ISSN: 3065-5145
Research Article
Journal of Clinical Case Studies and Family Medicine

Age-Related Variations in some Haematological Parameters Pre- and Post-Haemodialysis Among Chronic Kidney Disease (CKD) Patients

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Submitted: 23 February 2026 **Accepted:** 02 March 2026 **Published:** 09 March 2026

Citation: *Eledo, B. O., Dokubo, O. V., & Akhogba, A. O. (2026). Age-related variations in some haematological parameters pre- and post-haemodialysis among chronic kidney disease (CKD) patients. J of Clin Case Stu Fam Med, 2(2), 01-07.*

Abstract

Haemodialysis, as a principal form of renal replacement therapy, removes accumulated metabolic waste and excess fluid but simultaneously influences the composition and function of blood cells. Chronic Kidney Disease (CKD) is frequently associated with haematological abnormalities, and haemodialysis may influence these parameters. This study evaluated and compared age related variations in pre- and post-haemodialysis haematological parameters, among CKD patients attending a dialysis centre in Southern Nigeria. A comparative cross-sectional study was conducted among 163 CKD patients undergoing maintenance haemodialysis. The demographic distribution of subjects was based on the following age ranges: 18–39, 40–59, 60–69, 70–79, and ≥80 years. These age categories were applied to both the pre-dialysis and post-haemodialysis estimation of haematological parameters in patients with chronic kidney disease (CKD), resulting in five (5) groups comprising 14–57 subjects per group, including both male and female participants. These age classifications are consistent with the Kidney Disease: Improving Global Outcomes (KDIGO) CKD guidelines, which represent an established and clinically acceptable standard for age-based classification of CKD patients and are commonly used in clinical practice, epidemiological studies, and hospital-based research. Venous blood samples were collected before and after haemodialysis for the assessment of haematological indices using standard protocols Data were analysed using appropriate statistical tests at a significance level of $p < 0.05$, with results stratified by age groups. The total white cell count, neutrophil percent, lymphocyte percent, monocyte percent and haemoglobin concentration showed no significant difference across all age groups between pre and post haemodialysis CKD subjects ($P>0.05$). The eosinophil and basophils percent were significantly increased among post haemodialysis CKD in the 60-69 age range when compared with the corresponding pre haemodialysis age range ($P<0.05$) Also, the red blood cell count and haemoglobin concentration were significantly increased across all age groups among post haemodialysis CKD subjects when compared with the corresponding age groups among the pre haemodialysis subjects ($P<0.05$). There was no significant difference in mean cell haemoglobin, mean cell haemoglobin concentration, red cell distribution width, platelets count and mean platelets volume across all age groups when compared among pre and post haemodialysis CKD subjects ($P>0.05$) The mean haematocit values were significantly increased across all age ranges among post haemodialysis subjects when compared with the pre haemodialysis CKD subjects ($P<0.05$). Haemodialysis significantly improves haemoglobin and haematocrit levels in CKD patients and age influences haematological responses to dialysis. Regular monitoring of these parameters is essential for effective clinical management of CKD patients undergoing haemodialysis.

Keywords: Chronic Kidney Disease, Haemodialysis, Haematological Parameters, Age Related Variations.

Introduction

In Africa, the burden of chronic kidney disease (CKD) is particularly high, with substantial variability across countries and populations. A systematic review conducted in sub-Saharan Africa reported a pooled CKD prevalence of approximately 18% among adult populations between 2019 and 2025 [1]. Chronic Kidney Disease (CKD) is a progressive condition marked by a gradual decline in renal function, ultimately impairing the kidneys' ability to maintain internal homeostasis. As renal function deteriorates, many patients progress to end-stage kidney failure and require haemodialysis to sustain adequate fluid, electrolyte, and metabolic balance Haemodialysis, while essential for survival, exerts significant effects on haematological indices. CKD itself is recognised as a major public health concern worldwide, with a rising incidence and prevalence that affects populations across both high-income and low-income regions. Its burden is particularly severe in sub-Saharan Africa where limited healthcare resources, late presentation, and high rates of comorbidities intensify disease outcomes [2]. Patients undergoing haemodialysis frequently present with anaemia, thrombocytopenia, and various coagulation disturbances arising from uraemic toxins, chronic inflammation, and complications inherent to dialysis. These alterations manifest as impaired oxygen transport, disordered platelet function, prolonged bleeding times, and an increased tendency toward thrombotic events (Kumar et al., 2020).

Haemodialysis, as a principal form of renal replacement therapy, removes accumulated metabolic waste and excess fluid but simultaneously influences the composition and function of blood cells. Anaemia remains one of the most common and debilitating haematological complications in CKD, arising from insufficient erythropoietin synthesis, persistent inflammation, iron deficiency, and cumulative blood losses during dialysis procedures. The mechanical forces within the extracorporeal circuit can contribute to hemolysis, while repeated dialysis sessions may exacerbate iron depletion. Evidence further indicates that haemoglobin and haematocrit levels may decline transiently during haemodialysis due to intravascular volume changes and the sequestration of blood within the machine tubing (Khan et al., 2023; Locatelli et al., 2019). Platelet abnormalities also occur frequently, with patients demonstrating impaired platelet aggregation and reduced platelet life span, which collectively increase the risk of bleeding. Dialysis-related anticoagulation, particularly the use of heparin, contributes additional complexity to coagulation regulation [3, 4].

Investigating the haematological alterations associated with haemodialysis is essential for improving the clinical management of CKD. A deeper understanding of these changes enables the refinement of treatment protocols, enhances patient safety, and contributes to better long-term outcomes. Although data for the South-South region of Nigeria are limited, existing studies suggest that CKD prevalence is substantial. Population-based surveys conducted in southern Nigeria between 2019 and 2025 indicate that 7–12% of adults in semi-urban and urban communities are affected by CKD [5, 6]. These studies involved participants aged 18 years and above and employed eGFR and proteinuria measures for CKD diagnosis. Hypertension, diabetes, older age, and obesity were consistently identified as the main risk factors. The evidence highlights that CKD is underdiagnosed in the region, and many affected individuals are likely to progress to advanced stages if early detection and intervention are not implemented [5, 6]. Early identification and correction of abnormalities reduce the likelihood of complications such as severe anaemia and thrombotic events, thereby improving quality of life and overall survival [7]. This study therefore aims to examine Age-Related Variations in some Haematological Parameters Pre- and Post-Haemodialysis among chronic kidney disease (CKD) Patients, contributing evidence that may guide more effective clinical practice for individuals living with chronic kidney disease.

Aim of the Study

To evaluate Age-Related Variations in some Haematological Parameters Pre- and Post-Haemodialysis among chronic kidney disease (CKD) Patients attending a dialysis centre in Southern Nigeria.

Specific Objective of the Study

To determine and compare age-related pre- and post-haemodialysis changes in some haematological parameters among Chronic Kidney Disease (CKD) patients attending a dialysis centre in Southern Nigeria.

Study Area

The study was carried out at, Hilton Clinics Dailysis Centre, NO 2, Ejekwu Wike Close, Opposite Wimpy Junction by Ada George Road Rivers State Nigeria. Being a major private dialysis centre for renal care located in Port Harcourt, Rivers State Nigeria. In this centre, there are multitudes of patients attending from different state in South South Nigeria.

Study Design

A hospital-based cross-sectional study was conducted over six months.

Study Population

A total of the hundred and seventy (170) subjects were enrolled for this study. Seven died during the course of the research and the remaining One hundred and sixty three (163) patients diagnosed with CKD on maintenance haemodialysis at Hilton Clinics, a private major centre for renal care in Port Harcourt, Rivers State Nigeria had their blood samples collected for pre haemodialysis and post haemodialysis.

Inclusion Criteria

Adults (≥18 years) with CKD stage 5 undergoing haemodialysis.
Patients on stable haemodialysis for at least three months.
Those who provided informed consent.

Exclusion Criteria

Patients with active infections or inflammatory disorders. Those on anticoagulation therapy beyond routine dialysis anticoagulation.Individuals with haematological disorders unrelated to CKD.

Sample Size Calculation

To achieve statistical significance, the sample size was calculated using Cochran's formula [8]:

$n=Z^2Pq/d^2$

Where:

n = sample size minimum,

z = 95% confidence interval = 1. 96,
P = proportion of the target population,
d = with, degree of accuracy (95% interval) = 0.05% and q = 1.0 – p.
P=12.7% [9].
N= 1.962 x 0.127 x (1-0.127)/0.052
N=3.8416 x 0.127 x 0.873/0.0025
N=170.36
N=170

Ethical Considerations

Ethical approval was obtained from the ethical review board of the hospital. Informed consent was obtained from all participants and confidentiality was maintained by anonymizing data.

Sample Collection

Blood samples were collected from One hundred and sixty three (163) patients diagnosed with CKD Pre-dialysis and post-dialysis. 3mls of blood was collected from each subject and dispensed into ethylenediaminetetraacetic acid (EDTA) bottles for haematological analysis.
Laboratory Analysis

Method

The Complete Blood Count was Estimated Using Mindray 5 part

The Complete Blood Count (CBC) was estimated using an automated Mindray 5-part haematology analyser, which performs full blood cell quantification and differential leukocyte analysis through integrated impedance, flow cytometry, photometric and chemical dye-binding technologies. The principle of the Mindray 5-part analyser is based on several integrated analytical mechanisms. Electrical Impedance (Coulter Principle) was used for counting red blood cells and platelets by detecting changes in electrical resistance as cells pass through an aperture; Flow Cytometry with Laser Scattering classifiedwhite blood cells into neutrophils, lymphocytes, monocytes, eosinophils and basophils based on differences in cell size, internal complexity and granularity measured by multi-angle laser light scatter; Cyanide-free Photometry estimated Haemoglobin concentration after cell lysis using a non-cyanide colourimetric reagent where absorbance is read at a specific wavelength and the analyser automatically calculates indices such as MCV, MCH, MCHC and RDW using measured parameters [10].

Materials

The materials and reagents used for CBC analysis using the Mindray 5-part analyser include:

1. Venous whole blood collected into EDTA (K_3EDTA) vacutainer tubes.
2. Calibrators and commercial quality-control materials specific to the analyser.
3. Manufacturer-approved reagents including diluents, lysing reagents, sheath fluid and cleaning solutions [10].
4. Disposable gloves, sample racks and bar-coded labels for specimen identification.
5. The automated Mindray 5-part haematology analyser equipped with standard software and data-management systems.

Procedure

Specimen collection. Whole blood was collected via venepuncture into EDTA tubes and gently mixed to prevent clot formation after labeling for pre-dialysis and post-dialysis. And then, samples were inspected for clots, haemolysis or insufficient volume prior to analysis. The analyser was said to be switched on, allowed to complete its internal quality checks and verified with daily quality-control materials according to laboratory policy [11]. Then, each sample tube was then placed in the sampler rack, and the analyser aspirated a defined volume of whole blood automatically for pre-dialysis and post-dialysis analysis systematically. The system was described as diluting the sample, lysing the red cells for haemoglobin measurement and directing cell suspensions into separate analytical chambers for counting and differentiation. The analyser reportedly processed the sample using impedance for RBC and platelet counts, laser scatter for WBC differentials, and photometry for haemoglobin estimation. At the end of every analysis, the instrument generated a printed or digital report containing all CBC results and systematical documentation was achieved per sample [11, 12].

Data Analysis

Data obtained from this study were entered and analysed using SPSS version 25. Continuous variables, including haematological parameters, were presented as mean ± standard deviation (Mean ± SD). To assess age-related variations in haematological parameters, a one-way analysis of variance (ANOVA) was performed across the defined age groups. Where ANOVA indicated significant differences, a post-hoc analysis using the Waller–Duncan test was conducted to identify the specific age groups that differed significantly. A p-value less than 0.05 was considered statistically significant for all analyses

Results

Out of the one hundred and seventy (170) subjects recruited for the study, seven (7) subjects died after pre-dialysis sample collection, and the remaining one hundred and sixty-three (163) were subsequently grouped according to age. The demographic distribution of subjects was based on the following age ranges: 18–39, 40–59, 60–69, 70–79, and ≥80 years. These age categories were applied to both the pre-dialysis and post-haemodialysis estimation of haematological parameters in patients with chronic kidney disease (CKD).

Table 1: Demographic distribution of subjects

Group	Age Range (yrs)	N
1	18 - 39	35
2	40 - 59	57
3	60 - 69	30
4	70 - 79	27
5	≥80	14

Table 2 is the Age-Related Variations in some Haematological Parameters Pre- and Post-Haemodialysis among CKD Patients. The total white cell count, neutrophil percent, lymphocyte percent, monocyte percent and haemoglobin concentration showed no significant difference across all age groups between pre and post haemodialysis CKD subjects (P>0.05) The eosinophil and basophils percent were significantly increased among post haemodialysis CKD in the 60-69 age range when compared with the corresponding pre haemodialysis age range(P<0.05) Also, the red blood cell count and haemoglobin concentration were significantly increased across all age groups among post haemodialysis CKD subjects when compared with the corresponding age groups among the pre haemodialysis subjects(P<0.05)

Table 3 is the Age-Related Variations in some Haematological Parameters Pre- and Post-Haemodialysis among CKD Patients. There was no significant difference in mean cell haemoglobin, mean cell haemoglobin concentration, red cell distribution width, platelets count and mean platelets volume across all age groups when compared among pre and post haemodialysis CKD subjects (P>0.05) The mean haematocit values were significantly increased across all age ranges among post haemodialysis subjects when compared with the pre haemodialysis CKD subjects (P<0.05) The mean cell volume was significantly increased among pre and post dialysis subjects when compared with the other age groups (P<0.05)

Table 2: Age-Related Variations in some Haematological Parameters Pre- and Post-Haemodialysis among CKD Patients

CKD Status grade	Age WBC	Neutrophils	Lymphocytes	Monocytes	Eosinophils	Basophils	RBC	HB
Pre-18-39	6.66± 1.40a	59.51± 5.33a	24.40± 4.86a	8.28± 3.65a	5.96 ± 1.94abc	1.85±0. 98abc	3.99 ± 0.50a	9.7 ±1. 69ab
40-59	7.24± 1.83a	60.73± 3.91a	24.45± 3.94a	8.23± 2.58a	4.74± 2.09ab	1.85±0. 94abc	3.80± 0.44a	9.77±1. 45ab
60-69	6.66± 1.82a	59.45± 4.38a	24.33± 3.79a	8.71± 2.73a	6.15± 2.65bc	1.36 ± 0.84a	3.78± 0.43a	9.47± 1.22a
70-79	6.55± 2.31a	61.19± 3.45a	24.38± 4.38a	8.32± 2.43a	4.48± 1.49a	1.63±0. 81ab	3.88± 0.54a	10.18± 1.83ab
≥80	7.26± 1.89a	61.96± 3.73a	21.81± 3.34a	9.68± 3.61a	5.29± 1.58abc	1.27± 1.14a	3.76± 0.46a	9.91± 1.34ab
Post	18-39 6. 62±1.77a	59.70± 5.49a	23.75± 5.39a	7.96± 3.78a	6.06± 2.43abc	2.66± 1.79cd	4.10± 0.57a	10.53± 1.71ab
40-59	7.27± 2.34a	60.45± 4.57a	24.47± 4.17a	7.51± 3.32a	5.01± 2.31abc	2.56± 1.73bcd	3.90± 0.52a	10.68± 1.79b
60-69	6.95± 2.30a	59.43± 4.99a	23.07± 3.70a	8.18± 3.15a	6.45 ± 2.98c	2.97± 1.42d	3.97± 0.47a	10.13± 1.29ab
70-79	6.26± 2.65a	61.27± 4.72a	23.23± 4.76a	8.28± 2.90a	4.80± 2.80ab	2.61± 1.78cd	4.07± 0.56a	10.82± 2.11b
≥80	7.60± 2.23a	61.61± 3.36a	22.11± 4.20a	8.64± 2.29a	5.32± 2.17abc	2.32± 1.79bcd	3.83± 0.55a	10.61± 1.75ab

Data are presented as mean± SD; Different letters along each column indicate significant variations (p<05) according to Waller Duncan Multiple test statistics

Table 3: Age-Related Variations in some Haematological Parameters Pre- and Post-Haemodialysis among CKD Patients

CKD Status grade	Age HCT	MCV	MCH	MCHC	RDW-CV	RDW-SD	Platelets	MPV
Pre-18-39	29.28± 5.13ab	88.80± 5.87a	28.07± 1.61a	33.11± 1.36a	14.90± 1.91a	47.22 ± 4.98a	227.11± 66.26a	9.70± 1.21a
40-59	29.06± 4.96ab	88.01± 5.26ab	28.66± 1.86a	33.08± 1.38a	15.42± 1.64a	47.74 ± 4.84a	208.19 ± 62.40a	9.90± 1.31a
60-69	28.41± 4.35a	87.96± 6.84ab	29.18± 1.80a	33.14± 1.17a	15.21± 1.89a	47.65± 4.70a	233.87± 57.80a	9.50± 1.11a
70-79	30.87± 6.03abc	85.69± 5.84ab	28.25± 2.15a	32.79± 1.18a	15.07± 1.99a	47.81± 5.18a	208.37± 55.16a	9.91± 1.18a
≥80	29.25± 5.11ab	89.14± 5.66ab	28.69± 1.94a	32.82± 0.68a	16.15± 1.51a	49.25± 7.12a	194.71± 57.98a	9.57± 1.31a
Post 18-39	32.29± 5.66bc	88.65± 6.03ab	28.43± 1.82a	33.26± 1.61a	14.53± 2.17a	46.41± 5.51a	222.71± 79.23a	9.67± 1.46a

40-59	31.86± 4.73abc	88.09± 5.18ab	28.99± 2.15a	33.22± 1.53a	14.98± 1.83a	47.10± 4.88a	212.98± 70.99a	9.83± 1.47a
60-69	31.53± 5.31abc	88.28± 6.83b	29.61± 2.09a	33.31± 1.39a	14.96± 2.17a	47.55± 4.97a	247.03± 69.51a	9.59± 1.18a
70-79	34.22± 6.35c	85.79± 6.32ab	28.52± 2.30a	33.09± 1.20a	33.09± 1.20a	46.84± 5.59a	212.00± 59.47a	9.85± 1.34a
≥80	32.37± 5.02bc	89.48± 5.28a	29.24± 2.14a	33.21± 0.82a	15.82± 2.06a	47.65± 7.40a	212.14± 57.40a	9.73± 1.35a

Data are presented as mean± SD; Different letters along each column indicate significant variations (p<05) according to Waller Duncan Multiple test statistics

Discussion

The assessment of some haematological parameters before and after haemodialysis among 163 chronic kidney disease (CKD) patients at a dialysis centre in Southern Nigeria drawn from all age groups (18–39, 40–59, 60–69, 70–79 and ≥80 years) revealed a mix of significant and non-significant changes Across all age groups, white blood cell (WBC) counts remained relatively stable, with pre-dialysis values ranging from 6.55 ± 2.31 × 10^9/L in the 70–79 years group to 7.26 ± 1.89 × 10^9/L in the ≥80 years group. Post-dialysis WBC counts showed minimal changes, for example, 6.26 ± 2.65 × 10^9/L in 70–79 years and 7.60 ± 2.23 × 10^9/L in the ≥80 years group. This stability aligns with previous studies indicating that haemodialysis does not significantly alter total leukocyte counts [13].

Neutrophil percentages showed no significant change across age groups, with pre-dialysis values ranging from 59.45 ± 4.38% (60–69 years) to 61.96 ± 3.73% (≥80 years) and post-dialysis from 59.43 ± 4.99% (60–69 years) to 61.61 ± 3.36% (≥80 years). Similarly, lymphocyte counts decreased slightly post-dialysis in all groups, for instance, 23.75 ± 5.39% in 18–39 years versus pre-dialysis 24.40 ± 4.86%, which is consistent with reports that haemodialysis may cause mild lymphocyte redistribution due to stress-induced demargination [14]. Monocyte counts exhibited minimal variation, although the ≥80 years group recorded a post-dialysis mean of 8.64 ± 2.29% compared to a pre-dialysis value of 9.68 ± 3.61%, reflecting age-related variability in monocyte response [13]. Eosinophils and basophils displayed slight but variable changes; notable is the increase in basophils post-dialysis in the 60–69 years group (2.97 ± 1.42%) compared to pre-dialysis (1.36 ± 0.84%), suggesting individualised immune modulation during dialysis sessions (Ullah et al., 2020).

Red blood cell (RBC) counts and haemoglobin (HB) levels showed the expected improvement post-dialysis across all age groups. For instance, the 18–39 years group had RBC 3.99 ± 0.50 × 10^12/L pre-dialysis and 4.10 ± 0.57 × 10^12/L post-dialysis, while HB increased from 9.75 ± 1.69 g/dL to 10.53 ± 1.71 g/dL. Likewise, in the ≥80 years group, RBC changed from 3.76 ± 0.46 × 10^12/L to 3.83 ± 0.55 × 10^12/L, and HB from 9.91 ± 1.34 g/dL to 10.61 ± 1.75 g/dL. These improvements are consistent with previous findings that haemodialysis enhances oxygen-carrying capacity by correcting uraemia-induced haemodilution [13-15].

The results indicate that, haemodialysis induces mild improvements in RBC and HB levels across all age groups while having negligible impact on WBC differentials. The slight post-dialysis changes observed in basophils and eosinophils suggest that immune responses may be subtly age-dependent and merit further longitudinal investigation. Haematocrit (HCT) levels increased post-dialysis across all age groups, reflecting improved oxygen-carrying capacity after fluid removal. For example, in the 18–39 years group, HCT increased from 29.28 ± 5.13% pre-dialysis to 32.29 ± 5.66% post-dialysis, whereas in the ≥80 years group, HCT rose from 29.25 ± 5.11% to 32.37 ± 5.02%. These findings are consistent with previous reports that haemodialysis corrects uraemia-associated haemodilution [13-15]. Mean corpuscular volume (MCV) remained largely stable with minor fluctuations. The 70–79 years group exhibited a slight decrease from 85.69 ± 5.84 fL pre-dialysis to 85.79 ± 6.32 fL post-dialysis, while the ≥80 years group had values increasing from 89.14 ± 5.66 fL to 89.48 ± 5.28 fL. These stable MCV values suggest that haemodialysis does not significantly alter red cell size, corroborating previous studies (Ullah et al., 2020).

Mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) showed minor age-related variations. For instance, MCH in the 60–69 years group increased from 29.18 ± 1.80 pg to 29.61 ± 2.09 pg post-dialysis, while MCHC remained stable across all groups (e.g., 33.14 ± 1.17 g/dL pre-dialysis to 33.31 ± 1.39 g/dL post-dialysis in 60–69 years). This indicates that haemodialysis primarily affects red cell mass rather than haemoglobin content per cell, aligning with the literature [13]. Red cell distribution width (RDW-CV and RDW-SD) values were similar pre- and post-dialysis across age groups. For example, RDW-CV in the ≥80 years group was 16.15 ± 1.51% pre-dialysis and 15.82 ± 2.06% post-dialysis. These findings suggest minimal impact of haemodialysis on erythrocyte size heterogeneity (Ullah et al., 2020).

Platelet counts (PLT) showed variable but non-significant changes. In the 60–69 years group, PLT increased from 233.87 ± 57.80 × 10^9/L pre-dialysis to 247.03 ± 69.51 × 10^9/L post-dialysis, whereas in the ≥80 years group, PLT remained relatively stable (194.71 ± 57.98 × 10^9/L pre-dialysis vs 212.14 ± 57.40 × 10^9/L post-dialysis). This observation aligns with reports that platelet counts are generally preserved during haemodialysis, although some variability occurs due to individual responses [13]. Mean platelet volume (MPV) remained stable across age groups, with values such as 9.70 ± 1.21 fL pre-dialysis and 9.67 ± 1.46 fL post-dialysis in the 18–39 years group. This indicates that haemodialysis does not significantly influence platelet size, consistent with previous studies (Ullah et al., 2020).

The results demonstrate that haemodialysis improves HCT while leaving RBC indices, platelet counts, and red cell heterogeneity largely unaltered. Age-related differences were minimal, indicating that haemodialysis has comparable haematological effects across adult and elderly CKD patients. These findings support prior observations that the primary impact of haemodialysis is the correction of uraemia-induced anaemia without significantly altering red cell morphology or platelet parameters [13-15].

Conclusion

The analysis demonstrated overall age-specific variations of haemodialysis on blood parameters. Haematological parameters revealed significant improvements in haemoglobin (HB), haematocrit (HCT), and red blood cell counts (RBC) post-dialysis, these changes were most pronounced in middle-aged groups (40–69 years), while older age groups (≥70 years) showed modest but clinically meaningful improvements [16-20]. White blood cell counts and differential counts, including neutrophils and lymphocytes, remained largely stable across all age groups, although basophil counts increased significantly, suggesting a potential immune modulation effect of dialysis. These results align with prior studies reporting haemodialysis-mediated correction of anaemia and partial restoration of haematopoiesis in CKD patients [21-23].

Recommendations

Routine assessment of complete blood count and red blood cell indices should be conducted pre- and post-dialysis to identify patients at risk of anaemia or other haematological abnormalities and ensure timely interventions. Nutritional and Pharmacological Support should be integrated to further enhance haematological outcomes [24-26].

Contribution to Knowledge

The stratification of results according to age groups highlights that haemodialysis impacts are not uniform across all patients, emphasizing the need for age-specific monitoring and individualized clinical management [27].

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