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Original Research Article

Evaluation of Electrolytes and Electrocardiogram Changes in Chronic Renal Failure Pre and Post Dialysis: A Comparative Study

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Abstract

Background: Patients with chronic kidney disease (CKD) can remove harmful metabolic waste products from their blood in an artificial manner using dialysis. The death rate for dialysis patients remains high despite significant advancements in technology and pharmaceutical care. Nine to thirteen percent of hemodialysate patients in India pass away within a year. Patients with CKD commonly experience abnormal electrocardiographic (ECG) results.

Objectives: Reviewing the electrolyte changes following the dialysis process and figuring out how frequently different ECG abnormalities occur in CKD patients were the goals of the study.

Materials and Methods: This cross sectional study was conducted 214 patients with chronic kidney disease on Hemodialysis. All patients underwent 12 lead electrocardiograms (ECG). Blood samples for Serum Electrolytes were collected before and after Hemodialysis, and compared using Z test. p value less than 0.05 was considered as significant.

Results: Following hemodialysis, serum sodium increased but serum potassium and chloride decreased. In 21.0% and 9.4% of patients, respectively, left ventricular hypertrophy and atrial fibrillation were noted.

Conclusion: Prognostic relevance of blood potassium, sodium, and chloride anomalies in CKD patients receiving hemodialysis. To check for cardiovascular illness, an ECG should be performed on every hospitalised CKD patient.

Keywords: Chronic renal failure, electrocardiograms, hemodialysis, Left ventricular hypertrophy, serum electrolytes.

Introduction

Acid-base and electrolyte balance are crucially maintained and regulated by the kidneys. The regulatory processes are compromised by chronic kidney disease (CKD), which can have fatal consequences for the electrolyte and acid-base balances [1].CKD is a worldwide public health issue that affects 5–10% of the population

[2]. End-stage renal disease (ESRD) affects 150–200 people per million in India, where the prevalence of CKD is roughly 800 per million people.[3].

By dialyzing the patient's blood against fluid that contains no urea and has levels of minerals like potassium and calcium that are similar to their natural concentration in healthy blood, dialysis removes excess fluids and toxic last part products of metabolism like urea from the plasma and corrects electrolytes balance [4].In addition to treating hyperkalemia and uremia and lowering salt and serum creatinine levels in renal failure, hemodialysis (HD) is a helpful therapy option [5]. The death rate for dialysis patients remains high despite significant advancements in technology and pharmaceutical care. In India, between 9 and 13 percent of hemodialysis patients pass away within a year.[6].

Although this may not be visible on a clinical examination, most patients with stable CKD have a slight rise in their total body salt and water content [7,8].Since urinary potassium excretion is primarily regulated by aldosterone-dependent secretion in the distal nephron, the drop in GFR in CKD is not always accompanied by a corresponding decline in urine potassium excretion. In these patients, increased potassium excretion in the GI tract serves as another barrier against potassium retention. Despite these two homeostatic reactions, hyperkalemia can sometimes develop suddenly in specific circumstances. The consumption of more potassium through food, protein catabolism, hemolysis, bleeding, transfusion of red blood cells, and metabolic acidosis are a few of these.A variety of drugs can also prevent the kidneys from excreting potassium, which can result in hyperkalemia [8,9].

A typical problem in advanced CKD is metabolic acidosis. Most patients are still able to acidify their urine, but because they are producing less ammonia, they are unable to expel the regular number of protons along with this urinary buffer. If present, hyperkalemia further inhibits ammonia synthesis. Even at earlier stages of CKD (stages 1-3), patients with diabetic nephropathy, those with significant tubulointerstitial disease, or those with obstructive uropathy frequently have the combination of hyperkalemia and hyperchloremic metabolic acidosis; this is a non-anion-gap metabolic acidosis. [9].

Hypokalemia following dialysis is linked to severe cardiac arrhythmias and abrupt cardiac deaths [10]. Hyponatremia in dialysis patients is frequently dilated because of excessive water or hypotonic fluid intake. When persistent, hypernatremia has been observed in those who have a weakened sense of thirst or who don't drink enough water. Dysnatremia has a significant mortality rate in CKD and ESRD. [11].

Patients with CKD frequently experience electrocardiography (ECG) alterations, which can be used to predict future cardiovascular events in these patients[12,13]. The reported prevalence of different ECG abnormalities varies greatly between research.[13–16]. Following hemodialysis, CKD patients are particularly prone to medical problems, including sudden cardiac death due to internal milieu changes such electrolyte imbalances, blood pressure, etc. Monitoring CKD patients after hemodialysis thus becomes crucial.The current study's objectives were to analyse electrolyte changes following dialysis and assess the prevalence of various ECG abnormalities in CKD patients.

Materials and Methods

The Department of Medicine at Kiran C Medical College and Research Institute in Bharuch conducted this cross-sectional study over the course of six months, from April 1 to September 30, 2022. The study included 214 consenting adult patients with CKD receiving hemodialysis at Civil Hospital Bharuch or patients referred for hemodialysis from other institutions. Patients diagnosed with CKD stage 4 or stage 5 who attended dialysis units at the Department of Medicine at Civil Hospital, Bharuch, had to be older than 18 years old in order to be included in the study. The study excluded patients with acute kidney damage, active cancer, and pregnancy. Nonprobability sequential sampling was used as the sample method.

Detailed information regarding socio-demographic characteristics was acquired and put in the study proforma after receiving ethical approval from the Institutional Ethical Committee and written agreement from each study participant. All patients' blood samples were drawn under aseptic conditions, and the serum electrolytes levels were checked. On the day of the procedure, samples were taken both before and after the corresponding procedure. An electrocardiogram (ECG) was done while taking aseptic measures. A qualified doctor with training in interpreting ECG abnormalities interpreted the ECG.

Patients were classified as having hyponatremia if their sodium level was below 135 mEq/L and hypernatremia if it was over 145 mEq/L, hypokalemia if their potassium level was below 3.5 mEq/L and hyperkalemia if it was above 5.5 mEq/L, and hyperchloremia if it was above 95 mEq/L.

Statistical analysis

Epi info version 7.1.4.0 was used to analyse the data once it was entered in Microsoft Excel 2016. While categorical data was provided with frequency and percentage, continuous data was presented with mean and standard deviation. Continuous data comparisons were examined using the Z test. A p value of 0.05 or less was regarded as significant.

Results

A total of 214 participants with a mean age of 48.7±13.9 years participated in the study. 34.1% of the participants in the study were female. Participants' average pre-dialysis and post-dialysis weights were 59.4 kg and 56.9 kg, respectively. According to Tables 1 and 2, the pre-dialysis weight was statistically substantially higher than the post-dialysis weight.

Table 1: Basic characteristics of study participants (n-214)

Characteristics	Frequency	Percentage (%)
Age group		
21 to 30	26	12.1
31 to 40	47	22.0
41 to 50	41	19.2
51 to 60	47	22.0
61 to 70	44	20.6
71 to 80	6	2.8
81 to 90	3	1.4
Mean ± SD	48.71	13.90
Gender		
Male	142	66.4
Female	72	33.6
Hypertension		
Present	139	65.0
Absent	75	35.0

Table 2: Comparison of blood pressure and weight between pre and post Dialysis (n-214)

Parameter	Pre Dialysis	Post dialysis	p value
Weight (kg)	59.54 ± 11.99	56.95 ± 11.85	< 0.001
SBP (mmHg)	149.98 ± 25.17	150.1 ± 22.68	0.910
DBP (mmHg)	78.66 ± 14.63	77.3 ± 10.25	0.174

Table 3: Comparison of electrolytes between pre and post Dialysis (n-214)

Electrolyte	Pre Dialysis	Post dialysis	p value
S. Na+ (mEq/L)	139.12 ± 3.48	140.63 ± 3.73	< 0.001
S. K+ (mEq/L)	5.29 ± 1.03	3.73 ± 0.84	< 0.001
S. Cl- (mEq/L)	107.18 ± 3.01	105.71 ± 2.5	< 0.001

*(K= potassium, Cl= Chloride, Na= Sodium)

Post dialysis sodium (140.63 ± 3.73) was statistically significantly higher than pre dialysis sodium (139.12 ± 3.48, $p < 0.001$). Potassium level was also significantly reduced after dialysis (Pre dialysis: 5.29 ± 1.03 v/s 3.73 ± 0.84, $p < 0.001$). Similarly, post dialysis chloride was statistically significantly low than pre dialysis chloride ($p < 0.001$) (Table 3).

Post hemodialysis, 201 (93.9%) patients had normal heart rate. Only 7 (3.3%) and 6 (2.8%) patients had bradycardia and tachycardia. Atrial fibrillation was observed in 18 patients (9.4%). Right bundle branch block (RBBB) and Left bundle branch block (LBBB) were reported in 35 (16.4%) and 20 patients (9.3%). Left axis deviation (LAD) was observed in 19 patients (8.9%) and Right axis deviation (RAD) was observed in 14 (6.5%). Left ventricular hypertrophy (LVH) and Left atrial enlargement (LAE) were seen in 45 (21.0%) and 15 (7.0%) respectively. Whereas, right ventricular hypertrophy (RVH) and Right atrial enlargement (RAE) were seen in 10 (4.7%) and 9 patients (4.2%). ST depression or elevation, Tall T wave and T inversion were reported in 32 (15.0%), 10 (4.7%) and 2 patients (0.9%) respectively (table 4).

Table 4: ECG findings among of study participants (n-214)

Heart rate	**Frequency**	**Percentage (%)**
Normal	201	93.9
Bradycardia	7	3.3
Tachycardia	6	2.8
Other abnormalities		
Atrial fibrillation	18	8.4
RBBB	35	16.4
LBBB	20	9.3
Left axis deviation (LAD)	19	8.9
Right axis deviation (RAD)	14	6.5
Left ventricular hypertrophy (LVH)	45	21.0
Left atrial enlargement (LAE)	15	7.0
Right ventricular hypertrophy (RVH)	10	4.7
Right atrial enlargement (RAE)	9	4.2
ST depression or elevation	32	15.0
Tall T wave	10	4.7
T inversion	2	0.9

Discussion

In the impoverished world, CKD is the main cause of illness and mortality and is a major global health issue. Cardiovascular disease (CVD) is a serious danger for people with CKD [17]. Patients with End stage renal disease (ESRD) around the world are increasingly able to access HD, which offers a life-saving medication. Despite the fact that this procedure has been used in clinical settings for more than 50 years, descriptions of the magnitude of change in serum electrolytes with modern practise are still required to complement current clinical understanding of the biochemical changes during hemodialysis and to provide crucial information for dialysate prescription research. The objective of this cross-sectional study, which involved 214 CKD patients receiving hemodialysis at a tertiary care hospital, was to evaluate the changes in serum electrolytes following hemodialysis. After dialysis, serum sodium greatly increased in the current study, but serum potassium and chloride significantly decreased.

Hyperkalemia, which is frequently present in CKD patients, predisposes them to cardiovascular consequences such a decrease in action potential, an expansion of the QRS complex, and a prolonging of the PR interval. Haemodialysis causes 12–16 ECG alterations because of the rapid shift in serum K+, which causes hypokalemia17 and calls for close observation and treatment. Reduced resting membrane potential, slowed conduction velocity, and accelerated repolarization are all effects of hyperkalemia. The most common cause of mortality in the majority of patients on maintenance hemodialysis is hypokalemia, which on the other hand raises the resting membrane potential and refractory period and is possibly arrhythmogenic[18].

After HD, the potassium level in the current research dramatically decreased. (5.29 ± 1.03 v/s 3.73 ± 0.84, $p < 0.001$). In the study of AjamWH et al.[19], mean K+ levels in post-HD (3.69±0.65) were low compared to pre-HD Patients (4.48±0.83, $p< 0.001$). Also, the result consistent with other study[20,21] Tandukar et al.,[22] recommend keeping the potassium levels in CKD patients between 4.0 and 5.0 mmol/L.

In the current study, post-dialysis sodium (140.63±3.73 vs. 139.12±3.48, $p<0.001$) was substantially greater than pre-dialysis sodium. The pre-HD Na+ in the study by Ajam WH et al.[19] was 136.5±4.14 while the post-HD Na+ was 138.6±4.41 ($p = 0.36$). According to a study by Nauman, mean blood Na+ levels were higher in post-HD patients than in pre-HD patients (138.00 ± 4.41 vs. 136.87±4.14) [23]. After HD, Andrews L et al.[24] noticed a noticeably higher salt level. The inter-dialytic dietary salt intake and the intra-dialytic elimination of Na+ are the two main factors that affect Na+ balance in chronic hemodialysis patients [25]. Serum sodium levels in dialysis patients seem to have a certain fixed point.[26]. The dialysate sodium concentration has an impact on post-dialysis serum sodium concentrations. Most patients may experience a positive dialysate-to-serum sodium gradient when their dialysate sodium prescription exceeds 138 mEq/L [27]. However, using a typical dialysate sodium concentration, earlier modelling studies have demonstrated that serum sodium concentration declines during HD. A negative sodium balance would cause changes in blood pressure, and net sodium transfer from serum to dialysate is a possibility. [28,29].

Post-dialysis chlorine in the current study was statistically considerably lower than pre-dialysis chloride (p 0.001). The study by Kirschbaum B et al. [30] demonstrates that post-HD patients' mean serum chloride levels (Mean-103) were lower than those of pre-HD patients (Mean-103).In the study of Correa S et al. [9], sodium increased and chloride decreased after hemodialysis. Liborio et al.'s10 attempt to use hemodialysis to fix the unmeasured anions resulted in unchanged chloride after the procedure. The patients in their study had acidosis brought on by high unmeasured anions, hyperchloremia, and hyperphosphatemia. There was an alkalinizing effect of hypoalbuminemia. Hemodialysis mostly reduced phosphate and unmeasured anions, which helped to rectify acidosis. Chloride levels did not alter in the entire group following dialysis. The high-chloride group, however, showed a decrease in plasma chloride when data were analysed based on predialysis plasma chloride, leading to a superior base excess improvement (Delta standard base excess) than the low-chloride group. Na+, K+, and Cl- must be regulated within a relatively small physiological range in order to prevent potentially fatal occurrences.[31].

Conclusion

The most frequent electrocardiographic abnormality is LVH. Every CKD patient receiving hemodialysis should have an ECG to look for any abnormalities. After hemodialysis, there was a notable decrease in serum potassium and chloride levels and a notable increase in sodium levels. In CKD patients receiving hemodialysis, monitoring and treating electrolyte imbalances, particularly potassium, has a bearing on prognosis. To prevent or treat significant effects owing to serum electrolyte, it is advised that the dialysate be changed in accordance with pre-dialytic alterations for every patient.

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