

COMPARISON OF SERUM ZINC AND SERUM POTASSIUM CONCENTRATION IN CHRONIC RENAL FAILURE PATIENTS

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ABSTRACT

Abnormal serum zinc and serum potassium levels have been associated with increased mortality in numerous observational studies. Hypozinaemia is defined as a decrease in the serum zinc concentration to a level below 48-96 $\mu\text{g}/100\text{ ml}$. Hyperkalaemia occurs when serum potassium concentration is increased in chronic renal failure patients. Hyperkalaemia is dangerous because cardiac arrest can occur when plasma potassium exceeds 7 mmol/L. Both Hypozinaemia and Hyperkalaemia are common conditions, especially in hospitalized patients and in patients with various comorbid conditions such as chronic renal failure disease. The present paper includes the study of serum 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.

Keywords: Serum Zinc, Serum Potassium, Hypozinaemia, Hyperkalaemia, Chronic Renal Failure

INTRODUCTION

Zinc is an important cation in the body. In recent times, zinc has been recognized as a constituent of prime importance in a variety of metallo-enzyme systems and biochemical pathways essential for protein synthesis and metabolism of carbohydrates, fats and proteins. Zinc is therefore, crucial for growth and development. Potassium is 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 functions of 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. It also functions in the preservation of normal irritability of muscles and the permeability of the cells. Conclusive evidence of the essentiality of zinc to the normal growth and development of animals was not reported until 1934 (Tood *et al.*, 1934). The first concrete demonstration of a specific biologic function was published in 1939 (Keilen and Mann, 1939). More recently DNA dependent, RNA polymerase has been shown to be zinc dependent enzymes (Kichgesser *et al.*, 1976). The activity of ribonuclease has been demonstrated to increase in zinc deficient tissue, suggesting that RNA catabolism is regulated by zinc. The chronic renal failure (CRF) is one of the most severe diseases worldwide (Stenvinkel and Alvestrand, 2002). The renal failure occurs when the kidneys cannot properly remove wastes that causes buildup of waste and fluid in the body (Lise *et al.*, 2009). It was first reported that uremics had a factor in plasma that could reduce $\text{Na}^+ - \text{K}^+$ ATPase activity of normal erythrocyte using a cross incubation method (Cole *et al.*, 1968). The 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 aldosterone induced increase in $\text{Na} - \text{K}$ ATPase activity as long as urine output remains adequate (Bastl *et al.*, 1977). The evidence is also available to suggest a contribution of Potassium recycling to the overall handling of potassium along the loop of henle (Jamison *et al.*, 1982). The thick ascending limb of the loop of henle is an important site of sodium, potassium, bicarbonate and ammonium transport (Good *et al.*, 1984; Greger *et al.*, 1983). In patients of chronic renal insufficiency, fractional potassium excretion is greatly increased (Hene *et al.*, 1984). The 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 (Mujais *et al.*, 1986). The serum potassium values in the renal failure patients were not significantly different from normal values ($4.5 \pm 0.2\text{ meq/l}$ vs $4.2 \pm 0.1\text{ meq/l}$) (Ray *et al.*, 1990). 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. He also observed that no

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significant changes in plasma sodium concentration were observed. Moderately elevated plasma potassium levels were observed in another study of chronic hyperkalemia (Unwin *et al.*, 1994). Chronic kidney disease is known to affect by the disturbance in the concentration of serum urea, serum creatinine, serum electrolytes and serum uric acid (Yadav *et al.*, 2014).

MATERIALS AND METHODS

Experimental

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 zinc and serum potassium levels.

RESULTS AND DISCUSSION

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 1 year children (44 cases, 22.0%).

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Table IV: Serum Zinc and Serum Potassium Level in Normal Healthy Controls

	Zinc				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	76-115	80-114	83-115	76-115	4.5-6.0	2.5-5.9	4.2-6.0	2.5-6.0
Mean±S.D	103.75±	98.38±	97.61±	98.59±	5.25±	4.22±	5.14±	4.82±
.	16.08	28.86	9.26	10.41	0.56	0.97	0.52	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	73-80	85-110	80-109	73-110	3.5-4.5	3.0-4.0	3.8-4.9	3.0-5.0
Mean±S.D	73.00±	97.58±	97.33±	95.88±	4.10±	3.86±	4.40±	4.18±
.	9.32	8.46	9.44	10.84	0.34	0.98	0.37	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	73-115	80-114	80-115	73-115	3.5-6.0	2.5-5.9	3.8-6.0	2.5-6.0
Mean±S.D	97.60±	98.11±	97.52±	97.72±	5.02±	4.10±	4.89±	4.61±
.	18.92	9.49	9.29	10.79	0.67	0.92	0.59	0.84

The level of serum zinc in healthy subjects was 73-115 µg/100ml (mean 97.72±10.79 µg/100ml). In males, the range was 76-115 µg/100ml (mean 98.59±10.41 µg/100ml) and in females, the range was 73-110 µg/100ml (mean 95.88±10.84 µg/100ml). The highest serum zinc level was observed in the age group of 31-50 years, ranged as 80-114 µg/100ml (mean 98.11±9.49 µg/100ml) 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 zinc level was observed in the age group of 51-70 years, ranged as 80-115 µg/100ml (mean 97.52±9.29 µg/100ml) 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±0.92mmol/L). No significant difference was seen among the serum zinc and potassium levels of different age groups and sexes. Our observations are very close to the observations of many workers (Kavukcu *et al.*, 1993, normal serum potassium level is 4.1±0.2 mmol/L), (Unwin *et al.*, 1994, normal serum potassium level is 4.09±0.06 mmol/L), (Price 1978, normal serum potassium level is 3.4-5.4 mmol/L) and (Harper *et al.*, 1979, normal serum potassium level is 2.5-5.0 mmol/L).

Table V: Serum Zinc and Serum Potassium Levels before and after Treatment in Total Cases of Chronic Renal Failure

Interval	No. of Cases	Serum Zinc and Potassium			
		ZINC		POTASSIUM	
		Range (µg/100 ml)	Mean ±S.D.	Range (mmol/L)	Mean ± S.D.
Control	50	73-115	97.72±10.79	2.5-6.0	4.61±0.84
Before treatment	200	48-96	81.20±12.84***	3.2-8.0	6.46±1.32***
15 days after treatment	186	50-100	85.60±13.77***	3.0-7.5	5.92±1.15***
30 days after treatment	169	60-108	91.56±10.95***	2.8-6.9	5.27±0.99**
60 days after treatment	145	66-110	95.36±8.74	2.6-6.4	4.85±0.95
90 days after treatment	122	70-114	97.04±10.34	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 zinc level was significantly low before and after thirty days of treatment while range of serum potassium level was significantly high before and after fifteen days of treatment in the patients

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of chronic renal failure as compared to controls. The range of serum zinc before, after fifteen and thirty days of treatment were 48-96 $\mu\text{g}/100\text{ ml}$ (mean $81.20 \pm 12.84\text{ }\mu\text{g}/100\text{ ml}$), 50-100 $\mu\text{g}/100\text{ ml}$ (mean $85.60 \pm 13.77\text{ }\mu\text{g}/100\text{ ml}$) and 60-108 $\mu\text{g}/100\text{ ml}$ (mean $91.56 \pm 10.95\text{ }\mu\text{g}/100\text{ ml}$) respectively. Serum zinc level after sixty and ninety days of the treatment ranged as 66-110 $\mu\text{g}/100\text{ ml}$ (mean $95.36 \pm 8.74\text{ }\mu\text{g}/100\text{ ml}$) and 70-114 $\mu\text{g}/100\text{ ml}$ (mean $97.04 \pm 10.34\text{ }\mu\text{g}/100\text{ ml}$) respectively. The range of serum potassium level before treatment was 3.2-8.0 mmol/L (mean $6.46 \pm 1.32\text{ mmol/L}$). After fifteen, thirty, sixty and ninety days of treatment serum potassium ranged as 3.0-7.5 mmol/L (mean $5.92 \pm 1.15\text{ mmol/L}$), 2.8-6.9 mmol/L (mean $5.27 \pm 0.99\text{ mmol/L}$), 2.6-6.4 mmol/L (mean $4.85 \pm 0.95\text{ mmol/L}$) and 2.4-5.9 mmol/L (mean $4.54 \pm 0.89\text{ mmol/L}$) respectively.

After sixty and ninety days no significant difference was observed in serum zinc and serum potassium as compared to controls.

Discussion

Hypozinaemia in uremia is rather a result of a shift of zinc from plasma into tissue due to zinc while Hyperkalemia is generally occur in the patients of severe chronic renal failure due to potassium imbalance.

The mean whole blood zinc concentration of male and female hemodialysis patients was significantly below control values while mean whole blood potassium concentration of male and female patients was significantly high than control values during chronic renal failure. 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 uric acid from this study are discussed below-

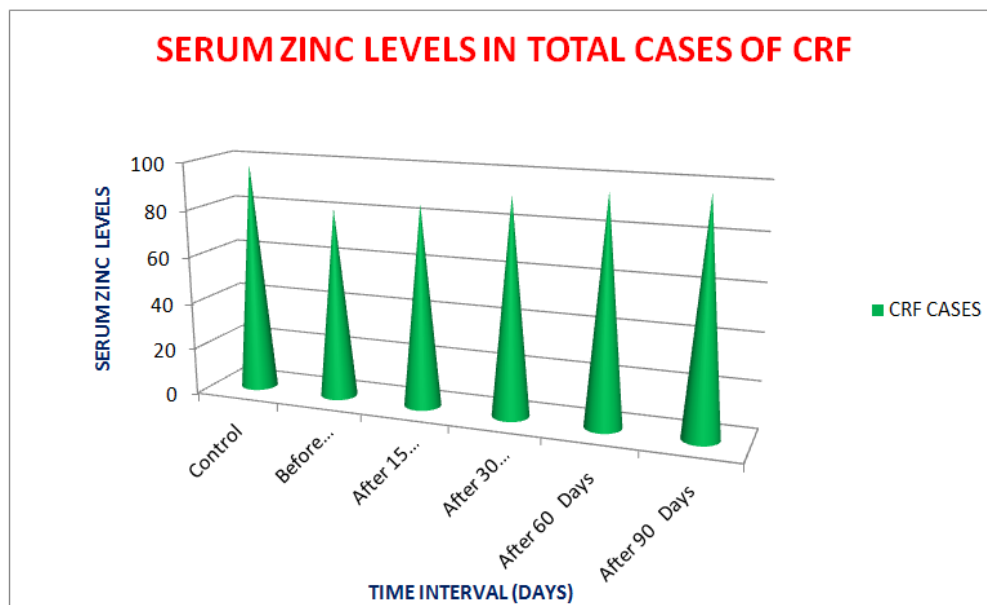
Out of 200 individuals, 128 (64%) controls were male's individuals and rest 72 (36%) were females. All the 200 individuals were between the age group of 10 above 70 years. The maximum number of cases, 103 (51.5%), were observed in the age group of 51-70 years followed by 75 (37.5%) cases in the age group 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.

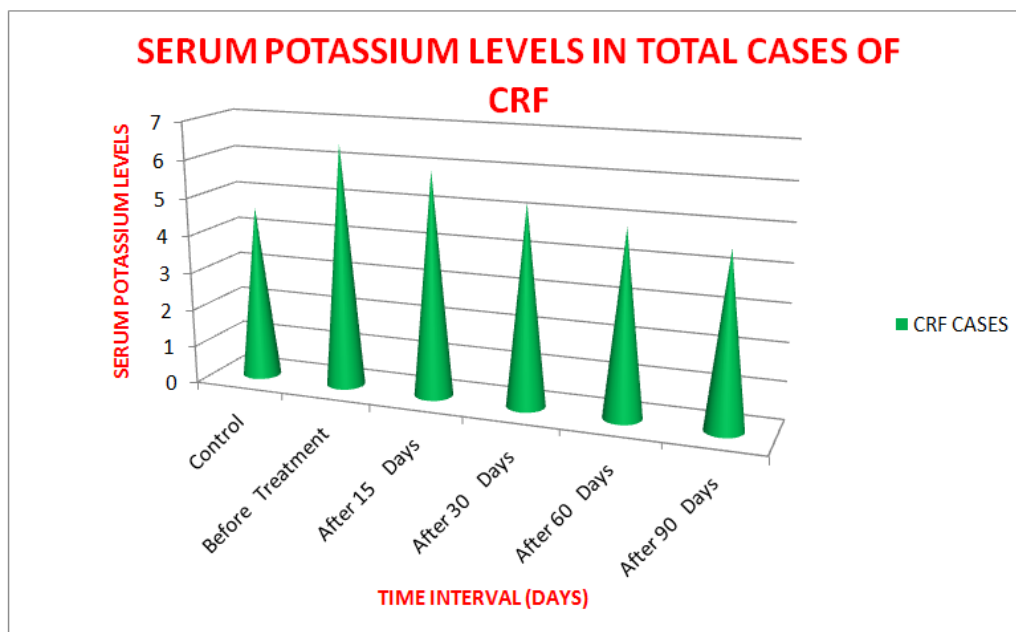
Biochemical Studies

The levels of serum zinc and serum potassium were studied in controls and in all cases of chronic renal failure. In normal healthy subjects serum zinc ranged from 73-115 $\mu\text{g}/100\text{ml}$ (mean $97.72 \pm 10.79\text{ }\mu\text{g}/100\text{ml}$). In males, it ranged from 76-115 $\mu\text{g}/100\text{ml}$ (mean $98.59 \pm 10.41\text{ }\mu\text{g}/100\text{ml}$) and in females, 73-110 $\mu\text{g}/100\text{ml}$ (mean $95.88 \pm 10.84\text{ }\mu\text{g}/100\text{ml}$) (Table IV). The range of serum potassium in healthy subjects was 2.5-6.0 mmol/L (mean $4.61 \pm 0.84\text{ mmol/L}$). In males, it was 2.5-6.0 mmol/L (mean $4.82 \pm 0.86\text{ mmol/L}$). And in females, it was 3.0-5.0 mmol/L (mean $4.18 \pm 0.58\text{ mmol/L}$) (Table IV). No significant difference was observed in the serum zinc level of different age groups and sex. In cases of chronic renal failure serum zinc was found to be depressed in 72% cases while serum potassium was found to be elevated in 84% cases. Before treatment serum zinc level was $81.20 \pm 12.84\text{ }\mu\text{g}/100\text{ ml}$ which was significantly low ($p < 0.001$) as compared to that of controls ($97.72 \pm 10.79\text{ }\mu\text{g}/100\text{ ml}$) and serum potassium level was $6.46 \pm 1.32\text{ mmol/L}$ which was significantly high ($p < 0.001$) as compared to that of controls ($4.61 \pm 0.84\text{ mmol/L}$).

Generally, Hypozinaemia occurs due to lower serum zinc level while hyperkalaemia occurs due to high serum potassium level in the patients of chronic renal failure. In Hypozinaemia the decreased intake of zinc due to low protein diet is regarded as a relevant factor in the development of zinc deficiency in chronic renal failure. The plasma zinc concentration is dependent on the balance between anabolic and catabolic processes.



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 7 mmol/L. So, the corrections of sodium and potassium electrolytes are very important for the improvement of the condition of patients.



Summary and Conclusion

The decreased levels of serum zinc caused hypozincaemia and increased levels of serum potassium levels caused Hyperkalaemia in chronic renal failure patients. In the study group, the levels of serum zinc were found decreased ranging between 48-96 $\mu\text{g}/100\text{ ml}$ and mean $81.20 \pm 12.84 \mu\text{g}/100\text{ ml}$ however the levels

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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 zinc and serum potassium levels are closely related to the severity of the disease.

The following conclusions are derived from this study:

- 1- There was insignificant difference in the levels of all the above mentioned parameters as regards to age or sex of the healthy controls included in this study.
- 2- Maximum probabilities of chronic renal failure were found in the age group of 51-70 years (51.5%).
- 3- Minimum probabilities of chronic renal failure were found in the age group of 10-30 years (3.5%).
- 4- The levels of serum zinc and serum potassium were found to be significantly depressed and elevated respectively in cases of chronic renal failure as compared to that of controls.
- 5- The levels of serum zinc and serum potassium remained low and high respectively after thirty days of treatment and then returned to normal.
- 6- The fall in the levels of serum zinc and serum potassium is related to the extent of the disease.
- 7- The levels shifted to normal range as the condition of patients improved clinically.

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