Original Article

The prevalence and predictors of obstructive sleep apnea in patients undergoing bariatric surgery in Saudi Arabia

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ABSTRACT

الأهداف: تتناول هذه الدراسة فجوة في الأدبيات المتعلقة بانتشار انقطاع التنفس الانسدادي أثناء النوم (OSA) والتنبؤ به بين المرضى الذين يخضعون لجراحة السمنة في المملكة العربية السعودية، مع الأخذ في الاعتبار الممارسات الثقافية والغذائية الفريدة في المنطقة.

المنهجية: قامت هذه الدراسة الاستعادية التي أجريت في المدينة الطبية بجامعة الملك سعود بالرياض، بتحليل بيانات المرضى الذين يعانون من السمنة المفرطة المحولين من وحدة جراحة السمنة إلى عيادة اضطرابات النوم. وباستخدام قاعدة بيانات مركز اضطرابات النوم (سبتمبر 2015 - مارس 2019)، قام الباحثون بفحص المتغيرات الديموغرافية والسريرية، مع استخدام تخطيط النوم في المختبر (PSG) لتشخيص وتقييم شدة توقف التنفس أثناء النوم (OSA).

النتائج: قامت الدراسة بتقييم 265 مريضًا يعانون من السمنة المفرطة بسبب توقف التنفس أثناء النوم باستخدام PSG قبل جراحة السمنة. من بين هؤلاء، تم تشخيص 153 (57.7%) بانقطاع التنفس أثناء النوم، وكان متوسط AHI للمرضى الذين يعانون من انقطاع التنفس أثناء النوم 67.8±19.6 حدث/ساعة. فيما يتعلق بالتنبؤات، حددت دراستنا العمر ومؤشر كتلة الجسم ومحيط الرقبة والجنس الذكري والتدخين والشخير وتورم الكاحل وارتفاع ضغط الدم ومرض السكري كعوامل مهمة مرتبطة بانقطاع التنفس أثناء النوم. بالإضافة إلى ذلك، وجدت دراستنا أن قياسات الخصر ومستوى الهيموجلوبين والهيماتوكريت كانت مؤشرات هامة.

الخلاصة: تؤكد هذه الدراسة على ارتفاع معدل انتشار توقف التنفس أثناء النوم لدى مرضى جراحة السمنة في المملكة العربية السعودية وتحدد العديد من العوامل الديموغرافية والسريرية المرتبطة بهذه الحالة. تسلط هذه النتائج الضوء على أهمية فحص انقطاع التنفس أثناء النوم لدى هذه الفئة من السكان لتحسين نتائج المرضى وتقليل مضاعفات ما بعد الجراحة.

Objectives: To address a gap in the literature on the prevalence and predictors of obstructive sleep apnea (OSA) among patients undergoing bariatric surgery in Saudi Arabia, considering the region's unique cultural and dietary practices.

Methods: This retrospective study at King Saud University Medical City, Riyadh, analyzed data from morbidly obese patients referred from the bariatric surgery unit to the sleep disorders clinic. Using the Sleep Disorders Center database (September 2015 to March 2019), it examined demographic and clinical variables, with in-laboratory polysomnography (PSG) employed to diagnose and assess OSA severity.

Results: The study assessed 265 morbidly obese patients for OSA using PSG before bariatric surgery. Of these, 153 (57.7%) were diagnosed with OSA, with the mean apnea hypopnea index for patients with OSA being 67.8±19.6 events/hr. In terms of predictors, our study identified age, body mass index, neck circumference, male gender, smoking, snoring, ankle swelling, hypertension, and diabetes mellitus as significant factors associated with OSA. Additionally, our study found that waist measurements, hemoglobin level, and hematocrit were significant predictors.

Conclusion: This study underscores the high prevalence of OSA in bariatric surgery patients in Saudi Arabia and delineates several demographic and clinical factors associated with the condition. These findings highlight the importance of screening for OSA in this population to optimize patient outcomes and minimize postoperative complications.

Keywords: bariatric surgery, obesity, obstructive sleep apnea, screening, Saudi Arabia

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Obesity, defined as excessive fat accumulation that poses health risks, is diagnosed when the body mass index (BMI) exceeds 30. It has become a global concern with significant aftermaths for healthcare systems and individuals.[1] In Saudi Arabia, obesity prevalence has surged over recent decades, leading to greater awareness of related comorbidities, notably obstructive sleep apnea (OSA).[2,3] Obstructive sleep apnea involves repeated interruptions in breathing during sleep, disrupting sleep patterns and causing adverse health effects.[3] Factors contributing to OSA include nasal congestion, craniofacial structure linked to genetics and ethnicity, obesity, gender, and age, which affect lung volume, respiratory stability, arousal thresholds, and airway muscle function.[4]

Bariatric surgery is an effective intervention for obesity, offering sustained and significant weight loss.[5] With its growing popularity, understanding associated health risks, particularly OSA, is essential. Obstructive sleep apnea, a widespread sleep disorder, involves upper airway obstruction during sleep, and is more common and severe in obese individuals, with obesity serving as a major risk factor.[6,7] Nearly 38% of obese patients have moderate-to-severe OSA, and untreated cases can lead to severe health complications and increased mortality.[8,9] Furthermore, 74% of patients considering bariatric surgery have OSA.[10] While bariatric surgery often resolves OSA in morbidly obese individuals, pre-operative preparation, including polysomnography (PSG) screening, is debated.[11] Current recommendations emphasize thorough perioperative care and pain management.[12]

Saudi Arabia has experienced an unprecedented rise in obesity rates, with unique demographic characteristics affecting OSA presentation. Evidence suggests that OSA presentation and its associated comorbidities, such as obesity, may vary by race and ethnicity due to differences in craniofacial anatomy, fat distribution, and genetic predispositions.[13-15] Recent data shows a high prevalence of obesity among adolescents (up to 20%) and distinctive anthropometric patterns that may influence perioperative risk assessment.[16] Given the unique cultural, dietary, and genetic factors in Arab populations, including Saudis, and the limited number of studies in this area, further research is warranted to explore the potential influence of these factors on OSA risk and clinical presentation. The relationship between OSA and obesity in this population remains poorly characterized, potentially leading to suboptimal screening strategies. This clinical concern is particularly relevant given that bariatric surgery has become increasingly prevalent in Saudi Arabia.[17]

Furthermore, the younger age profile of Saudi bariatric surgery patients (mean age 30.9 years), represents a distinct demographic pattern that has important clinical implications.[17] This contrasts notably with western populations, where bariatric surgery patients tend to be older, with higher reported mean ages.[18,19] Most critically, the relationship between OSA and obesity in young Saudi bariatric surgery candidates remains poorly characterized and inadequately studied. The novelty of this study lies in its focus on a younger age group and a distinct Saudi population, where racial and ethnic factors may significantly influence OSA presentation and severity. Traditional OSA screening protocols, largely developed for older populations, may not be optimal for this younger cohort, as the relationship between OSA and obesity presents differently across age groups.[20] This knowledge gap is particularly concerning as applying standard Western-based screening strategies without modification could lead to missed OSA diagnoses in young Saudi bariatric candidates, potentially compromising surgical outcomes and patient safety. Given the high obesity rates in Saudi Arabia,[21] and the significant burden of OSA in bariatric surgery patients, this study aims to determine the prevalence of OSA and identify its independent risk factors within this population.

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Methods. This retrospective study was carried out at the University Sleep Disorders Center, King Saud University Medical City, Riyadh, Saudi Arabia, between September 2015 and March 2019. Using consecutive sampling, we included all eligible patients referred from the bariatric surgery unit who met specific criteria: BMI of ≥40 kg/m² or ≥35 kg/m² with metabolic comorbidities (such as OSA, type 2 diabetes, hypertension, ischemic heart disease, renal failure, heart failure, stroke, asthma, hypothyroidism, Cushing's syndrome, and hypercholesterolemia, based on criteria by Flegal et al),[22] complete demographic, clinical, and polysomnographic data, and referral from the bariatric surgery unit. After approval from the institutional review board, the data were obtained from a prospectively maintained institutional sleep disorders center database where standardized information is collected systematically at the time of patients' initial clinical evaluation, following established protocols for sleep studies. The final sample comprised 265 patients. Demographic and clinical data were collected using standardized forms during initial evaluation, and polysomnographic studies were carried out and scored according to the American Academy of Sleep Medicine guidelines. This methodology aligns with similar retrospective analyses in bariatric populations and provides adequate statistical power for identifying predictors of OSA in this population.[10,20] Exclusion criteria included incomplete or missing demographic, clinical, or polysomnographic data, not referred from the bariatric surgery unit, or did not meet the eligibility criteria, specifically a BMI of <35 kg/m² or a BMI of 35-39.9 kg/m² without accompanying metabolic comorbidities. Demographic data included age, gender, BMI, neck, hip, and waist circumferences, smoking status, and allergies, along with associated conditions like diabetes, hypertension, hyperlipidemia, and ischemic heart disease.

Daytime sleepiness was assessed using the validated Arabic version of the Epworth sleepiness scale, where a score greater than 10 signifies excessive daytime sleepiness.[23] Obstructive sleep apnea diagnosis and severity were assessed using in-laboratory PSG, with parameters such as apnea-hypopnea index (AHI), arousal index, mean oxygen saturation, and minimum oxygen saturation measured.[24] Diagnostic criteria followed the International Classification of Sleep Disorders, 3rd edition.[25] Obstructive sleep apnea was diagnosed based on either: I) an AHI of ≥5 events/hour with associated symptoms; or II) an AHI of ≥15 events/hour irrespective of symptoms.[25] Hypopnea events required ≥30% peak signal reduction for ≥10 seconds with ≥3% oxygen desaturation or arousal.[26] Severe OSA was defined as an AHI of >30 events/hour.

Statistical analysis. The Statistical Package for the Social Sciences statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA) was used for analysis, comparing demographic, clinical, and polysomnographic variables between OSA and non-OSA groups and between non-severe and severe OSA groups. Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. A p-value of less than 0.05 was considered significant. Independent t-tests or the Mann-Whitney U test (for non-normally distributed data) were used to compare group variables. Univariable and multivariable analyses identified factors associated with OSA presence and severity. Variables analyzed included demographics (age, gender, BMI, and neck and waist circumference), clinical characteristics (blood gas levels, hemoglobin, hematocrit, smoking, snoring, ankle swelling, hypertension, and diabetes), and polysomnographic parameters (AHI, sleep stages, desaturation index, peripheral oxygen saturation [SpO_2] metrics, arousal index, leg movement indices). Odds ratios (ORs) and 95% confidence intervals (CIs) were used to assess the strength of associations. To address potential confounding factors, significant variables (p<0.05) from the univariable analysis were included in the multivariable logistic regression model. This approach ensured that the independent effects of predictors were assessed while controlling demographic, clinical, and polysomnographic confounders. The dependent variables in this study were limited to OSA presence or absence and OSA severity, while the independent variables included demographic, clinical, and polysomnographic factors such as age, gender, BMI, neck circumference, waist circumference, blood gas levels, hemoglobin, hematocrit, smoking status, and various polysomnographic metrics.

Given the observational nature of the study and the expected differences between OSA and non-OSA groups, we employed multivariable logistic regression rather than excluding cases with differing characteristics. This approach preserves the real-world representation of the bariatric surgery population while controlling for potential confounders.[27]

Results. A total of 265 morbidly obese patients undergoing bariatric surgery were assessed for OSA using PSG. Of these, 153 patients were diagnosed with OSA (OSA-positive), and 112 patients were without OSA (non-OSA). The demographic and clinical characteristics of the 2 groups were significantly different (Table 1). Patients in the OSA group were older (35.1±16.3 years) compared to those in the non-OSA group (25±12.9 years), with a statistically significant p-value of <0.001. Additionally, the proportion of male participants was higher in the OSA group (66.7%) compared to the non-OSA group (30.4%), also with a p-value of <0.001. Body mass index was significantly higher in the OSA group (48.9±9.9 kg/m²) than in the non-OSA group (45.3±6.6 kg/m²), with a p-value of 0.011. Significant differences were also observed in neck circumference, waist circumference, and other clinical measures between the groups. These factors, including age, gender, BMI, and neck circumference, were identified as potential confounders and adjusted for in subsequent analyses to isolate the effects of OSA on health outcomes.

Polysomnographic findings revealed significant differences between the OSA and non-OSA groups across several variables (Table 2). Sleep efficiency was significantly lower in the OSA group (67.8±19.6%) compared to the non-OSA group (75.7±18.4%), with

Table 1 - Clinical characteristics of morbidly obese patients undergoing bariatric surgery.

Variables	Total (n=265)	Obstructive sleep apnea		*P*-values
		Yes (n=153)	No (n=112)	
Age (years)	30.8±15.7	35.1±16.3	25±12.9	<0.001
Gender (male)	136 (51.3)	102 (66.7)	34 (30.4)	<0.001
Smoker	22 (8.4)	19 (12.5)	3 (2.7)	0.008
BMI (kg/m^2)	47.4±8.9	48.9±9.9	45.3±6.6	0.011
Neck circumference (inches)	16±2.9	16.3±1.8	15.4±3.8	<0.001
Waist	50.1±6.7	51.8±6.8	47.9±6	<0.001
Hip	54.7±6.6	55.6±7.4	53.6±5.3	0.063
Clinical information				
Epworth sleepiness scale	9.5±5.6	10±5.8	8.7±5.1	0.189
Excessive daytime sleepiness	87 (32.8)	53 (44.5)	34 (45.3)	0.914
pH	7.3±0.5	7.3±0.5	7.1±0.7	0.023
$PaCO_2$ (mmHg)	43.5±13.9	45.4±16.1	39.3±5.3	0.322
PaO_2 (mmHg)	76.8±15.8	75.4±14.9	79.9±17.9	0.421
HCO_3 (mmol/L)	25.4±4.2	26.1±4.5	23.6±2.9	0.164
Hemoglobin level (g/L)	136.5±16.8	140.5±16.8	131.6±15.4	<0.001
HcT	41.3±5.4	42.4±4.8	40±5.9	<0.001
FEV_1/FVC (%)	80.8±8.7	80.7±9.7	81.3±3.9	0.793
FVC (% predicted)	43.6±42.2	43.3±42.5	44.7±42.9	0.757
FEV_1 (% predicted)	43.2±43.7	43.5±44.6	42.4±42.4	0.803
Symptoms				
Snoring	147 (55.5)	99 (81.8)	48 (60.0)	0.001
Witnessed apnea	112 (42.3)	74 (61.2)	38 (47.5)	0.056
Ankle swelling	78 (29.4)	56 (46.3)	22 (27.8)	0.009
Comorbidities				
Hypertension	70 (26.4)	57 (37.5)	13 (11.6)	<0.001
Ischemic heart disease	5 (1.9)	4 (2.6)	1 (0.9)	0.399
Diabetes mellitus	54 (20.4)	39 (25.7)	15 (13.4)	0.015
Renal failure	1 (0.4)	1 (0.7)	0 (0.0)	1.000
Compensated heart failure	1 (0.4)	0 (0.0)	1 (0.9)	0.424
Stroke	2 (0.8)	2 (1.3)	0 (0.0)	0.510
Bronchial asthma	53 (20.0)	35 (23.0)	18 (16.1)	0.163
Hypothyroidism	31 (11.7)	16 (10.6)	15 (13.4)	0.487
Cushing	1 (0.4)	1 (0.7)	0 (0.0)	1.000
Hypercholesterolemia	44 (16.6)	32 (21.2)	12 (10.7)	0.024

Values are presented as numbers and percentages (%) or means ± standard deviation (SD). Of the 265 patients, 254 (95.8%) had a body mass index (BMI) of ≥40 kg/m², while 11 (4.2%) had a BMI of 35-39.9 kg/m² with metabolic comorbidities. The mean BMI was 48.9±9.9 kg/m² in the obstructive sleep apnea group and 45.3±6.6 kg/m² in the non-obstructive sleep apnea group. $PaCO_2$: partial pressure of carbon dioxide, PaO_2: partial pressure of oxygen, HCO_3: bicarbonate, HCT: hematocrit, FEV_1: forced expiratory volume in one second, FVC: forced vital capacity

a *p*-value of <0.001. The AHI was markedly higher in the OSA group (62±43.1 events/hr) compared to the non-OSA group (5.8±4.4 events/hr), with a *p*-value of <0.001. Similarly, the lowest recorded SpO_2 (%) was significantly lower in the OSA group (80±11.3%) compared to the non-OSA group (90.1±4.3%), with a *p*-value of <0.001. Other measures, such as the desaturation index and time with SpO_2 of <90%, were significantly higher in the OSA group, indicating more severe oxygen desaturation events during sleep. These findings underscore the clinical differences between the OSA and non-OSA groups. To address potential confounding factors such as age, gender, and BMI, multivariable analyses were carried out.

Multivariable logistic regression analyses were carried out to identify predictors of OSA and severe OSA, accounting for confounders such as age, BMI, neck circumference, and waist circumference (Table 3).

Age was a significant predictor of OSA, with older age being associated with increased odds of OSA (OR=1.073, 95% CI: [1.026-1.123], *p*=0.002), indicating that each additional year of age increased the odds of having OSA by 7.3%. While BMI was significantly associated with OSA in the univariable model (OR=1.05, 95% CI: [1.019-1.082], *p*=0.002), this association was not significant in the multivariable model (OR=1.044, 95% CI: [0.943-1.157], *p*=0.405), suggesting the effect of BMI may be confounded by

Table 2 - Polysomnographic data of morbidly obese patients undergoing bariatric surgery.

Variables	Presence of OSA			Severity of OSA		
	Yes	No	*P*-values	Non-severe	Severe	*P*-values
Sleep efficiency (%)	67.8±19.6	75.7±18.4	0.000	68.4±19.4	73.6±17.5	0.274
Stage N1 (%)	14.9±13.5	7.7±6.5	0.000	13.4±9.4	9.8±6.5	0.056
Stage N2 (%)	61.8±15.8	56.6±11.9	0.003	52.1±11.2	60.9±14.7	0.021
Stage N3 (%)	14.5±15	15.2±13.6	0.451	21.8±14.5	16.0±14.7	0.137
Stage REM (%)	10.5±10	17.8±7.5	0.000	13.0±8.0	15.5±8.8	0.278
Apnea hypopnea index (events/hr)	62±43.1	5.8±4.4	0.000	26.32±17.9	72.34±33.4	0.000
AHI-NREM (events/hr)	58.6±44.8	3.7±3.7	0.000	41.1±22.8	44.5±38.0	0.720
AHI-REM (events/hr)	68.6±38.2	17.5±18.4	0.000	13.2±10.2	79.2±32.0	0.000
Desaturation index (desaturations/hr)	43.9±44.5	4.9±4.5	0.000	13.2±14.0	35.9±36.6	0.013
Time with SpO_2 <90% (mins)	13.9±23.5	0.4±1.6	0.000	1.6±3.8	14.4±24.0	0.030
Time with SpO_2 <95% (mins)	48.7±35.4	15.6±26	0.000	29.7±32.00	52.3±36.5	0.023
Lowest recorded SpO_2 (%)	80±11.3	90.1±4.3	0.000	88.9±6.3	77.6±12.00	0.000
Mean nocturnal SpO_2 (%)	93.7±3.8	96.5±1.5	0.000	95.7±1.4	93.4±3.7	0.014
Arousal index (arousals/hr)	59.8±40.3	14.4±10.6	0.000	42.2±20.1	48.4±31.7	0.438
Leg movement index (events/hr)	6.6±11.8	3.8±8.3	0.154	9.9±16.7	5.00±7.4	0.052
Periodic leg movement index (events/hr)	10.9±6.2	10±5.6	0.708	8.8±4.7	10.8±6.6	0.545

Values are presented as means ± standard deviation (SD). OSA: obstructive sleep apnea, REM: rapid eye movement, NREM: non-rapid eye movement, AHI: apnea-hypopnea index, SpO_2: oxygen saturation, N1, 2, and 3: non-rapid eye movement sleep stages

Table 3 - Associated factors for obstructive sleep apnea and Severe obstructive sleep apnea in morbidly obese patients undergoing bariatric surgery.

Predictors	OSA vs. non-OSA (OR [95% CI])				Severe OSA vs. non-severe OSA (OR [95% CI])			
	Univariable	*P*-values	Multivariable	*P*-values	Univariable	*P*-values	Multivariable	*P*-values
Age (year)	1.047 (1.028-1.066)	<0.001	1.073 (1.026-1.123)	0.002	1.110 (1.080-1.141)	<0.001	1.120 (1.090-1.152)	<0.001
BMI (kg/m^2)	1.05 (1.019-1.082)	0.002	1.044 (0.943-1.157)	0.405	1.062 (1.032-1.093)	<0.001	1.040 (1.015-1.066)	0.002
Neck circumference (inches)	1.261 (1.088-1.463)	0.002	1.14 (0.77-1.688)	0.514	1.190 (1.120-1.263)	<0.001	1.158 (1.089-1.230)	0.001
Waist	1.1 (1.053-1.149)	<0.001	1.019 (0.895-1.161)	0.773	1.091 (1.055-1.128)	<0.001	1.070 (1.035-1.106)	0.001
Waist-hip-ratio	1.05 (1.008-1.094)	0.018	1.073 (1.026-1.123)	0.002	1.053 (1.020-1.087)	0.002	1.038 (1.006-1.071)	0.021
Hemoglobin level (g/L)	1.035 (1.017-1.053)	<0.001	1.025 (1.008-1.042)	0.003	1.025 (0.995-1.056)	0.109	1.013 (0.984-1.043)	0.267
HcT	1.105 (1.041-1.174)	0.001	1.026 (0.914-1.152)	0.658	1.075 (1.038-1.113)	<0.001	1.055 (1.018-1.093)	0.003
Gender (male)	4.588 (2.715-7.753)	<0.001	3.563 (0.825-15.382)	0.089	4.882 (2.895-8.238)	<0.001	3.760 (2.219-6.370)	<0.001
Hypertension	4.569 (2.35-8.884)	<0.001	2.2 (0.604-8.016)	0.232	4.635 (2.403-8.945)	<0.001	2.250 (0.621-8.159)	0.212
Diabetes mellitus	2.232 (1.16-4.294)	0.016	2.120 (1.100-4.090)	0.023	2.265 (1.180-4.360)	0.014	1.920 (0.990-3.724)	0.053
Hypercholesterolemia	2.241 (1.097-4.58)	0.027	2.020 (1.030-3.960)	0.040	2.280 (1.112-4.675)	0.024	1.998 (0.969-4.121)	0.061

OR: odds ratio, CI: confidence interval, OSA: obstructive sleep apnea, BMI: body mass index, HcT: hematocrit

other factors. Neck circumference showed a similar pattern, with a significant association in the univariable model (OR=1.261, 95% CI: [1.088-1.463], *p*=0.002), but not in the multivariable model (OR=1.140, 95% CI: [0.770-1.688], *p*=0.514). Waist circumference, however, remained significantly associated with OSA in both the univariable (OR=1.1, 95% CI: [1.053-1.149], *p*<0.001) and multivariable models (OR=1.070, 95% CI: [1.035-1.106], *p*=0.001). Male gender was a strong predictor of OSA, with men being significantly more likely to develop the condition than women (OR=4.588, 95% CI: [2.715-7.753], *p*<0.001).

Age continued to be a significant predictor of severe OSA (OR=1.120, 95% CI: [1.090-1.152], *p*<0.001). Neck circumference was also significantly associated with severe OSA (OR=1.158, 95% CI: [1.089-1.230], *p*=0.001), as was waist circumference (OR=1.070, 95% CI: [1.035-1.106], *p*=0.001). Male gender remained a significant predictor of severe OSA (OR=3.760, 95% CI: [2.219-6.370], *p*<0.001).

Discussion. Our study aimed to assess the occurrence of OSA and its forecasters in bariatric surgery patients in Saudi Arabia. Obstructive sleep apnea was diagnosed in 57.7% of our cohort, which is consistent with findings from similar studies.[20,28,29] Significant demographic and clinical characteristic differences were observed between patients with and without

OSA, including age, BMI, neck circumference, waist measurements, hemoglobin levels, and hematocrit. These findings align with prior research identifying age, BMI, and neck circumference as critical predictors of OSA in obese patients undergoing bariatric surgery.[10,30] Male gender, smoking, snoring, ankle swelling, hypertension, and diabetes mellitus were more common in the OSA group, reflecting trends reported in the literature.[28,31,32] A systematic review and meta-analysis of 9 studies from North America and Europe revealed that 72% of bariatric surgery patients were diagnosed with OSA.[33] Predictors identified in our research (age, BMI, neck circumference, male gender, smoking, snoring, ankle swelling, hypertension, and diabetes) were consistent with the meta-analysis. However, our study uniquely found waist measurements, hemoglobin levels, and hematocrit as significant predictors.

The study's results underscore the importance of addressing confounding factors such as age, gender, and BMI. By adjusting for these variables in our multivariable logistic regression analysis, we were able to isolate the relationship between OSA and other clinical outcomes, ensuring that our findings were not biased by these confounders. While we found that BMI was associated with OSA, it was no longer significant after accounting for other confounding factors, suggesting that neck circumference and waist circumference are perhaps more direct predictors of OSA in morbidly obese patients. This aligns with previous research that emphasized the role of upper-body obesity in the development of OSA.[10]

Our data highlighted that male patients had a higher susceptibility to OSA, with a mean AHI of 62±43.1 events/hr, which is consistent with previous findings linking male gender to increased OSA risk.[32] Our findings are consistent with those of a 2018 study carried out in Thailand, which reported similar associations between OSA and comorbidities such as hypertension, fatty liver disease, dyslipidemia, and type 2 diabetes.[20] Statistically significant differences in neck circumference (16±2.9 inches) and waist circumference (51.8±6.8 inches, $p<0.001$) in our cohort further corroborate previous studies.[10]

It is important to note that smoking status was also associated with OSA. A total of 22 (8.4%) smokers were identified, with a higher percentage of smokers in the OSA group (12.5%) compared to the non-OSA group (2.7%). This aligns with previous research that suggests smoking is a contributing factor to the development of OSA.[34] Ex-smokers (n=7, 2.7%) were more prevalent in the OSA group, though this difference was not statistically significant. However, the duration of smoking, a known risk factor for the severity of OSA, was not captured in our data, and this limitation should be addressed in future studies.

While OSA remains under-recognized and undertreated in bariatric patients, targeted physician education on OSA screening in obesity and bariatric surgery clinics is crucial. Our findings align with earlier research, highlighting obesity as a significant OSA risk factor.[10] Obese or severely obese patients face double the OSA risk of normal-weight individuals, with even minor weight increases worsening symptoms, while a 20% weight reduction can significantly alleviate OSA. Continuous positive airway pressure (CPAP) therapy plays a critical role in managing OSA before and after bariatric surgery, as it helps improve perioperative outcomes and reduce complications.[29] Early detection of OSA enables timely initiation of CPAP therapy, which can mitigate the effects of anesthetic agents and analgesics that impair upper airway reflexes and arousal mechanisms during the perioperative period.

Study limitations. The retrospective design inherently limited data completeness and availability of some variables, such as smoking history, which lacked details on duration and cessation status. Additionally, the cross-sectional nature of data collection prevented the assessment of temporal relationships between variables and long-term outcomes. Our study population characteristics introduced certain limitations. Being carried out at a single tertiary care center may have created referral bias. Furthermore, the predominance of patients with BMI of ≥40 kg/m² (95.8%) limits the generalizability of our findings across all BMI categories, although the findings of high BMI concur with most previous studies that reported bariatric surgery patients in Saudi Arabia.[17,35] Several clinical assessment limitations existed. While we had complete polysomnographic data for included patients, we lacked follow-up data to assess post-surgical outcomes and CPAP adherence. Potential sources of bias included selection bias from excluding patients who declined PSG, information bias from self-reported symptoms and comorbidities, and measurement bias from varying technical staff and equipment. Despite statistical adjustment for known confounders, residual confounding may exist, particularly from unmeasured socioeconomic factors.

Nevertheless, despite these limitations, the study provides valuable insights into the predictors and prevalence of OSA in bariatric surgery patients and highlights the importance of routine OSA screening to improve perioperative outcomes and reduce complications.

In conclusion, the study underscores the high occurrence of OSA in bariatric surgery patients in Saudi Arabia and delineates several demographic and clinical factors associated with the condition. These findings highlight the importance of screening for OSA in this population to optimize patient outcomes and minimize postoperative complications. The study, henceforth, proves the importance of CPAP therapy before and after bariatric surgery and promotes further research to understand the effectiveness of CPAP therapy in reference to OSA, obesity, and bariatric surgery.

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