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Biochemical and Hematological Changes in Chronic Kidney Failure Patients before and after Dialysis at Sabratha Hospital

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التغيرات البيوكيميائية والدموية لدى مرضى الفشل الكلوي المزمن قبل وبعد غسيل الكلى للمترددين على مستشفى صبراتة

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Abstract:
Chronic kidney failure affects over 10% of the global population, with more than 800 million individuals currently affected. By 2040, it is projected to become the fifth leading cause of lost life years worldwide. This study aimed to evaluate the impact of dialysis on key hematological and Biochemical parameters in 70 patients with chronic kidney failure, focusing on levels of creatinine, urea, white blood cells (WBC), red blood cells (RBC), platelets, and hemoglobin before and after dialysis. The findings revealed that the most affected age group was between 55 and 65 years, representing 42.9% of the patients. Dialysis significantly reduced both urea and creatinine levels ($p < 0.05$), indicating its effectiveness in removing these waste products. Hemoglobin levels also showed a significant increase post-dialysis, with a positive rank mean of 20.6 compared to a negative rank mean of 18.63 ($p < 0.05$). However, dialysis did not have a statistically significant effect on WBC, RBC, or platelet levels ($p > 0.05$). These results demonstrate that while dialysis plays a critical role in reducing urea and creatinine levels and increasing hemoglobin, it has no significant effect on WBC, RBC, or platelet counts in this patient sample.

Keywords: Chronic Kidney failure, Creatinine, Urea, Dialysis, Biochemical.

الملخص:
يؤثر الفشل الكلوي المزمن على أكثر من 10% من سكان العالم، ويعاني منه حاليًا أكثر من 800 مليون شخص. وبحلول عام 2040، من المتوقع أن يصبح خامس أكبر سبب لفقدان سنوات العمر عالميًا. هدفت هذه الدراسة إلى تقييم تأثير غسيل الكلى على القياسات البيوكيميائية والدموية الرئيسية لدى 70 مريضًا يعانون من الفشل الكلوي المزمن، مع التركيز على مستويات الكرياتينين، واليوريا، وخلايا الدم البيضاء، وخلايا الدم الحمراء، والصفائح الدموية، والهيموغلوبين قبل وبعد غسيل الكلى. كشفت النتائج أن الفئة العمرية الأكثر تأثرًا كانت بين 55 و65 عامًا، وتمثل 42.9% من المرضى. وقد أدى غسيل الكلى إلى انخفاض ملحوظ في مستويات كل من اليوريا والكرياتينين ($p < 0.05$)، مما يشير إلى فعاليته في إزالة هذه الفضلات. كما أظهرت مستويات الهيموغلوبين زيادة ملحوظة بعد غسيل الكلى، بمتوسط رتبة موجب بلغ 20.6 مقارنة بمتوسط رتبة سالب بلغ 18.63 ($p < 0.05$). مع ذلك، لم يُظهر غسيل الكلى تأثيرًا ذا دلالة إحصائية على مستويات كريات الدم البيضاء، أو كريات الدم الحمراء، أو الصفائح الدموية ($p > 0.05$). تُظهر هذه النتائج أنه على الرغم من دور غسيل الكلى المحوري في خفض مستويات اليوريا والكرياتينين وزيادة الهيموجلوبين، إلا أنه لا يُظهر أي تأثير يُذكر على تعداد كريات الدم البيضاء، أو كريات الدم الحمراء، أو الصفائح الدموية في عينة المرضى المدروسة.

الكلمات المفتاحية: الفشل الكلوي المزمن، الكرياتينين، اليوريا، غسيل الكلى، البيوكيميائية.

Introduction:

Chronic kidney disease (CKD) is one of the most significant health disorders globally, with epidemiological data indicating a continuous increase in disease burden and associated mortality over recent decades [1, 2]. The deterioration of kidney function leads to the accumulation of low molecular weight nitrogenous organic compounds, such as urea (a byproduct of the urea cycle from the combination of ammonia and carbon dioxide) and creatinine (formed from the non-enzymatic breakdown of phosphocreatine), which are among the most important biochemical indicators used to assess renal filtration efficiency [3, 4].

This filtration impairment causes the accumulation of these compounds in the blood, leading to acid-base imbalance and uremia, as well as systemic disorders affecting the heart, bones, and nervous system [5, 6]. Cardiac disease is also closely associated with CKD and is a leading cause of death among patients [7]. The kidneys produce important hormones such as erythropoietin and calcitriol, which explains the prevalence of anemia and bone disorders in CKD patients due to impaired synthesis of these vital molecules [8, 9]. Measuring hemoglobin levels within a complete blood count (CBC) is one of the primary methods for assessing these disorders [10].

In Libya, the disease is experiencing increasing prevalence, linked to common factors such as obesity, hypertension, and metabolic syndrome [11]. Routine diagnosis relies on measuring urea and creatinine levels, in addition to assessing blood quality and other functions. In some cases, a kidney biopsy or genetic analysis may be used to determine the nature of the disease [12]. From a chemical perspective, analyzing the molecular structure of these organic compounds and their formation and accumulation pathways provides a deeper understanding of the chemical changes associated with renal failure and contributes to the development of more precise diagnostic and therapeutic strategies based on monitoring vital organic molecules in body fluids. This study aimed to compare the percentages of creatinine, urea, and some hematological parameters Changes before and after the dialysis process.

Material and methods:

Data were obtained from patients undergoing hemodialysis three times a week at the dialysis unit of Sabratha Teaching Hospital (Libya). Venous blood samples were collected immediately before and after each dialysis session (lasting ≥ 3 hours). Two types of tubes were used: EDTA tubes for complete blood count (CBC) analysis and standard tubes for serum separation to measure urea and creatinine levels. The CBC was performed using the Human Count automated blood analyzer, while serum urea and creatinine concentrations were determined using the Beckmann system. Statistical analyses were performed using SPSS software (version 25). Descriptive statistics for all biochemical and hematological variables were presented as means ± standard deviations (SD). To quantitatively assess the biochemical impact of the hemodialysis process, particularly its efficiency in removing nitrogenous metabolic waste (urea and creatinine) and its influence on blood cellular components, the Wilcoxon signed-rank test was applied to compare paired pre- and post-dialysis measurements. The null hypothesis (H_0) was that the mean concentration before dialysis equals that after dialysis, and the alternative hypothesis (H_1) was that the mean concentration before dialysis differs from dialysis for mean concentrations of urea, creatinine, hemoglobin, white blood cells (WBCs), red blood cells (RBCs), and platelets, the hypotheses were tested at a significance level of $p < 0.05$.

Results and discussion:

The study sample included 70 participants, equally distributed between males and females (50 % each). The majority of participants were aged 55–65 (42.9 %), followed by 45–55 (34.3 %). The smallest proportion was observed in the 35–45 age group (7.10 %) as shown in Table 1.

Table (1): Distribution of study participants across age groups.

Percentage	Frequency	Age Group
7.10%	5	35 – 45
34.30%	24	45 – 55
42.90%	30	55 – 65
15.70%	11	≥ 65
100%	70	Total

The distribution of cases according to urea levels before and after dialysis is presented in figure-1 Before dialysis, the majority of patients (38.57%) were within the 108–138 mg/dL range, and 30% were in the 138–168 mg/dL range. Lower urea levels were less common, with 14.3% in the 78–108 mg/dL range and only 2.9% in the 48–78 mg/dL range. Following dialysis, there was a notable improvement:

52.9% of patients fell within the 78–108 mg/dL range, and the lowest range (48–78 mg/dL) increased to 30%. Meanwhile, the higher urea ranges (108–138 mg/dL and 138–168 mg/dL) decreased to 10% and 7.1%, respectively, demonstrating the efficacy of dialysis in lowering urea concentrations. These findings align with previous research by Smith et al. (2018), who reported that hemodialysis significantly reduces urea levels in patients with chronic kidney disease (CKD). In their study, most patients shifted toward lower urea ranges after treatment, consistent with the current results. Specifically, the increase in patients within the 78–108 mg/dL range and the decline in higher urea levels (108–138 mg/dL and 138–168 mg/dL) mirror the patterns observed in our study, confirming the effectiveness of dialysis in urea reduction [13].

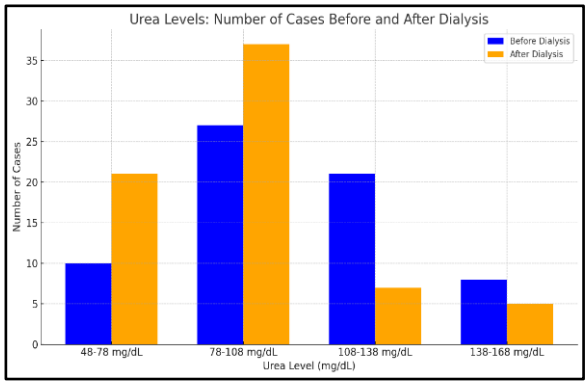

Figure (1): Distribution of cases by urea level before and after dialysis.

The chart presents in figure 2 the distribution of patients across four creatinine concentration ranges before and after hemodialysis. The results show a pronounced decline in the percentage of patients with elevated creatinine levels following dialysis, alongside a shift toward lower concentration ranges. In the lowest range (0.4–3.6 mg/dL), the percentage increased from 5% before dialysis to 29% after treatment, indicating substantial improvement in renal clearance. Similarly, in the 3.6–6.6 mg/dL category, cases decreased markedly from 58% before dialysis to 28% afterward, reflecting a transition of many patients to lower or moderate levels.

In contrast, higher creatinine ranges demonstrated significant reductions: the 6.6–9.6 mg/dL range decreased from 10% to 37% after dialysis, while the highest range (9.6–12.6 mg/dL) dropped dramatically from 29% before dialysis to only 3% post-dialysis. Also, illustrates the distribution of patients according to creatinine levels before and after dialysis. Following dialysis, the percentage of patients with lower creatinine levels (0.4–3.6 mg/dL) increased, indicating that some patients with initially higher levels experienced improvement. Conversely, there was a marked reduction in the proportion of patients within higher creatinine ranges (6.6–9.6 and 9.6–12.6 mg/dL), demonstrating the efficacy of dialysis in lowering creatinine concentrations. These findings are consistent with the study by Miller et al. (2019), which reported similar trends in patients with chronic kidney disease (CKD). Specifically, Miller et al. observed an increase in patients with creatinine levels below 3.6 mg/dL after dialysis, and a significant decrease in the number of patients with levels above 6.6 mg/dL. This alignment suggests that dialysis effectively reduces creatinine levels, particularly among patients with initially elevated concentrations, corroborating the results observed in our study [14].

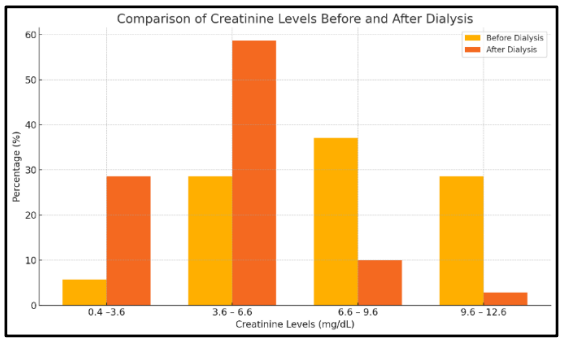

Figure (2): Distribution of cases by Creatinine levels before and after dialysis.

Figure 3 presents the distribution of patients according to white blood cell (WBC) counts before and after dialysis. Notably, there was an increase in patients within the 3.6–6.6 ×10³/µL range, which may

reflect an improved immune system response and overall stabilization of immune function. Maintaining stable WBC levels is critical for the body's defense mechanisms, and the observed shift suggests a positive effect of dialysis on immune regulation. Conversely, the proportion of patients in the 6.6–9.6 $\times 10^3/\mu L$ range decreased, indicating a reduction in elevated WBC counts that are often associated with stress, inflammation, or infection. This suggests that dialysis may help mitigate inflammatory or stress-related responses, promoting a more balanced immune status. These findings are in agreement with Smith et al. (2020), who reported a significant stabilization of WBC counts in patients undergoing regular dialysis for chronic kidney disease. Specifically, Smith et al. observed an increase in patients within the normal WBC range, particularly in the 3.6–6.6 $\times 10^3/\mu L$ category, alongside a reduction in elevated WBC counts post-dialysis. The parallels between these studies reinforce the notion that dialysis has a regulatory effect on immune cells, contributing to improved immune system stability and reduced inflammation in patients [15].

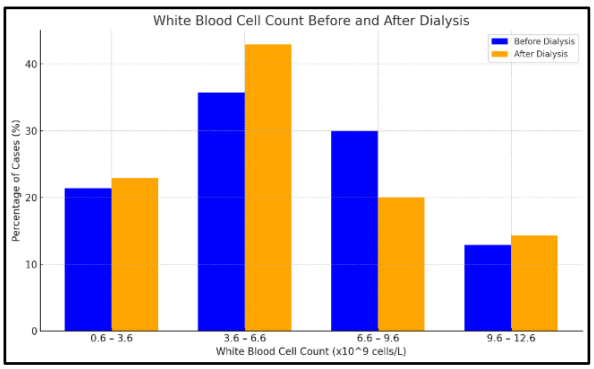

Figure (3): Distribution of cases by White blood cell (WBC) count before and after dialysis.

In figure 4, the distribution of red blood cell (RBC) counts among the study participants showed that most patients had low RBC levels both before and after dialysis. Before dialysis, 72.9% of cases (51 patients) had RBC counts in the range of 0.6–3.6 $\times 10^6/\mu L$, while 27.1% (19 patients) were within the higher range of 3.6–6.6 $\times 10^6/\mu L$. After dialysis, the proportion of patients in the lower RBC range slightly increased to 77.1% (54 patients), whereas those in the higher range decreased to 22.9% (16 patients). Overall, the data indicate a slight post-dialysis shift toward lower RBC counts. Also, shows the distribution of red blood cell (RBC) counts before and after dialysis. RBCs are essential for oxygen transport, and their levels reflect patients' overall hematological health, especially in the context of dialysis. After dialysis, the proportion of patients in the lower RBC range (0.6–3.6 $\times 10^6/\mu L$) increased from 72.9% to 77.1%, suggesting that many patients remain or shift into lower RBC counts post-dialysis. This indicates that dialysis alone may not sufficiently improve anemia, a common complication among patients undergoing regular dialysis. In contrast, the number of patients in the moderate RBC range (3.6–6.6 $\times 10^6/\mu L$) decreased from 27.1% to 22.9%, reflecting a reduction in those with more stable RBC levels. These findings suggest ongoing challenges in RBC production or retention despite dialysis. Previous studies support these observations. Hsu et al. (2002) reported that anemia remains prevalent in chronic kidney disease patients undergoing dialysis, and that dialysis alone does not consistently correct low RBC levels, often necessitating erythropoietin therapy or iron supplementation. Similarly, Fishbane et al. (2009) found that combining erythropoiesis-stimulating agents (ESAs) with dialysis enhances RBC production and improves anemia outcomes. Collectively, these findings indicate that while dialysis stabilizes some hematological parameters, additional medical interventions may be required to effectively address anemia in this patient population [16], [17].

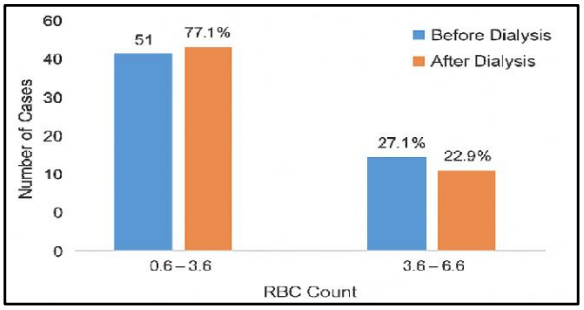

Figure (4): Distribution of cases by red blood cell (RBC) count before and after dialysis.

The distribution of hemoglobin levels among patients before and after dialysis showed noticeable changes across the studied categories. Before dialysis, most patients had hemoglobin levels between 7–9 g/dL (38.6%) and 9–11 g/dL (34.3%), with a smaller proportion falling within the 11–14 g/dL range (27.1%). After dialysis, however, the pattern shifted markedly: the proportion of patients in the lowest hemoglobin category (7–9 g/dL) decreased to 15.7%, while those in the 9–11 g/dL category increased substantially to 52.9%. Similarly, patients with hemoglobin levels between 11–14 g/dL rose to 31.4%. Overall, these findings suggest that dialysis contributed to an improvement in hemoglobin distribution, with fewer patients exhibiting markedly low hemoglobin levels following treatment. In figure 5 demonstrates significant changes in hemoglobin (Hb) levels before and after dialysis, highlighting the impact of the procedure on patients' hematological health.

The proportion of patients with low hemoglobin levels (7–9 g/dL) decreased markedly from 38.6% to 15.7%, indicating that dialysis helps alleviate severe anemia, a common complication in dialysis patients. Patients in the moderate hemoglobin range (9–11 g/dL) increased from 34.3% to 52.9%, reflecting improvements in oxygen-carrying capacity, although still below optimal levels. There was also a modest increase in patients within the 11–14 g/dL range (27.1% to 31.4%), suggesting a positive trend toward achieving healthy hemoglobin levels. Overall, these results indicate that dialysis contributes to correcting severe anemia in many patients; however, additional interventions may be necessary to normalize hemoglobin fully and enhance oxygen transport.

These findings align with the study by Sagheb et al. (2016), which reported a significant increase in hemoglobin levels post-hemodialysis (11.1 ± 1.1 g/dL vs. 11.9 ± 1.2 g/dL, $P < 0.001$) in patients with end-stage renal disease. While both studies demonstrate improvements in hemoglobin following dialysis, differences in percentage distributions and ranges may reflect variations in patient populations, dialysis protocols, or measurement techniques. Both studies consistently suggest that dialysis effectively reduces severe anemia but may require adjunct therapies for full correction [18].

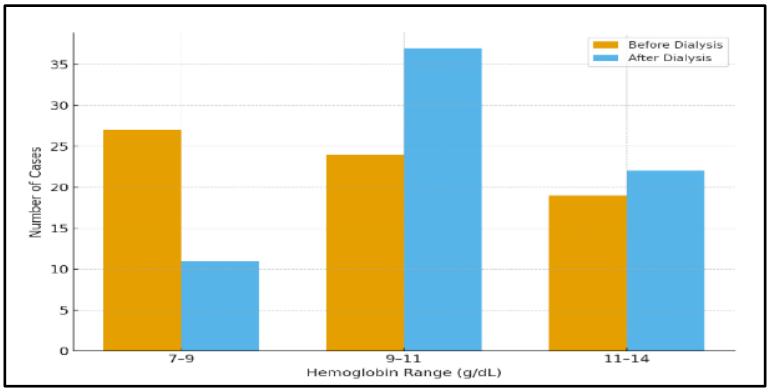

Figure (5): Distribution of cases by hemoglobin levels before and after dialysis.

The distribution of platelet counts among patients before and after dialysis showed notable changes. Prior to dialysis, the majority of patients had platelet counts in the 150–200 $\times 10^9$/L range (31.4%), followed by 100–150 $\times 10^9$/L (28.6%) and 200–250 $\times 10^9$/L (22.9%), with a small proportion having counts below 100 $\times 10^9$/L (8.6%). After dialysis, there was an observable increase in patients with higher platelet counts, particularly in the 200–250 $\times 10^9$/L category, which rose to 34.3%, while those in the 150–200 $\times 10^9$/L range decreased to 27.1%. Patients with low platelet counts (<100 $\times 10^9$/L) slightly decreased to 7.1%. These results indicate that dialysis may contribute to a relative improvement in platelet counts among chronic kidney disease patients. Also, in figure 6 presents the effects of dialysis on platelet counts in patients, showing variable changes across different platelet ranges. In the critically low range ("<100 $\times 10^3$/µL"), there was a slight reduction in both the number and percentage of patient's post-dialysis, indicating a minor improvement.

However, patients in this category remain at risk for bleeding, suggesting that dialysis alone may not sufficiently restore platelet levels and that additional medical interventions may be required. In the "100–150 $\times 10^3$/µL" range, there was a modest increase in both number and percentage, reflecting a stabilization effect of dialysis for patients with low but manageable platelet counts. Conversely, the "150–200 $\times 10^3$/µL" range showed a slight decrease post-dialysis, indicating fluctuations in moderate platelet levels that may require careful monitoring. The most notable improvement occurred in the "200–250 $\times 10^3$/µL" range, where the number of patients increased from 16 to 24 and the percentage rose from 22.9% to 34.3%. This shift demonstrates that dialysis can effectively elevate platelet levels closer to the normal range, which is essential for proper hemostasis. These results are partially consistent with

the study by Sagheb et al. (2016), which also reported improvements in higher platelet ranges but noted fluctuations in lower and moderate ranges post-dialysis.

In our study, the "200–250 ×10³/µL" range showed clear improvement, whereas critically low ranges, such as "<100 ×10³/µL," remained largely unchanged, mirroring Sagheb et al.'s observation that patients with extremely low platelet counts may require additional therapeutic interventions to achieve safe levels. Overall, the data suggest that dialysis can help normalize platelet counts for many patients but may not uniformly improve counts across all ranges [18].

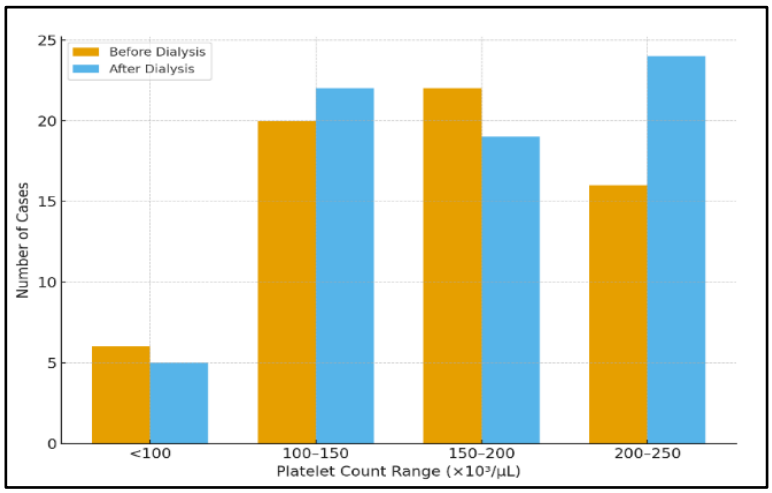

Figure (6): Distribution of cases by platelet count before and after dialysis.

Changes in Biochemical Parameters Before and After Hemodialysis:

The results showed a significant decrease in urea levels after dialysis ($p < 0.01$) and also a significant decrease in creatinine levels after dialysis ($p < 0.001$. The results in Table 2 demonstrate the statistical significance of changes in urea levels following dialysis. The mean of negative ranks (28.22) was higher than that of positive ranks (24.41), indicating that urea levels before dialysis were generally elevated compared to post-dialysis values. The test statistic ($Z = -2.77$) confirms a measurable decrease in urea levels after dialysis. The associated p-value (0.006), being below the significance threshold of 0.05, leads to the rejection of the null hypothesis (H_0). These findings indicate that the reduction in urea levels is statistically significant, confirming that dialysis effectively lowers urea concentration in the blood.

Table (2): Comparison of Changes in Biochemical Parameters levels before and after dialysis.

Parameters	Negative Ranks (Mean)	Positive Ranks (Mean)	Z	p-value
Urea	28.22	24.41	-2.77	0.006
Creatinine	26.28	17.00	-6.17	0.000

Also, the findings in Table 2 demonstrate significant changes in creatinine levels following dialysis. The mean of negative ranks (26.28) exceeded that of positive ranks (9), indicating that creatinine levels were generally higher before dialysis compared to after treatment. The test statistic ($Z = -6.17$) reflects a substantial negative shift, confirming a significant reduction in creatinine levels post-dialysis. With a p-value of 0.0, well below the 0.05 threshold, the null hypothesis is rejected. These results provide strong evidence that dialysis effectively lowers creatinine levels in patients, demonstrating its efficacy in managing renal function. Presents the analysis of hemoglobin levels, showing that the mean of positive ranks (20.6) was slightly higher than the mean of negative ranks (18.63), suggesting an overall increase in hemoglobin levels after dialysis. The test statistic ($Z = 2.615$) indicates a moderate positive shift, with the associated p-value of 0.01 falling below the 0.05 significance level. This leads to the rejection of the null hypothesis and supports the conclusion that dialysis has a statistically significant effect on hemoglobin levels, contributing to improved oxygen-carrying capacity in patients.

Changes in Hematological Parameters Before and After Hemodialysis:

In table (3) shows Hemoglobin levels differed significantly between pre- and post-dialysis samples ($p < 0.05$). no significant difference in white blood cell count, red blood cell and platelet counts were not significantly affected between pre- and post-dialysis samples ($p > 0.05$).

Table 3: Comparison of Changes in Hematological Parameters levels before and after dialysis.

Parameters	Negative Ranks (Mean)	Positive Ranks (Mean)	Z	p-value
Hemoglobin	18.63	20.60	-2.615	0.010
WBC	34.50	13.50	1.3	0.190
RBC	2.00	0.00	1.70	0.080
Platelet	19.08	9.50	0.75	0.400

In Table 3 presents the WBC analysis, showing that the mean of negative ranks (34.5) was higher than the mean of positive ranks (13.5), suggesting that WBC levels were generally higher before dialysis than after. However, the test statistic (Z = 1.3) is relatively low, and the p-value (0.19) exceeds the 0.05 significance threshold. These results indicate that the difference in WBC levels before and after dialysis is not statistically significant. Therefore, the null hypothesis is retained, implying that dialysis does not have a substantial effect on WBC levels in this sample. also, in table 3 evaluates RBC levels, showing that the mean of negative ranks (2) is greater than the mean of positive ranks (0), suggesting a slight tendency for RBC levels to decrease post-dialysis. The absence of positive ranks indicates no cases exhibited an increase in RBC levels. The test statistic (Z = 1.7) is moderately low, and the p-value (0.08) is above 0.05, leading to failure to reject the null hypothesis. Although not statistically significant, the p-value is close to the threshold, suggesting a potential trend that may warrant further investigation with a larger sample size. The examines platelet counts in table 3, revealing that the mean of negative ranks (19.08) exceeds the mean of positive ranks (9.5), suggesting a slight reduction in platelet levels after dialysis. The test statistic (Z = 0.75) and a p-value of 0.4 indicate that this difference is not statistically significant. Consequently, the null hypothesis is accepted, indicating that dialysis does not have a significant impact on platelet levels within this sample.

Conclusion:

The results showed that dialysis significantly contributes to lowering urea and creatinine levels, helping to cleanse the blood of waste products and toxins that damaged kidneys cannot remove. The study also indicated a marked improvement in hemoglobin levels after dialysis. There was no significant effect on white blood cell or platelet counts. Overall, dialysis is an effective and crucial treatment for improving the health of kidney failure patients, but it is not a comprehensive solution for all aspects of the condition. It remains essential to combine dialysis with other treatment strategies, including proper nutrition and ongoing medical care, to improve quality of life and increase patient survival rates. Dialysis plays a pivotal role in sustaining patients' lives, but its effectiveness can be enhanced through further research and innovation to ensure comprehensive and integrated care for kidney patients.

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