The K and Na concentrations have been measured in whole blood and serum using NAA aiming to diagnose electrolyte disturbance. The results for serum are in agreement with the reference values adopted in the conventional analysis. In addition, an application using whole shows the viability of using whole blood for clinical practice.

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