

Prevalence and clinical correlates of high risk for obstructive sleep apnea in kidney transplant recipients: a cross-sectional study using the Berlin Questionnaire

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Background

Obstructive sleep apnea (OSA) is increasingly recognized as a common comorbidity among kidney transplant recipients, yet it remains underdiagnosed in this population. Persistent metabolic abnormalities, weight gain following transplantation, and immunosuppressive therapy may contribute to ongoing sleep-disordered breathing despite restoration of renal function. This study aimed to evaluate the prevalence of high risk for OSA among kidney transplant recipients using the Berlin Questionnaire and to identify clinical and demographic factors associated with this risk.

Patients and methods

In this cross-sectional study, 85 kidney transplant recipients attending the Hamed Alessa Organ Transplant Center in Kuwait, were assessed using the validated Arabic version of the Berlin Questionnaire. Demographic data, comorbid conditions, BMI, immunosuppressive regimens, and renal function parameters (serum creatinine at baseline and most recent follow-up) were collected. Associations between high-risk status and clinical variables were analyzed using χ^2 tests, independent *t* tests, and crude odds ratios.

Results

Of 85 participants, 34 (40%) were classified as high risk for OSA. Female sex was significantly more prevalent in the high-risk group (44.1 vs. 23.5% in the low-risk group, $P = 0.04$). High-risk status was significantly associated with graft failure: nine (90%) of 10 graft failure cases occurred in the high-risk group (crude odds ratio = 18.0, 95% confidence interval: 2.2–149.7, $P = 0.001$). Patients at high risk had higher BMI at last follow-up (35.6 ± 6.7 vs. 26.5 ± 7.2 kg/m², $P = 0.009$) and higher most recent serum creatinine levels (283.8 ± 29.8 vs. 149.7 ± 25.4 μ mol/l, $P = 0.008$). Cyclosporine-based immunosuppression was more common in the high-risk group (35.3 vs. 15.6%, $P = 0.03$), and triglyceride levels were significantly elevated in this group (5.2 ± 0.2 vs. 1.9 ± 0.4 mmol/l, $P = 0.001$). No significant associations were observed between high-risk status and age, smoking, diabetes mellitus, hypertension, or ischemic heart disease in this cohort.

Conclusions

High risk for OSA, as assessed by the Berlin Questionnaire, is prevalent among kidney transplant recipients and is associated with adverse graft outcomes, higher BMI, and cyclosporine-based immunosuppression. These findings are hypothesis-generating and support the need for routine screening for high risk of OSA in transplant populations. Prospective studies using polysomnography are needed to confirm these associations and evaluate whether OSA treatment improves graft and cardiovascular outcomes.

Keywords:

berlin Questionnaire, graft outcome, kidney transplantation, obstructive sleep apnea, sleep-disordered breathing

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Introduction

Obstructive sleep apnea (OSA) is a chronic sleep-related breathing disorder characterized by recurrent partial or complete collapse of the upper airway during sleep, leading to intermittent hypoxemia, sympathetic nervous system activation, sleep fragmentation, and systemic inflammation [1,2]. These physiological disturbances have been linked to adverse cardiovascular and metabolic outcomes in susceptible populations [2].

Individuals with chronic kidney disease and kidney transplant recipients share a high burden of traditional cardiometabolic risk factors, including hypertension, diabetes mellitus, and obesity – conditions that independently increase the risk of OSA [3]. Although

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kidney transplantation alleviates many uremic symptoms and corrects fluid imbalances, sleep disorders, including OSA, remain prevalent after transplantation. Persistent metabolic abnormalities, weight gain (often related to corticosteroid use and improved appetite), and the direct or indirect effects of immunosuppressive medications may contribute to ongoing sleep-disordered breathing [4,5].

Recent evidence suggests that sleep disturbances and high risk for OSA persist in transplant recipients at rates significantly exceeding those observed in the general population [5]. Intermittent hypoxia and sleep fragmentation can activate the sympathetic nervous system, promote endothelial dysfunction, exacerbate metabolic dysregulation, and activate the renin-angiotensin system – all of which may compromise renal perfusion and graft health [1,2]. Observational data indicate that poor sleep quality and high risk for OSA may correlate with declining renal function even after successful transplantation, highlighting the clinical importance of identifying at-risk individuals [4,5].

Screening tools such as the Berlin Questionnaire offer a practical, cost-effective approach for identifying patients at high risk for OSA in clinical settings where polysomnography is not routinely feasible [6]. The Berlin Questionnaire has been validated in multiple languages, including Arabic [7], and assesses three domains: snoring and witnessed apnea, daytime sleepiness and fatigue, and hypertension or obesity. Applying validated screening instruments allows clinicians to detect individuals at high risk, examine associations with comorbid conditions and graft function, and prioritize patients for further diagnostic assessment or intervention.

This cross-sectional study aimed to evaluate the prevalence of high risk for OSA among kidney transplant recipients using the Berlin Questionnaire and to identify clinical, demographic, and transplant-related factors associated with this risk, including potential associations with graft outcomes.

Patients and methods

Study design and setting

This cross-sectional study was conducted at the Kuwait Center for Nephrology and Kidney Transplantation in Kuwait between October 2025 and March 2026. The center is Kuwait's National Referral Center for Kidney Transplantation.

Ethical approval

The study protocol was approved by the Kuwait Ministry of Health Ethical Committee

(Approval No. 1660/2021). Written informed consent was obtained from all participants before enrollment, in accordance with the principles of the Declaration of Helsinki [8].

Study population

A total of 85 adult kidney transplant recipients attending the outpatient transplant clinic during the study period were consecutively enrolled. Inclusion criteria were: (a) age more than 18 years, (b) functioning kidney graft for at least 6 months, and (c) regular follow-up at the study center. Exclusion criteria were: (a) refusal to participate, (b) inability to complete the questionnaire due to cognitive or language barriers, and (c) acute graft rejection or hospitalization within the preceding month.

Data collection

Data were collected through face-to-face interviews conducted in the outpatient clinic using a structured data collection sheet. The validated Arabic version of the Berlin Questionnaire was administered by the interviewer to assess the risk of OSA [7,9]. The Berlin Questionnaire classifies patients as low risk or high risk for OSA based on responses in three categories: Category 1 (snoring and apnea), Category 2 (daytime sleepiness and fatigue), and Category 3 (hypertension or obesity). Patients scoring positive in two or more categories are classified as high risk [9].

The collected data included:

- (1) Demographic characteristics: age and sex.
- (2) Clinical variables: smoking status (current or former smoker vs. never smoker), comorbidities including hypertension, diabetes mellitus, and ischemic heart disease.
- (3) Transplant-related parameters: time since transplantation, immunosuppressive regimen (categorized as cyclosporine-based or tacrolimus-based).
- (4) Anthropometric measurements: BMI calculated as weight in kilograms divided by height in meters squared (kg/m^2), recorded at pretransplant assessment and at the most recent follow-up visit.
- (5) Blood pressure: measured at the time of assessment following standard clinical practice guidelines [10].
- (6) Laboratory parameters: serum creatinine ($\mu\text{mol}/\text{l}$) from electronic medical records; baseline creatinine defined as the lowest stable serum creatinine value recorded within the first 3 months posttransplantation; most recent creatinine taken from the latest outpatient measurement in 2025.
- (7) Lipid profile: total cholesterol and triglycerides (mmol/l) from the most recent laboratory assessment.

Outcome definitions

- (1) High risk for OSA: defined as a positive Berlin Questionnaire (two or more positive categories) [9].
- (2) Graft failure: defined as return to maintenance dialysis or need for repeat kidney transplantation [11].
- (3) Impaired graft function: defined as serum creatinine elevated above the normal reference range ($\geq 115 \mu\text{mol/l}$ for adults) without meeting criteria for graft failure [11]

Statistical analysis

Data were analyzed using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, New York, USA). Normality of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed continuous variables were expressed as mean $\pm$ SD and compared between low-risk and high-risk groups using independent samples *t* tests. Categorical variables were presented as frequencies and percentages and compared using the χ^2 test or Fisher's exact test, as appropriate.

Crude odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate the strength of association between high-risk status and graft failure. Given the limited number of graft failure events ($n = 10$), multivariable logistic regression was not performed to avoid model overfitting (rule of thumb requiring at least 10 events per predictor variable).

All statistical tests were two-tailed, and a *P* value less than 0.05 was considered statistically significant. No adjustment was made for multiple comparisons, and findings should be interpreted as exploratory.

Results

Study population

A total of 85 kidney transplant recipients were included in the analysis. The mean age of the study population was 57.1 ± 8.1 years. The cohort included 58 (68.2%) males and 27 (31.8%) females. Based on the Berlin Questionnaire, 51 (60.0%) patients were classified as low risk for OSA, and 34 (40.0%) patients were classified as high risk for OSA.

Demographic characteristics

There was no significant difference in mean age between the low-risk and high-risk groups (57.2 ± 8.7 vs. 57.0 ± 7.8 years, $P = 0.88$). Age at transplantation also did not differ significantly between groups (37.9 ± 15.9 vs. 43.4 ± 13.8 years, $P = 0.14$).

Sex distribution differed significantly between groups ($P = 0.04$). Among males ($n = 58$), 39 (67.2%) were classified as low risk and 19 (32.8%) as high risk. Among females ($n = 27$), 12 (44.4%) were low risk, and 15 (55.6%) were high risk. Thus, females were disproportionately represented in the high-risk group. Moreover, we found no significant differences between the low-risk and high-risk groups with respect to donor type or transplant vintage ($P > 0.05$).

Comorbidities and lifestyle factors

No statistically significant associations were observed between high-risk status and smoking ($P = 0.33$), diabetes mellitus ($P = 0.29$), hypertension ($P = 0.43$), or ischemic heart disease ($P = 0.90$). The high baseline prevalence of hypertension (81.2% overall) and diabetes mellitus (51.8% overall) in this transplant population may have limited the discriminatory value of these variables.

Immunosuppressive regimen

A statistically significant association was observed between immunosuppressive regimen and OSA risk ($P = 0.03$). Among patients in the high-risk group, 12 (35.3%) were receiving cyclosporine-based immunosuppression compared to eight (15.6%) in the low-risk group. Conversely, tacrolimus-based regimens were more common in the low-risk group (84.4 vs. 64.7%). This association should be interpreted cautiously due to potential confounding by transplant era and vintage.

Anthropometric measures

Both pretransplant and most recent BMI were significantly higher in the high-risk group compared to the low-risk group. Pretransplant BMI was $29.8 \pm 3.9 \text{ kg/m}^2$ in the high-risk group versus $26.4 \pm 4.7 \text{ kg/m}^2$ in the low-risk group ($P = 0.03$). At last follow-up, the difference was more pronounced: 35.6 ± 6.7 versus $26.5 \pm 7.2 \text{ kg/m}^2$ ($P = 0.009$). These findings indicate substantial weight gain posttransplantation, particularly among high-risk individuals.

Blood pressure did not differ significantly between groups for either systolic (136.6 ± 26.9 vs. $133.2 \pm 15.6 \text{ mmHg}$, $P = 0.48$) or diastolic (83.4 ± 7.9 vs. $80.4 \pm 10.3 \text{ mmHg}$, $P = 0.15$) measurements.

Renal function and metabolic profile

Baseline serum creatinine (measured within 3 months posttransplant) did not differ significantly between groups (76.3 ± 4.6 vs. $54.1 \pm 1.4 \mu\text{mol/l}$,

$P = 0.25$). However, the most recent serum creatinine was significantly higher in the high-risk group (283.8 ± 29.8 vs. 149.7 ± 25.4 $\mu\text{mol/l}$, $P = 0.008$), indicating worse graft function in patients at high risk for OSA. Triglyceride levels were significantly higher in the high-risk group compared to the low-risk group (5.2 ± 0.2 vs. 1.9 ± 0.4 mmol/l , $P = 0.001$). Total cholesterol levels did not differ significantly between groups (4.2 ± 0.8 vs. 3.7 ± 0.6 mmol/l , $P = 0.08$).

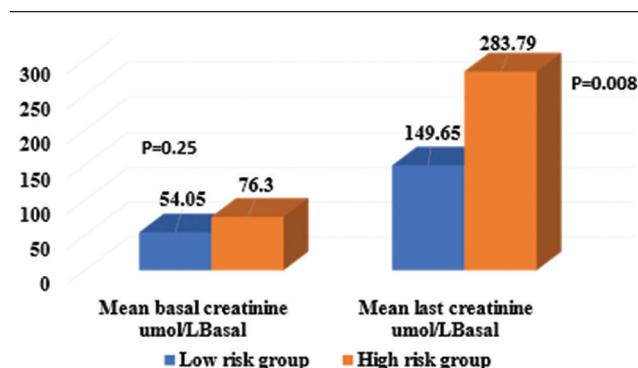
Graft outcomes

Graft outcome distribution differed significantly between the two groups ($P = 0.001$). Among the 10 patients with graft failure, nine (90.0%) were in the high-risk group after being considered as high risk for OSA, while only one (10.0%) was in the low-risk group. Normal graft function was present in 31 (60.8%) of 51 low-risk patients and 20 (58.9%) of 34 high-risk patients. Impaired graft function (elevated creatinine without dialysis requirement) was more common in the low-risk group (19/51, 37.3%) than in the high-risk group (5/34, 14.7%). The crude OR for graft failure among high-risk patients compared to low-risk patients was 18.0 (95% CI: 2.2–149.7, $P < 0.01$). This wide CI reflects the small number of graft failure events and should be interpreted with appropriate caution (Table 1 and Figs. 1 and 2).

Discussion

In this cross-sectional study of 85 kidney transplant recipients, 40% were classified as high risk for OSA using the validated Arabic version of the Berlin Questionnaire. This prevalence estimate aligns with prior screening-based studies that have demonstrated a high burden of sleep-disordered breathing in kidney transplant populations, likely attributable to persistent metabolic risk factors, posttransplant weight gain, and the residual effects of immunosuppressive therapy [3,4].

Figure 1



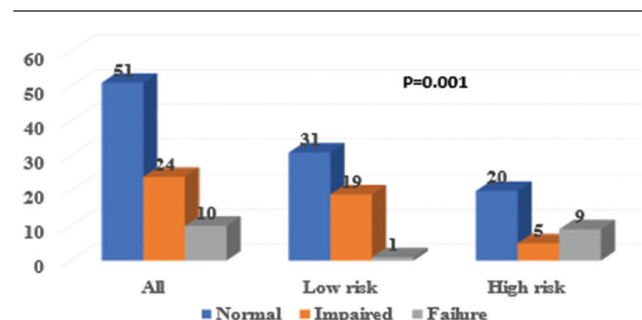
Graft function as represented by serum creatinine in the two groups.

The most striking finding of this study was the strong association between high-risk status and graft failure. Nine of 10 graft failure cases occurred in the high-risk group, with a crude OR of 18.0. While similar associations between OSA and adverse renal outcomes have been demonstrated in chronic kidney disease populations – where intermittent hypoxia promotes oxidative stress, endothelial dysfunction, and renin–angiotensin system activation, ultimately accelerating renal injury [12,13] – data in transplant recipients remain limited. These findings support the hypothesis that OSA may represent a modifiable, nonimmunological contributor to graft dysfunction. However, given the cross-sectional design and lack of multivariable adjustment, this association should be interpreted as hypothesis-generating rather than confirmatory.

Interestingly, female sex was more prevalent in the high-risk group, contrary to the well-established male predominance of OSA reported in community-based epidemiological studies [14]. Several explanations may account for this finding. First, the Berlin Questionnaire may have differential performance by sex, as women tend to report symptoms such as fatigue and insomnia more readily than the classic snoring and witnessed apnea that are more common in men. Second, posttransplant weight gain and hormonal factors may differentially influence OSA risk in female recipients. Third, this finding may reflect a true biological difference in this specific population, which warrants further investigation.

Consistent with existing literature, BMI was significantly higher among high-risk patients at both pretransplant and most recent assessments. Obesity is a central driver of OSA pathophysiology through mechanical upper airway narrowing, reduced pharyngeal neuromuscular control, and increased inflammatory burden [4]. In kidney transplant recipients, weight gain following transplantation – often related to corticosteroid use, improved appetite after uremia correction, and lifestyle changes – has been identified as a key determinant

Figure 2



Graft outcome in the studied groups.

Table 1 Comparison of demographic, clinical, laboratory, and transplant characteristics between low-risk and high-risk groups

Variables	All studied patients (n=85) n (%)	OSA group		P
		Low risk (n=51) n (%)	High risk (n=34) n (%)	
Sex				
Male	58 (68.2)	39 (76.5)	19 (55.9)	0.04
Female	27 (31.8)	12 (23.5)	15 (44.1)	
Age (years)				
Age at transplant	39.84±15.3	37.86±15.9	43.36±13.82	0.14
Age at last follow-up	57.08±8.11	57.22±8.68	57.01±7.84	0.88
Smoking				
Nonsmoker	27 (31.8)	13 (25.5)	14 (41.2)	0.33
Smoker	58 (68.2)	38 (74.5)	20 (58.8)	
Donor type				
Live related	26 (30.6)	11 (21.6)	17 (50)	0.026
Live unrelated	39 (45.9)	24 (47)	13 (38.3)	
Cadaver	20 (23.5)	16 (31.4)	4 (11.7)	
IHD				
Absent	45 (52.9)	28 (54.9)	19 (55.8)	0.9
Present	40 (47.1)	23 (45.1)	15 (44.1)	
DM				
Absent	41 (48.2)	27 (52.9)	14 (41.2)	0.29
Present	44 (51.8)	24 (47.1)	20 (58.8)	
HTN				
Absent	16 (18.8)	11 (21.6)	5 (14.7)	0.43
Present	69 (81.2)	40 (78.4)	29 (85.3)	
Mean HLA mismatch	3.2±1.6	3.32±1.5	2.5±1.7	0.088
Immunosuppression				
Induction				
None	4	4	0	0.44
Basilixmab	29	16	13	
Thymoglobulin	32	3	11	0.03
Maintenance				
CsA based	20 (23.5)	8 (15.6)	12 (35.3)	
Tacrolimus based	65 (76.5)	43 (84.3)	22 (64.7)	
Immediate graft function				
Immediate	64 (75.3)	34 (66.7)	29 (85.3)	0.11
Slow graft function	16 (18.8)	12 (23.5)	4 (11.8)	
Delayed graft function	5 (5.9)	5 (9.8)	1 (2.9)	
Serum creatinine (μmol/l)				
Mean±SD	62.9±3.1	54.05±1.4	76.3±4.6	0.25
Basal	204.6±26.4	149.65±25.43	283.79±29.81	0.008
Last follow-up				
Last follow-up eGFR	35 ml/min/1.73 m ²	47 ml/min/1.73 m ²	25 ml/min/1.73 m ²	0.007
Mean proteinuria (g/day)	0.145±0.22	0.145±0.22	0.147±0.22	0.97
BMI (mean±SD)				
Pretransplant	28.1±4.6	26.4±4.7	29.8±3.9	0.03
Last BMI	28.14±7.26	26.5±7.18	35.6±6.7	0.009
Systolic BP				
Mean±SD	135.3±22.8	133.17±15.6	136.6±26.9	0.48
Diastolic BP				
Mean±SD	82.15±9.1	80.44±10.25	83.4±7.93	0.15
Triglycerides (mmol/l)				
Mean±SD	3.5±0.3	1.9±0.4	5.2±0.2	0.001
Cholesterol (mmol/l)				
Mean±SD	4.14±0.7	3.7±0.6	4.2±0.8	0.08
Mean rejection episodes	1.17±1.33	1.43±0.97	0.8±1.7	0.044
Graft outcome				
Normal	51 (60)	31 (60.8)	20 (58.9)	0.001
Impaired	24 (28.2)	19 (37.3)	5 (14.7)	
Failure	10 (11.8)	1 (1.9)	9 (26.4)	

BP, blood pressure; OSA, obstructive sleep apnea.

of persistent or worsening OSA [3]. These findings reinforce the importance of weight management as a potential therapeutic target in this population.

Patients at high risk for OSA had significantly higher most recent serum creatinine levels compared to low-risk patients, indicating worse graft function. This observation is consistent with growing evidence of a bidirectional relationship between high risk for OSA and kidney disease. OSA may contribute to renal injury through chronic intermittent hypoxia, sympathetic overactivity, systemic inflammation, and endothelial dysfunction [12]. Conversely, declining kidney function can exacerbate fluid shifts to the upper airway during recumbency, worsening airway obstruction and creating a vicious cycle [13]. Such interactions may be particularly relevant in transplant recipients with marginal or declining graft function.

The observed association between cyclosporine use and high-risk status is noteworthy. Within the high-risk group, 35.3% of patients were on cyclosporine-based therapy compared to 15.6% in the low-risk group ($P = 0.03$). While direct evidence linking specific immunosuppressive agents to OSA is limited, cyclosporine has been associated with hypertension, neurohormonal activation, weight gain, and metabolic disturbances—all of which could indirectly increase OSA risk [11]. However, this finding should be interpreted cautiously. Cyclosporine is an older agent, and patients maintained on cyclosporine may differ systematically from those on tacrolimus in ways not captured in this analysis, including transplant vintage, prior rejection episodes, and overall comorbidity burden. Residual confounding cannot be excluded, and this association should be considered hypothesis-generating.

No significant associations were identified between high-risk status and either diabetes mellitus or hypertension. This finding diverges from the established literature, in which both conditions are strongly and consistently linked to OSA [4]. The most plausible explanation is the high baseline prevalence of these comorbidities in this transplant population (hypertension 81.2%, diabetes 51.8%), which reduces their discriminatory value in cross-sectional analyses. Additionally, hypertension is often well-controlled in transplant recipients, and blood pressure measurements at a single time point may not reflect the long-term exposure relevant to OSA pathogenesis.

Triglyceride levels were significantly higher in the high-risk group, consistent with prior studies linking OSA to dyslipidemia and metabolic dysfunction. Intermittent hypoxia has been shown to alter lipid metabolism, promote hepatic steatosis, and contribute to an atherogenic lipid profile [12]. This finding is

particularly relevant in transplant recipients, who already carry a high burden of cardiovascular morbidity.

This study has several strengths. First, it addresses an under-recognized clinical problem in a vulnerable population. Second, the use of a validated Arabic version of the Berlin Questionnaire enhances the reliability of risk assessment in the studied population. Third, the study evaluates clinically meaningful outcomes, including graft function and graft failure, which have not been extensively examined in screening-based high-risk OSA research in transplant recipients.

Limitations

Several limitations warrant acknowledgment.

Cross-sectional design: the cross-sectional design precludes any causal inference. The observed associations between high-risk status and graft failure, elevated creatinine, and other variables could reflect OSA contributing to graft dysfunction, OSA worsening graft function, or both. Findings should be interpreted as hypothesis-generating.

Screening, not diagnosis: OSA risk was assessed using the Berlin Questionnaire, a validated screening tool, rather than by polysomnography—the gold-standard diagnostic method. While appropriate for epidemiological and screening studies, some degree of misclassification cannot be excluded. The Berlin Questionnaire has not been specifically validated in kidney transplant populations.

Sample size and event count: although the overall sample size ($n = 85$) was adequate for exploratory analyses, the small number of graft failure events ($n = 10$) limited statistical power for subgroup analyses and precluded multivariable regression, as evidenced by the wide CI for the graft failure OR (95% CI: 2.2–149.7).

Unadjusted analyses: the analysis was based on crude associations without adjustment for potential confounders such as BMI, age, transplant vintage, or comorbidities. Residual confounding cannot be ruled out. The absence of multivariable adjustment is a significant limitation.

Single center: the study was conducted at a single national referral center, which may limit generalizability to other populations with different demographic characteristics, immunosuppressive practices, and obesity prevalence.

Conclusions

High risk for OSA, as assessed by the Berlin Questionnaire, is prevalent among kidney transplant

recipients, affecting 40% of this cohort. High-risk status was significantly associated with graft failure, higher BMI, elevated serum creatinine, cyclosporine-based immunosuppression, and hypertriglyceridemia. These findings are hypothesis-generating and suggest that screening for OSA risk may identify a subset of transplant recipients at increased risk for adverse outcomes.

Future research should focus on larger, multicenter prospective studies that incorporate objective diagnostic tools such as polysomnography to establish the true prevalence of OSA in this population. Longitudinal studies with multivariable adjustment are needed to determine whether OSA independently predicts graft failure or whether the association is explained by confounding factors. Most importantly, interventional studies are required to evaluate whether treatment of OSA – particularly with continuous positive airway pressure – can improve graft survival, slow decline in renal function, and reduce cardiovascular morbidity in kidney transplant recipients.

In the meantime, given the high prevalence and potential clinical significance, clinicians should maintain a low threshold for screening kidney transplant recipients for OSA risk, particularly those with obesity, weight gain, or declining graft function.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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