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High prevalence of patients with a high risk for obstructive sleep apnoea syndrome after kidney transplantation—association with declining renal function

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Abstract

Background. Obstructive sleep apnoea syndrome (OSAS) is much more prevalent in patients on dialysis than in the general population. Our aim was to assess for the first time the prevalence of patients with a high risk for OSAS and its clinical correlates in a large sample of kidney transplanted patients. We also wanted to compare the prevalence of the disorder between waitlisted dialysis patients (WL) and kidney transplanted patients (Tx).

Methods. One thousand sixty-seven kidney transplanted patients were asked to participate in a cross-sectional survey ('TransQoL-HU Study'). Socio-demographic data, history of renal disease, medication, comorbidity and laboratory parameters were collected at enrolment. Patients completed a battery of self-administered questionnaires including the Berlin Sleep Apnoea Questionnaire to assess risk status of OSAS.

Results. The final analyses included 841 Tx and 175 WL patients. The prevalence of high risk for OSAS was similar in the transplanted group *vs* WL patients (27% *vs* 33%). In multivariate logistic regression analysis male gender, older age, lower educational status, worse kidney function, use of hypnotic drugs and comorbidity were independent predictors for high risk of OSAS in kidney transplanted patients.

Conclusions. High risk for sleep apnoea is highly prevalent in the kidney transplanted population. In addition to the well-known risk factors of OSAS (male gender, obesity, use of hypnotic drugs, comorbidity), impaired kidney function was also independently associated with high risk for OSAS.

Keywords: chronic kidney disease; dialysis; kidney transplantation; obstructive sleep apnoea syndrome; waiting list for transplantation

Introduction

Obstructive sleep apnoea syndrome (OSAS) is characterized by disordered breathing during sleep resulting in symptoms such as snoring, morning headaches, restless sleep, frequent arousals, mood changes and daytime sleepiness [1].

The prevalence of OSAS is 2–4% in the general population. The prevalence of sleep-disordered breathing is significantly higher in men than in women and the disorder is associated with impaired quality of life [2]. Previous studies showed a high prevalence of OSAS (16–54%) in patients with chronic kidney disease (CKD) [3]. The prevalence of the disorder in CKD patients not yet requiring renal replacement was 54% and the apnoea–hypopnoea index (AHI) was correlated with renal function [4]. In a recent study, Chen *et al*. screened more than 700 dialysed patients using the Berlin Sleep Apnoea Questionnaire. In that survey, 20% of the patients were at high risk for OSAS [5]. Nocturnal haemodialysis that provides superb blood purification, significantly reduced the prevalence of OSAS compared with conventional dialysis, suggesting that uraemia-related factors may play a role in the pathogenesis of CKD associated OSAS [6].

In addition to the symptoms described earlier, nocturnal hypoxaemia predicts cardiovascular events

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in dialysed patients [7]. There is substantial evidence suggesting an association between the presence of OSAS and stroke, hypertension, diabetes mellitus, congestive hearth failure, arrhythmias and the metabolic syndrome [8,9]. Similarly, for patients on chronic dialysis, cardiovascular disease is the leading cause of death in the kidney transplanted population [10]. It is, therefore, conceivable that the presence of OSAS is an important cardiovascular risk factor in kidney transplanted patients (Tx). Despite the potential clinical impact, there is an almost complete lack of information about OSAS in kidney transplanted patients. The first case study was published in 1993 presenting two patients with OSAS which disappeared after kidney transplantation [11]. In 1999, Auckley *et al*. reported a similar case [12]. We are not aware of any published study assessing the prevalence and correlates of OSAS in kidney transplanted patient populations.

In this cross-sectional study we set out to describe the prevalence and clinical correlates of high risk for OSAS in a large sample of kidney transplanted patients. We hypothesized that declining renal function is associated with an increasing prevalence of high risk for OSAS. Furthermore, we expected that a high risk for OSAS would be less prevalent in Tx *vs* dialysis patients. To confirm this, we compared the prevalence of high risk for OSAS directly between transplanted and waitlisted dialysis patients (WL).

Subjects and methods

Sample of patients and data collection

All patients (Tx) 18 years or older ($n = 1067$) who were regularly followed at a single outpatient transplant centre at the Department of Transplantation and Surgery at the Semmelweis University, Budapest, were approached to participate in a cross-sectional study assessing sleep and mood disorders as well as health-related quality of life in renal transplant recipients ('TransQoL-HU Study' [13–15]). All patients had received their renal transplant between 1977 and 2002. Furthermore, the study included all WL receiving dialysis in Budapest (listed with the above transplant centre). We visited all the nine centres in Budapest and asked all waitlisted patients to participate ($n = 214$).

Demographic information and details of medical history were collected at enrolment, when information about age, gender, level of education, aetiology of CKD, the presence or absence of diabetes and other comorbidities were obtained. The patients completed a battery of validated questionnaires, that included the Berlin Sleep Apnea Questionnaire during the dialysis sessions or while waiting for their regular follow-up visit at the transplant centre.

Laboratory data were extracted from the patients' charts and from the electronic laboratory databases at the hospitals. The following laboratory parameters were tabulated: serum haemoglobin, serum C-reactive protein (CRP), serum creatinine, blood urea nitrogen (BUN), serum albumin. Estimated glomerular filtration rate (eGFR) was calculated using the abbreviated Modification of Diet in Renal Disease (MDRD) study formula:

$$\mathrm{eGFR(ml/\,min./1.73m^2)} = 186 \times (S_{Cr})^{-1.154}(\mathrm{Age})^{-0.203} \quad (\times 0.742 \text{ if female}).$$

Based on the eGFR, patients were classified into groups corresponding to CKD stages suggested by the Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines: group 1: eGFR $\geq$60 ml/min./1.73 m^2 ($\geq$1 ml/sec./1.73 m^2); group 2: eGFR 30–59 ml/min./1.73 m^2 (0.5–1 ml/sec./1.73 m^2); group 3: eGFR 15–29 ml/min./1.73 m^2 (0.25–1 ml/sec./1.73 m^2); group 4: eGFR $<$15 ml/min./1.73 m^2 ($<$0.25 ml/sec./1.73 m^2).

Transplant-and dialysis-related data extracted from the medical records included the following information: medications (including current immunosuppressive medications), hypnotic drug use, single-pool (sp) Kt/V, 'vintage', i.e. time elapsed since the transplant (transplant vintage) or since starting dialysis treatment (dialysis vintage). Time elapsed since the initiation of the first treatment for end-stage renal disease (ESRD) (cumulative ESRD time) was also calculated.

The study has been approved by the Ethics Committee of the Semmelweis University. Before enrolment, patients received detailed written and verbal information regarding the aims and protocol of the study and signed informed consent.

Assessment of obstructive sleep apnoea syndrome

The risk status for OSAS was assessed by using the Berlin Sleep Apnea Questionnaire [16]. This questionnaire is a self-administered tool which includes 10 questions regarding the most frequent clinical symptoms and consequences of OSAS. This instrument consists of three major domains. Questions in the first domain were associated with snoring behaviour and the presence of apnoea. The second domain relates to the consequences of the apnoea and the third domain assesses hypertension or abnormally high body mass index (BMI) ($>$30 kg/m^2). In dialysed patients, the 'dry weight' was used to calculate BMI. The questionnaire has been validated against polysomnography in the primary care population, and has been shown to be a reliable tool for screening for sleep apnoea with a positive predictive value being 89% [16]. The validation study of the Berlin Questionnaire against polysomnography in uraemic patients is lacking.

An individual is considered 'high risk' for OSAS if two of the three main domains are positive. If two or more of these domains are negative, the patient is classified as 'low risk'. Accordingly, the terms such as 'presence of OSAS' or 'without OSAS' in this paper should be interpreted as 'high risk' or 'low risk' for OSAS. If the questionnaire was not filled out completely or the patient did not follow the directions, the scale was not scored and the data was considered missing.

Self-reported comorbidity

Information on the presence or absence of comorbid conditions was obtained from the patients. Patients were asked at enrolment if they suffered from conditions (heart disease, cerebrovascular disease, peripheral vascular

Table 1. Patient characteristics

	Transplanted (Tx) patients ($n = 841$)	Waitlisted (WL) patients ($n = 175$)	*P* value
Prevalence of high risk of OSAS: % (Number of 'high risk' patients/Number of participant patients)	27 (231/841)	33 (58/175)	0.079
Male (%)	59	61	NS
Age (mean ± SD) (years)	49 ± 13	48 ± 13	NS
Level of education (%):			NS
Primary education or less	18	19	
Skilled workers	28	26	
High school or equivalent	32	35	
University diploma	22	20	
BMI (mean ± SD) (kg/m^2)	25 ± 4	26 ± 5	NS
Diabetes (%)	17	18	NS
Number of comorbid conditions (median; min–max)	2 (0–7)	2 (0–6)	NS
Serum haemoglobin (mean ± SD) (g/dl)	13.2 ± 1.9	11.2 ± 1.6	<0.001
Serum albumin (mean ± SD) (g/dl)	4.15 ± 0.34	4.08 ± 0.43	0.055
Serum CRP (median; IQR) (mg/l)	3; 6	5; 8	<0.001
eGFR (mean ± SD) (ml/min./1.73 m^2)	49 ± 19	N/A	N/A
sp Kt/V (mean ± SD)	N/A	1.28 ± 0.26	N/A
Transplant or dialysis 'vintage' (median; IQR) (months)	53; 63	34; 42	N/A
Cumulative ESRD time (median; IQR) (months)	79; 71	36; 43	<0.001
Hypnotic drugs (%)	5	14	<0.001

To convert serum haemoglobin in g/dl to g/l, multiply by 10; serum albumin in g/dl to g/l, multiply by 10; eGFR in ml/min to ml/s, multiply by 0.01667.

disease, bone, lung or eye disorders, neuropathy, diabetes mellitus or other not-defined conditions) that are assessed by the End Stage Renal Disease Severity Index (ESRD-SI) [17]. Self-reported comorbidity score was calculated by summing up the number of comorbid conditions the patients reported. Earlier work of our group suggested that this score correlates well with the overall clinical condition of the patients [15], and it was also independently associated with mortality in kidney transplanted patients [18].

Immunosuppressive therapy and hypnotic drugs

Standard immunosuppressive therapy generally consisted of prednisolone, either cyclosporine A (Neoral) (CsA) or tacrolimus, combined with mycophenolate mofetil (MMF) or azathioprine or rapamycine. The use of sleeping pills and other sedative drugs was also assessed.

Statistical analysis

Statistical analysis was carried out using the SPSS 10.0 software. Continuous variables were compared using Student's *t*-test or the Mann–Whitney U test and categorical variables were analysed with the chi-square test, as appropriate. For multivariate analysis, logistic regression was applied.

Results

Demographics and baseline characteristics of the sample

Of the 1281 eligible patients [1067 transplanted (Tx) and 214 WL]; 125 [108 Tx (10%) and 17 WL (8%)] refused to participate. Of the 1156 remaining patients, 140 patients [118 Tx (12% of the enrolled Tx patients) and 22 WL (11% of the enrolled WL patients)] did not fill out the Berlin Sleep Apnea Questionnaire completely. Consequently, the final study population, whose data was analysed in the paper, included 1016 (841 Tx and 175 WL) patients. We found no statistically significant differences between those who did *vs* did not complete the Berlin Sleep Apnea Questionnaire properly in both groups (data not shown). Baseline patient characteristics are shown in Table 1. Most of the variables were similar in the Tx and WL groups. The cumulative ESRD time was longer and the serum haemoglobin was significantly higher in Tx patients than in WL patients. The percentage of reported hypnotic drug use and CRP were higher in the WL group (Table 1).

The mean sp Kt/V of the WL patients was 1.28 ± 0.26. The mean eGFR in the Tx group was 49 ± 19 ml/min./1.73 m^2 (0.817 ± 0.317 ml/sec./1.73 m^2). The distribution of the underlying kidney diseases was similar in the Tx and WL groups except that the proportion of chronic pyelonephritis/tubulointerstitial nephritis was significantly smaller (11% *vs* 22%; $P < 0.001$) and unknown kidney disease was significantly higher (28% *vs* 13%; $P < 0.001$) in the Tx *vs* the WL group, respectively. Nine percent of the patients had more than one kidney transplantations.

Seventy percent (586) of the Tx patients were taking CsA, 729 (87%) were administered prednisolone, 64% were on MMF, 150 (18%) patients were administered tacrolimus and 98 patients (12%) were on azathioprine. Only 19 transplanted patients (2%) were given sirolimus.

Prevalence of high risk for obstructive sleep apnoea syndrome in kidney transplanted vs waitlisted dialysis patients

All questions of the Berlin Sleep Apnea Questionnaire were completed properly by 841 (88%) of the transplanted patients who agreed to participate in the study. The prevalence of patients at 'high risk' for OSAS was 27% in the Tx group.

The prevalence of high risk for obstructive sleep apnoea was compared between the 841 transplanted *vs* 175 dialysed patients, who completed the questionnaires correctly. The basic characteristics of the two groups were similar (Table 1). To our surprise, the prevalence of high risk for OSAS was similar in the two groups. Twenty seven percent of the Tx group ($n=231$) *vs* 33% ($n=58$) of the WL had a 'high risk' for OSAS. ($P=0.079$; Table 1).

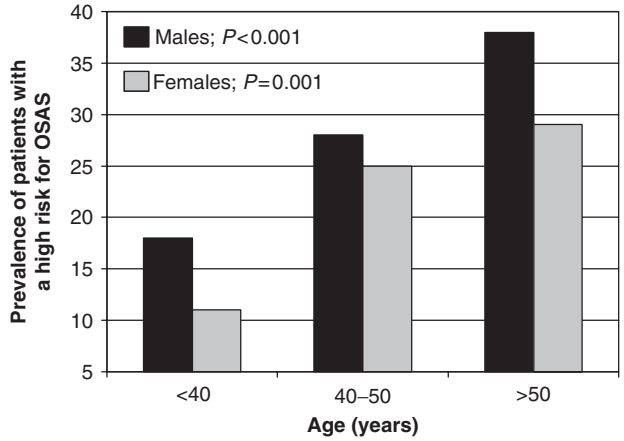

Fig. 1. Association between the presence of a high risk for OSAS and groups formed by age.

Correlates of sleep apnoea in the transplanted group

Socio-demographic characteristics. The prevalence of high risk for OSAS in the groups formed by age were: 18%, 28% and 38% in males ($P<0.001$ linear-by-linear association) and 11%, 25% and 29% in females ($P=0.001$ linear-by-linear association) for the groups under 40 years of age, 40–50 years and older than 50 years, respectively (Figure 1). Kidney transplanted patients with a high risk for sleep apnoea were significantly older (52 ± 11 years *vs* 47 ± 13 years, $P<0.001$) (Table 2) and had significantly higher BMI ($27\pm5\,kg/m^2$ *vs* $24\pm4\,kg/m^2$; $P<0.001$) than patients without sleep apnoea. In the 'high risk' group for OSAS, the proportion of males was significantly higher than in the 'low risk' group (64% *vs* 56%, $P<0.05$) (Table 2). A negative association was found between the level of education and the prevalence of high risk for sleep apnoea ($P<0.01$). Twenty-five percent of the patients in the high risk OSAS group had primary education or less, while this ratio was only 15% in the group with a low risk for OSAS (Table 2).

Self-reported comorbidity. The prevalence of diabetes was higher in the 'high risk' group than amongst 'low risk' patients (22% *vs* 15%; $P<0.05$) (Table 2). The prevalence of cerebrovascular disease (40% *vs* 26%; $P<0.001$) and heart disease (37% *vs* 25%; $P<0.001$) was also higher in the 'high risk' group than amongst 'low risk' patients (Table 2). In patients with high risk for OSAS, the number of self-reported comorbid conditions was significantly higher than in the group with a low risk for OSAS ($P<0.001$). The prevalence of high risk for OSAS increased with increasing number of self-reported comorbid conditions: no comorbid condition: 18%; 1 comorbid conditions: 24%; 2 comorbid conditions: 25%; 3 or

Table 2. Characteristics of patients with high *vs* low risk for OSAS in the transplanted group

	High risk for OSAS ($n=231$)	Low risk for OSAS ($n=610$)	*P* value
Age (mean ± SD) (years)	52 ± 11	47 ± 13	<0.001
Male (%)	64	56	<0.05
Years of formal education: Less or equal to 8 years (%)	25	15	<0.01
Number of comorbid conditions (%): No comorbid condition as reference	16	27	<0.001
1 comorbid condition	20	23	
2 comorbid conditions	20	22	
3 or more comorbid conditions	44	28	
Diabetes (%)	22	15	<0.05
Cerebrovascular disease (%)	40	26	<0.001
Heart disease (%)	37	25	<0.001
Serum albumin (mean ± SD) (g/dl)	4.14 ± 0.31	4.15 ± 0.35	NS
Serum haemoglobin (mean ± SD) (g/dl)	13.2 ± 1.8	13.2 ± 1.9	NS
Serum CRP (median; IQR) (mg/l)	3; 7	2; 5	<0.05
eGFR (mean ± SD) (ml/min./1.73 m^2)	46 ± 18	51 ± 19	<0.01
Cumulative ESRD time (median; IQR) (months)	75; 69	81; 72	NS
Transplant 'vintage' (median; IQR) (months)	47; 57	55; 63	NS
Hypnotic drugs (%)	10	4	<0.01

To convert eGFR in ml/min to ml/s, multiply by 0.01667; serum haemoglobin in g/dl to g/l, multiply by 10; serum albumin in g/dl to g/l, multiply by 10.

more comorbid conditions: 37% ($p < 0.001$ linear-by-linear association).

Renal function and laboratory data. Transplanted patients with a high risk for OSAS had significantly lower eGFR than patients with a low risk for sleep apnoea 46 ± 18 ml/min./1.73 m^2 in the high risk group *vs* 51 ± 19 ml/min./1.73 m^2 in the low risk group ($P < 0.01$) (Table 2). The prevalence of patients with a high risk for sleep apnoea was inversely associated with kidney function. The prevalence of the condition in the CKD groups was 22%, 28%, 35% and 44% for the CKD stage 1–2, CKD 3, CKD 4 and CKD 5 stage, respectively ($P = 0.004$; linear-by-linear association) (Figure 2).

Serum CRP was significantly higher in the 'high risk' group than in the 'low risk' patients. Serum albumin and serum haemoglobin levels, on the other hand, were similar in the two groups.

'Transplant vintage' and number of previous transplants. The median time since transplantation ('transplant vintage') was similar in patients with a high *vs* low risk for OSAS (Table 2). The prevalence of high risk for OSAS was also similar in patients who had their first *vs* second or third transplanted kidneys (data not shown).

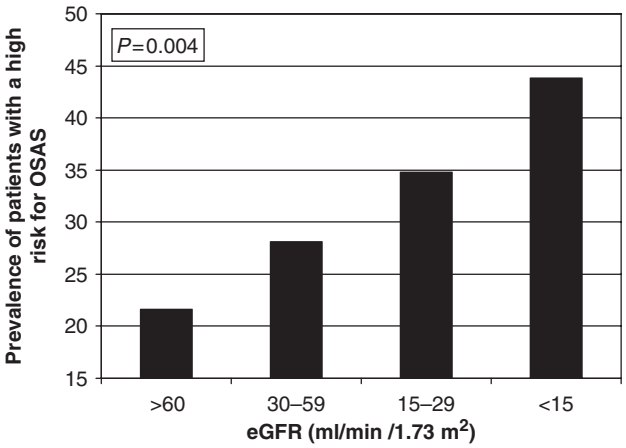

Fig. 2. Association between the presence of a high risk for OSAS and groups formed by eGFR corresponding to chronic kidney disease stages in the transplanted population.

Immunosuppressive medications and hypnotic drugs. None of the immunosuppressive medications were significantly associated with the presence of high risk for OSAS. Hypnotic drug use was significantly more frequent (10% *vs* 4%, $P < 0.01$) in the group with a high risk for sleep apnoea.

Multivariate analysis

Binary logistic regression analysis was used to determine the independent association between the presence of a high risk for sleep apnoea and the following variables: age, gender, eGFR, CRP, use of hypnotic drugs, number of comorbid conditions and educational status. We included all variables that were significantly associated with a high risk for OSAS. In the transplanted population, male gender, older age, lower eGFR, use of hypnotic drugs, the presence of three or more comorbid conditions and lower educational status were independent and significant predictors for a high risk of OSAS (Table 3).

Discussion

In the present work, we showed for the first time using large samples of transplanted and waitlisted patients with comparable characteristics that the prevalence of patients with a high risk for OSAS is similar in kidney transplanted *vs* WL. The prevalence of the condition was very high in the Tx population with almost every third patient identified as 'high risk' for OSAS. Furthermore, we are the first to show that the prevalence of high risk for OSAS increases with declining renal function in kidney transplanted patients.

Table 3. Binary logistic regression analysis of correlates of high risk for OSAS in transplanted patients

	Odds ratio	95.0% C.I. for odds ratio		*P* value
		Lower	Upper	
Male gender	1.910	1.340	2.722	<0.001
Age (1 year increase)	1.017	1.003	1.032	0.019
Years of formal education: (More than 8 years as reference)	1.977	1.317	2.967	0.001
Less or equal to 8 years				
Groups formed by number of comorbid conditions (No comorbid condition as reference)				0.008
1 comorbid condition	1.388	0.826	2.334	0.216
2 comorbid conditions	1.384	0.820	2.335	0.223
3 or more comorbid conditions	2.156	1.354	3.431	0.001
eGFR (1 ml/min./1.73 m^2 decrease)	1.016	1.007	1.026	0.001
Serum CRP (1 mg/l increase)	1.001	0.990	1.013	0.864
Hypnotic drug use	2.705	1.429	5.120	0.002

To convert eGFR in ml/min to ml/s, multiply by 0.01667.

In contrast to the dialysis population, there is a complete lack of information on the epidemiology of OSAS in kidney transplanted patients. Two previous case studies suggested that OSAS may improve after successful kidney transplantation [11,12]. Furthermore, OSAS disappeared in a group of dialysis patients after they had been switched to nocturnal dialysis, a dialysis modality that provides unprecedented blood purification [6]. Therefore, we expected that the prevalence of high risk for OSAS would be lower in transplanted patients than in WL. To our surprise, we found that a high risk for OSAS was similarly frequent in both groups. The explanation of this finding is not immediately clear. More than 70% of the patients in the Tx group had an eGFR <60 ml/min/1.73 m^2. Tx patients with close to normal renal function (CKD stage 1–2) had significantly less high risk for OSAS than WL. Furthermore, the association between declining renal function and a higher prevalence of high risk for OSAS remained significant after controlling for several covariables. It is possible, that the surprisingly high prevalence of high risk for OSAS observed in the Tx population is the consequence of declining renal function in these patients. These results suggest, in accordance with the results obtained in nocturnal dialysis patients, that uraemia-related factors may be involved in the pathogenesis of CKD-associated OSAS. Markou *et al*. found a similar association in CKD patients not yet on dialysis [4] lending further support to this hypothesis.

Epidemiologic studies demonstrated a higher prevalence of OSAS in men in the general population [2]. The gender difference seemed to be similar in our Tx group: the reported male : female ratio is 2–3 : 1 in the general population [2,19], and it was 2 : 1 in our transplanted patients. The prevalence of high OSAS risk was higher in males than in females in all age groups analysed. High risk for OSAS was also associated with lower educational status and older age both in population surveys [8] and in our kidney transplanted patients. These associations remained significant even after adjustment for covariables in the multivariate regression analysis. The mechanism for this association, however, is not clearly understood. It has been reported [20,21] that several risk factors of OSAS (smoking, alcohol consumption, obesity) are associated with social status, of which education is the best marker. Similar results have been found in a recent survey enrolling a large, representative sample of the Hungarian general population (unpublished data). Therefore, we suggest that higher risk for OSAS in individuals with lower educational status may be explained in part by a clustering of risk factors for OSAS in this group.

Somatic comorbidity and the presence of diabetes are also associated with OSAS in the general population [9]. In the present study, three or more self-reported comorbid conditions was an independent predictor of high risk for OSAS in the multivariate analysis for Tx patients. High risk for OSAS was also more prevalent in diabetic patients, in patients with cerebrovascular disease or heart disease. In this analysis we relied on self-reported information about comorbidity. We can not rule out the possibility that patients with a high risk for OSAS would report comorbid conditions due to co-existing psychological conditions or for other reasons.

Hypnotic drug use is a known risk factor for obstructive sleep apnoea. Patients with OSAS frequently complain of sleep fragmentation and deprivation, and consequently, they frequently use hypnotics—which makes their condition worse. In the present study, the use of sleeping pills was associated with a high risk for OSAS. Significantly more 'high risk' patients reported regular use of hypnotics than patients with a low risk for OSAS. After controlling for covariables in the multivariate model, the use of hypnotic drugs was associated with a three times higher risk for the condition. This finding underscores the importance of recognizing this disorders as uncontrolled use of hypnotics in OSAS further impairs sleep and overnight oxygenization and may have a significant negative effect on the clinical outcome of these patients.

Several limitations of this report, however, should also be noted. The cross-sectional design of our survey precludes any directional or causal conclusions. A prospective study involving WL is under way to document the natural history of OSAS in CKD patients undergoing renal transplantation. Similar to previous works [15], we relied on self-report to assess comorbidity in this analysis that could have introduced certain elements of bias into our analysis.

OSAS is diagnosed by polysomnography. The clinical diagnosis of OSAS should not be based on questionnaires [22]. However, the use of questionnaires as a screening tool may still be necessary in studies involving large number of patients. The Berlin Questionnaire has not been validated against polysomnography in patients with end-stage renal failure. The questionnaire includes questions related to snoring habits. Without a bed partner, these questions may be somewhat unreliable. Multiple factors could potentially contribute to daytime sleepiness in this population, including impaired renal function, anaemia and insomnia. The prevalence of hypertension is high in this population, which may impair the reliability of the Berlin Questionnaire. This instrument has been used in dialysis patients by others who reported a similar prevalence of high risk for OSAS [5,22] to what we have found. This prevalence, however, was lower than earlier data obtained with polysomnography [23,24]. This is somewhat surprising, as one would have expected a higher prevalence obtained with the Berlin Questionnaire, as screening tools tend to overestimate the true prevalence of a condition. This could perhaps be explained, at least in part, by the fact that earlier polysomnographic studies in dialysis patients enrolled a relatively small number of patients who were also to some extent pre-selected on the basis of sleep-related complaints. Validation of the Berlin Questionnaire against polysomnography is currently

under way by our group. Finally, the proportion of missing data and refusal rate was substantial in this study; however, it is unlikely that this introduced a systematic bias that would distort our conclusions significantly.

In summary, this is the first study enrolling a large number of kidney transplanted patients to compare the prevalence of high risk for OSAS between Tx and dialysed patients. The prevalence of high risk for OSAS was unexpectedly high in the transplanted group. In addition to male gender, older age, the use of hypnotic drugs, severe comorbidity, lower educational status, and lower eGFR was also independently associated with high risk for OSAS in Tx. This finding supports the hypothesis that, in addition to the known risk factors, uraemia-related factors may contribute to the high prevalence of OSAS in kidney transplanted patients and perhaps even in other patients with CKD not requiring renal replacement therapy—although this assumption will need further observational confirmation.

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Conflict of interest statement. None declared.

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