ORIGINAL ARTICLE

Observational Study

Impact of anxiety symptoms on dialysis adherence and complication rates: A longitudinal observational study

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Abstract

BACKGROUND
Anxiety is a common psychological comorbidity in patients undergoing dialysis, yet its impact on treatment adherence and complication rates remains under-studied. We designed a longitudinal observational study to investigate these relationships, based on the hypothesis that higher anxiety symptoms would be associated with increased complication rates and negatively associated with adherence to the dialysis regimen.

AIM
To investigate the relationship between anxiety symptoms, dialysis adherence, and complication rates in patients undergoing dialysis over a 24-month period.

METHODS
This observational study analyzed data from 250 adult patients who underwent hemodialysis or peritoneal dialysis at three Affiliated Hospitals of Youjiang Medical University for Nationalities over a period of 24 months. Anxiety symptoms were assessed using the Hospital Anxiety and Depression Scale-Anxiety subscale at baseline and every 6 months. Dialysis adherence was evaluated through attendance records, interdialytic weight gain, and patient-reported medication adherence. We recorded complications (infections, cardiova-

scular events, and hospitalizations) and used mixed-effects models and survival analyses to infer associations between anxiety symptoms, adherence measures, and complication rates.

RESULTS
Higher anxiety symptoms were significantly associated with poorer dialysis adherence, including increased missed sessions [incidence rate ratio = 1.32, 95% confidence interval (CI): 1.18-1.47, $P < 0.001$], greater interdialytic weight gain (β = 0.24, 95%CI: 0.15-0.33, $P < 0.001$), and lower medication adherence (odds ratio = 0.85, 95%CI: 0.78-0.93, $P < 0.001$). Patients with clinically significant anxiety (Hospital Anxiety and Depression Scale-Anxiety subscale ≥ 8) had a higher risk of complications [hazard ratio (HR) = 1.68, 95%CI: 1.32-2.14, $P < 0.001$], particularly infections (HR = 1.89, 95%CI: 1.41-2.53, $P < 0.001$) and cardiovascular events (HR = 1.57, 95%CI: 1.18-2.09, $P = 0.002$). The relationship between anxiety and complications was partially mediated by adherence measures.

CONCLUSION
Anxiety symptoms in patients undergoing dialysis are associated with poorer treatment adherence and increased complication rates. Regular screening and targeted interventions to address symptoms may improve adherence and clinical outcomes.

Key Words: Anxiety; Dialysis; Adherence; Complications; End-stage renal disease

Core Tip: This study highlights the significant impact of anxiety symptoms on adherence to treatment and complication rates in patients who undergo dialysis. The findings reveal that higher anxiety is associated with increased missed treatment sessions, greater interdialytic weight gain, and lower adherence to medication. Consequently, anxiety leads to a higher risk of infections, cardiovascular events, and hospitalization. Addressing anxiety through regular screening and targeted interventions could improve adherence and reduce complications, enhancing overall patient outcomes.

INTRODUCTION

End-stage renal disease (ESRD) is a chronic condition affecting millions of people worldwide, and has a considerable impact on the quality of life and long-term health outcomes[1]. Dialysis, either hemodialysis or peritoneal, is a life-sustaining treatment for patients with ESRD. However, the dialysis regimen is complex and demanding, requiring strict adherence to treatment schedules, dietary restrictions, and medication regimens[2]. Psychological comorbidities, particularly anxiety and depression, are prevalent among patients who undergo dialysis treatment[3]. The prevalence of anxiety in this population ranges from 12% to 52%, depending on the assessment method and study population[4]. The high prevalence of anxiety in patients who require dialysis can be attributed to various factors, including stress from chronic illness, fear of complications, lifestyle restrictions, and uncertainty about the future[5]. While the impact of depression on dialysis outcomes has been investigated extensively[6], the specific role of anxiety in dialysis adherence and complication rates remains understudied. Anxiety symptoms may interfere with the patient's ability to adhere to the complex dialysis regimen, potentially leading to adverse health outcomes[7]. Despite this knowledge, the mechanisms through which anxiety affects dialysis adherence and complications are not well understood.

Adherence to dialysis treatment is crucial for optimal outcomes in patients with ESRD. Non-adherence can manifest in various forms, including skipping or shortening dialysis sessions, excessive interdialytic weight gain (IDWG), and poor medication adherence[8]. Previous studies have shown that non-adherence to dialysis is associated with increased morbidity and mortality[9], but the relationship between anxiety symptoms and specific adherence behaviors in patients who receive dialysis has not been thoroughly investigated. Complications are a significant concern in patients undergoing dialysis, contributing to increased healthcare utilization, reduced quality of life, and mortality[10]. Common complications include infections (particularly access-related infections), cardiovascular events, and hospitalizations[11]. While several risk factors for complications have been identified, the potential role of anxiety as a modifiable risk factor has received limited attention.

Understanding the relationship between anxiety symptoms, dialysis adherence, and complication rates is crucial for several reasons. First, it can help identify patients at higher risk of poor outcomes, allowing for targeted interventions. Second, addressing anxiety symptoms may be a modifiable factor to improve adherence and reduce complications. Lastly, elucidating the mechanisms through which anxiety affects outcomes can inform the development of more effective and integrated care approaches for patients. Previous research in this area has been limited by cross-sectional

designs, small sample sizes, and a focus on either adherence or complications, but not both[12,13]. A longitudinal study examining the relationships between anxiety, adherence, and complications over time is needed to provide a more comprehensive understanding of these complex interactions. The primary objective of this study was to investigate the effects of anxiety symptoms on dialysis adherence and complication rates in a cohort of patients undergoing dialysis over a 24-month period. We hypothesized that higher levels of anxiety would be associated with poorer dialysis adherence and increased complication rates. Furthermore, we expected that the relationship between anxiety and complications would be partially mediated by adherence measures.

MATERIALS AND METHODS

Study design and participants

This prospective, longitudinal observational study was conducted at three dialysis centers affiliated with Affiliated Hospital of Youjiang Medical University for Nationalities in Baise, China between January 2021 and December 2022. The study protocol was approved by the Institutional Review Board of Affiliated Hospital of Youjiang Medical University for Nationalities, Baise (approval number: YYFY-LL-2022-241), and all participants provided written informed consent. Eligible participants were adults aged 18 years or older with ESRD who had been on either hemodialysis or peritoneal dialysis for at least 3 months prior to enrollment. The exclusion criteria were as follows: (1) Cognitive impairment that would interfere with the ability to provide informed consent or complete study assessments; (2) Active psychosis or severe mental illness; (3) Terminal illness with life expectancy of less than 6 months; (4) Inability to understand or communicate in the local language; and (5) Planned living donor kidney transplantation within the next 6 months. A total of 250 patients were enrolled in the study. The sample size was determined based on power calculations to detect clinically meaningful associations between anxiety symptoms, adherence measures, and complication rates.

Data collection

Baseline assessment: At enrollment, the participants underwent a comprehensive baseline assessment that included: (1) Demographic information: Age, sex, education level, marital status, and employment status; (2) Clinical characteristics: Dialysis modality, vintage (time on dialysis), primary cause of ESRD, comorbidities, and medications; (3) Laboratory values: Hemoglobin, albumin and phosphate levels, and Kt/V (a measure of dialysis adequacy, where K refers to clearance, t to time, and V to volume); and (4) Psychosocial measures: Social support, assessed using the Multidimensional Scale of Perceived Social Support[14].

Anxiety assessment: Anxiety symptoms were assessed using the Hospital Anxiety and Depression Scale-Anxiety subscale (HADS-A)[15]. HADS-A is a widely used and validated 7-item self-report measure that assesses anxiety symptoms in the previous week. Each item is scored on a 4-point Likert scale (0-3), with total scores ranging from 0 to 21. Higher scores indicate greater anxiety symptoms, with scores ≥ 8 considered indicative of clinically significant anxiety. HADS-A was administered at baseline and every 6 months throughout the 24-month study period, resulting in a total of five anxiety assessments per participant.

Adherence measures: Adherence to dialysis was assessed using multiple measures: (1) Attendance: The number of missed or shortened (by > 10 minutes) dialysis sessions was recorded monthly for the patients in hemodialysis. For the patients undergoing peritoneal dialysis, adherence to the prescribed number of exchanges was documented through self-reports and verified *via* dialysis logs; (2) IDWG: For the patients in hemodialysis, IDWG was calculated as the difference between the pre-dialysis weight and the weight at the end of the previous session, averaged over each month. For the patients in peritoneal dialysis, daily weight fluctuations were recorded and averaged monthly; and (3) Medication adherence: The 8-item Morisky Medication Adherence Scale (MMAS-8)[16] was used to assess self-reported medication adherence at baseline and every 6 months.

Complication assessment: Complications were recorded throughout the study period and categorized as follows: (1) Infections: Access-related infections (such as catheter-related bloodstream infections and peritonitis) and other infections requiring medical attention or hospitalization; (2) Cardiovascular events: Myocardial infarction, stroke, heart failure exacerbation, and other cardiovascular events requiring hospitalization; (3) Hospitalizations: All-cause hospitalizations, excluding scheduled admissions for procedures; and (4) Complications were verified through medical record review and confirmed by the treating nephrologist.

Statistical analysis

All statistical analyses were performed using R version 4.1.0 (R Foundation for Statistical Computing, Vienna, Austria). A two-sided *P*-value < 0.05 was considered to indicate statistical significance. The statistical methods of this study were reviewed by Si-Dan Wang from Affiliated Hospital of Youjiang Medical University for Nationalities.

Descriptive statistics: The baseline characteristics were summarized using mean ± SD for continuous variables, and frequencies and percentages for categorical variables. Changes in anxiety scores over time were examined using repeated-measures ANOVA.

Anxiety and adherence: The association between anxiety symptoms and adherence measures was analyzed using mixed-effects models to account for the repeated measures design. For missed dialysis sessions, a generalized linear mixed

model with a Poisson distribution was used, with the number of missed sessions per month as the outcome. For IDWG, a linear mixed model was employed, with the monthly average IDWG as the outcome. For medication adherence, an ordinal mixed model was used, with MMAS-8 categories as the outcome. All models included anxiety scores as the primary predictor, adjusting for relevant covariates (age, sex, dialysis vintage, comorbidities, and social support). Random intercepts for participants and dialysis centers were included to account for clustering.

Anxiety and complications: The relationship between anxiety symptoms and complication rates was examined using Cox proportional hazards models with time-varying covariates. Separate models were constructed for each complication category (infections, cardiovascular events, and hospitalizations) and all complications. The anxiety scores were treated as a time-varying predictor, updated at each 6-month assessment. The models were adjusted for baseline demographics, clinical characteristics, and time-varying adherence measures.

RESULTS

Participant characteristics

Of the 250 patients enrolled in the study, 235 (94%) completed the 24-month follow-up assessment. The baseline characteristics of the study population are presented in Table 1.

Anxiety symptoms over time

The mean HADS-A score at baseline was 6.8 ± 4.2, with 92 participants (36.8%) meeting the criteria for clinically significant anxiety (HADS-A ≥ 8). Over the 24-month study period, there was a slight overall decrease in anxiety symptoms [$F_{(4, 930)}$ = 3.72, P = 0.005]. The proportion of participants with clinically significant anxiety at each time point was: 36.8% (baseline), 34.4% (6 months), 33.2% (12 months), 31.6% (18 months), and 30.8% (24 months).

Anxiety and adherence to dialysis

Missed dialysis sessions: Higher anxiety symptoms were significantly associated with an increased rate of missed dialysis sessions [incidence rate ratio = 1.32, 95% confidence interval (CI): 1.18-1.47, P < 0.001] (Table 2). For each one-point increase in the HADS-A score, the rate of missed sessions increased by 32%. Patients with clinically significant anxiety had, on average, 2.1 times the rate of missed sessions compared to those without clinically significant anxiety (incidence rate ratio = 2.13, 95%CI: 1.76-2.58, P < 0.001).

Assessment of IDWG: Anxiety symptoms were positively associated with IDWG ($β$ = 0.24, 95%CI: 0.15-0.33, P < 0.001) (Table 2). For each one-point increase in the HADS-A score, IDWG increased by 0.24 kg. Patients with clinically significant anxiety had, on average, 0.78 kg higher IDWG than those without clinically significant anxiety (95%CI: 0.51-1.05, P < 0.001).

Adherence to medication: Higher anxiety symptoms were associated with lower medication adherence, as measured using MMAS-8 (odds ratio = 0.85, 95%CI: 0.78-0.93, P < 0.001) (Table 2). For each one-point increase in the HADS-A score, the odds of being in a higher adherence category decreased by 15%. Patients with clinically significant anxiety had 2.6 times higher odds of being in the low adherence category than those without clinically significant anxiety (odds ratio = 2.62, 95%CI: 1.89-3.64, P < 0.001).

Anxiety and complication rates

Overall complications: Patients with clinically significant anxiety (HADS-A ≥ 8) had a significantly higher risk of experiencing any complication during the study period [hazard ratio (HR) = 1.68, 95%CI: 1.32-2.14, P < 0.001] (Table 3).

Infections: Clinically significant anxiety was associated with an increased risk of infections (HR = 1.89, 95%CI: 1.41-2.53, P < 0.001) (Table 3). The incidence rate of infections was 0.42 per patient-year in those with clinically significant anxiety compared to 0.23 per patient-year in those without.

Cardiovascular events: Patients with clinically significant anxiety had a higher risk of cardiovascular events (HR = 1.57, 95%CI: 1.18-2.09, P = 0.002) (Table 3). The incidence rate of cardiovascular events was 0.31 per patient-year in those with clinically significant anxiety compared to 0.20 per patient-year in those without.

Risk of hospitalization: Clinically significant anxiety was associated with an increased risk of all-cause hospitalization (HR = 1.45, 95%CI: 1.15-1.83, P = 0.002) (Table 3). The incidence rate of hospitalization was 0.89 per patient-year in those with clinically significant anxiety compared to 0.63 per patient-year in those without.

DISCUSSION

This longitudinal observational study provides compelling evidence for the significant impact of anxiety symptoms on dialysis adherence and complication rates in patients with ESRD. Our findings demonstrate that higher levels of anxiety are associated with poorer treatment adherence across multiple domains and an increased risk of infections, cardio-

Table 1 Baseline characteristics of the study participants

Characteristic	Value (*n* = 250)
Age, years (mean ± SD)	58.3 ± 14.7
Sex, *n* (%)	
Male	142 (56.8)
Female	108 (43.2)
Dialysis modality, *n* (%)	
Hemodialysis	187 (74.8)
Peritoneal dialysis	63 (25.2)
Dialysis vintage, months, median (IQR)	36 (18-72)
Primary cause of ESRD, *n* (%)	
Diabetic nephropathy	95 (38.0)
Hypertensive nephrosclerosis	62 (24.8)
Glomerulonephritis	45 (18.0)
Polycystic kidney disease	23 (9.2)
Other/unknown	25 (10.0)
Comorbidities, *n* (%)	
Diabetes mellitus	128 (51.2)
Hypertension	218 (87.2)
Cardiovascular disease	87 (34.8)
Baseline HADS-A score (mean ± SD)	6.8 ± 4.2
Clinically significant anxiety (HADS-A ≥ 8), *n* (%)	92 (36.8)

IQR: Interquartile range; ESRD: End-stage renal disease; HADS-A: Hospital Anxiety and Depression Scale-Anxiety subscale.

Table 2 Association between anxiety symptoms and dialysis adherence measures

Adherence measure	Effect size	95%CI	*P* value
Missed dialysis sessions (IRR)	1.32	1.18-1.47	< 0.001
Interdialytic weight gain (*β*)	0.24	0.15-0.33	< 0.001
Medication adherence (OR)	0.85	0.78-0.93	< 0.001

IRR: Incidence rate ratio; OR: Odds ratio; CI: Confidence interval.

Table 3 Complication rates in patients with and without clinically significant anxiety

Complication	Clinically significant anxiety	No clinically significant anxiety	HR (95%CI)	*P* value
Overall complications	0.89 per patient-year	0.53 per patient-year	1.68 (1.32-2.14)	< 0.001
Infections	0.42 per patient-year	0.23 per patient-year	1.89 (1.41-2.53)	< 0.001
Cardiovascular events	0.31 per patient-year	0.20 per patient-year	1.57 (1.18-2.09)	0.002
Hospitalization	0.89 per patient-year	0.63 per patient-year	1.45 (1.15-1.83)	0.002

HR: Hazard ratio; CI: Confidence interval.

vascular events, and hospitalization. The prevalence of clinically significant anxiety in our cohort (36.8% at baseline) is consistent with previous reports on populations undergoing dialysis[14-17]. The slight decrease in anxiety symptoms over the 24-month study period may reflect adaptation to the dialysis regimen over time or the effects of routine clinical care. Despite this observation, the persistently high prevalence of anxiety underscores the need for ongoing psychological assessment and support in this population.

Our results showed a strong association between anxiety symptoms and various measures of dialysis non-adherence. The 32% increase in missed dialysis sessions for each one-point increase in the HADS-A score is particularly concerning, given the critical importance of regular dialysis treatments for maintaining health in patients with ESRD. Similarly, the positive association between anxiety and IDWG suggests that patients who experience anxiety may have difficulty adhering to fluid restrictions, a crucial aspect of dialysis management[18]. The negative impact of anxiety on medication adherence is consistent with findings in other populations with chronic disease[19]. Poor medication adherence in patients who receive dialysis treatment can lead to inadequate control of comorbid conditions, electrolyte imbalances, and increased risk of complications[20]. Our findings highlight the need to address anxiety as a potential barrier to medication adherence in this population.

The observed association between anxiety and increased complication rates is particularly noteworthy. The 68% higher risk of overall complications in patients with clinically significant anxiety underscores the clinical significance of anxiety symptoms in patients in dialysis. The strongest association was observed for infections, with patients with anxiety having nearly twice the risk of developing infectious complications. This finding may be related to the known effects of chronic stress and anxiety on immune function[21], as well as potential behavioral factors such as poor adherence to hygiene practices or delayed reporting of symptoms.

The increased risk of cardiovascular events in patients with high anxiety burden is consistent with the growing body of evidence linking psychological distress to cardiovascular outcomes in various populations[22]. In dialysis, patients who are already at a high risk for cardiovascular disease, anxiety may represent an additional modifiable risk factor that warrants attention. The higher rate of hospitalization among patients with anxiety likely reflects the cumulative impact of poor adherence and increased complications. Frequent hospitalizations not only affect the patients' quality of life but also contribute significantly to healthcare costs in the population with ESRD[23].

Several limitations of our study should be acknowledged. First, while the longitudinal design allows for temporal associations to be established, causality cannot be definitively inferred. Second, reliance on self-reported measures for some variables, particularly adherence to medication, may be subject to recall bias or social desirability effects. Third, while we adjusted for several potential confounders, residual confounding due to unmeasured factors cannot be ruled out. Lastly, our study was conducted in a single geographical region, which may limit the generalizability of our findings to other settings or populations. Despite these limitations, our study has several strengths, including its longitudinal design, comprehensive assessment of both adherence and complications, and use of validated measures of anxiety and adherence. The inclusion of both patients in hemodialysis and peritoneal dialysis enhances the generalizability of our findings to the broader population with ESRD demonstrates that anxiety symptoms in patients in dialysis are associated with poorer treatment adherence and increased rates of infections, cardiovascular events, and hospitalizations.

CONCLUSION

Regular screening for anxiety symptoms and targeted interventions to address high anxiety levels may improve adherence and clinical outcomes in this vulnerable population.

FOOTNOTES

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