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ORIGINAL ARTICLE

Analysis of Biochemical and Hematological Parameters of Chronic Kidney Disease Patients with Hemodialysis

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ABSTRACT

Background: *Chronic Kidney Disease (CKD) poses a significant public health burden worldwide, especially in low- and middle-income countries like Bangladesh. Hemodialysis (HD), the most common renal replacement therapy in the region, is associated with a wide range of biochemical and hematological disturbances that impact patient outcomes.* ***Aim of the study:*** *To evaluate and compare biochemical and hematological parameters in CKD patients undergoing maintenance hemodialysis with healthy controls to identify key abnormalities for better clinical management.* ***Methods & Materials:*** *A cross-sectional analytical study was conducted at Dhaka Medical College Hospital from October 2018 to September 2019 involving 90 participants: 45 CKD patients on hemodialysis and 45 age- and sex-matched healthy controls. Various biochemical, hematological, and liver enzyme parameters were analyzed using standardized laboratory methods. Statistical analysis was performed using SPSS v22.0, with a p-value ≤ 0.05 considered significant.* ***Result:*** *Significant differences were observed between the case and control groups in several parameters. CKD patients showed elevated levels of creatinine, urea, phosphate, and ALP, and reduced calcium levels. Hematological analysis revealed lower hemoglobin, hematocrit, red blood cell count, platelet count, and total leukocyte count. Liver enzymes ALT and AST were significantly lower in CKD patients, while ALP was markedly higher ($p < 0.001$ for all).* ***Conclusion:*** *CKD patients on hemodialysis experience profound biochemical and hematological alterations, underscoring the need for routine monitoring to improve patient outcomes and inform treatment strategies.*

Keywords: *Chronic kidney disease, Hemodialysis, Biochemical parameters, Hematological abnormalities, Liver enzymes*

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INTRODUCTION

Chronic kidney disease (CKD) has emerged as a major global public health concern, characterized by a gradual and irreversible decline in kidney function over time, ultimately progressing to end-stage renal disease (ESRD) if not appropriately managed.[1] It is increasingly recognized as a silent epidemic with serious socioeconomic implications. According to the statistics, more than 850 million individuals globally are affected by various forms of kidney disorders, with CKD ranking as the 12th leading cause of death and projected to rise to the top 10 within the next decade.[2] The situation is more severe in low- and middle-income countries (LMICs), where limited awareness, delayed diagnosis, and inadequate treatment access further exacerbate the disease burden. In Bangladesh, recent epidemiological data indicate that approximately 2.4million people, accounting for 11% of the adult population, are living with some degree of CKD.[3] The increasing incidence is attributed to the rising prevalence of diabetes mellitus, hypertension, obesity, and aging, making CKD a rapidly growing health challenge in the region.[4] For patients reaching ESRD, renal replacement therapy (RRT) becomes essential to sustain life. Among the available

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modalities hemodialysis (HD), peritoneal dialysis, and kidney transplantation hemodialysis remains the most widely utilized option in Bangladesh due to limited transplant infrastructure and economic constraints.[5] Although HD significantly improves survival and quality of life, it is associated with numerous biochemical and hematological disturbances arising from both the disease process and the dialysis procedure itself.[6] These include anemia, electrolyte imbalances, alterations in calcium-phosphorus metabolism, hypoalbuminemia, dyslipidemia, and elevated inflammatory markers.[7] These parameters not only serve as markers of disease severity but also play a crucial role in predicting hospitalization rates, cardiovascular complications, quality of life, and overall mortality. Anemia is one of the most common hematological complications in HD patients, primarily due to erythropoietin deficiency, iron dysregulation, chronic inflammation, and shortened red blood cell lifespan.[8] Biochemical changes such as hyperphosphatemia and hypocalcemia contribute significantly to chronic kidney disease–mineral and bone disorder (CKD-MBD), which is linked to vascular calcification and cardiovascular events.[9] Furthermore, fluctuations in serum electrolytes, particularly potassium and sodium during dialysis sessions, can precipitate life-threatening complications such as arrhythmias or cardiac arrest.[10] Elevated serum creatinine and blood urea nitrogen (BUN) levels are reflective of inadequate dialysis or declining residual renal function and are vital for evaluating treatment efficacy.[11] Despite the increasing burden of CKD and growing numbers of patients on HD in Bangladesh, systematic evaluations of biochemical and hematological parameters remain inadequate.[12] Many dialysis centers lack structured follow-up protocols and consistent laboratory monitoring, which hampers optimal patient management and leads to heterogeneous outcomes.[13] Moreover, regional variations in practice patterns, dietary intake, socioeconomic status, and comorbidities necessitate localized data to inform national clinical guidelines.[14] This study aims to analyze and correlate the biochemical and hematological profiles of CKD patients on maintenance hemodialysis in a Bangladeshi tertiary care center to identify key abnormalities and guide improved clinical management.

METHODS & MATERIALS

This cross-sectional analytical study was conducted in the Department of Nephrology at Dhaka Medical College and Hospital, Dhaka, over a one-year period from October 2018 to September 2019. A total of 90 individuals participated in the study and divided into two groups according to need.

Case (n=45): Patients with chronic kidney disease (CKD) undergoing maintenance hemodialysis

Control (n=45): Age- and sex-matched healthy individuals

All of the patients were carefully observed to meet the research objectives and provide valuable insights within the specified timeframe. A purposive non-randomized sampling technique was used to recruit participants based on predefined inclusion and exclusion criteria.

Inclusion Criteria:

- Participants aged over 18 years.
- Patients with diagnosed CKD undergoing regular hemodialysis for at least one year.
- Healthy individuals without any known renal, hepatic, or systemic illnesses for the control group.

Exclusion Criteria:

- Patients with acute kidney injury.
- Patients diagnosed with CKD for less than one year.
- Individuals with known chronic liver disease.
- Patients with excessive alcohol consumption (more than 40 grams/day for males and 20 grams/day for females).
- Pregnant or postpartum women.
- Patients using medications known to affect liver enzymes (e.g., statins, rifampicin).
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Ethical Considerations

Ethical approval for the study was obtained from the Ethical Review Committee of Dhaka Medical College. Written informed consent was taken from all participants after a full explanation of the study's objectives, procedures, risks, and benefits. All information was kept confidential, and participants were assured of their right to withdraw from the study at any point without any consequences. No financial incentives were provided.

Data Collection

After screening for eligibility, participants were enrolled and evaluated. Data were collected using a structured questionnaire and preformed data collection sheet. Demographic information (age, sex), disease characteristics (CKD stage, duration, probable etiology), and various laboratory parameters were documented. Biochemical parameters included serum creatinine, urea, sodium, potassium, calcium, and phosphate. Hematological assessments comprised hemoglobin levels, hematocrit, red blood cell count, white blood cell count, and platelet count. In addition, liver enzyme levels—serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP)—were measured. Blood samples were collected using standard aseptic techniques. Complete blood counts (CBC) were performed using an automated hematology analyzer. Biochemical analyses, including liver enzyme measurements, were conducted using an automated biochemical analyzer based on kinetic methods to ensure accuracy and reliability.

Statistical Analysis

Data were first entered and cleaned using Microsoft Excel 2010 and then exported to SPSS (Version 22.0, SPSS Inc., Chicago, IL, USA) for analysis. Descriptive statistics were used to summarize the data. Continuous variables were presented as mean ± standard deviation (SD) and compared between groups using the independent samples Student's *t*-test. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test. A *p*-value of ≤ 0.05 was considered statistically significant.

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RESULT

The majority of both cases (patients with chronic kidney disease undergoing hemodialysis) and controls were within the 31–60-year age range. Specifically, 31.1% of cases and 28.9% of controls were aged 51–60 years. The mean age of the cases was significantly higher than that of the controls (47.97 ± 10.93 vs. 41.58 ± 9.26 years, $p = 0.006$) (Table I). In the case group, 56% of the participants were male, while 44% were female. Similarly, in the control group, 53.3% were male and 46.7% were female (Figure 1). All patients (100%) in the study were in stage 5 of chronic kidney disease. The majority had been living with the disease for 3–6 years (53.3%). The mean duration of the disease was 4.66 ± 3.00 years (Table II). Among the CKD patients, glomerulonephritis was the most common probable cause with 44.4% of cases. Less common etiologies included polycystic kidney disease (PCKD) and systemic lupus erythematosus (SLE), each at 6.7% (Table III). The biochemical analysis revealed significantly elevated levels of creatinine, urea, and phosphate in CKD patients undergoing hemodialysis compared to controls ($p < 0.001$). Conversely, serum calcium was significantly lower in cases (7.79 ± 0.72 mg/dl) than in controls (9.36 ± 0.41 mg/dl, $p < 0.001$). No statistically significant differences were observed in sodium and potassium levels between the two groups (Table IV). The hematological analysis showed significantly lower levels of hemoglobin, hematocrit, and red blood cell count in CKD patients on hemodialysis compared to controls ($p < 0.001$). Platelet count was also significantly reduced in cases (208,920.25 ± 69,165.12/mm^3) compared to controls (309,729.83 ± 77,304.54/mm^3, $p < 0.001$). Additionally, total leukocyte count was significantly lower in cases ($p = 0.016$) (Table V). There were significantly lower levels of ALT and AST in CKD patients undergoing hemodialysis than controls ($p < 0.001$), with mean ALT at 17.49 ± 5.04 U/L and AST at 17.73 ± 4.41 U/L. In contrast, serum ALP levels were markedly elevated in the patient group (117.38 ± 13.73 U/L) in comparison of controls (27.62 ± 5.78 U/L, $p < 0.001$) (Table VI).

Table – I: Age distribution of the study groups (*n*=90)

Age (years)	Case (n=45)		Control (n=45)		P-value
	n	%	n	%	
18-30	3	6.7	7	15.6	0.176
31-40	10	22.2	15	33.3	
41-50	12	26.7	10	22.2	
51-60	14	31.1	13	28.9	
>60	6	13.3	0	0	
Mean±SD (in years)	47.97 ± 10.93		41.58 ± 9.26		0.006

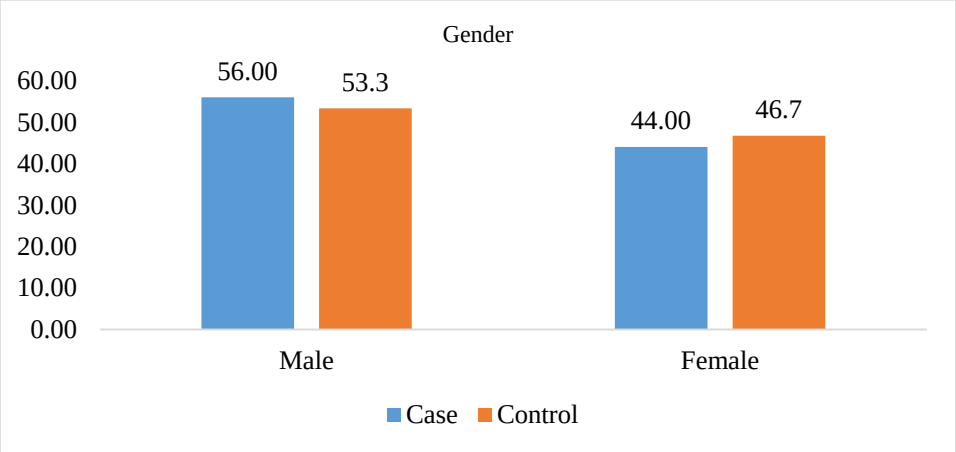

Figure – 1: Gender distribution of the study population (*n*=90)

Table – III (a): Disease characteristics of the patients (*n*=45)

Variables	Frequency (n)	Percentage (%)
Stages of CKD		
Stage-4	0	0
Stage-5	45	100
Duration of disease (years)		
1-3	17	37.77
3-6	24	53.3
>6	4	8.8
Mean±SD (years)	4.66 ± 3.00	

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Table – III (b): Probable etiology of chronic kidney disease (CKD) patients (*n*=45)

Etiology	Frequency (n)	Percentage (%)
Glomerulonephrits	20	44.4
Hypertension	2	4.4
Diabetes mellitus	16	35.6
PCKD	3	6.7
SLE	3	6.7
Obstructive nephropathy	0	0
Others	1	2.2

Table – IV: Biochemical parameters among study population

Parameter	Case (Mean ± SD)	Control (Mean ± SD)	P-value
Creatinine (mg/dl)	8.95 ± 1.49	0.97 ± 0.12	<0.001
Urea (mg/dl)	121.56 ± 51.34	26.87 ± 6.75	<0.001
Sodium (mmol/l)	133.27 ± 11.84	137.65 ± 4.29	0.2
Potassium (mmol/l)	3.48 ± 1.89	3.11 ± 1.56	0.1
Calcium (mg/dl)	7.79 ± 0.72	9.36 ± 0.41	<0.001
Phosphate(mg/dl)	7.54 ± 0.75	3.91 ± 0.43	<0.001

Table – V: Hematological parameters among study population

Parameter	Case (Mean ± SD)	Control (Mean ± SD)	P-value
Hemoglobin (gm/dl)	7.98 ± 2.45	11.58 ± 3.37	<0.001
Hematocrit (%)	26.76 ± 3.43	43.26 ± 1.88	<0.001
Red blood cell count (Million/mm^3)	1.87 ± 1.69	3.75 ± 1.81	<0.001
Total leukocyte count (Thousands/mm^3)	7455.71 ± 1580.35	8232.27 ± 1645.38	0.016
Platelet count (Lakhs/mm^3)	208920.25 ± 69165.12	309729.83 ± 77304.54	<0.001

Table – VI: Serum liver enzyme levels of CKD patients with hemodialysis and control group

Parameter	Case (Mean ± SD)	Control (Mean ± SD)	P-value
Serum ALT (U/L)	17.49 ± 5.04	33.42 ± 4.57	<0.001
Serum AST (U/L)	17.73 ± 4.41	30.56 ± 4.86	<0.001
Serum ALP (U/L)	117.38 ± 13.73	27.62 ± 5.78	<0.001

DISCUSSION

Chronic Kidney Disease (CKD) is a progressive condition marked by the gradual loss of kidney function, often requiring hemodialysis in advanced stages. Hemodialysis significantly alters various biochemical and hematological parameters, which are crucial for patient monitoring and management. This study was conducted to analyze these parameters in CKD patients undergoing hemodialysis to assess their clinical implications and treatment outcomes. The mean age of CKD patients was significantly higher than that of controls (47.97 ± 10.93 vs. 41.58 ± 9.26 years; p = 0.006), indicating that CKD predominantly affects older individuals. This aligns with other studies of increased CKD prevalence with advancing age.[15,16] In the study population, males were more commonly affected with 55.6% in case group. This trend is consistent with findings from Bapat et al., who reported 66% male and 44% female CKD patients.[17] The higher prevalence among males may be attributed to socio-economic and sociocultural influences. According to our study, all patients were in Stage 5 CKD, with a mean disease duration of 4.66 ± 3.00 years. Haq et al. reported that the majority of their CKD patients were newly diagnosed.[16], suggesting that the likelihood of requiring dialysis increases with disease progression and duration. Additionally, Allawi et al., in a cross-sectional study, found that all of their hemodialysis patients were in Stage 5 CKD, which is consistent with the findings of our study.[18] The primary etiologies identified were glomerulonephritis (44.4%) and diabetes mellitus (35.6%). These findings are consistent with the study of Malekmakan et al, which has reported glomerulonephritis and diabetes as leading causes of CKD.[19] Elevated levels in CKD patients (Creatinine: 8.95 ± 1.49 mg/dl; Urea: 121.56 ± 51.34 mg/dl) reflect impaired renal excretory function which were significantly high (p<0.001) as compared to control. A similar study conducted by Amin et al. and Khasawnah et al. reported a significant elevation in urea and creatinine levels among patients with CKD.[20,21] CKD patients exhibited hyponatremia (133.27 ± 11.84 mmol/l) and hyperphosphatemia (7.54 ± 0.75 mg/dl), while potassium levels were slightly elevated (3.48 ± 1.89 mmol/l). These disturbances are common in CKD due to impaired electrolyte regulation.[22] In our study, the mean serum calcium in CKD subjects was 7.79 ± 0.72 and in controls was 9.36 ± 0.41 with p value < 0.001 which was statistically significant. Majority of our study subjects were hypocalcemic. Our result is similar to the study of Singh and Bhatta.[23] We observed lower hemoglobin (7.98 ± 2.45 gm/dl), hematocrit

(26.76 ± 3.43%), and red blood cell count (1.87 ± 1.69 million/mm^3) which indicate anemia, commonly seen in CKD due to reduced erythropoietin production. This aligns with previous study reporting anemia as a prevalent complication in CKD associated with diabetes mellitus, hypertension and glomerulonephritis. [24] Total leukocyte count was slightly lower in CKD patients (7455.71 ± 1580.35 thousands/mm^3) compared to controls, while platelet count was significantly reduced (208920.25 ± 69165.12 lakhs/mm^3). These findings suggest a compromised immune response and increased bleeding risk in CKD patients. Singh et al found similar findings.[23] Significantly reduced levels of ALT (17.49 ± 5.04 U/L) and AST (17.73 ± 4.41 U/L) were observed in CKD patients than control group in our study. Possible mechanisms include low pyridoxine (vitamin B6) levels—a coenzyme for aminotransferase—along with elevated uremic toxins, water retention, and hemodilution in advanced CKD, as well as the presence of UV-absorbing substances that may interfere with transaminase detection. [25,26] Reduced synthesis or release of AST and ALT from hepatocytes, or their accelerated clearance, may also contribute. [27] Furthermore, renal treatments often worsen B6 deficiency, especially in hemodialysis patients. Erythropoietin increases B6 demand for hemoglobin production, while phosphate binders like sevelamer-HCl reduce B6 absorption by about 30%. Due to its low molecular weight (MW 245) and limited body storage, B6 levels can decline within 3–4 months. [28] According to our study, serum ALP level was significantly higher (p= <0.001) case group (117.38 ± 13.73) compared to control group (27.62 ± 5.78). This may reflect high-turnover bone disease, a common complication in CKD. This is consistent with previous research linking increased ALP levels to bone metabolism disorders in CKD. [25]

LIMITATIONS OF THE STUDY

- The cross-sectional design restricts the ability to establish causal relationships or observe long-term trends.
- Potential confounding factors such as dietary habits, medication adherence, and socioeconomic status were not comprehensively evaluated.
- The findings may not account for regional or institutional differences in dialysis practices or patient management.

CONCLUSION

This study highlights significant biochemical and hematological abnormalities in patients with chronic kidney disease undergoing maintenance hemodialysis in Bangladesh. The observed disturbances—such as elevated urea, creatinine, phosphate, and ALP levels, along with reduced calcium, hemoglobin, and transaminases—reflect the systemic burden of CKD and the physiological impact of hemodialysis. These findings stress the necessity for routine, comprehensive laboratory monitoring in dialysis centers to guide timely interventions. Special attention should be paid to correcting anemia, mineral imbalance, and liver enzyme alterations, which may contribute to complications if left unaddressed. Implementing structured follow-up protocols and individualized treatment plans can improve quality of life and reduce morbidity among CKD patients on dialysis.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee.

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