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Changes in Electrolytes Level and ECG Parameters in Chronic Kidney Disease Patients Post Haemodialysis and the Correlation of Their Changes : A Cross-Sectional Study Done In Karwar, Karnataka

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Conflicts of Interest: Nil

Abstract

Background: Patients with chronic kidney disease undergoing maintenance haemodialysis have Electrocardiogram abnormalities.

Aims & Objectives: To compare the serum electrolytes level and ECG parameters in chronic kidney disease patients pre and post haemodialysis and to cor-relate their changes.

Materials & Methods: This cross-sectional study was conducted in KAIMS, hospital over chronic kidney disease patients enrolled for routine haemodialysis. 12-Lead ECG was recorded 4 times over each patient, 1st -15 min prior to haemodialysis, 2nd- 1 hr after the dialysis had begun, 3rd –1 hr later to 2nd recording, 4th -within 10 min post haemodialysis. Two venous blood samples of each patients were drawn one 15 min prior to haemodialysis and another within 10 min post haemodialysis to assess the serum sodium, chloride, potassium, calcium and phosphate levels using semi-autoanalyser.

Results: Significant increase in serum Na^+ and Calcium levels with significant decrease in serum K^+ and phosphate levels were noted post haemodialysis. There was significant decrease in PR interval with significant increase QRS duration. There was insignificant increase in QTc interval. There was highly significant increase in SV1 voltage, Sokolow-Lyon voltage and Sokolow-Lyon product. There was medium significant correlation between rise in heart rate and fall in K^+ level and between increase in QRS duration and decrease in serum phosphate level.

Conclusion: Patients with chronic kidney disease undergoing maintenance haemodialysis have ECG abnormalities due to electrolyte changes, which would increase the mortality rate among these patients.

Keywords: Chronic kidney disease, ECG, Haemodialysis, Serum Electrolytes.

Introduction:

Cardiovascular disease is the major cause of death in patients with chronic kidney disease undergoing haemodialysis [1]. The death in about 30% of these patients is attributed to arrhythmias and sudden cardiac arrest [2,3]. This increased mortality rate is not only due to coronary disease, left ventricular hypertrophy and diabetes, but also due to the effect of stress caused by electrolyte changes, acid- base imbalance, plasma volume changes associated specifically with haemodialysis treatment on a heart which is already in an unhealthy state [4].

Potassium is the major intracellular cation which maintains intracellular osmotic pressure. About 90% of it is excreted by kidneys and rest of it is by gastrointestinal tract. Depending on the potassium intake, kidneys can

increase or decrease its excretion [5]. Normal serum level of Potassium is 4-5.5 meq/L [6]. Because the normal range of potassium is kept at a very narrow margin, even minor increase in its level is life threatening. In Hyperkalemia, increased membrane excitability leads to ventricular arrhythmias and ventricular fibrillation [5]. Sodium is the major cation of the ECF compartment, which is required for the fluid maintenance. Kidney is the major route of its excretion, and 99% of sodium is reabsorbed by renal tubules by an active process [7]. Advanced renal failure leads to sodium retention [8]. Haemodialysis is one of the effective means of treating hyperkalemia and uremia in patients of EDRD [9]. Severe Hyperkalemia could occur in 10-19% of patients undergoing haemodialysis, which could prolong the QTC interval predisposing to arrhythmias and sudden death [10-12]. Various studies have reported that a sudden increase and decrease in serum potassium cause arrhythmias in patients undergoing haemodialysis [13-16]. So the present study intended to assess and compare the serum electrolytes level and ECG parameters in CKD patients pre and post haemodialysis, and to correlate their changes.

Materials and methods:

This was a cross-sectional study done between July 2016 and Dec 2016. All the patients registered for maintenance haemodialysis in Karwar Institute of Medical Sciences Hospital, Karwar, Karnataka were included in the study. Institutional ethical clearance was taken before starting the study. The participants were explained about the intention of the study.

Inclusion criteria

- The patients who gave informed written consent.
- Patients with routine dialysis duration minimum of 3 months.

Exclusion criteria

- Patients with cardiac illness diagnosed
- Patients on drugs affecting QT interval

Patients fulfilling the inclusion criteria were undergoing haemodialysis at a frequency of 2-3 times per week. Each sitting of haemodialysis lasted for 3-4hr with flow rate of 250-300ml/min. The dialysate used had conc of K 2 mEq/Land Ca 3mEq/L mixed with bicarbonate solution. The dialyser used was Haemodialysis system DBB-27 containing Hemoflow F6HPS Fresenius polysulfone membrane.

Venous blood samples of the patients were drawn using syringe and then stored in plain vacutainer to assess the serum sodium, chloride, potassium, calcium and phosphate levels. Two venous samples of each patient were drawn, one 15 min prior to haemodialysis and another within 10 min post haemodialysis. 9180 Electrolyte Analyzer of ROCHE make was used to assess Na, K and Cl. Chem-5 PlusV2 semi-auto analyzer of ERBA Mannheim make was used to assess Ca and Phosphate levels.

EDAN SE-3 12- Lead ECG was used to record ECG over all the patients. ECG was recorded 4 times over each patient, 1st recording was done 15 min prior to haemodialysis, 2nd recording was done 1hr after the dialysis had begun, 3rd recording was done during dialysis 1hr later to 2nd recording, 4th was done within 10 min post haemodialysis. The ECG parameters used for statistical analysis were Heart Rate, duration of P wave, QRS complex, QT/QTc interval, T-wave, voltage RV5 and SV1.

The data of serum electrolytes and ECG parameters were compiled in Microsoft excel. Data was represented in terms of Mean and Standard deviation. Student's paired t test was used to analyze pre and post heamodialysis values of serum electrolytes and ECG parameters. Pearson's

correlation coefficient was used to correlate between the changes in values of electrolytes and changes in the values of ECG parameters post haemodialysis. Statistical tests were applied using Microsoft Excel 2010.

Results:

24 patients were registered for maintenance hemodialysis over a period of 6 months from July 2016 to Dec 2016. All the patients were included in the study after their consent. Mean Age of patients was 54.67±10.82yr and mean duration of dialysis was 1.86±1.51yr.

Table 1. Patients mean age, duration of dialysis, height, weight, BMI- pre and post haemodialysis

Patient details	Mean	SD
Mean Age (yr)	54.67	10.82
Mean duration of dialysis (yr)	1.86	1.51
Mean Height (cm)	159.83	7.21
Mean weight pre-dialysis (kg)	56.42	9.26
Mean weight post-dialysis (kg)	53.45	9.09
BMI- pre-dialysis (kg/m^2)	22.17	3.32
BMI- post-dialysis (kg/m^2)	20.97	3.29

N=24

Co-morbid conditions like DM and HTN were noted in 13(54.17%) and 19(79.1%) patients respectively.

Table 2. List of Diagnosis for which patients were undergoing haemodialysis.

Diagnosis	No. of patients
ESRD secondary to chronic glomerulonephritis	1 (4.1%)
ESRD secondary to Adult polycystic kidney disease	5 (20.8%)
CKD secondary to HTN	6 (25%)
CKD secondary to DM	3 (12.5%)
CKD secondary to HTN and DM	8 (33.3%)
Acute pyelonephritis	1 (4.1%)

N=24

Majority of patients had CKD as a complication of DM/HTN/DM and HTN

Table 3. Comparison of electrolytes level pre and post haemodialysis

Electrolytes	Prehaemodialysis		Posthaemodialysis		p value
	Mean	SD	Mean	SD	
Na (mEq/L)	135	10.26	139.17	6.39	0.028*
K (mEq/L)	5.21	1.44	3.8	1.38	0.028*
Cl (mEq/L)	105.13	11.1	103.71	5.08	0.273
Ca (mg/dL)	8.7	0.88	11.24	3.29	0.001*
Phosphate (mg/dL)	4.83	1.83	3.16	1.7	0.001*

N=24, Student's paired *t* test

There is significant increase in serum Na^+ and calcium levels with significant decrease in serum K^+ ion and phosphate concentration after haemodialysis.

Table 4. Comparison of values of ECG parameters pre and post haemodialysis.

ECG parameters	Pre-haemodialysis		Post-haemodialysis		p value
	Mean	SD	Mean	SD	
HR (bpm)	79.36	13.69	82.38	16.87	0.14
P wave (msec)	114.54	12.95	108.63	27.96	0.144
PR interval (msec)	181.83	26.5	167.08	46.61	0.035*
QRS (msec)	88.33	9.6	91.92	9.15	0.022*
QT interval (msec)	381.75	39.64	379.46	40.52	0.335
QTc interval (msec)	434.21	17.47	437.83	23.59	0.166
P (°)	42.4	22.1	41.89	24.64	0.44
QRS (°)	23.32	28.82	23.04	26.2	0.456
T axis (°)	65.28	40.42	67.53	48.13	0.312
RV5 (mV)	1.3	1	1.45	1.33	0.18
SV1(mV)	1.24	0.56	1.61	0.86	0.0008***
Sokolow-Lyon voltage (SV1 + max [RV5, RV6]) (mV)	2.53	1.17	3.06	1.42	0.0097**
Sokolow-Lyon product (SV1 + max [RV5, RV6].QRS)	227.44	115.38	281.2	134.01	0.0058**

Students' paired *t* test * p value <0.05, ** p value <0.01, *** p value <0.001

There is significant decrease in PR interval with significant increase in QRS duration. There is insignificant increase in QTc interval. There is highly significant

increase in SV1 voltage, **Sokolow-Lyon voltage and Sokolow-Lyon product.**

Table 4.Pearson's correlation of changes in electrolytes level with changes in ECG parameters post haemodialysis.

Correlation (r value*)	ΔHR	ΔP	ΔPR	ΔQRS	ΔQT	ΔQTc
Δ K	0.32	0.143	0.17	0.13	0.11	0.16
Δ Cl	0.14	0.098	0.19	0.18	-0.13	0.14
Δ Ca	-0.11	-0.08	-0.03	-0.05	-0.01	-0.05
Δ P	0.02	-0.02	-0.06	0.31	0.20	0.01

N=24, **r value - Pearson's correlation co-efficient**

There is medium significant correlation between rise in heart rate and fall in serum K^+ level and between increase in QRS duration and decrease in serum phosphate level.

Discussion:

Chronic kidney disease patients undergo maintenance haemodialysis as a renal replacement therapy. Mortality is relatively higher in patients undergoing haemodialysis when compared to peritoneal dialysis [17]. Sudden cardiac death is the quite common cause of death among these patients due to cardiac manifestations as a result of changes in electrolytes level during haemodialysis. Some ECG changes suggestive of cardiac disease are noted in patients prior to haemodialysis due to rise in K+ levels. Some changes in ECG manifest during haemodialysis which persist for some time even after haemodialysis. Cardiac monitoring is highly required among these patients and the easiest way is by screening using ECG.

Various manifestations in ECG are correlated with serum electrolyte levels of K, Ca. Changes in Na levels usually doesn't have any effect on the ECG. Hypercalcaemia is commonly associated with shortened QT interval, prolonged QRS duration, bradycardia, increased QRS amplitude, diminished T wave amplitude. Hypocalcaemia is associated with lengthened QT interval, shortened QRS duration, AV block, sinus bradycardia, SA block, ventricular fibrillation. Hyperkalemia is associated with pointed T waves, wider P wave with decreased amplitude, prolonged PR interval, ST segment elevation, wider QRS complex. Hypokalaemia is associated with wider T wave with low amplitude, ST segment depression prominence of U waves along with T wave inversion and increase of amplitude of P wave [18]. Serum phosphate level has inverse relationship with serum calcium. QT interval is also dependent on age and gender.

ECG changes noted in CKD patients on haemodialysis are combined effects of changes in various serum electrolytes level, uraemia, acid-base imbalance [4]. Also the manifestations are related with the type of dialysate being used, i.e., the K, Ca, bicarbonate levels in the dialysate [19]. In this study component A of dialysate had K 2mEq/L, Ca 3mEq/L, component B was bicarbonate solution which were mixed with distilled water.

In this study, mean age of the patients is on the higher side. Serum K^+ level significantly reduced after haemodialysis as noted in earlier studies [14, 19-22]. Serum Ca level significantly increased as noted in earlier studies [19]. Even serum Na^+ level significantly increased. These results are consistent with earlier studies [22-24]. There was significant decrease in serum phosphate level which correlates with serum Ca level.

Significant rise in HR is noted post dialysis in earlier studies [20], but here the rise was insignificant. PR interval was significantly reduced indicating improved conduction of impulses which can be explained based on K level changes post haemodialysis. QRS duration was significantly prolonged which can be explained based on changes in Ca levels post haemodialysis [20, 25]. Significant QT/QTc interval prolongation is associated with fall in serum K, Ca, Phosphate as noted in earlier studies [20]. In this study QT/QTc interval prolongation

was insignificant though there was significant decrease in K and Phosphate levels post dialysis. This may be explained with increased serum Ca level post dialysis. Significant change in SV1 voltage, Sokolow-Lyon voltage and product suggestive of left ventricular hypertrophy changes manifesting during dialysis.

Medium significant negative correlation(r=-0.32) is noted between fall in K levels and change in HR postdialysis. Low significant negative correlation(r=-0.25) is noted between rise in Na levels and change in PR interval post dialysis. Medium significant negative correlation(r=-0.31) is noted between fall in phosphate levels and change in QRS duration post dialysis. Low significant positive correlation(r=0.2) is noted between fall in phosphate levels and changes in QT interval. These correlations explain the changes in ECG post dialysis as depicted in earlier studies [20, 26].

Prolonged QRS duration indicate poor ventricular depolarization. Prolonged PR interval indicate poor conductance of impulse and prolonged QTc interval indicate poor ventricular depolarization and repolarization. Increase in SV1 voltage, Sokolow-Lyon voltage and product suggest left ventricular hypertrophy. These changes in ECG indicate the predisposition of patients to conduction defects in the form of Heart blocks, Left ventricular hypertrophy and Arrhythmias

Conclusion:

Significant electrolyte changes in CKD patients undergoing maintenance haemodialysis predispose them to cardiac electrical disturbances. Screening by ECG is highly required to avoid sudden cardiac death of these patients.

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