TPM Vol. 32, No. S1, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

IMPACT OF DIALYSIS ON HEMATOLOGICAL PROFILES IN CHRONIC KIDNEY DISEASE

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Abstract

Background

Chronic Kidney Disease (CKD) is an intriguing phenomenon that impacts hematological indices, boxes the various organ systems in the body and also affects the functional wellbeing of an individual affected by it. Since, there are multiple causative factors of CKD it's imperative to understand the effects as well as the damage it causes in the body.Hemodialysis, has been shown to have a positive benefit in terms of improving the hematological investigations.This study aims to offer foresight into the role of hemodialysis in mitigating hematological abnormalities in CKD patients, ultimately aiming towards enhancement of clinical management strategies.

Objective

To examine the correlation between chronic kidney disease and hematological measures, and to study the repercussions of hemodialysis on these variables.

Subjects and Methods

This observational study was conducted at a tertiary care hospital between September 2024 and March 2025, involving 60 subjects divided into two groups, each comprising 30 participants.. Group I included patients with chronic kidney disease (CKD) not undergoing hemodialysis (NDD-CKD), while Group II comprised patients with CKD on hemodialysis (DD-CKD).

Detailed medical histories were collected for all participants and appropriate investigations performed on both the groups and data represented and analyzed for correlation.

Results: Dialysis-dependent CKD patients (Group II) tend to be older, predominantly male, and have a higher prevalence of diabetes mellitus and anemia compared to non-dialysis CKD patients (Group I). Group II demonstrates significantly improved hematological indices, including higher hemoglobin, hematocrit, RBC count, and erythrocyte parameters, while exhibiting lower platelet count but increased MPV and WBC indices. Biochemical markers indicate enhanced waste elimination, calcium-phosphate balance, and nutritional status, with lower urea, creatinine, phosphorus, and parathyroid hormone levels. Extended dialysis further improves hematological parameters, reducing RDW and boosting erythrocyte quality, while biochemical indicators continue to stabilize. These findings emphasize the crucial role of prolonged dialysis in optimizing hematological and biochemical health in CKD patients.

Conclusion: CKD serves as an influential factor on all hematological parameters and hemodialysis further modulates the effect.

Keywords: Chronic Kidney Disease, Anemia, Hemodialysis, Hematological Parameters.

INTRODUCTION

Chronic kidney disease (CKD) is characterized by progressive and often permanent decline of renal function. It has been recognized as a leading public health problem worldwide [1]. The global estimated prevalence of CKD is 13.4% [2]. The commonest complication of CKD is end stage renal disease, a gradual and progressive disease that

shuts down systems of the body leading to death [3].As the kidneys fail, they are unable to perform important functions such as waste product filtering, electrolyte management, and erythropoietin secretion.Initial signs ofCKD patients demonstratesignificant changes in hematological parameters [4].

The changes seen in red blood cell indices are decreased hemoglobin levels, decreased hematocrit, and morphological abnormalities. Furthermore, low thrombocyte count, poor aggregation and morphology of thrombocytes, abnormalities in white blood cell indices imply underlying immunological dysregulation, susceptibility to infections, and chronic inflammation. These are some of the earliest reflections of kidney functions gradually shutting down [5] [6] [7]

To avert the rapid progression of CKD into ESRD, Hemodialysis, a cornerstone of renal replacement therapy, provides a lifeline to patients [8] [9]. Many uremia symptoms are relieved by hemodialysis, which mechanically purifies the blood and corrects fluid imbalances [10]. However, its effects on hematological profiles are complex and bidirectional [11]

The complex link between CKD, hematological indices, and hemodialysis requires investigation to understand the effects of CKD on haematological indices in pre dialysis as well as post dialysis patients. Thereby, aiming to improve the survival outcomes and the quality of life for those dealing with CKD and its complications.

Subjects and Methods

This cross-sectional study was conducted in the tertiary care institute between September 2024 and March 2025involving 60 subjects divided into two groups, each comprising 30 participants using purposive sampling method. Group I included patients with chronic kidney disease (CKD) not undergoing hemodialysis (NDD-CKD), while Group II comprised patients with CKD on hemodialysis (DD-CKD).

$n=(Z_{\alpha/2}+Z_{\beta})2 \times ((SD_1)^2+(SD_2)^2)(P_1-P_2)^2$

Using a study by Alghythan AK et al [12]

$SD_1=1.29$**,** $SD_2=1.57$, $P_1=11.70$**,** $P_2=13.16$

$Z_{\alpha/2}=2.57$ (for 99% confidence interval),

$Z_{\beta}=0.84$ (for 80% power).

$n= (2.57+0.84)\ 2 \times ((1.29)^2 + (1.57)^2)\ (11.70-13.16)^2$

$=11.676256 \times 4.129/2.1316$

= 22.63 participants

˜30 participants per group

Participants of both sexes, aged over 18 years, with a confirmed diagnosis of CKD and documented evidence of elevated renal profile for more than three months, were included in the study. Patients who underwent at least 1 month of dialysis for group 2 were chosen. Patients with long-term systemic treatment using immunosuppressive drugs, major bleeding episodes within the previous three months, recent infections, primary hematological disorders, HIV infection, life-threatening malignancies, or multiple myeloma were excluded. Additionally, pregnant or lactating women and those who had received blood transfusions were also excluded from the study.

A detailed history was obtained from all participants, with a particular focus on demographic details and co-morbid conditions such as diabetes mellitus and hypertension. Each participant underwent a thorough clinical evaluation. Blood samples were collected and analyzed for various hematological parameters among the two groups.

Ethical approval and certificate was sanctioned by the Institutional Ethics Committee (IEC). Written and oral informed consent was obtained from all the participants.

Statistical Analysis: Data analysis was performed using IBM SPSS software version 22.0. Descriptive statistics and inferential statistics were described using frequencies and percentages, along with graphs wherever possible and based on normality of the data either parametric or non-parametric tests were applied.

RESULTS

Table 1: Demographic profile compared between group 1 and group 2

Variable	Group I (NDD-CKD) (n-30)(%)	Group II (DD-CKD) (n-30) (%)
Age (Mean ± SD)	58 ± 12	60 ± 11
Male (%) **Female (%)**	(16.5) 55% (13.5) 45%	 (19) 63% (11) 37%
Diabetes Mellitus (%)	(16.5)55%	(19.5) 65%
Hypertension (%)	(21)70%	(24) 80%
Anemia (%)	(24.6) 82%	(28.5) 95%
CKD duration (yrs)	4.5 ± 1.8	6.2 ± 2.1

The average age of patients in Group II (DD-CKD) is slightly higher (60 ± 11 years) compared to Group I (NDD-CKD) (58 ± 12 years).A higher percentage of males (63%) is observed in Group II. Group II have 65% diabetes mellitus indicating a higher association with dialysis dependency. Anemia is more in dialysis patients (95%) compared to non-dialysis patients (82%) Patients in Group II have a longer average duration of CKD (6.2 ± 2.1 years), suggesting more advanced disease in dialysis-dependent cases.

Table 2: Red Blood Cell Indices

Parameter	Group I (NDD-CKD)	Group II (DD-CKD)	p-value
Hemoglobin (g/dL)	9.2 ± 1.5	10.0 ± 1.3	< 0.001
Hematocrit (%)	30 ± 5	32 ± 4	< 0.001
RBC Count (×10⁶/µL)	3.2 ± 0.5	3.5 ± 0.4	< 0.001
MCV (fL)	84 ± 6	88 ± 5	< 0.001
RBCS	5.2 ± 0.4	5.5 ± 0.3	0.024
MCH (pg)	27 ± 2	29 ± 2	< 0.001
MCHC (g/dL)	32 ± 1.5	34 ± 1.3	< 0.001
RDW (%)	16 ± 2.5	14 ± 2.0	0.048

Group II (DD-CKD) exhibits significantly higher hematological indices than Group I (NDD-CKD), including hemoglobin (10.0 ± 1.3 vs. 9.2 ± 1.5), hematocrit (32 ± 4 vs. 30 ± 5), RBC count (3.5 ± 0.4 vs. 3.2 ± 0.5), MCV (88 ± 5 vs. 84 ± 6), MCH (29 ± 2 vs. 27 ± 2), and MCHC (34 ± 1.3 vs. 32 ± 1.5). All differences are highly significant ($p < 0.001$) except in RDW and RBCS. This may suggest better management or physiological adjustments related to dialysis in chronic kidney disease patients.

Table 3: Platelet and White Blood Cell Indices

PARAMETER	GROUP I (NDD-CKD)	GROUP II (DD-CKD)	P-VALUE
PLATELET COUNT (×10³/µL)	190 ± 25	170 ± 28	< 0.001
MEAN PLATELET VOLUME (MPV, FL)	10.5 ± 1.0	11.2 ± 0.9	< 0.001
TOTAL LEUKOCYTE COUNT (×10³/µL)	8.9 ± 1.2	9.2 ± 1.3	< 0.001
NEUTROPHIL (%)	65 ± 8	68 ± 7	< 0.001
NEUTROPHIL COUNT (×10³/µL)	5.8 ± 1.0	6.3 ± 0.9	< 0.001
LYMPHOCYTE COUNT (×10³/µL)	2.1 ± 0.5	2.3 ± 0.6	< 0.001
MONOCYTE COUNT (×10³/µL)	0.7 ± 0.2	0.8 ± 0.3	0.09
EOSINOPHIL COUNT (×10³/µL)	0.4 ± 0.1	0.3 ± 0.1	0.02
BASOPHIL COUNT (×10³/µL)	0.1 ± 0.05	0.1 ± 0.04	0.15

Group I (NDD-CKD) shows a higher mean platelet count (190 ± 25 vs. 170 ± 28, $p < 0.001$), while Group II (DD-CKD) demonstrates elevated MPV (11.2 ± 0.9 vs. 10.5 ± 1.0), total leukocyte count (9.2 ± 1.3 vs. 8.9 ± 1.2),

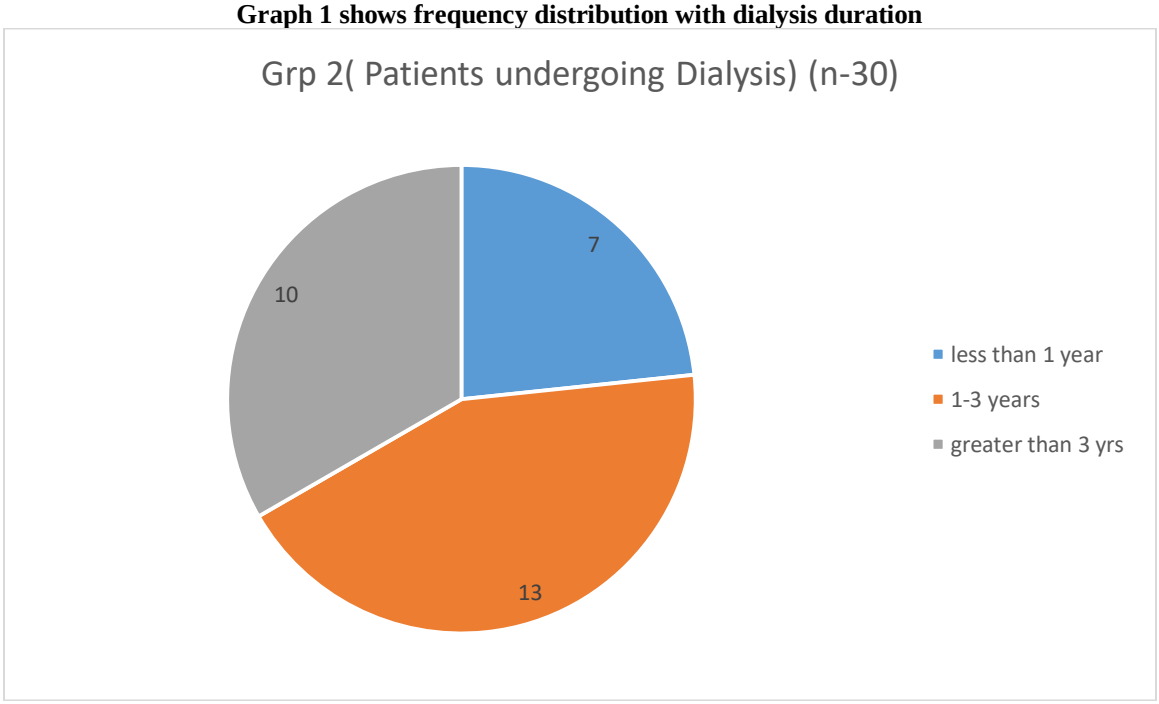
neutrophil proportion (68 ± 7 vs. 65 ± 8), neutrophil count (6.3 ± 0.9 vs. 5.8 ± 1.0), and lymphocyte count (2.3 ± 0.6 vs. 2.1 ± 0.5). All differences are highly significant ($p < 0.001$) except in monocyte, eosinophil and basophil count.

Table 4: Serum Biochemical Parameters

PARAMETER	GROUP I (NDD-CKD)	GROUP II (DD-CKD)	P-VALUE
UREA (MG/DL)	90 ± 15	65 ± 10	< 0.001
CREATININE (MG/DL)	4.5 ± 1.0	3.2 ± 0.8	< 0.001
SODIUM (MEQ/L)	138 ± 4	140 ± 3	0.02
POTASSIUM (MEQ/L)	4.8 ± 0.6	4.5 ± 0.5	0.05
CALCIUM (MG/DL)	8.5 ± 0.7	9.0 ± 0.6	< 0.001
PHOSPHORUS (MG/DL)	4.8 ± 1.0	4.2 ± 0.9	< 0.001
ALBUMIN (G/DL)	3.5 ± 0.5	3.8 ± 0.4	< 0.001
TOTAL PROTEIN (G/DL)	6.8 ± 0.6	7.2 ± 0.5	< 0.001
PARATHYROID HORMONE (PG/ML)	150 ± 40	120 ± 35	< 0.001

In comparing biochemical parameters between the two groups, Group II (DD-CKD) consistently shows improved levels across several markers compared to Group I (NDD-CKD). Notably, Group II exhibits significantly lower mean urea (65 ± 10 vs. 90 ± 15 mg/dL) and creatinine (3.2 ± 0.8 vs. 4.5 ± 1.0 mg/dL), both with highly significant p-values (<0.001). Sodium is slightly higher in Group II (140 ± 3 vs. 138 ± 4 mEq/L, $p = 0.02$), whereas potassium levels are marginally lower (4.5 ± 0.5 vs. 4.8 ± 0.6 mEq/L, $p = 0.05$). Group II also presents with elevated calcium (9.0 ± 0.6 vs. 8.5 ± 0.7 mg/dL, $p < 0.001$) and albumin (3.8 ± 0.4 vs. 3.5 ± 0.5 g/dL, $p < 0.001$), alongside higher total protein (7.2 ± 0.5 vs. 6.8 ± 0.6 g/dL, $p < 0.001$). Conversely, phosphorus (4.2 ± 0.9 vs. 4.8 ± 1.0 mg/dL, $p < 0.001$) and parathyroid hormone levels (120 ± 35 vs. 150 ± 40 pg/mL, $p < 0.001$) are notably lower in Group II. These findings highlight significant biochemical variations associated with dialysis dependence in CKD patients.

Graph 1 shows frequency distribution with dialysis duration



Out of 30 patients that presented as undergoing haemodialysis, 13 (43.33%) with CKD underwent dialysis for time period of greater than 3 years.

Table 5: Changes in Hematological Indices and Biological parameters Based on Dialysis Duration in Group II

PARAMETER	<1 YEAR	1-3 YEARS	>3 YEARS	P-VALUE
HEMOGLOBIN (G/DL)	9.8 ± 1.2	10.0 ± 1.1	10.2 ± 1.0	< 0.001
HEMATOCRIT (%)	31 ± 4	32 ± 3	33 ± 3	< 0.001
RBC COUNT (×10⁶/µL)	3.3 ± 0.5	3.5 ± 0.4	3.6 ± 0.3	< 0.001
MCV (FL)	85 ± 5	87 ± 4	88 ± 4	< 0.001
RBCS	5.3 ± 0.4	5.5 ± 0.3	5.6 ± 0.3	< 0.001
MCH (PG)	28 ± 2	29 ± 2	30 ± 1.5	< 0.001
MCHC (G/DL)	32 ± 1.5	33 ± 1.3	34 ± 1.2	< 0.001
RDW (%)	16 ± 2.5	15 ± 2.3	14 ± 2.0	< 0.001
PLATELET COUNT (×10³/µL)	175 ± 30	170 ± 25	165 ± 28	< 0.001
MEAN PLATELET VOLUME (MPV, FL)	10.2 ± 0.9	10.5 ± 0.8	11.0 ± 0.7	< 0.001
TOTAL LEUKOCYTE COUNT (×10³/µL)	9.0 ± 1.3	9.2 ± 1.4	9.5 ± 1.5	< 0.001
NEUTROPHIL (%)	66 ± 7	68 ± 6	70 ± 5	< 0.001
NEUTROPHIL COUNT (×10³/µL)	6.0 ± 0.9	6.3 ± 0.8	6.5 ± 0.7	< 0.001
LYMPHOCYTE COUNT (×10³/µL)	2.2 ± 0.5	2.4 ± 0.5	2.5 ± 0.4	< 0.001
MONOCYTE COUNT (×10³/µL)	0.7 ± 0.2	0.8 ± 0.2	0.9 ± 0.2	< 0.001
EOSINOPHIL COUNT (×10³/µL)	0.4 ± 0.1	0.3 ± 0.1	0.3 ± 0.1	0.02
BASOPHIL COUNT (×10³/µL)	0.1 ± 0.05	0.1 ± 0.04	0.1 ± 0.03	0.15
UREA (MG/DL)	90 ± 15	80 ± 12	70 ± 10	< 0.001
CREATININE (MG/DL)	4.5 ± 1.0	3.8 ± 0.9	3.2 ± 0.8	< 0.001
SODIUM (MEQ/L)	138 ± 4	139 ± 3	140 ± 3	0.02
POTASSIUM (MEQ/L)	4.9 ± 0.5	4.7 ± 0.5	4.5 ± 0.4	0.05
CALCIUM (MG/DL)	8.5 ± 0.6	8.8 ± 0.5	9.0 ± 0.5	< 0.001
PHOSPHORUS (MG/DL)	4.9 ± 0.9	4.5 ± 0.8	4.2 ± 0.7	< 0.001
ALBUMIN (G/DL)	3.5 ± 0.5	3.7 ± 0.4	3.8 ± 0.4	< 0.001
TOTAL PROTEIN (G/DL)	6.8 ± 0.5	7.0 ± 0.5	7.2 ± 0.4	< 0.001
PARATHYROID HORMONE (PG/ML)	155 ± 38	140 ± 35	120 ± 30	< 0.001

Hematological indices improve progressively with longer dialysis duration. Hemoglobin and hematocrit levels show a significant upward trend, accompanied by an increase in RBC count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC), indicating enhanced erythrocyte quality ($p < 0.001$). Conversely, red cell distribution width (RDW) declines, reflecting reduced variability in RBC size. Platelet count decreases with prolonged dialysis, while mean platelet volume (MPV) increases, suggesting larger platelet size ($p < 0.001$). White blood cell indices, including total leukocyte count, neutrophils, lymphocytes, and monocytes, show a significant rise, indicating heightened immune activity ($p < 0.001$).

Biochemical parameters also exhibit favorable changes with extended dialysis. Urea and creatinine levels decline significantly, demonstrating improved waste elimination ($p < 0.001$). Calcium and albumin concentrations rise, reflecting better calcium-phosphate balance and nutritional status, while phosphorus levels decrease, suggesting improved phosphate control ($p < 0.001$). Parathyroid hormone levels drop notably, indicating better secondary hyperparathyroidism management ($p < 0.001$). Among electrolytes, sodium levels show a modest increase ($p = 0.02$), whereas potassium levels decline slightly with borderline significance ($p = 0.05$). These findings collectively suggest a positive impact of longer dialysis duration on hematological, biochemical, and immune parameters in CKD patients.

DISCUSSION

The "Impact of Dialysis on Hematological Profiles in Chronic Kidney Disease" study compared hematological parameters in CKD patients not undergoing hemodialysis (NDD-CKD) with those on hemodialysis (DD-CKD).

This study found a significant association between CKD and alterations in red blood cell (RBC) indices, with hemodialysis further influencing these changes. A marked decrease in mean platelet count was observed in CKD groups compared to healthy controls, and notable variations in white blood cell (WBC) indices were evident

between the two CKD groups, with significant differences in total leukocyte count (TLC). Similar study by **Habib A et al (2017)** [13] found thatRBC count, hemoglobin levels, and platelet counts are significantly reduced in patients with chronic renal failure**,** andhemodialysis further decreases the levels of all these parameters. There was a slight increase in total leucocyte count in CRF patients and a significant leukocytosis induced by dialysis. ESR was significantly high in CRF patients, and dialysis decreased ESR value.

The study concluded that CKD influences all hematological parameters and hemodialysis modulates this effect. Notably, the DD-CKD group showed consistently improved red blood cellparameters compared to the NDD-CKD group. However**,** platelet count was reduced in the DD-CKD group**,** while MPV, TLC, and specific WBC counts were elevated. Similar study by **Habib A et al (2017)** [13] found improved RBC parameters in the dialysis group compared to the non-dialysis group, but aligns with the observation of decreased platelet counts with dialysis. Both studies noted changes in WBC counts with dialysis**. Shittu AO et al (2013)** [14] found that on pre-dialysis CKD patients found significantly lower hemoglobin concentration and total red cell count in severe CKD compared to controls. MCV, MCH, and MCHC were not significantly different, indicating normocytic normochromic anemia. Total WBC count was consistently high as the disease progressed, and platelet count declined. Another study by **Singh S et al (2018)** [15] in Nepal on pre-dialysis CKD patients found that hemoglobin, hematocrit, red blood cell count, total leukocyte count, and platelet count were reducedand statistically significant compared to controls similar to our study.**Kaze F F et al (2020)** [16] observed a regenerative normocytic normochromic anemia in 86.7% of participants, mainly normocytic and normochromic. Leucopenia, hyperleucocytosis, thrombopenia, and thrombocytosis were also observed, but none of the full blood count parameters were associated with CKD stages similar to our study.

Prolonged dialysis duration in the DD-CKD group was associated with further significant improvements in hemoglobin, hematocrit, RBC count, MCV, MCH, and MCHC, and a decrease in RDW. Platelet count declined with longer dialysis, while MPV and WBC indices increased. A study by **Abdulla JE et al (2020)** [17] in Iraq found contrasting finding that some hematological parameters **increased after hemodialysis**, including MID cell (%), RBC count, HGB, and HCT (%). However, Total WBC count, Lymphocyte, and Granulocyte decreased after dialysis. Platelet count significantly increased after dialysis. But echoes similar finding to present study that increased platelet count with longer dialysis duration. Similar study by **Abdelnabi AM et al (2021)** [18] in Egypt, compared healthy individuals with NDD-CKD and DD-CKD patients found a significant association between CKD and changes in RBC indices, with hemodialysis having a significant effect. Mean hemoglobin and hematocrit were significantly decreased in CKD groups. Mean MCV was decreased in CKD groups but within the normal range. RBC count was significantly decreased. This study shows both CKD groups with and without dialysis have reduced hemoglobin and hematocrit compared to controls. Also, in similar study by **Iyawe IO et al (2018)** [19]CKD patients with increased WBC count was significantly higher than the control subjects.The mean cell volume was significantly lower in the CKD group compared to the control subjects ($P = 0.000$) . Severity of anaemia was significantly associated with CKD stage ($P = 0.000$) but not with etiology ($P = 0.27$).**Muhammad A et al (2020)**[20] examined the effect of hemodialysis on hematological parameters. It found that RBC, Hb, HCT, MCHC, RDW, TLC, and platelets were significantly **decreased in hemodialysis patients compared to the control group**. However, RBC, HB, HCT, and MCHC significantly **increased in post-dialysis** compared to pre-dialysis, while TLC and platelets decreased.

CONCLUSION

Our findings indicate that CKD affects not only RBC measurements but also a wide range of hematological parameters, all of which are further influenced by hemodialysis. Adequate dialysis is essential to support and optimize hematological health in CKD patients. Given the comprehensive impact on blood indices, we emphasize the importance of incorporating a full spectrum of hematological markers in the ongoing assessment and management of these patients to ensure effective monitoring and intervention [21] [22].

Financial support and sponsorship: None.
Conflict of interest: None.

REFERENCES

1) Perico N, Remuzzi G. Chronic kidney disease: a research and public health priority. Nephrology Dialysis Transplantation. 2012 Oct 1;27(suppl_3):iii19-26.

2) Lv JC, Zhang LX. Prevalence and disease burden of chronic kidney disease. Renal fibrosis: mechanisms and therapies. 2019:3-15.
3) López-Novoa JM, Martínez-Salgado C, Rodríguez-Peña AB, Hernández FJ. Common pathophysiological mechanisms of chronic kidney disease: therapeutic perspectives. Pharmacology & therapeutics. 2010 Oct 1;128(1):61-81.
4) Asif N, Hasan S, Hassan K. Hematological changes in patients of chronic renal disease and their response to treatment with erythropoietin. International Journal of Pathology. 2018 Nov 18:14-9.
5) Kadhim HM, Al-Ghanimi HH, Al-Dedah RM. Haematological parameters and biochemical indices in patients with chronic kidney disease before haemodialysis Al-Furat Al-Awsat Governorates/Iraq. InAIP Conference Proceedings 2020 Dec 4 (Vol. 2290, No. 1). AIP Publishing.
6) George C, Matsha T, Erasmus R et al (2018):Haematological profile of chronic kidney disease in a mixed-ancestry South African population: a cross-sectional study. BMJ Open, 8(11): 25694-99.
7) Aziz A, Saad A, Bazeed M et al (2018):A comparative study of platelet parameters in chronic kidney disease, end-stage renal disease patients undergoing hemodialysis and healthy individuals. Egypt J Hosp Med., 71(6):3429-33.
8) Himmelfarb J, Vanholder R, Mehrotra R, Tonelli M. The current and future landscape of dialysis. Nature Reviews Nephrology. 2020 Oct;16(10):573-85.
9) Canaud B, Collins A, Maddux F. The renal replacement therapy landscape in 2030: reducing the global cardiovascular burden in dialysis patients. Nephrology Dialysis Transplantation. 2020 Mar 1;35(Supplement_2):ii51-7.
10) Azar AT, Canaud B. Hemodialysis system. Modelling and Control of Dialysis Systems: Volume 1: Modeling Techniques of Hemodialysis Systems. 2013:99-166.
11) Gnanasekar A. Modelling and control of hemodialysis systems for better treatment management of Chronic Kidney Disease patients.
12) Alghythan AK, Alsaeed AH. Hematological changes before and after hemodialysis. Scientific Research and Essays. 2012 Jan 30;7(4):490-7.
13) Habib A, Ahmad R, Rehman S. Hematological changes in patients of chronic renal failure and the effect of hemodialysis on these parameters. Int J Res Med Sci. 2017 Nov;5(11):4998-5003.
14) Shittu AO, Chijioke A, Biliaminu S, Makusidi AM, Sanni M, Abdul-Rahman M, Abdul-Azeez I. Haematological profile of patients with chronic kidney disease in Nigeria. Journal of Nephrology and Renal transplantation. 2013;5(1):2-10.
15) Singh S, Ghimire TR. Chronic Kidney Disease: Emphasis on its Burden and Challenges in Nepal.
16) Kaze FF, Meto DT, Halle MP, Ngogang J, Kengne AP. Prevalence and determinants of chronic kidney disease in rural and urban Cameroonians: a cross-sectional study. BMC nephrology. 2015 Dec;16:1-0.
17) Abdulla JE, Shakor JK, Shallal AF, Kheder R. Effect of dialysis on some Hematological and Electrolyte parameters in chronic kidney patients. Annals of Tropical Medicine and Public Health. 2020;23(11):9-13.
18) Abdelnabi AM, Ismaeyl EM, Abdellatif AM. Hematological indices in chronic kidney disease patients and the effect of hemodialysis on these indices. Egyptian Journal of Hospital Medicine. 2021;85(2):4257-62.
19) Iyawe IO, Adejumo OA. Hematological profile of predialysis chronic kidney disease patients in a tertiary hospital in Southern Nigeria. Journal of Medicine in the Tropics. 2018 Jan 1;20(1):36-41.
20) Muhammad A, Zeb MA, Ullah A, Afridi IQ, Ali N. Effect of haemodialysis on haematological parameters in chronic kidney failure patients Peshawar-Pakistan. Pure and Applied Biology. 2020 Mar 1;9(1):1163-9.
21) Shastry I, Belurkar S. The spectrum of red blood cell parameters in chronic kidney disease: A study of 300 cases. Journal of Applied Hematology. 2019 Apr 1;10(2):61-6.
22) Singh S, Bhatta S. Biochemical and hematological parameters in chronic kidney disease. Journal of Manmohan Memorial Institute of Health Sciences. 2018 Sep 22;4(1):4-11.