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Effect of Hyponatremia and Hyperkalaemia in Chronic Renal Failure Patients

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Abstract: Both Hyponatremia and Hyperkalaemia are common conditions, especially in hospitalized patients and in patients with various comorbid conditions such as chronic renal failure disease. Abnormal serum sodium and serum potassium levels have been associated with increased mortality in numerous observational studies. Hyponatraemia is defined as a decrease in the serum sodium concentration to a level below 136 mmol/l. Although plasma osmolality is closely related to serum sodium concentration, hyponatraemia can be associated with low, normal, or high osmolality. Osmolality or tonicity refers to the contribution to osmolality of solutes such as sodium, glucose, and urea that cannot freely move across the cell membrane thereby reducing transcellular shifts in water. Hyperkalaemia occurs when serum potassium concentration is increased in chronic renal failure patients. Chronic renal failure does not cause severe or progressive hyperkalaemia unless oliguria supervenes. Hyperkalaemia may develop rapidly if the potassium load is increased or excretory capacity is limited which cause cardiac arrhythmias, excessive sensitivity to digitalis, muscles weakness and renal damage. Hyperkalaemia is dangerous because cardiac arrest can occur when plasma potassium exceeds 7 mmol/L. The present paper includes the study of serum sodium and potassium levels of 200 patients (according to age group and sex) with chronic renal failure (CRF) before and after the process of treatment and it has been compared with 50 normal healthy individuals comprising the control group.
Key Words: Chronic Renal Failure, Serum sodium, Serum Potassium, Hyponatremia, Hyperkalaemia.

Introduction

Both sodium and potassium are the major components of the cations of the extracellular fluid and exists in the body in association with the anion is chloride, bicarbonate, phosphate and lactate. The important function of sodium and potassium are to regulate acid-base equilibrium and maintenance of the osmotic pressure of the body fluid thus protecting the body against excessive fluid loss. They also function in the preservation of normal irritability of muscles and the permeability of the cells. Studies differ regarding the status of serum sodium and potassium in chronic renal failure patients. The normal adult range of serum potassium is 3.6-5.5 meq/L[1-6]. The relative free water excretion as measured by CH_2O/GFr, is usually in renal failure, there is a proportionate decrease in loop delivery and free water clearance (CH_2O) resulting in dilutional hyponatremia[7]. The first report that uremics had a factor in plasma that could reduce Na^+-K^+ ATPase activity of normal erythrocyte using a cross incubation method[8]. Potassium balance is usually maintained in the early stage of chronic renal failure through the increased potassium excretion per functioning nephron and the colon by aldosteron induced increase in Na-K ATPase activity as long as urine output remains adequate[9]. A rise in erythrocyte sodium efflex rate constant was found in uraemics[10]**.** ATP concentration is usually increased in uraemic erythrocyte[11]. A stimulation of erythrocyte Na-pump by catecholamines was observed which had been increased in uraemics[12]. The evidences are also available to suggest a contribution of Potassium recycling to the overall handling of potassium along the loop of henle[13]. The thick assending limb of the loop of henle is an important site of sodium, potassium, bicarbonate and ammonium transport[14-15]. Some patients had mild

hyperkalaemia due to increase in serum potassium concentration[16]. In the patients of chronic renal insufficiency, fractional potassium excretion is greatly increased[17]. In uraemia the concentration of sodium and potassium in plasma are often abnormal and may small and middle size molecules accumulate in plasma[18]. There was no significant hyponatremia even if the patients is suffering from severe renal failure[19]. The mean value of RBC sodium in the controls was significantly higher than that in the uraemics but not than that in the undialyzed uraemics. In addition, RBC Na in the dialyzed uraemics was significantly lower as compared with that in the undialyzed uraemics[20]. Deficiency in the pump's energy substrate the ATP itself may perhaps be ruled out since the pump is saturated with ATP under physiological conditions[21]. The serum sodium, potassium values in the renal failure patients were not significantly different from normal values. For sodium (141 ± 1 meq/l vs 140 ± 1 meq/l respectively) and for potassium (4.5 ± 0.2 meq/l vs 4.2 ± 0.1 meq/l respectively)[22]. The relationship between changes in potassium balance and electrolyte and fluid transport, particularly with respect to potassium along the loop of henle remains to be fully elucidated. It has been also observed that no significant changes in plasma sodium concentration were observed. Moderately elevated plasma potassium levels were observed in another study of chronic hyperkalemia[23]. Chronic kidney disease is known to affect by the disturbance in the concentration of serum urea, serum creatinine, serum electrolytes and serum uric acid[24-26].

Experimental

Materials and methods:

CIBA-CORNING 644 is a sodium, potassium and chloride ion selective electrode (ISE) analyzer. It is designed for fast and accurate determination of sodium, potassium and chloride ion in undiluted serum, plasma, whole blood and pre diluted urine samples. Minimum sample volume is 65 µl and result is displayed on the alpha numeric in mmol/L (Milimoles per liter). Potentiometric measurement of electrolyte is in principle similar to the pH measurement. Each electrolyte requires a specific ion selective membrane, an internal filling solution and a reference electrode, which may be in common with the pH system. The internal filling solution (Na^+ & K^+) is a potassium chloride at a fixed concentration with an Ag/AgCl wire to provide electrical concentration. In the 644 the sodium ion selective electrode is equipped with a glass membrane selective to sodium ions however the potassium electrode is equipped with a valynomicine based membrane.

The present study was carried out on 200 adult patients of chronic renal failure attended in the S.V.B.P. hospital attached to L.L.R.M. Medical College, Meerut and also 50 normal healthy individuals with age, sex matched who had no history of renal failure to serve as controls. All the known cases of chronic renal failure were included in this study on the basis of clinical and biochemical criteria. After confirmation of diagnosis on the above parameters, blood samples were drawn from these patients for the estimation of serum electrolyte (Na & K).

Observations:

Table I: Showing Distribution of C.R.F. cases according to Age Group and Sex

Age Groups (Years)	Number of cases		Total
	Males	Females	
10-30	5	2	7(3.5%)
31-50	50	25	75(37.5%)
51-70	63	40	103(51.5%)
71-above	10	5	15(7.5%)
Total	128(64.0%)	72(36.0%)	200(100.0%)

Out of 200 individuals, 128 (64%) controls were male's individuals and rest 72 (36%) were females. All the 200 individuals were between the age group of 10 above 70 years. The maximum number of cases, 103 (51.5%), were observed in the age group of 51-70 years followed by 75 (37.5%) cases in the age group of 31-50 years, 15(7.5%) cases in the age group of above 70 years and 7 (3.5%) cases in the age group of 10-30 years. It is observed that the incidence of chronic renal failure reaches its maximum strength during middle age and later part of life.

Table II: Showing Distribution of Control cases according to Age Group and Sex

Age Groups (Years)	Number of cases		Total
	Males	Females	
10-30	4	1	5(10.0%)
31-50	12	6	18(36.0%)
51-70	18	9	27(54.0%)
Total	34	16	50(100.0%)

Out of 50 control cases, 34 (68.0%) cases were males and 16 (32.0%) were females. 54.0% were found in the age group 51-70 years, 36.0% were 31-50 years age group and 10.0% were 10-30 years age group.

Table III: Distribution of C.R.F. Cases according to Duration of Illness

Duration of illness	No. of cases	Percentage %
3 months-6 months	42	21.0%
6 months-1 year	114	57.0%
More than 1 year	44	22.0%
Total	200	100.0%

The majority of chronic renal failure cases were among more than 6 months- 1 year duration (114 cases, 57.0%) and then more than I year children (44 cases, 22.0%).

Table IV: Serum Sodium Potassium level in Normal Healthy Controls

	Sodium				**Potassium**			
	Age in years				**Age in years**			
MALE	**10-30**	**31-50**	**51-70**	**Total**	**10-30**	**31-50**	**51-70**	**Total**
No.	4	12	18	**34**	4	12	18	**34**
Range (mmol/L	130-145	132-146	130-150	**130-150**	4.5-6.0	2.5-5.9	4.2-6.0	**2.5-6.0**
Mean±S.D.	137.5± 5.59	138.0± 4.20	141.9± 5.94	**140.0± 5.72**	5.25± 0.56	4.22± 0.97	5.14± 0.52	**4.82± 0.86**
FEMALE	**10-30**	**31-50**	**51-70**	**Total**	**10-30**	**31-50**	**51-70**	**Total**
No.	1	6	9	**16**	1	6	9	**16**
Range (mmol/L	130-145	135-143	135-144	**130-145**	3.5-4.5	3.0-4.0	3.8-4.9	**3.0-5.0**
Mean±S.D.	140.0± 2.90	138.5± 2.81	140.8± 2.97	**139.9± 3.02**	4.10± 0.34	3.86± 0.98	4.40± 0.37	**4.18± 0.58**
TOTAL	**10-30**	**31-50**	**51-70**	**Total**	**10-30**	**31-50**	**51-70**	**Total**
No.	5	18	27	**50**	5	18	27	**50**
Range (mmol/L	130-145	132-146	130-150	**130-150**	3.5-6.0	2.5-5.9	3.8-6.0	**2.5-6.0**
Mean±S.D.	138.0± 5.09	138.2± 3.80	141.6± 5.18	**140.1± 5.02**	5.02± 0.67	4.10± 0.92	4.89± 0.59	**4.61± 0.84**

The highest serum sodium level was observed in the age group of 51-70 years, ranged as 130-150 mmol/L (mean 141.6±5.18mmol/L) while highest serum potassium level was observed in the age group of 10-30 years, ranged as 3.5-6.0 mmol/L (mean 5.02±0.67mmol/L). The lowest serum sodium level was observed in the age group of 10-30 years, ranged as 130-145 mmol/L (mean 138.0±5.09mmol/L) while lowest serum potassium level was observed in the age group of 31-50 years, ranged as 2.5-5.9 mmol/L (mean 4.10±0.92 mmol/L). No significant difference was seen among the serum sodium and potassium levels of different age groups and sexes. Our observations are very close to the observations of many workers (normal serum sodium level is 139.1±0.6 mmol/L)[18],(normal serum sodium level is 140±1.0 mmol/L and normal serum potassium

level is 4.2±0.1 mmol/L)[22],(normal serum sodium level is 144.8±1.5 mmol/L and normal serum potassium level is 4.09±0.06 mmol/L)[23], (normal serum sodium level is 140.6±3.7 mmol/L and normal serum potassium level is 4.1±0.2 mmol/L)[27], (normal serum sodium level is 145±2.2 mmol/L)[28], (normal serum potassium level is 3.4-5.4 mmol/L)[29] and (normal serum potassium level is 2.5-5.0 mmol/L)[30].

Table V: Serum Sodium and Potassium levels Before and after treatment in total cases of Chronic Renal Failure

Interval	No. of Cases	Serum Uric acid			
		SODIUM		POTASSIUM	
		Range (mg/100 ml)	Mean ±S.D.	Range(mg/100 ml)	Mean ± S.D.
Control	50	130-150	140.1±5.02	2.5-6.0	4.61±0.84
Before treatment	200	120-141	136.0±5.28**	3.2-8.0	6.46±1.32***
15 days after treatment	186	122-143	137.1±5.22**	3.0-7.5	5.92±1.15***
30 days after treatment	169	126-145	139.3±5.14	2.8-6.9	5.27±0.99**
60 days after treatment	145	128-148	140.5±5.25	2.6-6.4	4.85±0.95
90 days after treatment	122	131-152	141.3±5.21	2.4-5.9	4.54±0.89

P- Significance, control vs treatment
*p < 0.05, **p < 0.01, ***p < 0.001.

The range of serum sodium level before treatment was 120-141 mg/100 ml (mean 136.0±5.28 mg/100 ml) while the range of serum potassium level before treatment was 3.2-8.0 mg/100 ml (mean 6.46±1.32 mg/100 ml). No significant difference was observed in serum sodium and serum potassium levels as compared to controls.

Discussion

Both hyponatraemia and hyperkalaemia initially present with non-specific signs and symptoms and can only be diagnosed if a high index of suspicion is maintained for these conditions. The treatment of both these conditions is tricky, as over-treatment can lead to potentially dangerous complications and under-treatment is associated with significant mortality and morbidity. It is therefore essential to monitor the serum sodium and serum potassium concentration every 2 – 4 hours to prevent treatment related complications. The present study is conducted on a total of 250 individuals, out of which 50 are normal healthy individuals comprising the control group and rest 200 is of chronic renal failure. Results of biochemical parameter like serum sodium and serum potassium from this study are discussed below-

Out of 200 individuals, 128 (64%) controls were male's individuals and rest 72 (36%) were females. All the 200 individuals were between the age group of 10 above 70 years. The maximum number of cases, 103 (51.5%), were observed in the age group of 51-70 years followed by 75 (37.5%) cases in the age group of 31-50 years, 15(7.5%) cases in the age group of above 70 years and 7 (3.5%) cases in the age group of 10-30 years (Table I). Out of 50 healthy controls, 34 (68%) controls were male's individuals and rest 16 (32%) were females (Table II). It is observed that the incidence of chronic renal failure reaches its maximum strength during middle age and later part of life.

Biochemical Studies:

The levels of serum sodium and serum potassium were studied in controls and in all cases of chronic renal failure. The range of serum sodium in healthy subjects was 130-150 mmol/L (mean 140.1±5.02mmol/L). In males, it was 130-150 mmol/L (mean 140.0±5.72mmol/L).and in females, it was 130-145 mmol/L (mean 139.9±3.02mmol/L) (Table IV). The range of serum potassium in healthy subjects was 2.5-6.0 mmol/L (mean 4.61±0.84mmol/L). In males, it was 2.5-6.0 mmol/L (mean 4.82±0.86mmol/L).and in females, it was 3.0-5.0 mmol/L (mean 4.18±0.58mmol/L) (Table IV).No significant difference in respect of age and sex was noted in this study. In cases of chronic renal failure, serum sodium was found to be decreased in 48% cases while serum potassium was found to be elevated in 84% cases. Before treatment, serum sodium level was 136.1±5.28 mmol/L and serum potassium level was 6.46±1.32 mmol/L. The level of serum sodium was significantly lower ($p < 0.01$) as compared to that of controls (140.1±5.02 mmol/L) while the level of serum potassium was

significantly high ($p < 0.001$) as compared to that of controls (4.61±0.84 mmol/L). Generally hyponatraemia occurs due to lower serum sodium level while hyperkalaemia occurs due to high serum potassium level in the patients of chronic renal failure. The hyponatraemia results due to excess urinary loss of sodium and water. The most common pathogenesis of hyponatraemia is mixed salt and water depletion. Due to salt deficiency cerebral and cardiovascular abnormalities occur, if salt deficiency is not corrected. Patients may die rapidly from peripheral circulatory failure. Hyperkalaemia is caused by various metal disorders, shift of potassium from tissues etc. Hyperkalaemia may also develop rapidly if the potassium load is increased or excretory capacity is limited. Hyperkalaemia is dangerous because cardiac arrest can occur when plasma potassium exceeds 7mmol/L. So, the corrections of sodium and potassium electrolytes are very important for the improvement of the condition of patients.

Summary and Conclusions

The decreased levels of serum sodium and increased levels of serum potassium were observed in chronic renal failure patients. In the study group, the levels of serum sodium were found decreased ranging between 121-141 mmol/L and mean 136.0±5.28 mmol/L however the levels of serum potassium were found highly increased, ranging between 3.2-8.0 mmol/L and mean 6.46±1.32 mmol/L. Significant difference ($p < 0.01$) was observed among the chronic renal failure patients and controls. The serum sodium and serum potassium levels are closely related to the severity of the disease.

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