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Full Length Research Paper

Plasma sodium and potassium changes in sickle cell patients

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The aim of this study was to measure the body electrolytes (in plasma) such as sodium (Na^+) and potassium (k^+) in adult sickle cell patients with genotype (HbSS) genotype and compare with controls normal with (HbAA) genotype. The study involved a total of 38 individuals, both males and females in the age range of 16 - 40 years. There were 3 study groups; steady state group, crisis state group and control group. Flame photometry was used to analyze sodium and potassium. In the males there was a statistically significant reduction in the concentration of sodium in both the steady state (129.40 ± 1.462) and crisis state (121.60 ± 0.678) when compared with control group (134.40 ± 2.040). Also, there was a statistically significant increase ($P < 0.05$) in the concentration of potassium in both the steady state (4.58 ± 0.171 mmol/l) and crisis state (4.66 ± 0.154 mmol/l) when compared with normal group (3.50 ± 0.172 mmol/l). The regular measurement of plasma sodium and potassium is, therefore, necessary in the management of the sickle cell disease patients.

Key words: Steady state, crisis state, plasma sodium, plasma potassium.

INTRODUCTION

Sickle cell disease is a group of haemoglobin disorders in which the sickle beta (β) globin gene is inherited (Hoffbrand et al., 2006). Sickle cell disease affects millions of people worldwide, which poses significant challenges for clinicians and scientists as one of the most commonly observed haemoglobinopathies.

There are excellent treatments for the symptoms and complications of the condition, but in most cases there is no cure. Some researchers believe that bone marrow transplant may offer a cure in a small number of cases (Harvey, 2002).

The clinical manifestation of sickle cell anaemia in India seems to be milder than in Africa and Jamaica (Mohanty et al., 2002). In Africa few children with sickle anaemia survive to adult life without medical attention. Even with standard medical care approximately 15% die by the age of 20 years and 50% by the age of 40 years (Boon et al., 2006). Harvey (2002) reported that sickle cell gene for haemoglobin(s) Hb(s) is the most common inherited blood condition in America, about 72,000 Americans (mostly African Americans) have sickle cell disease.

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Blood electrolytes

Electrolytes are substances that become ions in solution and acquire the capacity to conduct electricity. The balance of electrolytes in the body is essential for the normal functioning of the cells and organs.

Electrolytes measured by blood testing includes sodium (Na^+), Potassium (K^+), Chloride (Cl^-) and bicarbonate (HCO_3^-). Electrolytes have normal range values, and complications may arise, if any of the electrolytes are higher or lower than the normal range values.

Sodium (Na^+) is the major positive ion (cation) in the fluid outside of the cells. In combination with chloride, it forms a salt (NaCl). Sodium (Na^+) regulates the amount of total body water and plays a critical role in electrical communication especially in the brain, nervous systems and muscles.

The abnormal increase of sodium (Na^+) concentration in blood is referred to as hypernatremia and the abnormal decrease of sodium in blood is referred to as hyponatremia. A Normal blood sodium level is 135 - 145 millimole/Liter. Potassium (K^+) is the major positive ion

(cation) found inside the cells. The proper level for potassium is necessary for normal cell function. Among the many functions of potassium in the body are regulation of the heart beat and function of the muscles. An abnormal increase of potassium in blood is referred to as hyperkalemia and a decrease of potassium in blood is referred to as hyperkalemia. The normal blood potassium level is (3.5 - 5.0) milliequivalent (meq/L).

Blood analysis is one of renal function tests. Certain substances that are normally removed from the blood may accumulate in the blood in kidney dysfunction (Obika, 2002).

Biochemical abnormalities have been associated with sickle cell disease; however there is paucity of information on the roles of these ions in the pathogenesis and management of sickle cell disease (Oladipo et al., 2005).

In sickle cells, an abnormal activation of potassium chloride (K^+Cl^-) co-transport system was proposed to be involved in cell potassium (K^+) loss and dehydration (Vitoux et al., 1989).

Deoxygenation of sickle cell is known to increase cation permeability of sodium (Na^+), Potassium ($K^{+)}$ and calcium (Ca^{2+}) (Rhoda et al., 1990), At lower Hydrogen ion concentration (pH), urea was able to stimulate potassium – chloride ($K\text{-}Cl^-$) loss from sickle cells, leading to cellular dehydration, even in regions of low pulmonary oxygen tension (PO_2) (Gibson et al., 1998). Potassium – Chloride (K^+ Cl^-) co-transport is abnormally active in erythrocytes containing positive charged haemoglobins such as haemoglobin (S) (HbS) (SS: beta 6 Glutamic and → valine) or haemoglobin (C) (HbC) (CC: beta 6 Glutamic → lysine) (Vitoux et al., 1999).

On deoxygenation, haemoglobin(S) (HbS) cells exhibit a distinctive solute permeability pathway, P sickle, activated stochastically and partially inhibited by 4,4-disothiocyano 2 - 2 disulfostibene (DIDS) and dipyridamole. It is often referred to as a cation channel although its permeability characteristics remains vague and it molecular identity is unknown (Browning et al., 2007).

Renal function in sickle cell disease

End stage renal disease (ESRD) in sickle cell anaemia is the ultimate consequence of sickle cell-induced damage to the renal micro vasculature by sickle cells. The arterial bed of the kidney, which has low oxygen tension and low pressure in a slow flow system, is suited to facilitate the polymerization of haemoglobin S (HbS) and micro vascular occlusion (Wong et al., 2003).

Progression to end-stage renal disease in sickle cell anaemia start with hyposthenuria, which leads to an increased glomerular filteration rate (GFR), resulting in glomerulosclerosis and finally end stage renal failure.

Ter Maaten et al. (2002) assessed the effects of insulin and atrial natriuretic peptide (ANP) on renal sodium handling in eight patients with sickle cell disease (SCD), who were characterised by loss of vasa recta, and loop of Henle and it was matched with control subjects. During insulin infusion, fractional sodium excretion decreased in patients with sickle cell, whereas fractional distal sodium reabsorption increased in the same subject. Atrial natriuretic peptide (ANP) infusion did not affect renal sodium handling in patient with sickle cell disease but increased fraction sodium excretion in control subject.

SUBJECTS

Twenty eight (28) individuals with sickle cell disease of genotype (Hb SS) in University of Benin Teaching Hospital (UBTH) and sickle cell centre (BENIN) were used for this study. They were males (n = 13) and females (n = 25) of the age range 16 - 40 years. This study included sickle cell individuals both in their steady state and crisis state.

Ten (10) normal volunteers with the genotype (HbAA) males (n = 5) and females (n = 5) of the same age range of 16 - 40 years (Table 1).

All the individuals used were randomly picked; the individuals in their crisis state having their samples collected from them before administration of drugs or any form of treatments. Approval was obtained from ethic committee of the University of Benin Teaching hospital.

SAMPLE COLLECTION

5 ml of whole blood sample were collected from the subjects through vein puncture and were stored in lithium heparin bottles. The samples were stored cold and transported to the laboratory for analyses.

METHODOLOGY

The electrolyte measured was in plasma, the sample was first centrifuged and the plasma was extracted for test.

Sodium (Na+) and potassium (K+) analysis was done in the laboratory by the use of flame photometer.

STATISTICAL METHODS

The statistical package used was Statistical package for Social Sciences (SPSS) version 13.0. In it we ran the following statistical analysis:

The descriptive statistics: mean, Standard error of mean (sem), Student *t* test.

RESULTS

Control group and (SCD) crisis state group

In this study, a significant difference ($p < 0.05$) existed between the male groups in the mean value concentration of sodium (134.40 ± 2.040 and 121.60 ± 0.678 mmol/l) and potassium (3.56 ± 0.172 and 4.66 ± 0.154 mmol/l).

Table 1. Description of subjects used.

	Males	Females
Control adult Hb(AA)16 - 40 years	5	5
Steady state Hb(SS) adult 16 - 40 years	8	10
Crisis Hb(SS) adult 16 - 40 years	5	5

Table 2. $p < 0.05$ Control vs (SCD) steady state and (SCD) crisis state groups.

Male groups	Sodium (mmol/L)	Potassium (mmol/L)
Control	134.40 ± 2.040	3.50 ± 0.172
Steady state	132.13 ± 1.517	4.58 ± 0.171
Crisis state	121.60 ± 0.678	4.66 ± 0.154

Table 3. $p < 0.05$ (SCD) steady state vs (SCD) crisis state groups.

Female groups	Sodium (mmol/L)	Potassium (mmol/L)
Control	134.80 ± 0.860	3.60 ± 0.152
Steady state	129.40 ± 1.462	4.60 ± 0.259
Crisis state	123.20 ± 1.772	5.20 ± 0.399

Between the female control groups, a significant difference ($p < 0.05$) existed in the mean value concentration of sodium (134.80 ± 0.860 and 123.20 ± 1.772 mmol/l) and potassium (3.60 ± 0.152 and 5.20 ± 0.399 mmol/l).

Control group and (SCD) steady state group

Between the male groups, a significant difference ($p < 0.05$) existed in the mean value concentration of potassium (3.56 ± 0.172 and 4.56 ± 0.171 mmol/l).

STEADY STATE GROUP AND CRISIS STATE GROUP

There was a significant difference ($p < 0.05$) existed between the male groups in the mean value concentration of sodium (132.13 ± 1.517 and 121 ± 0.678 mmol/l).

Between female groups a significant difference ($p < 0.05$) existed in the mean value concentration of sodium (129.40 ± 1.462 and 123.20 ± 1.773 mmol/l).

Between the male and female groups, no significant difference ($p < 0.05$) existed in the mean value of potassium (Tables 2 and 3, Figures 1 - 4).

DISCUSSION

In this study, the plasma sodium and potassium were compared between the control group (Hb AA) subjects, the (SCD) steady state and (SCD) crisis state group subjects. It was observed in the male and female that control groups had a higher concentration of sodium than both the (SCD) steady state and (SCD) crisis state groups, which was supported by the findings of Brugnara (2000). The sodium concentration was much lower in the (SCD) crisis state group which indicated hyponatremia.

Brugnara (2000) reported that the hyponatremia observed was due to dehydration, but was very difficult to maintain. Clark et al. (1981) reported that dehydration was one of the causes of sodium movement into the sickle cell. During crisis the patients experienced dehydration, which could be a possible cause of sodium loss from the extracellular fluid into the intracellular fluid?

The potassium concentration was lower in both the male and female control groups than the (SCD) steady state group and (SCD) crisis state groups which was similar to the finding reported by Joiner et al., (1986). The (SCD) crisis state group had a higher concentration than the other groups which was supported by the findings of Clark et al., (1981).

Clark et al. (1981) suggested dehydration and de-oxygenation caused excessive potassium losses resulting in cation depletions. Harvey (2002) reported that dehydration and hypoxia was one of the characteristic features of crisis state. This may account for the potassium losses experienced from the cell into the extracellular fluid which caused a rise in plasma potassium concentration.

Conclusion

In this study, it was observed that there were differences in the plasma sodium and potassium concentrations in

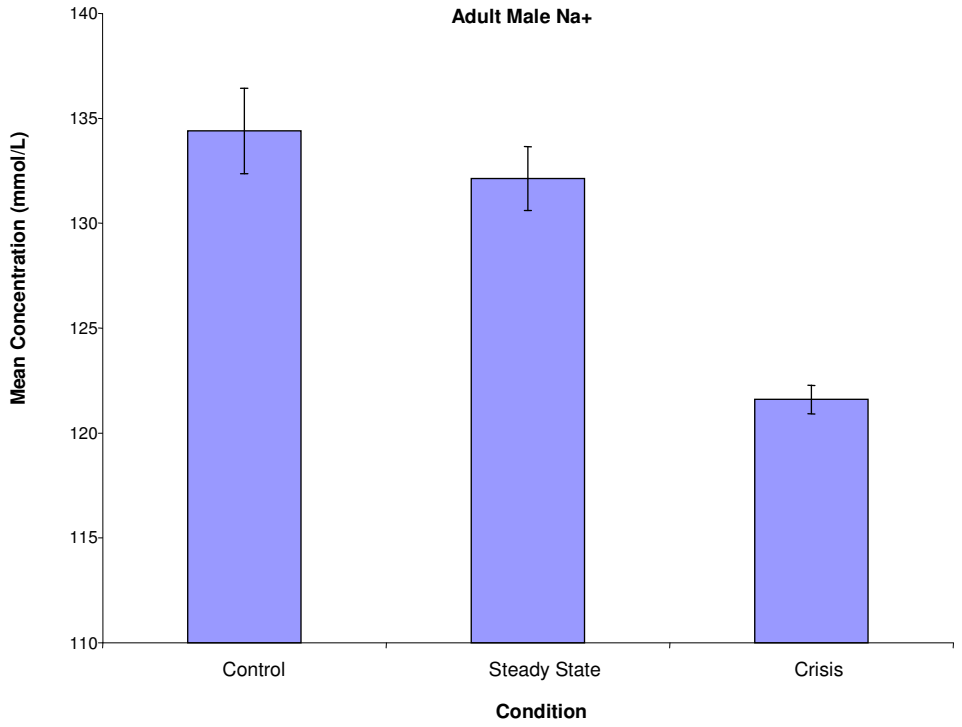

Figure 1. Graphic representations of adult male sodium.

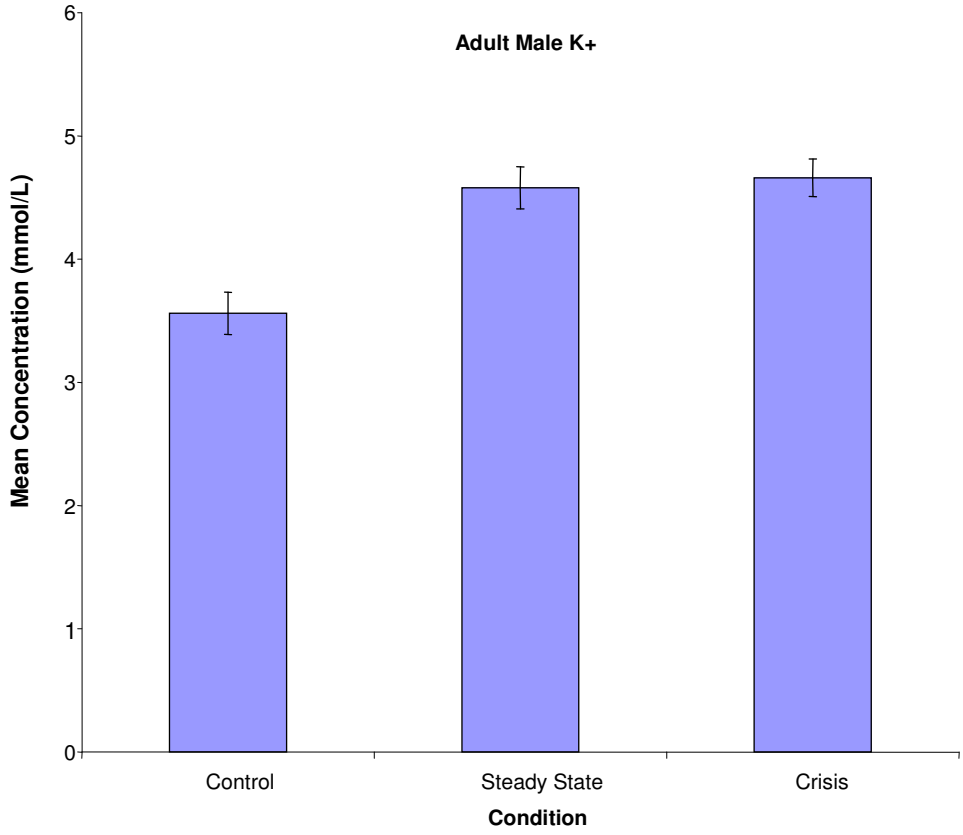

Figure 2. Graphic representations of adult male potassium.

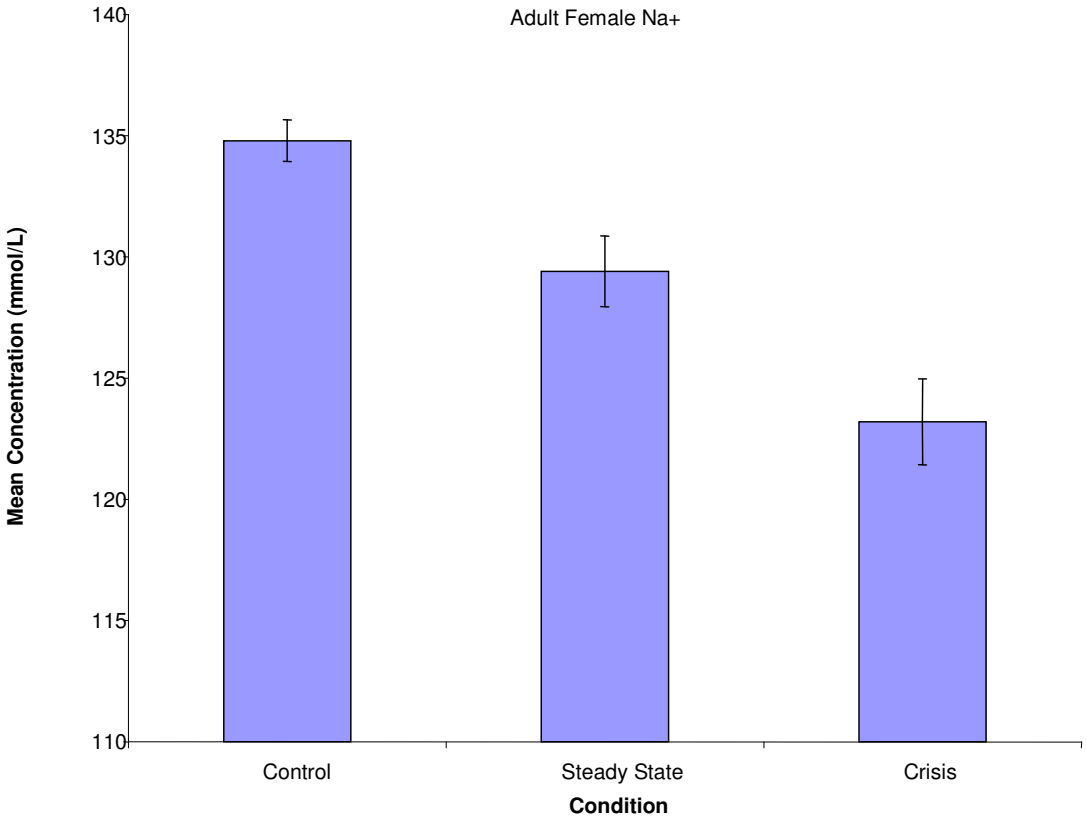

Figure 3. Graphic representations of adult female sodium.

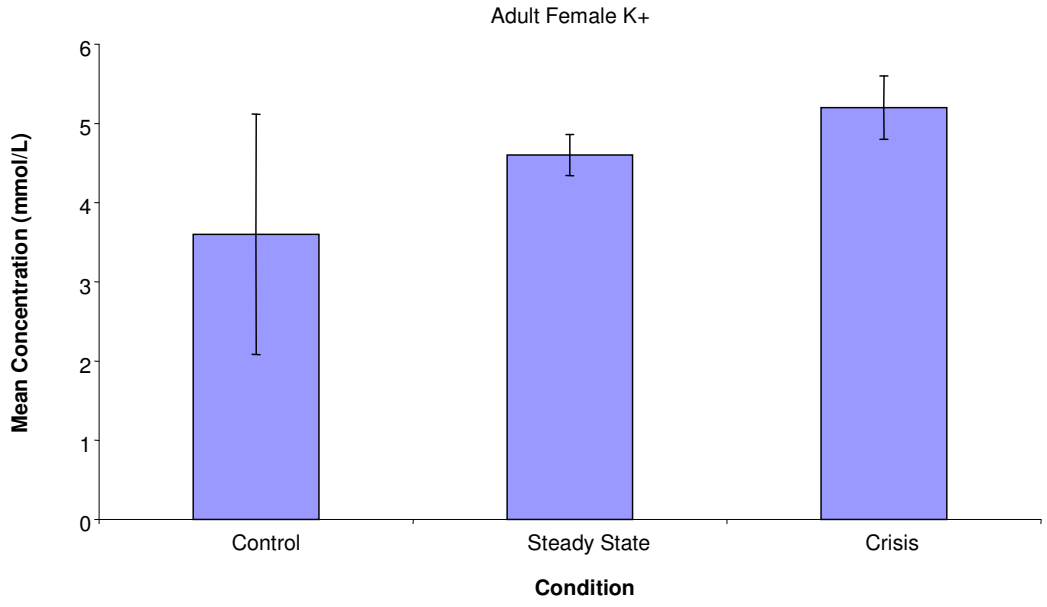

Figure 4. Graphic representations of adult female potassium.

the control, (SCD) steady state, (SCD) crisis state groups. It could be inferred that sodium and potassium imbalance exists in (SCD) crisis state.

The regular measurement of plasma sodium and po-

tassium is necessary in the management of the sickle cell disease patients. More researches should be done in this field, so the management of these individuals would be easier.

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