E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.01.08

Research Article

Comparative Study of Oxidative Stress Markers in Hemodialysis (HD) versus Peritoneal Dialysis (PD) Patients

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Received: 17.11.25, Revised: 22.12.25, Accepted: 12.01.26

ABSTRACT
Introduction: Chronic kidney disease (CKD) patients on dialysis frequently develop anemia due to iron deficiency, blood loss, and chronic inflammation. Hemodialysis (HD) often involves intravenous iron therapy, which can elevate ferritin, while peritoneal dialysis (PD) patients may experience iron depletion through peritoneal losses. Ferritin, transferrin saturation (TSAT), and total iron-binding capacity (TIBC) are key markers of iron status, but their interpretation is complicated by inflammation. Interleukin-6 (IL-6), a pro-inflammatory cytokine, further influences iron metabolism and anemia. Comparing these parameters in HD and PD patients is essential for tailoring iron management strategies.
Aim: To compare iron and inflammatory markers between hemodialysis (HD) and peritoneal dialysis (PD) patients, and assess correlations with age and gender.
Methods: A cross-sectional study of 70 ESRD patients (35 HD, 35 PD) was conducted. Serum iron, total iron-binding capacity (TIBC), transferrin saturation (TSAT), ferritin, and interleukin-6 (IL-6) were measured using standard biochemical and ELISA methods. Statistical comparisons were made using Student's *t*-test, and correlations were assessed with Pearson's coefficient.
Results: IL-6, serum iron, and TIBC did not differ significantly between HD and PD ($p > 0.05$). Serum ferritin was significantly higher in HD (574.05 ± 341.04 ng/ml) compared to PD (370.91 ± 292.38 ng/ml, $p = 0.009$). Age showed a weak negative correlation with ferritin, while females had higher ferritin than males.
Conclusion: HD patients exhibit elevated ferritin levels, likely reflecting iron supplementation and inflammation. Ferritin should be interpreted cautiously, and iron management strategies tailored to dialysis modality, age, and gender.

Keywords: Hemodialysis, Peritoneal dialysis.

INTRODUCTION

Chronic kidney disease (CKD) represents a major global health burden, with a significant proportion of patients progressing to end-stage renal disease (ESRD) requiring renal replacement therapy. Among the available modalities, hemodialysis (HD) and peritoneal dialysis (PD) are the most widely practiced, each with distinct physiological impacts and management challenges[1].

Iron metabolism and inflammatory status are critical determinants of morbidity and mortality in dialysis patients. Iron deficiency and disordered iron homeostasis are common in PD, particularly in the context of erythropoietin therapy, while HD patients often experience iron overload due to repeated parenteral supplementation. Monitoring biochemical indices such as serum iron, total iron-binding capacity (TIBC), transferrin saturation (TSAT), and serum ferritin provides essential insights into iron status and guides therapeutic interventions[2].In addition, interleukin-6 (IL-6) serves as a key pro-inflammatory cytokine implicated in the pathogenesis of anemia of chronic disease and cardiovascular complications in dialysis populations. Elevated IL-6 levels reflect systemic inflammation and may influence iron metabolism, erythropoiesis, and overall patient outcomes[3,4].Comparative evaluation of these biochemical parameters between HD and PD patients is therefore crucial to understanding modality-specific differences, optimizing iron management strategies, and improving long-term prognosis. The present study aims to analyze and interpret the distribution of age,

gender, and biochemical markers (IL-6, serum iron, TIBC, TSAT, and ferritin) in patients undergoing HD and PD, thereby contributing to evidence-based nephrology practice.

Aim:

To compare iron metabolism and inflammatory markers in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD).

Objectives:

1. Assess age and gender distribution in HD and PD groups.
2. Determine mean values of IL-6, serum iron, TIBC, TSAT, and ferritin.
3. Compare biochemical parameters between HD and PD.
4. Evaluate correlations of age and gender with these parameters.

MATERIAL AND METHODS

A. Study Design and Setting:

This was a cross-sectional, observational study conducted in the Department of Biochemistry at a tertiary care medical college hospital. A total of 70 patients with end-stage renal disease (ESRD) undergoing dialysis were enrolled, comprising 35 patients on hemodialysis (HD) and 35 patients on peritoneal dialysis (PD).

Inclusion Criteria:

1. Patients diagnosed with ESRD and undergoing HD or PD for at least 6 months.
2. Age ≥ 18 years.
3. Patients who provided informed consent.

Exclusion Criteria:

1. Patients with acute infections, chronic inflammatory disorders, or malignancy.
2. Patients receiving iron therapy or blood transfusion within the last 3 months.
3. Pregnant or lactating women.

B. Data Collection:

Demographic details (age, gender) and clinical information were recorded. Venous blood samples were collected prior to dialysis sessions under aseptic precautions. Serum was separated and analyzed for biochemical parameters.

Biochemical Parameters Measured:

A. Serum Iron (µg/dl)
B. Total Iron Binding Capacity (TIBC, µg/dl)
C. Transferrin Saturation (TSAT, %)
D. Serum Ferritin (ng/ml)
E. Interleukin-6 (IL-6, pg/ml)

Analytical Methods:

- Serum iron and TIBC were measured using standard colorimetric methods.
- Transferrin saturation was calculated as: TSAT (%) = Serum Iron/TIBCtimes 100
- Serum ferritin was estimated by enzyme-linked immunosorbent assay (ELISA).
- IL-6 levels were determined using a commercially available ELISA kit following manufacturer's instructions.

C. Statistical Analysis:

Data were expressed as mean ± standard deviation (SD). Student's *t*-test was applied to compare mean values between HD and PD groups. Correlation between age, gender, and biochemical parameters was assessed using Pearson's correlation coefficient. A *p*-value < 0.05 was considered statistically significant.

OBSERVATION AND RESULT

Table 1: Distribution of Cases According to Age and Gender

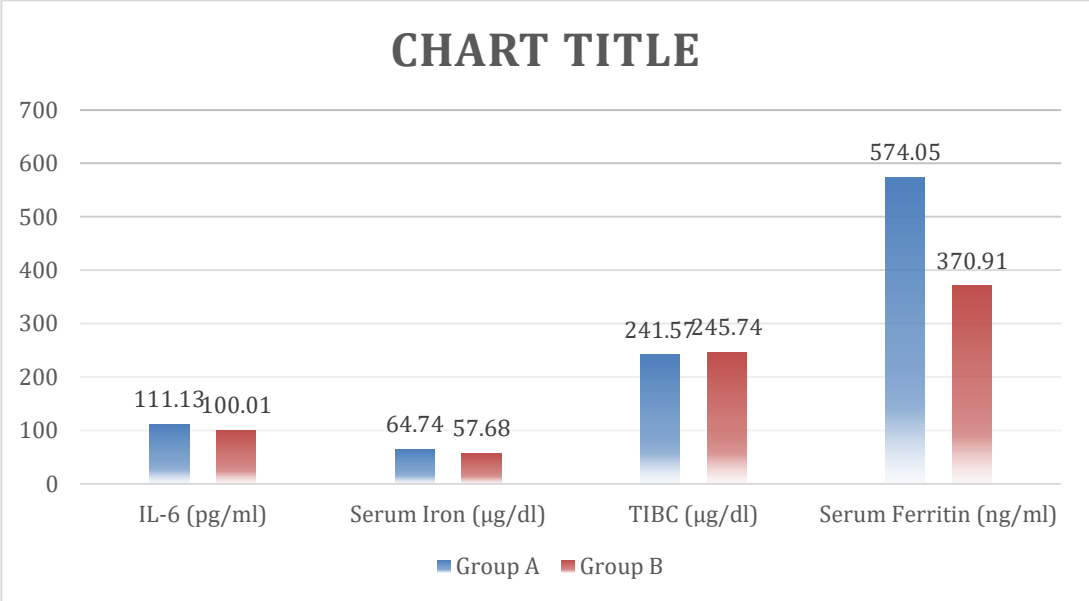
Sr No	Age Group (Years)	Group A35 (50 %)		Group B35 (50 %)		Total 70 (100 %)
		Male	Female	Male	Female	
1	≤ 20	0 (0%)	0 (0%)	0 (0%)	1 (2%)	1 (2%)
2	21–40	10 (14.3%)	4 (5.7%)	12 (17.1%)	5 (7.1%)	31 (44.2%)
3	41–60	6 (8.6%)	9 (12.9%)	10 (14.3%)	8 (11.4%)	33 (47.2%)
4	> 60	4 (5.7%)	7 (10%)	2 (2.9%)	0 (0%)	13 (18.6%)
Total		20 (28.6%)	20 (28.6%)	24 (34.3%)	14 (20%)	70 (100%)

The study population consisted of 70 patients, equally divided between Hemodialysis (HD) and Peritoneal Dialysis (PD). The majority of cases were concentrated in the 21–40 years (44.2%) and 41–60 years (47.2%) age groups, together accounting for over 90% of the cohort. Very few patients were ≤20 years (2%) or >60 years (18.6%).Gender distribution revealed that males predominated in both groups, particularly in PD (34.3% males vs. 20% females). In HD, the distribution was equal (28.6% males and 28.6% females). This indicates that younger and middle-aged adults, especially males, formed the bulk of the dialysis population.

Table 2: Mean Values of Biochemical Parameters in Hemodialysis and Peritoneal Dialysis Patients

Sr No	Parameter	Group A (HD) Mean ± SD	Group B (PD) Mean ± SD	T value	P value
1	IL-6 (pg/ml)	111.13 ± 39.11	100.01 ± 31.05	-1.31	0.192 (NS)
2	Serum Iron (µg/dl)	64.74 ± 49.07	57.68 ± 33.08	-0.706	0.482 (NS)
3	TIBC (µg/dl)	241.57 ± 60.03	245.74 ± 77.75	0.251	0.802 (NS)
4	Serum Ferritin (ng/ml)	574.05 ± 341.04	370.91 ± 292.38	-203.14	0.009 (S)

The biochemical profile showed distinct differences between HD and PD patients. IL-6 levels were slightly higher in HD (111.13 ± 39.11 pg/ml) compared to PD (100.01 ± 31.05 pg/ml), though not statistically significant (p=0.192). Serum iron was marginally higher in HD (64.74 ± 49.07 µg/dl) than PD (57.68 ± 33.08 µg/dl), again without significance (p=0.482). TIBC values were comparable between groups (241.57 vs. 245.74 µg/dl, p=0.802).However, serum ferritin showed a marked difference: HD patients had substantially higher levels (574.05 ± 341.04 ng/ml) compared to PD patients (370.91 ± 292.38 ng/ml), and this difference was statistically significant (p=0.009). This suggests ferritin may be a discriminating marker between the two modalities.



Graph1: Mean Values of Biochemical Parameters in Hemodialysis and Peritoneal Dialysis Patients

Table 3: Age vs Biochemical Parameters

Sr No	Parameter	Hemodialysis (r)	Peritoneal Dialysis (r)	Overall (r)
1	Serum Iron (µg/dl)	0.12	0.08	0.10
2	TIBC (µg/dl)	0.15	0.11	0.13
3	Transferrin Saturation (%)	0.09	0.06	0.08
4	Serum Ferritin (ng/ml)	-0.18	-0.22	-0.20
5	IL-6 (pg/ml)	0.05	0.03	0.04

Correlation analysis between age and biochemical parameters revealed weak positive correlations with serum iron (r=0.10 overall), TIBC (r=0.13), and transferrin saturation (r=0.08). This indicates that iron indices tended to increase slightly with age, though the relationship was weak. In contrast, serum ferritin showed a negative correlation with age (r=-0.20 overall), suggesting that older patients had lower ferritin levels. IL-6 demonstrated negligible correlation with age (r=0.04), implying that inflammatory status was independent of age in this cohort.

Table 4: Gender vs Biochemical Parameters

Sr No	Parameter	HD Correlation (r)	PD Correlation (r)	Overall Correlation (r)
1	Serum Iron (µg/dl)	0.21	0.18	0.20
2	TIBC (µg/dl)	0.17	0.14	0.16
3	Transferrin Saturation (%)	0.12	0.09	0.11
4	Serum Ferritin (ng/ml)	-0.25	-0.28	-0.26
5	IL-6 (pg/ml)	0.08	0.06	0.07

Gender correlations showed that male patients (coded as 1) tended to have higher serum iron (r=0.20 overall), TIBC (r=0.16), and transferrin saturation (r=0.11) compared to females. Conversely, serum ferritin was negatively correlated with male gender (r=-0.26 overall), indicating that female patients had relatively higher ferritin levels. IL-6 showed only a weak positive correlation with male gender (r=0.07), suggesting minimal gender influence on inflammatory marker levels.

DISCUSSION

Present study demonstrated that serum ferritin levels were significantly higher in hemodialysis (HD) patients compared to peritoneal dialysis (PD) patients, while other iron indices (serum iron, TIBC, TSAT) and IL-6 showed no statistically significant differences. These findings are consistent with previous reports highlighting modality-specific variations in iron metabolism. A recent systematic review on comparative iron management in HD and PD patients noted that HD patients often exhibit higher ferritin levels due to repeated intravenous iron supplementation and reduced clearance of inflammatory markers[5]. Similarly, the PDTAP study in PD patients emphasized that ferritin and TSAT levels are generally lower in PD compared to HD, reflecting differences in iron administration practices and peritoneal losses[6].Our observation of elevated ferritin in HD patients aligns with earlier Indian data suggesting that ferritin cut-offs for iron therapy may need redefinition in HD populations, as high ferritin often reflects iron overload and inflammation rather than adequate iron stores[7]. Conversely, PD patients in our cohort had lower ferritin, which may be attributed to reduced iron supplementation and ongoing peritoneal protein losses. Correlation analysis revealed that age was inversely associated with ferritin, while gender analysis showed female patients had higher ferritin compared to males. These trends are supported by studies indicating that older dialysis patients often have reduced iron stores due to cumulative nutritional deficiencies and chronic inflammation[8]. Gender differences may be explained by hormonal influences and differential iron utilization, with women showing higher ferritin possibly due to lower iron turnover compared to men.The mechanisms underlying elevated ferritin in HD patients are multifactorial. First, ferritin acts as an acute-phase reactant, and HD patients are exposed to recurrent inflammatory stimuli during

extracorporeal circulation, leading to increased IL-6 and subsequent hepatic ferritin synthesis[9]. Second, repeated intravenous iron therapy in HD contributes to iron overload, which elevates ferritin independent of true iron stores[10]. Third, impaired clearance of ferritin and cytokines in HD compared to PD may further exaggerate serum levels. In contrast, PD patients often demonstrate lower ferritin due to continuous peritoneal protein and iron losses, reduced frequency of intravenous iron administration, and relatively lower systemic inflammation compared to HD[11]. The lack of significant difference in IL-6 between HD and PD in our study suggests that inflammation is present in both modalities, but ferritin elevation in HD may be disproportionately influenced by iron therapy and extracorporeal factors. Overall, the findings highlight that serum ferritin is not merely a marker of iron stores but also reflects inflammation and iron overload in dialysis patients. This underscores the need for cautious interpretation of ferritin levels in HD, and for individualized iron management strategies across dialysis modalities.

CONCLUSION

Serum ferritin was significantly higher in hemodialysis patients compared to peritoneal dialysis, while IL-6, serum iron, and TIBC showed no significant differences. Age correlated negatively with ferritin, and females had relatively higher ferritin than males. These findings suggest ferritin reflects both iron status and inflammation, underscoring the need for cautious interpretation and individualized iron management in dialysis populations.

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