Prevalence of Sleep Apnea and its Associated Factors in Chronic Kidney Disease Patients

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Background: This study aimed to determine the prevalence of sleep apnea and its associated factors in patients with chronic kidney disease (CKD).

Materials and Methods: This population-based cross-sectional study included 47 CKD patients, referred to the dialysis unit of Kosar Hospital in Semnan, Iran, in 2017. Two questionnaires were used for data collection. The first questionnaire included demographic and clinical variables, and the second questionnaire (STOP-BANG questionnaire) was used to measure sleep apnea in CKD patients. Also, the Apnea-Hypopnea Index (AHI) was calculated for all patients and was considered as the gold standard. To determine the factors associated with sleep apnea, univariate and multiple logistic regression models were used. Finally, the area under the receiver operating characteristic curve (ROC) was determined for assessing the discriminative ability of the model, as well as the accuracy of STOP-BANG questionnaire. STATA version 14 was used for data analysis.

Results: The prevalence of sleep apnea in CKD patients was 53.2%. Also, its prevalence in women and men was 52% and 48%, respectively. In the multiple logistic regression model, body mass index (BMI) (OR: 1.21, 95% CI: 1.04-1.31) and blood urea nitrogen (BUN) (OR: 0.94, 95% CI: 0.91-0.98) had significant associations with sleep apnea in CKD patients; the area under the ROC curve was 0.7982 for this model. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the ROC curve of STOP-BANG questionnaire for AHI≥15 were 71.43, 61.54, 60, 72.73, and 0.6932, respectively.

Conclusion: This study showed that the prevalence of sleep apnea in CKD patients was high. Given the acceptable validity of STOP-BANG questionnaire, this scale can be used to screen sleep apnea in CKD patients.

Key words: Prevalence, Sleep apnea, CKD, STOP-BANG questionnaire, AHI

INTRODUCTION

Sleep apnea refers to interrupted breathing in the upper respiratory tract during sleep for more than ten seconds. It may occur due to upper airway obstruction during sleep and increased sympathetic activity, caused by repeated respiratory arousal during sleep and hypoxia (1,2). Sleep apnea can lead to reduced quality of life, respiratory arousal during sleep, oxygen desaturation, daytime sleepiness, and cognitive impairment. This disorder is a common respiratory problem with 5% prevalence in adults. One of the diseases associated with sleep apnea is...
chronic kidney disease (CKD) (3, 4). Studies have reported the high prevalence of sleep apnea in hemodialysis patients (5-8). Estimates show that the prevalence of sleep apnea in hemodialysis patients is ten times higher than healthy people. According to statistics, 50-70% of hemodialysis patients have sleep apnea (9, 10).

The absence of breathing sounds is an important symptom, suggesting sleep apnea. Nighttime restlessness, interrupted sleep, disturbed nocturnal sleep, daytime sleepiness, headache, and fatigue are the most common complaints of patients with sleep apnea. The importance of sleep apnea in nephrology is related to the fact that hemodialysis patients are prone to cardiovascular comorbidities and mortality, because repeated oxygen saturation drops can lead to increased oxidative stress and stimulate the sympathetic system, which ultimately causes hypertension and cardiovascular diseases (11-15). The association between CKD and sleep apnea and its exact mechanism are still unclear; however, increased sympathetic nervous discharge, increased blood pressure in patients with sleep apnea during attacks, and persistence of high blood pressure can be influential factors in susceptibility to sleep apnea in CKD patients (7).

Moreover, the results of some previous studies have shown that factors, such as excessive fluid accumulation, are important in increased susceptibility to sleep apnea in CKD patients (16). On the other hand, a number of studies have shown that metabolic acidosis, by creating a compensatory flow of respiratory alkalosis, leads to hypercapnia ventilation and ultimately triggers the onset of sleep apnea in CKD patients (9,10). Nevertheless, factors associated with the higher prevalence of sleep apnea in CKD patients are not completely clear, although some studies have examined non-dialysis patients (17,18).

Considering the importance of sleep apnea and the high morbidity and mortality rates of cardiovascular diseases and complications in CKD patients, besides the limitations of previous studies on the prevalence of this disease and its factors in CKD patients in Iran, the present study aimed to determine the prevalence of sleep apnea and its associated factors in CKD patients, referred to Kosar Hospital of Semnan, Iran.

**MATERIALS AND METHODS**

**Study design and population**

This population-based cross-sectional study aimed to evaluate the prevalence of sleep apnea and its associated factors in CKD patients, referred to Kosar Hospital in Semnan, Iran. The study population included all CKD patients, referred to the dialysis unit of Kosar Hospital of Semnan in 2017. The inclusion criteria were as follows: CKD patients aged ≥18 years; glomerular filtration rate (GFR) <15 ml/min/1.73 m²; and at least three dialysis sessions per week. The exclusion criteria were neurological defects (acquired or congenital); psychiatric disorders; craniofacial abnormalities (CFA); congestive heart failure (CHF), and opium dependence.

**Data collection**

In the present study, two questionnaires were used for data collection. The first one included demographic and clinical variables, such as age, sex, body mass index (BMI), systolic and diastolic blood pressure, medical history (e.g., diabetes mellitus, hypertension, and ischemic heart disease), duration of CKD (months), duration of dialysis (months), hours of dialysis per week, and laboratory criteria, including serum creatinine, blood urea nitrogen (BUN), GFR, phosphorus, albumin, calcium, and hemoglobin. The GFR was calculated based on Equation 1 (19):

\[
GFR = \frac{(140 - \text{Age}) \times \text{weight (Kg)}}{\text{Plasma Creatinine (mg/dl)}^{0.72}}
\]  

Equation 1

It is worth mentioning that Equation 1 was multiplied by 0.85 for women. The second questionnaire was the STOP-BANG questionnaire, which was used to measure sleep apnea in CKD patients. This questionnaire consisted of eight items, including snoring, tiredness, observed sleep apnea, hypertension, BMI ≥35 kg/m², age ≥50 years, neck circumference >40 cm, and male gender. For “Yes” and “No” items, scores of one and zero were assigned, respectively. Finally, scores of 0-2 and ≥3 were considered as low- and high-risk groups for sleep apnea, respectively.
Previously, Sadeghniiat-Haghighi et al. examined the reliability and validity of the Persian version of STOP-BANG questionnaire in a sleep clinic population. It should be noted that the risk group consisted of patients with sleep apnea.

In the present study, for all patients, a polygraph test was taken by an experienced pulmonologist. To perform the test, the patient was hospitalized for one night in the room designed for the test. During sleep, some electrodes and related devices were attached to the patient for recording the essential information. The apnea-hypopnea index (AHI) was calculated as the number of apneas and hypopneas per hour of recording. AHI was then classified as follows: 5/h ≤ mild <15/h; 15/h ≤ moderate <30/h; severe, ≥30/h. In the present study, the polygraph test was considered as the gold standard and used to determine the validity of STOP-BANG questionnaire.

**Statistical analysis**

After obtaining informed consent and explaining the research objectives to the participants, data collection was conducted. Relevant data were entered in STATA version 14 for analysis. In descriptive analyses, mean (standard deviation) and number (percentage) were measured for quantitative and qualitative variables, respectively. Then, univariate and multiple logistic regression models were employed to determine the factors associated with sleep apnea in CKD patients. Finally, the crude and adjusted odds ratios (ORs) with 95% confidence interval (CI) were calculated. Also, the area under the receiver operating characteristic (ROC) curve (AUC) was calculated for assessing the discriminative ability of the multiple logistic regression model and examining the accuracy of STOP-BANG questionnaire in comparison with AHI (gold standard). P-value <0.05 was considered statistically significant.

This research was conducted according to the principles of the Declaration of Helsinki and was approved by the Deputy of Research and Ethics Committee of Semnan University of Medical Sciences (Semnan, Iran) (code: IR.SEMUMS.REC.1396.125).

**RESULTS**

A total of 47 CKD patients, who were referred to the dialysis unit of Kosar Hospital of Semnan during 2017, were included. Overall, 22 (46.8%) and 25 (53.2%) patients had low (score <3) and high (score ≥3) risks of sleep apnea, respectively. Table 1 presents the mean, standard deviation (SD), minimum, and maximum of STOP-BANG score for central apnea, obstructive sleep apnea (OSA), and overnight desaturation index (ODI) in patients. As can be seen, the mean (SD) scores of STOP-BANG questionnaire in the general, low-risk (score <3) and high-risk (score ≥3) groups were 2.96 (1.78), 1.45 (0.74), and 4.28 (1.31), respectively.

**Table 1.** Mean, Standard Deviation, min and max of STOP-BANG score, Central, OSA and ODI in Patients under Study

| STOP-BANG Score | Number | Mean | S.D | Minimum | Maximum |
|-----------------|--------|------|-----|---------|---------|
| General         | 47     | 2.96 | 1.78| 0       | 8       |
| Low Risk (Score <3) | 22    | 1.45 | 0.74| 0       | 2       |
| High Risk (Score ≥3) | 25   | 4.28 | 1.31| 3       | 8       |
| AHI             |        |      |     |         |         |
| Central         | 47     | 2.63 | 9.45| 0       | 63.60   |
| OSA             | 47     | 8.28 | 13.14| 0      | 70.50   |
| ODI             | 47     | 19.40| 19.85| 0      | 89.40   |

Also, the mean (SD) scores of central apnea, OSA, and ODI were 2.63 (9.45), 8.28 (13.14), and 19.40 (19.85), respectively. Since the high-risk group (score≥3) included patients with sleep apnea, the overall prevalence of sleep apnea was 53.2% in CKD patients; it was also 52% and 48% in women and men, respectively. Table 2 presents the details of STOP-BANG questionnaire in patients under study. The mean (SD) age of low-risk and high-risk groups was 58.54 (14.32) and 64.92 (11.98) years, respectively. Also, the mean (SD) BMI of low-risk and high-risk groups was 24.12 (4.85) and 27.33 (5.11) kg/m², respectively. Other demographic and clinical characteristics of CKD patients, as well as the results of univariate logistic regression analysis, are presented in Table 3.
Table 2. The Various Dimensions of STOP-Bang Questionnaire in patients under Study

| STOP-Bang      | Number | %    |
|----------------|--------|------|
| S: Snoring     | Yes    | 20   | 42.55 |
|                | No     | 27   | 53.45 |
| T: Tiredness   | Yes    | 18   | 38.30 |
|                | No     | 29   | 61.70 |
| O: Observed    | Yes    | 14   | 29.80 |
|                | No     | 33   | 70.20 |
| P: Pressure    | Yes    | 6    | 12.80 |
|                | No     | 41   | 87.20 |
| > 35m2/kg : B BMI | Yes | 5    | 10.60 |
|                | No     | 42   | 89.40 |
| A: > 50 year Age | Yes | 35   | 74.50 |
|                | No     | 12   | 25.50 |
| N: Neck > 40 cm | Yes | 11   | 23.40 |
|                | No     | 36   | 76.60 |
| G: male Gender | Yes    | 20   | 42.60 |
|                | No     | 27   | 57.40 |

The results of univariate logistic regression model showed that only BMI and BUN had significant associations with the occurrence of sleep apnea in CKD patients (P<0.05). In other words, for every unit increase in BMI, the odds of sleep apnea in the high-risk group was 1.45 times higher than the low-risk group (OR: 1.45, 95% CI: 1.01-1.30). Similarly, for every unit of BUN increase, the odds of sleep apnea in the high-risk group was 4% lower than the low-risk group (OR: 0.96, 95% CI: 0.92-0.99). Other variables had no significant association with the occurrence of sleep apnea in CKD patients (P>0.05) (Table 3).

To eliminate potential confounding factors, variables with P≤0.20 in the univariate logistic regression model were included in the multiple logistic regression model simultaneously. After adjusting for the confounding variables in the multiple logistic regression model, the occurrence of sleep apnea in CKD patients showed significant associations with BMI (adjusted OR: 1.21, 95% CI: 1.04-1.31) and BUN (adjusted OR: 0.94, 95% CI: 0.91-0.98) (P<0.05). Table 4 shows the results of multiple logistic regression analysis.

Figure 1 shows the AUC for significant variables in the multiple logistic regression model. As can be seen, the AUC was 0.7982 (95% CI: 0.6720-0.9250, P<0.001), which indicated the high discriminative power of this model in distinguishing high-risk and low-risk CKD patients for sleep apnea. Also, Table 5 shows the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of STOP-BANG questionnaire at different cut-off points as compared to AHI (gold standard). The highest sensitivity, specificity, PPV, and NPV of STOP-BANG questionnaire for AHI≥15 were 71.43, 61.54, 60, and 72.73, respectively. Also, the AUC for the accuracy assessment of STOP-BANG questionnaire relative to AHI was 0.6932 (95% CI: 0.5510-0.8266; P=0.024), which indicates the adequate validity of STOP-BANG questionnaire in the diagnosis of sleep apnea in CKD patients (Figure 2).
### Table 3. Demographic and Clinical Characteristics of CKD Patients Under Study and the Association of These Factors with Sleep Apnea Using Univariate Logistic Regression Model

| Quantitative Variables (Mean, SD) | Low Risk (<3) (N=22) | High Risk (≥3) (N=25) | Crude OR (95% CI) | P-Value |
|-----------------------------------|-----------------------|------------------------|-------------------|---------|
| Age (Year)                        | 58.54 (14.32)         | 64.92 (11.98)          | 1.04 (0.99-1.08)  | 0.108   |
| BMI (Kg/m²)                       | 24.12 (4.85)          | 27.33 (5.11)           | 1.45 (1.01-1.30)  | 0.042   |
| Duration of CKD (Month)           | 43 (37.02)            | 61.40 (62.49)          | 1.07 (0.99 – 1.02) | 0.240   |
| Duration of Dialysis (Month)      | 26.45 (30.75)         | 22.48 (27.50)          | 0.99 (0.97 – 1.01) | 0.635   |
| Hours of Dialysis per Week        | 11.41 (2.20)          | 11.56 (1.87)           | 1.04 (0.78 – 1.39) | 0.705   |
| GFR Before Dialysis               | 13.85 (5.10)          | 15.58 (5.09)           | 1.07 (0.94 – 1.22) | 0.290   |
| Hemoglobin (g/dl)                 | 10.61 (1.04)          | 10.38 (1.46)           | 0.86 (0.54 – 1.37) | 0.536   |
| Hematocrit (%)                    | 33.20 (3.46)          | 31.91 (4.32)           | 0.92 (0.78 -1.07) | 0.267   |
| Creatinine (mg/dl)                | 4.70 (1.41)           | 4.47 (1.67)            | 0.91 (0.61 – 1.32) | 0.610   |
| BUN (mg/dl)                       | 49.90 (14.94)         | 38.52 (19.41)          | 0.96 (0.92 – 0.99) | 0.038   |
| Fasting Blood Glucose (mg/dl)     | 128.41 (68.95)        | 134.60 (75.80)         | 1.001 (0.99 – 1.009) | 0.767   |
| Heart Rate (Pulse)                | 75.72 (13.17)         | 80 (14.60)             | 1.02 (0.98 – 1.07) | 0.297   |
| Albumin (g/l)                     | 3.68 (0.31)           | 3.60 (0.50)            | 0.61 (0.15 – 2.44) | 0.482   |
| Phosphorus (mg/dl)                | 4.67 (0.81)           | 4.74 (0.88)            | 1.11 (0.56 – 2.23) | 0.310   |
| Calcium (mg/dl)                   | 9.21 (0.62)           | 9.13 (0.69)            | 0.84 (0.34 – 2.04) | 0.699   |

#### Qualitative Variables

| Qualitative Variables (Number, %) | Low Risk (<3) (N=22) | High Risk (≥3) (N=25) | OR (95% CI) | P-Value |
|-----------------------------------|-----------------------|------------------------|-------------|---------|
| Sex                               |                       |                        |             |         |
| Male                              | 8 (36.4)              | 12 (48)                | Reference   | 0.422   |
| Female                            | 14 (63.6)             | 13 (52)                | 0.62 (0.19 – 1.99) |         |
| History of Diabetes               |                       |                        |             |         |
| No                                | 9 (40.9)              | 9 (36)                 | Reference   | 0.730   |
| Yes                               | 13 (59.1)             | 16 (64)                | 1.23 (0.38 – 4.01) |         |
| History of Hypertension           |                       |                        |             |         |
| No                                | 8 (36.4)              | 8 (32)                 | Reference   | 0.310   |
| Yes                               | 14 (63.6)             | 17 (68)                | 1.21 (0.36 – 4.06) |         |
| History of Ischemic Heart Disease |                       |                        |             |         |
| No                                | 15 (68.2)             | 19 (76)                | Reference   | 0.551   |
| Yes                               | 7 (31.8)              | 6 (24)                 | 0.68 (0.19-2.44) |         |
| History of Hypothyroidism         |                       |                        |             |         |
| No                                | 21 (95.5)             | 22 (88)                | Reference   | 0.378   |
| Yes                               | 1 (4.5)               | 3 (12)                 | 2.86 (0.27 – 29.75) |         |

### Table 4. The effective Factors on the Occurrence of Sleep Apnea in CKD Patients under study using multiple logistic regression model

| Quantitative Variables | Low Risk (<3) (N=22) | High Risk (≥3) (N=25) | Adjusted OR (95% CI) | P-Value |
|------------------------|-----------------------|------------------------|----------------------|---------|
| Age (Year)             | 58.54 (14.32)         | 64.92 (11.98)          | 1.04 (0.99-1.10)     | 0.130   |
| BMI (Kg/m²)            | 24.12 (4.85)          | 27.33 (5.11)           | 1.21 (1.04-1.31)     | 0.014   |
| BUN (mg/dl)            | 49.90 (14.94)         | 38.52 (19.41)          | 0.94 (0.91-0.98)     | 0.014   |

Area under the ROC Curve: 0.7982 (CI95%; 0.6720-0.9250); P-Value <0.001
Table 5. Determination of Sensitivity, Specificity, PPV & NPV of STOP-BANG Questionnaire in Different Cut points in Compared to AHI

| Cut point | Sensitivity (%) | Specificity (%) | *PPV   | **NPV   |
|-----------|-----------------|-----------------|--------|---------|
| 0         | 100             | 0               | 44.68  | 0       |
| 1         | 100             | 11.54           | 47.73  | 100.00  |
| 2         | 100             | 34.62           | 55.26  | 100.00  |
| 3         | 71.43           | 61.54           | 60.00  | 72.73   |
| 4         | 42.86           | 73.08           | 56.25  | 61.29   |
| 5         | 23.81           | 80.77           | 50.00  | 56.76   |
| 6         | 9.52            | 92.31           | 49.99  | 55.81   |
| 7         | 4.76            | 100             | 100.00 | 56.52   |
| 8         | 0               | 100             | 0      | 55.32   |

Area under ROC Curve: 0.6932 (CI95%: 0.5510 - 0.8266); P-Value 0.024

*PPV: Positive Predictive Value
**NPV: Negative Predictive Value

**DISCUSSION**

The present study was designed to determine the prevalence of sleep apnea in CKD patients and to investigate the effective factors in the occurrence of sleep apnea in these patients. The results showed that the overall prevalence of sleep apnea in CKD patients was 53.2% (52% and 48% for women and men, respectively). The results of multiple logistic regression analysis showed that only BMI and BUN had significant associations with sleep apnea in CKD patients; also, the AUC for this model was 0.7982. In the present study, we found that the sensitivity, specificity, PPV, and NPV of STOP-BANG questionnaire for AHI≥15 were 71.43, 61.54, 60, and 72.73, respectively. Also, the AUC for accuracy assessment of STOP-BANG questionnaire relative to AHI was 0.6932.

The results of the present study indicated that the overall prevalence of sleep apnea in CKD patients was 53.2%; this finding is consistent with similar studies in this area (11, 20, 22). In this regard, a study by Forni Ogna et al., which aimed to determine the prevalence of sleep apnea and introduce a diagnostic approach for hemodialysis patients in Switzerland, showed that the prevalence of moderate to severe sleep apnea in CKD patients was 56% (11). Moreover, a study by Ghanei Geshlagh et al. showed that 41.7% of hemodialysis patients had sleep apnea in Iran (20). Also, a study by Sabry et al. which aimed to determine the prevalence of sleep disorders in hemodialysis patients in Saudi Arabia showed that 31.8% of patients had these abnormalities (22).

In contrast, some other studies reported the very high prevalence of sleep apnea in CKD patients (7-9, 14, 15, 23, 24). For example, a study by Huang et al. showed that 80% of CKD patients had moderate or severe sleep apnea (8). Also, another study investigated the prevalence of sleep disorders in hemodialysis patients in Iran and showed that the total prevalence of sleep disorder was 75% in these patients (10). Overall, the prevalence of sleep apnea is high in CKD patients, and the observed difference in the prevalence rates of different studies may be due to differences in the sample size, screening tools, diagnostic tools for measuring sleep apnea, and also genetics (25).

The main cause of the high prevalence of sleep apnea in CKD patients is unknown. However, some studies have shown that uremic toxins, metabolic acidosis, chronic hypocapnia, amino-acid metabolism abnormalities, and hormone imbalance are associated with the occurrence of sleep apnea in CKD patients (26-28). Given the high prevalence of sleep apnea in CKD patients, its negative impact on the mental health and adaptability of patients, and its role in the increased cardiovascular morbidity and mortality of patients (24,29), it is essential to design and implement regular screening programs for the detection of sleep apnea in CKD patients.

In the present study, although the prevalence of sleep apnea in women was higher than men (52% vs. 48%), the
difference was not statistically significant (P>0.05); this result is in line with the results of some similar studies (22,30,31). In contrast, several studies have shown a significant association between sex and sleep apnea (32-35). Although the exact causes of distinction in the prevalence of sleep apnea between men and women are unknown, some studies have highlighted factors, such as obesity, anatomy of the upper airways, respiratory control, and secretion of sex hormones in the circadian rhythm (36). It should be also noted that the higher prevalence of sleep apnea in women may be due to the larger number of female participants in our study.

Moreover, in the present study, although the mean age of the high-risk group was higher than the low-risk group for sleep apnea (64.92 vs. 58.54), the difference was not significant (P>0.05). This finding is inconsistent with the results of previous studies, as they suggested older age as a risk factor for sleep apnea (20,37,38). This discrepancy may be attributed to the small sample size of our study. However, changes in the quantity and quality of sleep and the increased risk of sleep apnea in the elderly were more observed, which may be due to the poor performance of muscles holding the open airway in the elderly (39).

The findings of the present study showed that BMI (adjusted OR: 1.21, 95% CI: 1.04-1.31) had a significant association with the occurrence of sleep apnea in CKD patients, which is in line with similar studies in this area (21,40-44). A study by Sadeghniat-Haghighi et al., which aimed to determine the reliability and validity of the Persian version of STOP-BANG questionnaire in a sleep clinic population (n=603), demonstrated a significant association between BMI and sleep apnea (21). Two other studies by Lurie and Moroni et al. showed a linear association between the increase in BMI and AHI (45,46). Also, previous studies have shown that a weight loss of 10% in obese patients could reduce AHI by 27% (47). Considering the important role of BMI and overweight in the development of sleep apnea, attention to this risk factor in the preventive and control programs of sleep apnea seems necessary.

Moreover, the present study showed a significant association between BUN and sleep apnea in CKD patients (OR: 0.94, 95% CI: 0.91-0.98), which is consistent with the results of other studies. For example, a study by Hanly et al. demonstrated a significant association between the reduction in BUN and the severity of sleep apnea (48). Also, two studies by Millman et al. and Tada et al. indicated a significant association between uremia (BUN and Cr) and sleep apnea in CKD patients (27,49). Overall, the mechanism of sleep apnea in CKD patients by uremia is unclear. However, a number of studies have suggested that sleep apnea results from a sharp decline in the airway muscle tone due to the effect of uremic toxins on the central nervous system during sleep, besides the instability of respiratory control due to the dis-coordination of the diaphragm and upper airway muscle activities (28).

In this study, we found that the sensitivity, specificity, PPV, and NPV of STOP-BANG questionnaire for AHI≥15 were 71.43, 61.54, 60, and 72.73, respectively. Also, the AUC for accuracy assessment of STOP-BANG questionnaire as compared to AHI was 0.6932. In a study by Chung et al., the sensitivity, specificity, PPV, NPV, and AUC of STOP questionnaire for AHI≥5 were 65.6, 60, 78.4, 44, and 0.703, respectively (50). Another study by Pecotic et al. reported the sensitivity, specificity, PPV, NPV and AUC of STOP questionnaire for AHI≥5 to be 96, 83, 61, 95, and 0.84, respectively (51). According to this finding, the BANG questionnaire has appropriate validity; therefore, it can be used as a screening tool for the diagnosis of sleep apnea in CKD patients.

One of the limitations of this study is its cross-sectional design, because the assumption of temporality was not taken into consideration (52,53). Also, the small sample size (n=47) and the use of polygraphy rather than polysomnography, as the gold standard, are the other limitations of this study.

**CONCLUSION**

This study highlighted the high prevalence of sleep apnea in CKD patients. The increased risk of sleep apnea was significantly associated with BMI and BUN of CKD
patients. Also, the AUC for accuracy assessment of STOP-BANG questionnaire as compared to AHI was 0.6932; therefore, the STOP-BANG questionnaire can be used to screen sleep apnea in CKD patients. Finally, considering the high prevalence of sleep apnea in CKD patients, we suggest that regular screening programs be designed and implemented for the early detection of this disorder. Also, control of major risk factors associated with this disease is recommended in CKD patients.

**Competing interests**
The authors declare that they have no competing interests.

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**REFERENCES**

1. Harsch IA. Metabolic disturbances in patients with obstructive sleep apnoea syndrome. *European Respiratory Review* 2007;16(106):196-202.

2. Ameli J, Ghanei M, Aslani J, Karami GH, Ghoddoci K, Kachoei H. Polysomnography of 31 devotee with mustard gases that suffering from sleeping respiration problems in Baghiatolah hospital. *Med Mil J* 2007;9(1):7-14.

3. Peled N, Kassirer M, Shitrit D, Kogan Y, Shlomi D, Berliner AS, et al. The association of OSA with insulin resistance, inflammation and metabolic syndrome. *Respir Med* 2007;101(8):1696-701.

4. Stevens PE, Levin A. Kidney disease: improving global outcomes chronic kidney disease guideline development work group M. Evaluation and management of chronic kidney disease: synopsis of the kidney disease: improving global outcomes. 2012:825-30.

5. Mucsi I, Molnar MZ, Rethelyi J, Vamos E, Csepanyi G, Tompa G, et al. Sleep disorders and illness intrusiveness in patients on chronic dialysis. *Nephrol Dial Transplant* 2004;19(7):1815-22.

6. Chen J, Gu D, Chen CS, Wu X, Hamm LL, Muntner P, et al. Association between the metabolic syndrome and chronic kidney disease in Chinese adults. *Nephrol Dial Transplant* 2007;22(4):1100-6.

7. Kuhlmann U, Becker HF, Birkhahn M, Peter JH, von Wichert P, Schütterle S, et al. Sleep-apnea in patients with end-stage renal disease and objective results. *Clin Nephrol* 2000;53(6):460-6.

8. Huang HC, Walters G, Talaulikar G, Figurski D, Carroll A, Hurwitz M, et al. Sleep apnea prevalence in chronic kidney disease - association with total body water and symptoms. *BMC Nephrol* 2017;18(1):125.

9. Chen WC, Lim PS, Wu WC, Chiu HC, Chen CH, Kuo HY, et al. Sleep behavior disorders in a large cohort of chinese (Taiwanese) patients maintained by long-term hemodialysis. *Am J Kidney Dis* 2006;48(2):277-84.

10. Astanegi S, Omidvarborna M, Nourmohammadi B. Prevalence of sleep disorder in hemodialysis patients referred to Dialysis Center of Emam Reza hospital affiliated to Kermanshah University of Medical science. *J Clin Res Paramed Sci* 2012;1(1):e82170.

11. Forni Ogna V, Ogna A, Pruijm M, Bassi I, Zuercher E, Halabi G, et al. Prevalence and Diagnostic Approach to Sleep Apnea in Hemodialysis Patients: A Population Study. *Biomed Res Int* 2015;2015:103686.

12. Zoccali C. Sleep apnoea and nocturnal hypoxaemia in dialysis patients: mere risk-indicators or causal factors for cardiovascular disease? *Nephrol Dial Transplant* 2000;15(12):1919-21.

13. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep* 1999;22(5):667-89.

14. Tang SC, Lam B, Lai AS, Pang CB, Tso WK, Khong PL, et al. Improvement in sleep apnea during nocturnal peritoneal dialysis is associated with reduced airway congestion and better uremic clearance. *Clin J Am Soc Nephrol* 2009;4(2):410-8.
15. Venmans BJ, van Kralingen KW, Chandi DD, de Vries PM, ter Wee PM, Postmus PE. Sleep complaints and sleep disordered breathing in hemodialysis patients. *Neth J Med* 1999;54(5):207-12.

16. Jhamb M, Unruh ML. Volume overload as a mechanism for obstructive sleep apnea in CKD? *Nephrol Dial Transplant* 2012;27(4):1291-3.

17. Shanmugam GV, Abraham G, Mathew M, Ilangovan V, Mohapatra M, Singh T. Obstructive sleep apnea in nondialysis chronic kidney disease patients. *Ren Fail* 2015;37(2):214-8.

18. Nicholl DD, Ahmed SB, Loewen AH, Hemmelgarn BR, Sola DY, Beecroft JM, et al. Diagnostic value of screening instruments for identifying obstructive sleep apnea in kidney failure. *J Clin Sleep Med* 2013;9(1):31-8.

19. Jun JC, Chopra S, Schwartz AR. Sleep apnoea. *Eur Respir Rev* 2016;25(139):12-8.

20. Ghanai Geshlagh R, Hemmati Maslakpak M, Ghoci S. Sleep apnea and metabolic syndrome in hemodialysis patients. *Studies in Medical Sciences* 2011;22(4):339-45.

21. Sadeghniiaat-Haghighi K, Montazeri A, Khajeh-Mehrizi A, Ghajarzadeh M, Alemohammad ZB, Aminian O, et al. The STOP-BANG questionnaire: reliability and validity of the Persian version in sleep clinic population. *Qual Life Res* 2015;24(8):2025-30.

22. Sabry AA, Abo-Zenah H, Wafa E, Mahmoud K, El-Dahshan K, Hassan A, et al. Sleep disorders in hemodialysis patients. *Saudi J Kidney Dis Transpl* 2010;21(2):300-5.

23. Chan CT. Sleep apnea with intermittent hemodialysis: time for a wake-up call! *J Am Soc Nephrol* 2006;17(12):3279-80.

24. Yayan J, Rasche K, Vlachou A. Obstructive sleep apnea and chronic kidney disease. In: Clinical Management of Pulmonary Disorders and Diseases. Springer, Cham, 2017; pp. 11-8.

25. Unruh M, Miskulin D, Yan G, Hays RD, Benz R, Kusek JW, et al. Racial differences in health-related quality of life among hemodialysis patients. *Kidney Int* 2004;65(4):1482-91.

26. Kagawa S, Fukumori T. Sleep apnea syndrome in dialysis patients. *Nihon Rinsho* 2004;62 Suppl 6:411-5.

27. Millman RP, Kimmel PL, Shore ET, Wasserstein AG. Sleep apnea in hemodialysis patients: the lack of testosterone effect on its pathogenesis. *Nephron* 1985;40(4):407-10.

28. Fein AM, Niederman MS, Imbriano L, Rosen H. Reversal of sleep apnea in uremia by dialysis. *Arch Intern Med* 1987;147(7):1355-6.

29. Lin CH, Perger E, Lyons OD. Obstructive sleep apnea and chronic kidney disease. *Curr Opin Pulm Med* 2018;24(6):549-554.

30. Bastos JP, Sousa RB, Nepomuceno LA, Gutierrez-Adrianzen OA, Bruin PF, Aratújo ML, et al. Sleep disturbances in patients on maintenance hemodialysis: role of dialysis shift. *Rev Assoc Med Bras* (2002) 2007;53(6):492-6.

31. Sabbatini M, Pisani A, Mirenghi F, Cianciaruso B, Crispo A. The impact of haemoglobin on the quality of sleep in haemodialysis patients: which is the truth? *Nephrol Dial Transplant* 2003;18(9):1947-8.

32. Sloand JA, Shelly MA, Feigin A, Bernstein P, Monk RD. A double-blind, placebo-controlled trial of intravenous iron dextran therapy in patients with ESRD and restless legs syndrome. *Am J Kidney Dis* 2004;43(4):663-70.

33. de Oliveira Rodrigues CJ, Marson O, Tufic S, Kohlmann O Jr, Guimarães SM, Togeiro P, et al. Relationship among end-stage renal disease, hypertension, and sleep apnea in nondiabetic dialysis patients. *Am J Hypertens* 2005;18(2 Pt 1):152-7.

34. Gigli GL, Adorati M, Dolso P, Pianu A, Valente M, Brotini S, et al. Restless legs syndrome in end-stage renal disease. *Sleep Med* 2004;5(3):309-15.

35. Molnar MZ, Szentkiralyi A, Lindner A, Czira ME, Szabo A, Mucsi I, et al. High prevalence of patients with a high risk for obstructive sleep apnoea syndrome after kidney transplantation--association with declining renal function. *Nephrol Dial Transplant* 2007;22(9):2686-92.

36. Lin CM, Davidson TM, Ancoli-Israel S. Gender differences in obstructive sleep apnea and treatment implications. *Sleep Med Rev* 2008;12(6):481-96.

37. Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnea: a population health perspective. *Am J Respir Crit Care Med* 2002;165(9):1217-39.
38. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med* 1993;328(17):1230-5.

39. Edwards BA, O'Driscoll DM, Ali A, Jordan AS, Trinder J, Malhotra A. Aging and sleep: physiology and pathophysiology. *Semin Respir Crit Care Med* 2010;31(5):618-33.

40. Strobel RJ, Rosen RC. Obesity and weight loss in obstructive sleep apnea: a critical review. *Sleep* 1996;19(2):104-15.

41. Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. *JAMA* 2004;291(16):2013-6.

42. Knorst MM, Souza FJ, Martinez D. Obstructive sleep apnea-hypopnea syndrome: association with gender, obesity and sleepiness-related factors. *J Bras Pneumol* 2008;34(7):490-6.

43. Setareh J, Mehrnia M, Mirabi A. The Risk of Obstructive Sleep Apnea and Daytime Sleepiness in Patients with Cardiovascular Disease. *Journal of Mazandaran University of Medical Sciences* 2018;28(167):29-41.

44. Argekar P, Griffin V, Litaker D, Rahman M. Sleep apnea in hemodialysis patients: risk factors and effect on survival. *Hemodial Int* 2007;11(4):435-41.

45. Lurie A. Obstructive sleep apnea in adults: epidemiology, clinical presentation, and treatment options. In: Obstructive Sleep Apnea in Adults. Karger Publishers, 2011; 46: pp. 1-42.

46. Moroni L, Neri M, Lucioni AM, Filipponi L, Bertolotti G. A new means of assessing the quality of life of patients with obstructive sleep apnea: the MOSAS questionnaire. *Sleep Med* 2011;12(10):959-65.

47. Svensson M, Lindberg E, Naessen T, Janson C. Risk factors associated with snoring in women with special emphasis on body mass index: a population-based study. *Chest* 2006;129(4):933-41.

48. Hanly PJ, Gabor JY, Chan C, Pierratos A. Daytime sleepiness in patients with CRF: impact of nocturnal hemodialysis. *Am J Kidney Dis* 2003;41(2):403-10.

49. Tada T, Kusano KF, Ogawa A, Iwasaki J, Sakuragi S, Kusano I, et al. The predictors of central and obstructive sleep apnoea in haemodialysis patients. *Nephrol Dial Transplant* 2007;22(4):1190-7.

50. Chung F, Yegneswaran B, Liao P, Chung SA, Vairavanathan S, Islam S, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology* 2008;108(5):812-21.

51. Pecotic R, Dodig IP, Valic M, Ivkovic N, Dogas Z. The evaluation of the Croatian version of the Epworth sleepiness scale and STOP questionnaire as screening tools for obstructive sleep apnea syndrome. *Sleep Breath* 2012;16(3):793-802.

52. Hanis SM, Shadmani FK, Mansori K. Letter to editor: The waist circumference-adjusted associations between hyperuricemia and other lifestyle-related diseases: methodological issues in cross-sectional study. *Diabetol Metab Syndr* 2017;9:23.

53. Mansori K, Hanis SM, Shadmani FK. Letter to the Editor: Postpartum modern contraceptive use in northern Ethiopia: prevalence and associated factors-methodological issues in this cross-sectional study. *Epidemiology and health* 2017;39.