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Article

Sleep Quality in Hemodialysis Patients According to Renal Anemia Treatment Outcomes

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Abstract

Backgound: We assessed the impact of renal anemia treatment on sleep quality among hemodialysis (HD) patients. Methods: To be included in the study, patients had to have received epoetin (EPO) therapy within the past year. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), with poor sleepers defined as those with a global PSQI score > 5. The target hemoglobin level (THb) was defined as a hemoglobin (Hb) level greater than 11.0 g/dL in the three months preceding the sleep survey. Results: A total of 78 patients were included, with a median age of 59.0 years. The mean HD vintage was 50.5 months. THb levels were achieved in 43 patients (55.1%), while 46 patients (59.0%) were identified as poor sleepers. Median PSQI score was 6 (4–11) in patients who achieved THb, compared with 7 (4–9) in those who did not (p=0.217). Mean Hb level was 11.2±1.3 g/dL among poor sleepers and 11.3±1.2 g/dL among non-poor sleepers (p=0.603). There was no significant correlation between PSQI score and Hb level (p=0.955). The frequency of poor sleepers was significantly higher in patients receiving EPO therapy (68.0%) compared to those not receiving EPO therapy (42.8%) (p=0.027). Furthermore, EPO use was identified as an independent risk factor for poor sleep quality (OR: 2.822, 95% CI: 1.029–7.737). Neither Hb level nor achieving THb were found to be independent predictors of poor sleep quality. Conclusion: Successful anemia treatment did not have a positive impact on sleep quality among HD patients.

Keywords

Hemodialysis, Anemia, Epoetin, Erythropoietin, Sleep quality

Article History

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1. Introduction

Chronic kidney disease (CKD) is becoming a public health problem worldwide and the number of people undergoing hemodialysis (HD) is increasing annually. Despite HD does not provide an entire replacement of kidney functions, patient survival is closely related to the removal of uremic solutes by dialysis [1].

However, patients on maintenance HD often suffer several complications resulting from fluid and solute clearance during dialysis or subsequently. Therefore, medical treatment of CKD and proper adjustment of HD procedures are significant in complications management [2].

In dialysis patients, sleep disturbances are commonly observed problems. Poor sleep quality directly impacts life quality in HD patients [3]. Approximately 70% of dialysis patients suffer from sleep abnormalities and the prevalence is higher than the general population. Insomnia, increased daytime sleepiness, obstructive sleep apnea, and restless leg syndrome (RLS) are listed in frequently reported complaints [3,4]. Also, risk factors for sleep quality are not limited to medical status because social and economic factors also affect sleep quality in HD patients [5].

Anemia is another prevalent complication of CKD, contributing significantly to the symptomatology associated with declining renal function. Common manifestations include fatigue, depression, diminished exercise capacity, and dyspnea [6]. Additionally, anemia in CKD is strongly linked to adverse clinical outcomes, including increased cardiovascular morbidity and mortality, as well as a higher risk of hospitalization and prolonged hospital stays [7].

The underlying mechanisms of anemia associated with CKD are diverse and complex. Diminished endogenous erythropoietin production, reduced erythrocyte survival duration, functional iron deficiency, and inflammation with increased hepcidin levels are some of causes [8,9].

In anemic HD patients, the primary approach should involve addressing deficiencies through iron repletion or other nutritional factors supplementation as needed. Adequate iron level is crucial for erythropoiesis, particularly in patients receiving erythropoiesis-stimulating agents (ESAs) [10,11].

ESAs are a cornerstone of anemia therapy in iron-replete HD patients. A variety of recombinant human erythropoietin preparations are commercially available [12]. Recently, hypoxia-inducible factor prolyl hydroxylase inhibitors (HIF-PHIs), such as roxadustat and daprodustat, have also been introduced as a therapeutic option for anemia in patients with CKD [13,14].

In most dialysis patients undergoing ESAs or HIF-PHIs treatment, hemoglobin (Hb) levels are typically maintained between 11 and 12 g/dL. Nonetheless, an optimal target hemoglobin (THb) level for patients receiving an ESAs or HIF-PHIs remains uncertain. Targeting higher Hb levels (>13 g/dL) is generally avoided due to an increased risk of complications, such as thrombosis and hypertension.

Based on the hypothesis that successful treatment of renal anemia could exert beneficial effects on sleep, this study examined the potential association between anemia management and sleep quality in HD patients from multiple perspectives.

2. Materials and Methods

2.1 Ethical Considerations

The trial protocol was approved by the Agri Ibrahim Cecen Univserity Ethics Committee with the decision numbered 148 on 25/04/2024. This cross-sectional study was conducted at a single-center in Hemodialysis Unit of Agri Training and Research Hospital at 01/06/2024 to 31/07/2024. This clinical investigation was carried out in accordance with the Helsinki Declaration. Also, written informed consent was obtained from all participating patients.

2.2 Study Design

For inclusion, the HD patients should have received epoetin (EPO) therapy within the last one year. HD treatment was defined as three times per week, lasting four hours for each dialysis session. The main exclusion criterion was the presence of any possible cause of anemia related to other concurrent diseases, such as hematological diseases, bleeding, or malignancies. Also, patients who were unable or refused to answer the sleep questionnaire appropriately were excluded.

2.3 Data Collection

We administered a questionnaire-based examination for symptoms that reflect sleep disorders. The Pittsburgh Sleep Quality Index (PSQI) was used for sleep quality evaluation and scoring in this study. The PSQI assesses and reflects sleep quality over the preceding four weeks. In scoring the PSQI, seven component scores are derived, each scored 0 (no difficulty) to 3 (severe difficulty). The component scores are summed to produce a global score (range 0 to 21). Higher scores indicate worse sleep quality. The patient was defined as a poor sleeper if the global PSQI score was > 5 points [15].

THb was defined as Hb level maintained above 11.0 g/dL in the last 3 months. Afterward, patients were separated into two groups for analysis: 1) THb achieved, and 2) THb not achieved.

EPO dosing was defined as follows: initial dosage (150 IU/kg/week) and maintenance dosage (75 IU/kg/week). Anemia treatment algorithm with EPO in this study was as follows: EPO was started with an initial dosage if the Hb level was below 10.0 g/dL. EPO dosing was switched to maintenance dosage if Hb level increased to above 11.0 g/dL. Lastly, EPO treatment was discontinued if the Hb level exceeded 12.0 g/dL. Only EPO alpha, beta, and zeta products were administered in this study with similar dosing. The patient selection and classification algorithm is demonstrated in Figure 1.

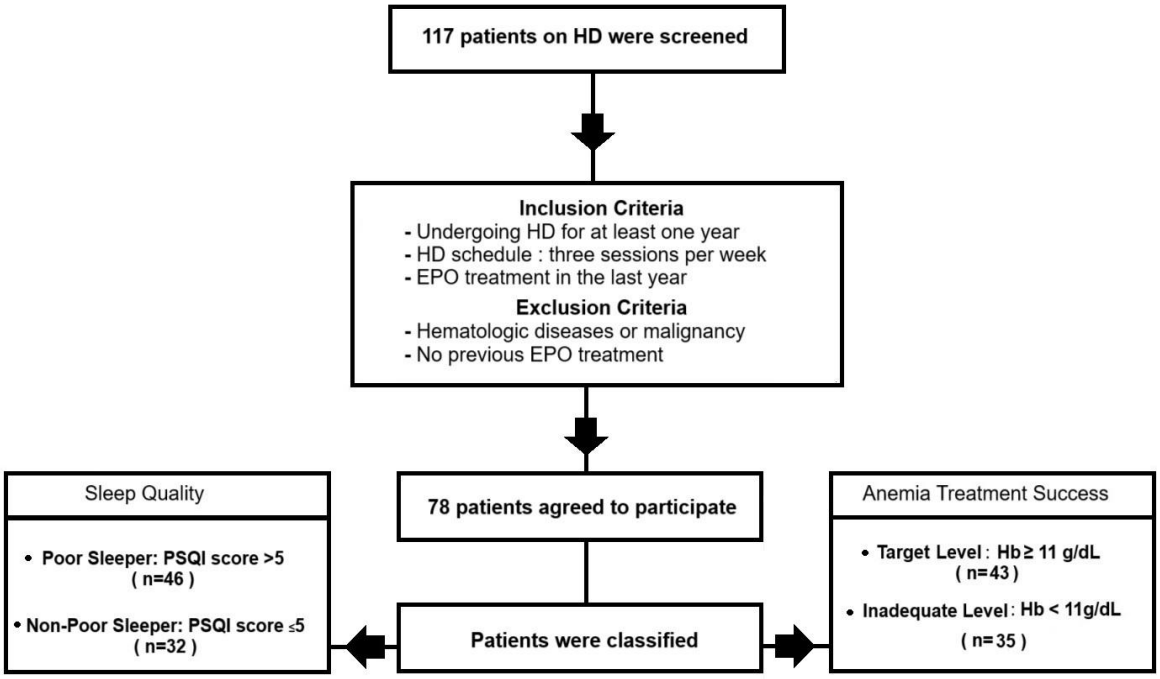

Figure 1. The patient selection and classification algorithm.

In the laboratory, pre-dialysis blood sampling was performed before the HD procedure. Urea, creatinine, uric acid, electrolytes, bicarbonate, glucose, protein, albumin, parathyroid hormone (PTH), hemogram, ferritin, and transferrin saturation (TSAT) percentages were recorded as predialysis. Post-dialysis blood sampling was performed when the blood pump rate was decreased to 100 mL/min for 15 seconds and stopped. Post-dialysis urea and creatinine levels were recorded. Urea reduction ratio (URR) and Kt/V were used to assess dialysis efficacy adequacy. Kt/V was calculated using a second-generation single-pool Daugirdas formula [16]. Dialysis adequacy was defined as Kt/V>1.2 in this study.

2.4 Statistical Analysis

SPSS version 22 software (IBM Corp., Armonk, NY, USA) was used for data analysis. Histogram and q-q plots were examined, and the Shapiro-Wilk test was performed to assess the data normality. Levene's test was applied to test variance homogeneity. To compare the differences between groups, either a two-sided independent samples T-test or Mann-Whitney U test was used for continuous variables. Pearson χ^2 analysis or Fisher's exact test was used to comparison of groups regarding categorical variables. Kruskal-Wallis Test was utilized to analyze the differences between three or more groups for continuous variables. The Spearman test was used to explore the association between numerical parameters. Binary logistic regression analysis was used in to identify the risk factors of poor sleepers in patients. A p-value below 0.05 was accepted as the significance level.

3. Results

In this study, a total of 78 patients were analyzed. The patients consisted of 42 males (53.8%) and 36 females (46.2%). The median age of patients was 59.0 (44.5-66.0) years. The average body mass index (BMI) was 23.8 ± 4.2 kg/m^2 and body surface area (BSA) was 1.7 ± 0.3 m^2.

The average time underwent on HD was 50.5 (25.5-94.5) months. The mean URR was 71.7 ± 6.9 and the median Kt/V value was 1.55 (1.37-1.80). Dialysis inadequacy was determined in 4 patients (5.1%). 13 patients (16.7%) had tunneled dialysis catheters, 62 patients (79.5%) had arteriovenous fistula, and 3 patients (3.8%) had arteriovenous graft as vascular access. The baseline characteristics of the patients are summarized in Table 1.

Table 1. Baseline characteristics of the patients.

Parameters	Results
Gender	
Male	42 (53.8%)
Female	36 (46.2%)
Age (years)	59.0 (44.5-66.0)
BMI (kg/m²)	23.8 ± 4.2
BSA (m^2)	1.7 ± 0.3
HD duration (months)	50.5 (25.5-94.5)
Vascular access	
Tunneled catheters	13 (16.7%)
AV fistula	62 (79.5%)
AV graft	3 (3.8)
Comorbidities	
Hypertension	35 (44.8%)
Diabetes Mellitus	33 (42.3%)
COPD	6 (7.7%)
Heart Failure	8 (10.3%)
Stroke	4 (5.1%)
Anemia treatment	
EPO-ongoing	53 (67.9%)
EPO-discontinued	25 (32.1%)
Iron repletion	16 (20.5%)
Blood transfusion	4 (5.1%)
Kt/V	1.55 (1.37-1.80)
URR (%)	71.7 ± 6.9
PSQI survey scores	
Global score	7 (4–10)
Sleep quality	1 (1-2)
Sleep latency	2 (1-3)
Sleep duration	1 (0-2)
Sleep efficiency	0 (0-1)
Sleep distubances	1.5 (1-2)
Sleep medication	0 (0-0)
Daytime dysfunction	1 (0-2)
Sleep drugs use	3 (3.8%)

Note: Values are expressed as n (%), mean ± standard deviation, median (1^{st}-3^{rd} quartiles); BMI: body mass index; BSA: body surface area; COPD: chronic obstructive pulmonary disease; URR: urea reduction rate; AV: arteriovenous; EPO: epoetin agents.

THb achievement was identified in 43 patients (55.1%), and also the THb did not be achieved in 35 patients (44.9%). The distribution of patients according to anemia treatment was as follows: 53 patients (67.9%) were ongoing EPO therapy, and EPO therapy was discontinued in 25 patients (22.1%) due to Hb levels exceeding 12.0 g/dL. Additionally, 4 patients (5.1%) underwent a blood transfusion within the last year.

The median PSQI score was 7 (4–10) points, and poor sleeper was identified in 46 patients (59.0%). The mean Hb level was 11.2 ± 1.3 g/dL in poor sleepers and 11.3 ± 1.2 g/dL in non-poor sleepers (p=0.603). The mean ferritin level was 509±131 ng/mL in poor sleepers, and 610 ± 149 ng/mL in non-poor sleepers (p = 0.130). The median TSAT percentage

was 28 (23-41) in poor sleepers, and 30 (23-50) in non-poor sleepers (p=0.927). A detailed comparison of sleep quality groups based on clinical and laboratory parameters is summarized in Table 2.

Table 2. Comparison of the patients according to sleep quality.

Parameters	Poor Sleepers (*n*=46)	Non-Poor Sleepers (*n*=32)	*p*
Age (years)	60 (47-67)	58 (35-65)	0.284
BMI (kg/m^2)	23.9 ± 4.7	23.5±3.4	0.708
Dialysis duration (months)	47.5 (26-99)	61(24-93)	0.684
URR (%)	72.6 ± 6.8	70.5 ± 7.0	0.209
Kt/V	1.59 (1.40-1.60)	1.45 (1.24-1.79)	0.275
Urea (mg/dL)	143 ± 34	147 ± 38	0.657
Creatinine (mg/dL)	8.3 (3.3-6.2)	9.2 (3.5-9.1)	**0.011**
Uric acid (mg/dL)	5.9 (5.5-6.9)	6.3 (4.2-6.5)	0.146
Protein (g/dL)	6.7 ± 0.5	6.6 ± 0.4	0.723
Albumin (g/dL)	3.8 ± 0.4	3.8 ± 0.5	0.103
Sodium (mmol/L)	137 (135-138)	138 (136-139)	0.417
Potassium (mmol/L)	5.1 ± 0.5	5.1 ± 0.4	0.645
Calcium (mg/dL)	8.8 (8.4-9.6)	8.3 (7.7-9.2)	**0.023**
Phosphate (mg/dL)	5.7 ± 0.6	5.1 ± 0.6	0.133
PTH (pg/mL)	489 (315-899)	595 (256-974)	0.803
Hemoglobin (g/dL)	11.2 ± 1.3	11.3 ± 1.2	0.603
TSAT (%)	28 (23-41)	30 (23-50)	0.927
Ferritin (µg/L)	509 ± 131	610 ± 249	0.130

Note: Values are expressed as mean ± standard deviation, median (1st-3rd quartiles). BMI: body mass index; PTH: parathyroid hormone; URR: urea reduction rate; TSAT: transferrin saturation.

Sleep quality was evaluated according to EPO treatment status. While the frquency of poor sleepers was higher in the patients with EPO therapy (68.0%) compared to patients were not ongoing EPO therapy (42.8%), this difference was statistically significant (p=0.027).

The median PSQI score was 7 (5-10) points in patients who were ongoing EPO, and it was 5.5 (4-9) points in patients who discontinued EPO. There was not a statistically significant difference (p=0.283) between the two groups. The results are demonstrated in Figure 2.

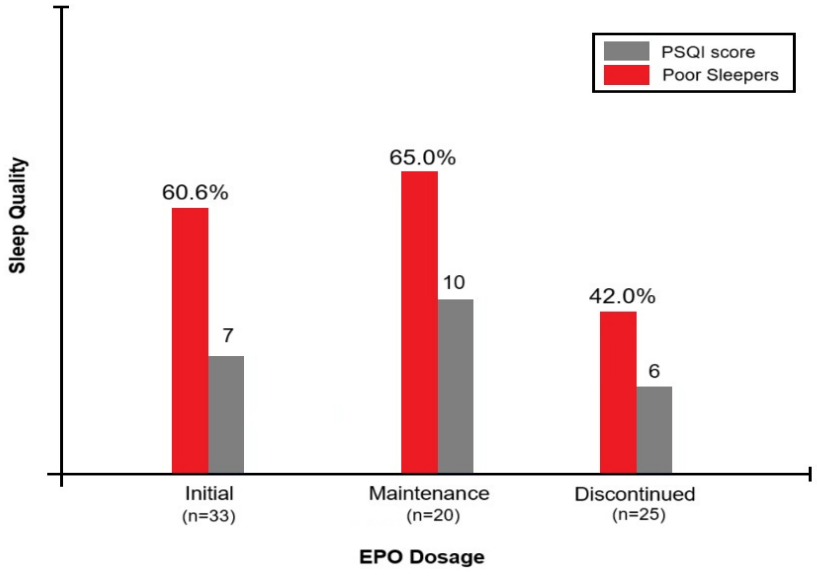

Figure 2. Sleep quality scores according to EPO treatment.

The median PSQI score was 6 (4-11) points in patients who achieved THb and 7 (4-9) points in patients did not achieve THb. There was not a statistically significant difference (p=0.217) between the two groups.

While the prevalence of poor sleepers was lower in the patients with THb (58.2%) compared to patients without THb (60.0%), this difference was not statistically significant (p=0.527). The results are demonstrated in Figure 3.

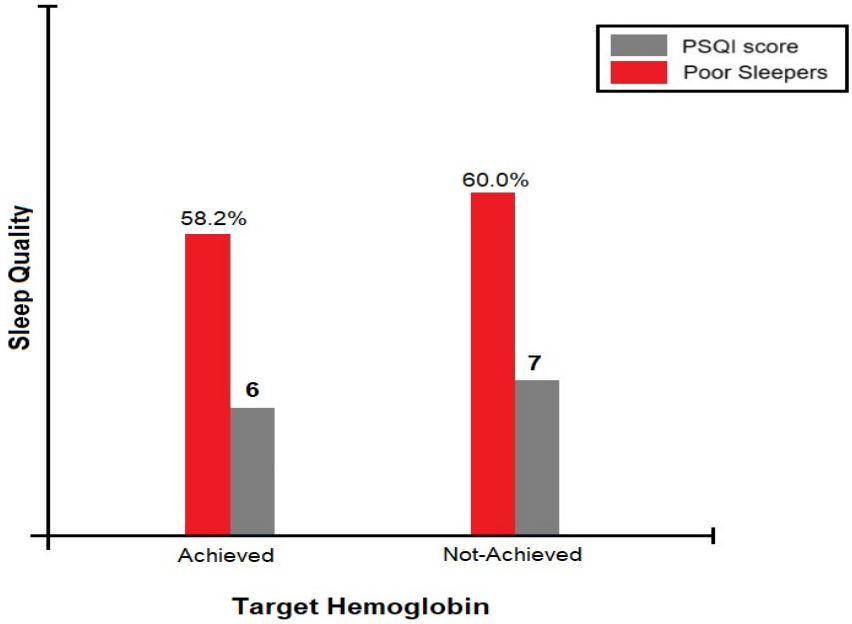

Figure 3. Sleep quality scores according to renal anemia treatment success.

No correlation was identified between PSQI scores and Hb levels (r=-0.006, p=0.955). Also, PSQI scores were not correlated with ferritin levels (r=-0.058, p=0.612) and TSAT percentages (r=0.090, p=0.433). The results are demonstrated in Figure 4. In addition, only predialysis creatinine levels had a negative correlation with PSQI scores (r=-0.265, p=0.019) in the analysis of laboratory parameters.

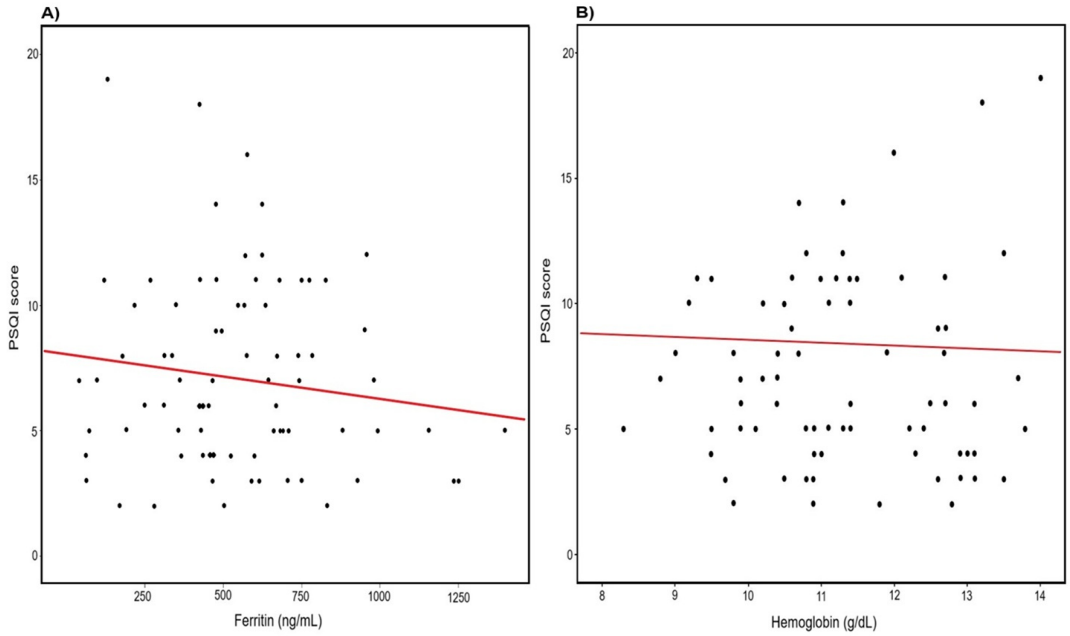

Figure 4. The correlation analysis of PSQI scores and anemia parameters in scatter plots.

For the poor sleep quality, binary logistic regression analyses results are shown in Table 3. Nagelkerke R^2 statistic was calculated as 0.403 and the predictor variables explained 73.1% of the poor sleep quality. The Hosmer–Lemeshow test resulted as $\chi 2$=6.740 p=0.565 for the poor sleepers. The results revealed that achieving THb and Hb level were not determined to be independent risk factors in predicting poor sleep quality. EPO usage was determined as independent risk factors in predicting poor sleep quality (p=0.044) and odds ratio was 2.822 (95% CI: 1.029-7.737). In addition, total serum calcium level was identified as an independent risk factor for predicting poor sleep quality, with an odds ratio of 2.912 (95% CI: 1.261-6.726, p=0.022).

Table 3. The results of binary logistic regression analysis.

Parameters	β	HR	95% CI	*p*
Achieving THb	-0.383	1.467	0.184-11.690	0.717
EPO usage	1,038	2.822	1.029-7.737	0.044
Hemoglobin	0.257	1.293	0.439-3.812	0.641
TSAT	0.011	1.011	0.969-1.054	0.627
Ferritin	-0.002	0.998	0.995-1.000	0.069
Dialyis duration	0.001	1.001	0.989-1.013	0.828
Age	0.011	0.674	0.939-1.041	0.674
Female gender	1.336	0.263	0.060-1.154	0.077
Calcium	1.069	2.912	1.261-6.726	**0.012**
Phosphate	0.459	1.582	1.055-2.489	0.147
PTH	-0.001	0.999	0.997-1.001	0.181
Creatinine	0.266	1.305	1.066-1.596	0.010
URR	0.079	1.083	0.869-1.348	0.479
KT/V	-1.178	0.308	0.022-4.361	0.641

Abbreviations: HR: hazard ratio; CI: confidence interval; EPO: erythropoietin; PTH: parathyroid hormone; URR: urea reduction rate; TSAT: transferrin saturation; THb: target hemogblobin.

4. Discussion

Outcomes revealed that achieving THb did not improve sleep quality among HD patients. Moreover, no association was identified between Hb levels and sleep quality index. However, there was a significant association between EPO use and higher PSQI scores.

4.1 Anemia in CKD

Anemia impairs life quality and worsens the mortality rate in dialysis patients [17]. In CKD, anemia primarily results from an absolute or relative deficiency of erythropoietin. Moreover, erythrocyte lifespan is significantly shortened, further exacerbating the anemic state in these patients [18]. Renal anemia is typically an isolated normochromic and normocytic. Several factors—including advanced age, higher BMI, use of renin-angiotensin system blockers, diabetes mellitus, and severe secondary hyperparathyroidism–are associated with higher EPO dosage requirements [19-21].

In our cohort, the mean Hb level was 11.3 g/dL, with target Hb levels achieved in 43 patients (55.1%). Additionally, ongoing EPO therapy was maintained in 53 patients (67.9%). The KDIGO (Kidney Disease: Improving Global Outcomes) guidelines recommend initiating erythropoiesis-stimulating agent therapy in patients undergoing dialysis when Hb levels fall between 9.0 and 10.0 g/dL, aiming to prevent further decline below 9.0 g/dL. Furthermore, it is advised that EPO treatment should not be used to maintain Hb concentrations above 12.0 g/dL in adult CKD patients [22].

In dialysis patients, the goal of anemia treatment is essentially to mitigate related symptoms and reduce the likelihood of a blood transfusion requirement. Most HD patients who have anemia will experience well-being and amelioration in symptoms after treatment, and also this beneficial effect is remarkable in severe anemia. Whether treating anemia also improves clinical endpoints (eg, mortality, morbidity, cardiovascular events, and hospitalizations) is uncertain [23].

The vast majority of HD patients undergo Hb monitorization monthly and also iron parameters monitorization quarterly at dialysis units. The association between anemia and sleep quality in dialysis patients has been examined in many studies previously. However, the results were confusing. Ilescu et al. first reported a negative correlation between Hb level and sleep quality in 89 HD patients [24]. In contrast, forward many studies have not revealed any correlation. Recently, Jamelo et al. also reported that Hb levels did not have a significant association with quality of sleep in 85 HD patients [25].

4.2 Highlights of Current Study

The main difference between the current study and previous studies was focusing on anemia treatment rather than Hb levels. Anemia treatment success, iron status, EPO utilization, EPO dosing, and quantitative Hb level were underscored parameters in this study. Therefore, EPO usage in the last year due to severe anemia (Hb<10 g/dL) was stated as an inclusion criterion in this study.

The average Hb level was 11.2 g/dL in poor sleepers and 11.3 g/dL in non-poor sleepers. We could easily state that anemia treatment was accomplished in both groups. Additionally, blood iron levels and ferritin levels were determined as adequate in both two sleep quality groups. Consequently, sleep quality has not been ameliorated by the accomplishment of THb and adequate iron levels in our outcomes. EPO use was associated with poor sleep quality when considered in the context of potential side effects; however, a causal relationship could not be established. It is important to emphasize that this finding reflects an association rather than a causal link between EPO use and impaired sleep quality.

4.3 EPO Usage and Sleep Disorders

A review of the literature revealed no studies specifically investigating the relationship between EPO use and sleep disorders. Recent studies have shown that EPO receptors are also present in brain tissue. EPO preparations have also been shown to cross the blood-brain barrier. However, numerous questions remain regarding the potential physiological role of EPO within the central nervous system, as well as the factors and environmental conditions that regulate its expression [26]. It may be hypothesized that pharmacological doses of EPO could disrupt sleep patterns by acting through these receptors. The most commonly reported adverse effects associated with EPO therapy include elevated blood pressure, increased risk of thrombosis, allergic reactions, and dermatological side effects. In rare cases, the development of antibodies against exogenous EPO preparations may lead to pure red cell aplasia [27].

Before the availability of EPO, dialysis patients commonly experienced blood transfusions, exposing them to the risks of iron overload, transmission of viral infection, and immunosensitization, which diminished the kidney transplantation success. However, the advent of EPO altered this process completely [14].

In the United States arm of Phase I of the Dialysis Outcomes and Practice Patterns Study (DOPPS), a cohort study was conducted involving 5.517 patients. Patients with Hb levels <11 g/dL demonstrated increased mortality compared to those with Hb levels between 11 and <12 g/dL. These results reinforce the survival advantage associated with maintaining Hb levels ≥11 g/dL in maintenance HD patients, while suggesting no incremental benefit with Hb levels ≥12 g/dL [28].

4.4 Sleep Disorders in Dialysis Patients

Patients undergoing HD frequently experience a range of neuropsychiatric symptoms, which may arise from dialysis procedures, uremia, or comorbidities. Sleep disturbances are among the most prevalent of these symptoms. We identified the frequency of poor sleepers as 59.0% which was consistent with the literature.

Several risk factors are indicated for sleep disorders in HD patients; including senility, dialysis inadequacy, electrolyte imbalances, depression, diabetic neuropathy, and hypervolemia [29,30]. However, any significant association was not identified between poor sleep and age, gender, time underwent HD, Kt/V, URR, PTH, or Hb level in our results.

Tosun et al. did not determine asscociation between dialysis adequacy and sleeep quality in 119 HD paitents. They reported that mean Kt/V was 1.36 ± 0.18 in good sleepers, whereas it was 1.39 ± 0.20 poor sleepers. Similarly, mean URR was 67.6% in good sleepers, whereas it was 69.4% poor sleepers [31].

The high prevalence of sleep disturbances is not unique to dialysis patients. Sleep disorders are also commonly observed in kidney transplant recipients, despite kidney transplantation being considered the most effective form of kidney replacement therapy. In a study involving 872 kidney transplant recipients, 33% of male and 49% of female recipients reported poor sleep quality, rates significantly higher than those observed in age- and sex-matched healthy controls [32].

Notably, the literature shows considerable variation in the reported risk factors for poor sleep quality, with some conflicting results, likely due to the complex pathophysiology of sleep disorders. Also, outcomes are also influenced by social factors. The relationships between age, gender, sedentary lifestyle, marital status, and occupational status with sleep quality in HD patients have been documented in previous studies [5,33].

Several studies have compared sleep quality between peritoneal dialysis (PD) and HD patients. Turkmen et al. reported comparable sleep quality scores between HD and PD patients. Similarly, the study by Holley et al. found no significant differences between HD and PD patients in terms of the frequency or severity of sleep disturbances. However, according to Masoumi et al., undergoing HD was associated with a higher risk of poor sleep quality compared to PD [34,35].

Managing poor sleep quality, a common issue among dialysis patients, remains a significant challenge for clinicians. Various pharmacological agents have been investigated to address this problem, among which melatonin has garnered increasing attention in recent years. Edalat-Nejad and colleagues evaluated the effects of exogenous melatonin administration in HD patients. Their findings demonstrated that melatonin treatment significantly improved global PSQI scores, with notable enhancements in subjective sleep quality, sleep efficiency, and sleep duration This has been associated with the absence of nocturnal increases in melatonin concentration in HD patients and the pharmacological mimicry of this condition [36].

4.5 PSQI Questionnaire

PSQI evaluates several parameters related to sleep, including sleep duration, quality, latency, efficiency, disturbances, medication use, and daytime dysfunction. Only three poor sleepers (3.8%) noticed using sleep medication in this study. Despite the high prevalence of poor sleepers, the number of patients using sleep medication in our cohort was notably low. This situation may be associated with the patients' already high medication burden and territorial factors.

The PSQI survey has a subjective structure and lacks objective assessment, making it a significant factor influencing the outcomes of this study [37]. Eloot et al. have previously reported that objectively measured sleep parameters were not associated with subjective PSQI scores in HD patients. Additionally, they found no correlation between sleep quality and uremic toxicity or comorbidity scores, underscoring the complexity of sleep disorders in this population [38].

5. Limitation of Study

Lacking of evaluation of several clinical entities associated with sleep disorders is a major limitation of this study, such as anxiety, depression, RLS, and social status. These factors could have provided additional insights into the sleep quality of HD patients. Also, incorporating polysomnographic measures of nocturnal sleep would have contributed to a more accurate and objective evaluation of sleep disturbances. As previously stated, the subjective assessment of sleep quality using the PSQI remains a recognized limitation.

6. Conclusion

The current study did not identify a beneficial impact of successful renal anemia treatment on sleep quality among HD patients. Also, EPO utilization were associated with poor sleep quality. However, In addition, our outcomes were in accordance with data on literature. Current findings suggest that the underlying causes of sleep disturbances in this population extend beyond uremia and dialysis-related complications.

Conflicts of Interest

The authors have no conflicts of interest.

Generative AI Statement

The authors declare that no Gen AI was used in the creation of this manuscript.

List of Abbreviations

CKD: chronic kidney disease
EPO: epoetin
ESAs: erythropoiesis-stimulating agents
Hb: hemoglobin
HD: hemodialysis
HIF-PHIs: hypoxia inducible factor prolyl hydroxylase inhibitors
PD: peritoneal dialysis
PSQI: pittsburgh sleep quality index
PTH: parathyroid hormone
RLS: restless leg syndrome
THb: target hemoglobin
TSAT: transferrin saturation
URR: urea reduction rate

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