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Hematological and Urine Analysis Changes in Pre and Post Hemodialysis Patients with Chronic Kidney Disease in a Tertiary Care Hospital in Puducherry- South India

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ABSTRACT

Background: Chronic kidney disease (CKD) often necessitates hemodialysis, which can impact hematological and urine parameters. This study aims to evaluate the changes in these parameters in CKD patients undergoing hemodialysis at a tertiary care hospital in Puducherry.

Methods: An observational study was conducted at a tertiary care hospital involving 55 CKD patients (44 males and 11 females) aged 29 to 80 years (mean age 58.11 ± 1.46 years). Hematological and urine samples were collected pre- and post-dialysis. Complete blood count, coagulation profiles, and urine analysis were carried out using automated machinery. The paired t-test assessed significant differences between pre- and post-dialysis values.

Results: Post-dialysis, there was a significant increase in mean hemoglobin (Hb) levels (7.70 g/dL to 8.35 g/dL, P = 0.0009) and a slight, non-significant decrease in hematocrit (HCT) levels (25.62% to 24.24%, P = 0.2772). Platelet counts significantly decreased (186.1818 x103/µl to 162.3455 x103/µl, P = 0.0008), with a slight reduction in platelet distribution width (PDW). Clotting time significantly increased (4.117273 minutes to 4.291818 minutes, P = 0.0241). Red blood cell (RBC) indices remained stable, with minor changes in MCV, MCH, and MCHC. Urine analysis showed no significant differences in pre- and post-dialysis.

Conclusion: Hemodialysis in CKD patients induces significant hematological changes, particularly in Hb concentration, platelet count, and coagulation parameters, without significant alterations in urine composition. Limitations include the small sample size and single-center design. Future research should involve larger, multi-center cohorts and longitudinal follow-up to understand long-term trends and outcomes better.

INTRODUCTION

were measured using 5 wide mouth 2 L. flasks. Each flask

Chronic kidney disease (CKD) or chronic kidney failure is a pervasive and progressive condition that significantly impacts global health.[1] chronic kidney disease (CKD), which is characterized by a progressive loss of kidney function over an extended period of time, can result in end-stage renal disease (ESRD), which necessitates renal replacement therapies, such as hemodialysis, to replace the kidney's functions. When the kidneys can no longer adequately filter waste materials and extra fluid from the blood, hemodialysis, an intermittent therapy, is an essential treatment for individuals with end-stage renal disease (ESRD).[2,3] Hemodialysis is a semi-membrane filtering or solute diffusion procedure.[4] Although the operation is life-sustaining, it causes a number of physiological alterations, especially in the parameters related to the blood and urine. Optimizing patient care and treatment results requires an understanding of this changes.[5]

The goal of hemodialysis is to eliminate solutes as they flow from a region of higher concentration to one of lower concentration across a semi-permeable membrane. In this way, the blood's tiny poisons and electrolytes are eliminated.[6] The dialyzer, a specialized filter that functions as an artificial kidney, is used to pump heparinized blood from the patient's body. The blood is propelled at a flow rate ranging between 300 and 500 mL per minute.[7] Heparin, an anticoagulant, is used to prevent blood clotting within the dialyzer. To avoid blood clotting inside the dialyzer, heparin, an anticoagulant, is employed. At 500 to 800 mL per minute, a dialysate solution concurrently flows through the dialyzer in the other direction, a process known as counter-current flow.

The counter-current flow maximizes the concentration gradient between the blood and the dialysate, enhancing the removal of waste products and excess electrolytes from the blood.5 The

dialyzer's intrinsic ability to filter and eliminate solutes, as well as the blood and dialysate flow rates through it, are the two primary determinants of the hemodialysis process's effectiveness. Greater exchange of substances results from increased flow rates, which enhance waste product removal.8 In order to avoid difficulties, it is also recommended that all patients receiving dialysis be screened during the process.[9]

Hematological parameters are vital indicators of a patient's overall health and are particularly significant in the context of CKD and hemodialysis. These parameters, which include hemoglobin (Hb), Hematocrit (HCT), red blood cells (RBCs), white blood cells (WBCs), platelets, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width-standard deviation (RDW-SD), red cell distribution width-coefficient of variation (RDW-CV), platelet distribution width (PDW), and various white cell subtypes like neutrophils, basophils, eosinophils and monocytes, provide comprehensive insights into the hematological status of patients. Changes in these parameters can reflect the body's response to dialysis, underlying health conditions, and the effectiveness of the treatment.[4,10]

A vital part of red blood cells, hemoglobin is in charge of carrying oxygen throughout the body.[11] Anemia, characterized by low Hb levels, is a common complication in CKD patients due to reduced erythropoietin (a glycoprotein hormone) production by the diseased kidneys, leading to diminished RBC production.[12] An increase in hemoglobin levels is frequently seen after hemodialysis. This increase can be attributed to the removal of excess fluid from the bloodstream, resulting in hemoconcentration, where the relative concentration of hemoglobin increases despite the actual number of red blood cells remaining unchanged. This phenomena emphasizes how crucial it is to keep an eye on hemoglobin levels in order to properly treat anemia in individuals with chronic kidney disease.[13]

It is crucial to evaluate other hematological parameters such bleeding time, clotting time, and prothrombin time in CKD patients receiving hemodialysis. These parameters are critical indicators of the hemostatic balance in the body, which is often disrupted in CKD patients. Bleeding time, which gauges platelet function and blood vessel integrity, is the amount of time it takes for bleeding to stop.[14] This is especially important for CKD patients since they often have platelet dysfunction, which raises their risk of bleeding problems both during and after dialysis.

Clotting time, on the other hand, shows how well blood can form clots and offers insights on the intrinsic process of coagulation. Close monitoring is necessary to prevent bleeding and thrombotic events because hemodialysis can cause mechanical stress on blood cells, which may activate platelets and change coagulation dynamics.[15,16] Anticoagulation therapy, which is frequently given during hemodialysis to avoid clot formation in the dialysis circuit, and the detection of clotting problems depend on prothrombin time, a measure of the extrinsic pathway of coagulation.[17]

Platelets are essential for hemostasis because they help form blood clots, which stop excessive bleeding. Changes in platelet function and quantity are common in CKD patients; which raises the risk of bleeding and thrombotic events.[18] White blood cells (WBCs) are also vital parts of the immune system, protecting the body from foreign invaders and illnesses. WBC counts and their subtypes can be affected by CKD and hemodialysis, which may have an effect on the patient's immunological response.[19] Red blood cell size and hemoglobin concentration can be determined in detail using the MCV, MCH, and MCHC indices. These indices are useful for tracking and detecting various forms of anemia. A non-invasive diagnostic method for determining the presence of different compounds in the urine and vital information about kidney function is urine analysis. Hematuria, proteinuria, and the development of cellular casts are examples of parameters that can reveal underlying kidney injury or dysfunction.[20]

This study was conducted in a tertiary care hospital in Puducherry, a region with a diverse patient population. Understanding the specific changes in hematological and urine parameters in this demographic is crucial for tailoring hemodialysis treatment protocols to meet the unique needs of the population. The significant variation in Hb content, platelet count, and clotting time observed in this study provides valuable insights into the physiological adjustments occurring during hemodialysis. The lack of significant changes in other hematological parameters and urine analysis suggests that the observed effects are specific and not indicative of widespread hematological disruption. Altogether, the study of hematological and urine analysis changes in pre- and post-hemodialysis patients with CKD provides essential insights into the physiological impact of this treatment.

MATERIALS AND METHODS

Study Population

The observational study was carried out with Fifty-five patients who had chronic kidney disease regularly undergoing hemodialysis were randomly chosen for this study. The study cohort comprised of 11 female and 44 male patients between 29 and 80 years old and a mean (± standard error) age of 58.11±1.46. The study was conducted over a period of one year with prior approval from the Institutional Ethics Committee (SVMC/SRC/2023/09/CTR878).

Patients with chronic kidney disease undergoing regular hemodialysis were included in the study and patients with history of coagulation disorders, known history of chronic hematological health conditions, acute infections, double inclusions, and insufficient sampling were excluded.

Methodology

Informed consent was obtained from the patients before the sample collection. 5 ml of blood was collected in a syringe from the antecubital vein in two vacutainers. One lavender colored vacutainer with EDTA for complete blood count and one light blue vacutainer with Sodium citrate to assess the coagulation profile. The same procedure was repeated within 2h after the hemodialysis procedure. The collected samples were processed in the Hematology and Clinical pathology sections at the Department of Pathology. The complete blood count, coagulation profile, and bleeding time were analyzed by Duke's method and the clotting time was determined by the capillary tube method. The complete blood count was carried out using the automated Mindray BC5150 machine. The coagulation profile was determined using the Erba Mannheim ECL 105. Urine analysis was done for all patients before and after hemodialysis were analyzed by the urine analyzer U120 smart Machine

Statistical Analysis

The significant difference between the pre- and post-dialysis was analyzed using the paired t-test. The statistical data analysis was carried out using SPSS version 23.0 (IBM Corp, Armonk, New York, USA) and Graph Pad Prism (version 10; GraphPad Software, Inc.). Data are presented as the mean ± standard error of the mean. $P<0.05$ was considered to indicate a statistically significant difference.

RESULTS

The mean (± standard error) age of the age group in this study was 58.11±1.46 years. Of them, 80% were men and 20% were women. The pre-dialysis and post-dialysis mean WBCs were 6.9 and 6.69 x103/µl, respectively. Assessing and treating anemia, a prevalent consequence in chronic kidney disease, requires regular monitoring of hemoglobin (Hb) and hematocrit (HCT) levels in patients before and after dialysis. All patients had mean Hb and Hct concentrations of 7.70 g/dL compared 8.35 g/dL ($P = 0.0009$) and 25.62% versus 24.24% ($P = 0.2772$) before and after dialysis. Post-dialysis patients have a markedly elevated Hb concentration (Table I; Fig.1). RBC, RDW-SD, and RDW-CV measurements are also carried out concurrently. Following hemolysis, the RBC count (0.10 million cells/µl), RDW-SD (1.10 Fl), and RDW CV (0.18%) values show a little decline (Table II). Prior to dialysis, the mean RBC indices of CKD patients, specifically MCV, MCH, and MCHC, were 84.47455 Fl, 28.06727 Pg, and 33.07673 g/dl. After dialysis, the MCV showed a modest increase, reaching 85.19273 Fl. However, the MCH and MCHC indices showed a decline, with respective values of 28.05636 Pg

and 33.06182 g/dl. There was no discernible variation in the RBC indices (Table III).

In pre- and post-hemodialysis patients with chronic kidney disease, monitoring platelets and clotting time is critical as these parameters help assess the risk of bleeding and thrombosis, which are common complications due to altered platelet function and coagulation pathways. The study observed significant changes in clotting time and platelet counts in patients with chronic kidney disease undergoing hemodialysis. The clotting time increased from a pre-dialysis average of 4.117273 minutes to a post-dialysis average of 4.291818 minutes, with the difference being statistically significant (P = 0.0241). Additionally, platelet counts showed a notable decrease, dropping from 186.1818 x103/µl pre-dialysis to 162.3455 x103/µl post-dialysis, with this reduction also being statistically significant (P=0.0008) (Table V). These findings emphasize the impact of hemodialysis on coagulation parameters and platelet function in this patient population (Table I and Table IV). The PDW slightly decreased from 15.79455% pre dialysis to 15.64364% post dialysis. This minor reduction with P value (P = 0.3178) may reflect changes in platelet size variability due to the dialysis process. There was an increase in bleeding time with P value (P = 0.8963) and a decrease in prothrombin time with P value (P = 0.2526) observed in patients undergoing hemodialysis. These results indicate alterations in coagulation parameters due to the dialysis process. In urine analysis there is no specific differences between pre dialysis and post dialysis condition.

DISCUSSION

The current study concentrated on the alterations seen in the analysis of urine and hematological samples of patients with chronic kidney disease in a tertiary care hospital before and after hemodialysis. Fifty-five individuals with chronic renal disease who were receiving hemodialysis on a regular basis were included in the study. These patients ranged in age from 29 to 80 years, with 11 females and 44 males. The participants were 58.11 years old on average, with a standard error of ±1.46 years. To take part in this study, the patients were chosen at random. We noticed significant hematological alterations in CKD patients receiving hemodialysis. These modifications are essential because they shed light on how dialysis affects the hematological profile, especially when it comes to treating anemia, a prevalent CKD consequence.

In order to diagnose and treat anemia, hemoglobin (Hb) and hematocrit (HCT) levels must be regularly monitored. After dialysis, the mean Hb levels increased from 7.70 g/dL to 8.35 g/dL (P = 0.0009), a statistically significant rise. The reason for this rise is that dialysis concentrates the components of blood, including hemoglobin, by removing extra fluid.5 However, after dialysis, HCT levels dropped marginally from 25.62% to 24.24% (P = 0.2772). The non-significant change in HCT indicates that fluid clearance is the main factor regulating hemoglobin concentration since it shows that although hemoglobin concentration rises, the total red cell mass does not change appreciably.

After dialysis, the platelet count significantly decreased from 186.1818 x103/µl to 162.3455 x103/µl (P = 0.0008). This decrease is clinically significant since it may make patients more susceptible to bleeding. Platelet consumption and activation brought on by dialysis may result in lower platelet numbers.[21] Furthermore, the modest drop in PDW (15.79455% to 15.64364%; P = 0.3178) would suggest a decrease in platelet size variability, perhaps as a result of altered platelet production dynamics or the selective elimination of larger platelets. The impact of dialysis on coagulation parameters is further supported by the increase in bleeding time and the decrease in prothrombin time, both of which are not statistically significant. These changes emphasize how crucial it is to closely monitor and control coagulation status in CKD patients receiving hemodialysis.[22]

TABLES AND FIGURES

Similarly, the study found that the clotting time increased significantly from 4.117273 minutes to 4.291818 minutes (P = 0.0241) after dialysis. This delay raises the possibility of bleeding since it implies that dialysis alters the coagulation pathways.[23,24] Following dialysis, there were slight declines in the red blood cell (RBC) count, RDW-SD, and RDW-CV, which were indicative of slight changes in the variability and morphology of red blood cells. Even if they are minor, these alterations could be brought on by the dialysis procedure itself, which can alter red cell turnover and induce some hemolysis. The RBC indices, including MCV, MCH, and MCHC, showed little change after dialysis, with MCV rising slightly (85.19273 Fl vs. 84.47455 Fl). The idea that variations in Hb are mostly caused by fluid shifts rather than modifications in red cell generation or death is supported by the stability of these indices, which show that the dialysis procedure has no discernible effect on the total size and hemoglobin concentration of red blood cells. Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Haemoglobin Concentration (MCHC) are collectively known as the RBC indices that directly indicate the anemic condition of the patient.[25] MCV specifically helps to define the basis of anemia.[26] Furthermore; MCH and MCHC help to classify the type of anemia i.e. microcytic or macrocytic. These indices also give insight into the hemoglobin content and their concentration in the RBCs.[27] Studying these indices pre- and post-dialysis gives valuable information about the efficiency of dialysis and the maintenance of bodily fluids. Insignificant changes imply that there is a proper balance of fluids before and after dialysis. Hence, dialysis effectively removes toxins without affecting the RBC indices. However, long-term monitoring is needed to conclude this as significant changes may not be observable in a single dialysis.

Interestingly, the urine analysis did not show significant differences between pre-dialysis and post-dialysis conditions. This lack of change could be due to the primary effect of hemodialysis being on the blood rather than directly on urine composition. However, urine analysis remains an essential tool for overall kidney function assessment and monitoring long-term changes in CKD patients.

The discussion of this study on hematological and urine analysis changes in pre- and post-hemodialysis patients with chronic kidney disease highlights several important findings but has notable limitations. The small sample size of 55 patients and the single-center design restricts the generalizability of the results, as a larger and more diverse

cohort from multiple centers would provide more robust data. Additionally, the lack of significant differences in urine analysis suggests either a limitation in the study's sensitivity or that dialysis primarily affects blood parameters. The absence of longitudinal data further limits understanding of long-term trends and outcomes. To enhance the reliability and applicability of these findings, future studies should include larger, multi-center cohorts, a broader range of hematological parameters, and longitudinal follow-up.

CONCLUSION

In summary, hemodialysis in CKD patients induces significant hematological changes, particularly in hemoglobin concentration, platelet count, and coagulation parameters. These findings highlight the complex interplay between dialysis and hematological homeostasis, necessitating careful monitoring and individualized treatment strategies to optimize patient outcomes. Further research is needed to explore the underlying mechanisms of these changes and to develop interventions that can mitigate the adverse effects of dialysis on hematological parameters.

Table I RBC indices and comparative analysis to assess the impact of dialysis

Parameters	Mean		Standard Deviation		Standard Error Mean		P Value (Significance paired two-tailed)
	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	
RBC count	2.966182	2.868	0.651862	0.615685	0.087899	0.083021	0.1526
MCV (fL)	84.47455	85.19273	9.967247	6.405925	1.344019	0.863798	0.5109
MCH (pg)	28.06727	28.05636	2.311009	2.411451	0.311625	0.325169	0.9616
MCHC (g/dL)	33.07673	33.06182	1.29601	1.12505	0.174759	0.151706	0.9340

Table II Comparison of immune cell populations to evaluate the effect of dialysis

Parameters	Mean		Standard Deviation		Standard Error Mean		P Value (Significance paired two-tailed)
	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	
WBC count	6.900727	6.690364	3.032708	3.773034	0.408941	0.508769	0.5048
Neutrophil (%)	73.29273	72.64364	8.97521	9.727962	1.210249	1.311753	0.6004
Lymphocyte (%)	20.15636	20.26727	7.942636	8.117016	1.071013	1.094527	0.9154
Eosinophil (%)	3.527273	3.42	1.198062	1.25527	0.161551	0.169265	0.5519
Basophil (%)	2.925455	3.105455	2.098784	1.982742	0.283008	0.26736	0.4374
Monocyte (%)	0.583636	0.745455	0.744303	0.737568	0.100364	0.099456	0.1971

Table III Coagulation test results to assess the impact of dialysis

Parameters	Mean		Standard Deviation		Standard Error Mean		P Value (Significance paired two-tailed)
	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	
BT (mins)	2.581818	2.665455	0.542829	0.583244	0.073197	0.078647	0.2526
CT (mins)	4.117273	4.291818	0.547572	0.580849	0.073837	0.078324	0.0241
PT (sec)	23.04545	22.69091	19.69015	16.72931	2.655091	2.25584	0.8963

Table IV Distribution indices of red blood cells and platelets to evaluate the impact of dialysis on red blood cell and platelet size distribution

Parameters	Mean		Standard Deviation		Standard Error Mean		P Value (Significance paired two-tailed)
	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	
Hb (g/dL)	8.346909	7.698182	1.940081	1.701687	0.261607	0.229462	0.0009
Hct (%)	25.62364	24.23636	10.09699	5.519473	1.361515	0.744265	0.2772
Platelet ($x10^3/uL$)	186.1818	162.3455	65.7718	68.72738	8.868905	9.267446	0.0008
MPV (fL)	9.270909	9.372727	0.872135	1.306459	0.117602	0.176168	0.5396

Table V Evaluation of key hematological parameters

Parameters	Mean		Standard Deviation		Standard Error Mean		P Value (Significance paired two-tailed)
	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	Before hemodialysis	After hemodialysis	
RDW-SD (fL)	52.89818	51.80364	5.072456	6.027221	0.683988	0.812732	0.1609
RDW-CV (%)	16.35273	16.17455	2.030312	1.700242	0.273775	0.229267	0.3217
PDW (%)	15.79455	15.64364	0.560231	1.11368	0.075544	0.150173	0.3178

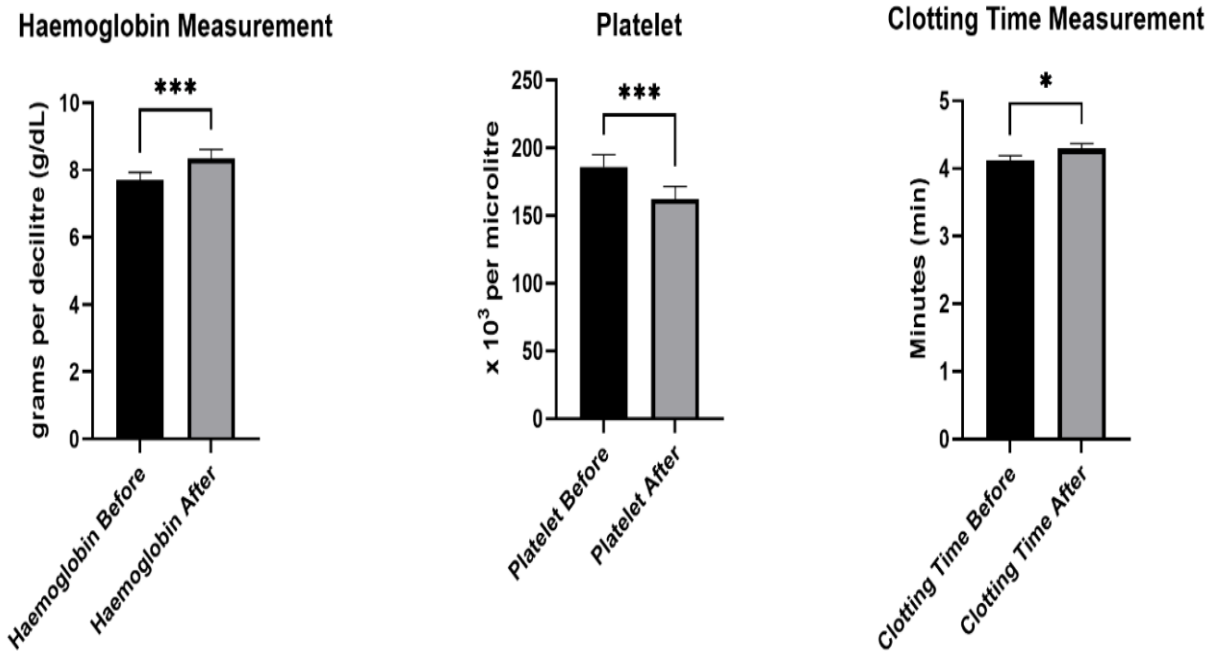

Fig.1. Key hematological parameters before and after dialysis

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