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ORIGINAL CONTRIBUTIONS

Preoperative Assessment of Obstructive Sleep Apnea in Bariatric Patients Using Polysomnography or Polygraphy

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Abstract

Background Preoperative assessment of obstructive sleep apnea (OSA) in patients scheduled for bariatric surgery can be performed by in-laboratory polysomnography (PSG) or by portable polygraphy (PP) at home. We aimed to evaluate the association between PSG/PP, OSA diagnosis, and implementation of continuous positive airway pressure (CPAP) therapy.

Methods All patients who underwent bariatric surgery from 2015 to 2017 were retrospectively reviewed. Patients underwent preoperative PSG or PP, based on prevailing protocols or at the physician's discretion. Logistic regression analyses were performed to determine predictors of CPAP implementation. OSA-related postoperative complications were analyzed in both groups.

Results During the study period, 1464 patients were included. OSA was diagnosed in 79% of 271 patients undergoing PSG, compared to 64% of 1193 patients undergoing PP ($p < 0.001$), with median apnea–hypopnea index (AHI) of 15.8 and 7.7, respectively. CPAP treatment was initiated in 52% and 27% of patients, respectively, $p < 0.001$. Predictors (with adjusted odds ratio) in multivariate regression analysis for CPAP implementation were as follows: male gender (5.15), BMI ≥ 50 (3.85), PSG test (2.74), hypertension (2.38), and age ≥ 50 (1.87). OSA-related complications did not differ between groups ($p = 0.277$).

Conclusion Both PSG and PP are feasible options for preoperative OSA assessment in bariatric patients. When PP is performed, some underdiagnosis may occur as cases of mild OSA may be missed. However, clinically relevant OSA is detected by both diagnostic tools. No difference in OSA-related complications was found. PP is a safe, less invasive option and can be considered as a suitable measure for OSA assessment in this population.

Keywords Obstructive sleep apnea · Polygraphy · Polysomnography · Preoperative care · Bariatric surgery · Continuous positive airway pressure

Key Points OSA was diagnosed in 79% undergoing PSG, compared to 64% undergoing PP.

Of the PSG patients, 51.7% started CPAP treatment, compared to 27.2% PP patients.

OSA-related post-bariatric complications were similar among the PSG and PP groups.

Both PSG and PP are feasible options to detect OSA and prevent complications.

Introduction

Obstructive sleep apnea (OSA) is the most prevalent sleep-related breathing disorder in obese patients scheduled for bariatric surgery with an estimated prevalence of 60–70% [1, 2]. OSA is characterized by recurrent collapses of the

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upper airway during sleep, resulting in partial (hypopnea) or complete (apnea) cessations of breathing. In the general population, OSA is treated in order to minimize symptoms and reduce long-term morbidity and complications. In surgical patients, detecting and treating OSA is also performed to prevent complications. Undiagnosed or untreated OSA increases perioperative risk, as opioids and sedatives administered during general anesthesia can induce respiratory depressant effects during the first night after surgery [3–5]. These effects can result in severe hypoxemia and long-lasting apneas and can consecutively cause serious cardiopulmonary or thromboembolic complications and even death [5].

Strategies that aim to prevent these rare but serious complications mostly consist of preoperative OSA-screening and subsequent treatment with continuous positive airway pressure (CPAP) for patients with moderate or severe OSA [6]. The preoperative screening for OSA in the bariatric population varies from the use of questionnaires, e.g., STOP-BANG, alternative non-invasive screening devices such as wearables, and portable polygraphy up to the gold standard in-laboratory polysomnography (PSG) [7–9]. Despite the effectiveness and thorough approach of a preoperative PSG, it is a time-consuming measurement, costly, and often limited in availability. A less comprehensive alternative to diagnose OSA is portable polygraphy (PP), a portable monitoring device that is less invasive and less expensive. Both forms of sleep study establish the apnea–hypopnea index (AHI), which is most accepted as indicative of disease severity.

The crucial difference between these sleep studies is that PSG does not only focus on respiratory efforts but simultaneously conducts an electroencephalography. Hence, PSG has the ability to distinguish between an awake state and sleep and can measure accurate sleeping time to calculate the AHI. PP denominates the AHI through total recording time (e.g., self-reported sleeping time) instead of objective sleeping time, which generally reduces the AHI. Still, PP identifies moderate or severe OSA and is recommended in patients with a high pre-test probability for OSA, such as the bariatric population [9, 10].

Both PSG and PP testing are widely applied in bariatric clinics, but it is unclear whether this has a substantial impact on diagnosing clinically relevant OSA, without compromising the prevention of major cardiopulmonary and thromboembolic complications in bariatric patients. We hypothesize that clinically relevant OSA that could induce postoperative complications will be detected by both PSG and PP. The aim of this study was to evaluate the prevalence of OSA (AHI ≥ 5 events/hour) detected by PSG (the gold standard), compared to PP in patients scheduled for bariatric surgery. In addition, we analyzed the implementation of CPAP treatment and OSA-related adverse postoperative outcomes.

Methods

Study Design and Patient Population

This is a retrospective review of a prospectively maintained database that contains all consecutive patients who underwent bariatric surgery and preoperative OSA assessment between January 2015 and January 2018 in a high-volume bariatric center: OLVG, Amsterdam, the Netherlands. This database contained general patient characteristics, OSA-specific data, and surgical outcomes such as complications. Patients were excluded if they had undergone PSG or PP before surgical consultation, or because they did not undergo PSG or PP before revisional surgery. During the study period, a transition in preoperative OSA assessment using PSG to PP was made (temporal changes from PSG to PP will be reported in Table 1). Patients were referred for either PSG or PP based on the availability of resources, the prevailing protocol, waiting lists for PSG tests, and at the discretion of the treating physician as no formal protocols for the referral selection were used. Patients were divided into two groups based on the type of sleep study used for OSA assessment. The local ethical committee gave permission to perform this retrospective study, without the need for formal informed consent as data was used anonymously.

Sleep Studies Performed

Patients undergoing polysomnography were admitted for a full-night sleep study using the Embla recorder (Flaga Medical devices, Reykjavik, Iceland). PSG were performed either attended or unattended and comprised measurements of respiratory efforts (thoracic and abdominal sensors), sleep architecture (electroencephalogram, electrooculogram, and submental electromyogram), leg and body position (motion sensor), oxygen saturation, and heart rate (pulse oximetry), and airflow and snoring (pressure sensor).

Portable polygraphy was performed at home using the Vivisol recorder (Dolby Vivisol, Stirling, UK)/Embla. The same parameters were measured, except for sleep architecture.

In case of incomplete results, sleep studies were repeated and the results of the complete measurement were used for the analyses.

Prevalence and severity of OSA were based on AHI: an AHI < 5 excluded OSA prevalence, while 5 ≥ AHI < 15 defined mild, 15 ≥ AHI < 30 moderate, and AHI ≥ 30 severe OSA. Patients diagnosed with moderate or severe OSA were treated with CPAP. Patients with mild OSA

Table 1 Baseline characteristics

	PSG $N=271$ (18.5%)	PP $N=1193$ (81.5%)	p-value
Gender, female (n, %)	206 (76.0)	1015 (85.1)	0.001
Age, years (mean, SD)	47.2 ± 11.8	43.5 ± 12.0	< 0.001
BMI, kg/m^2 (mean, SD)	42.8 ± 5.8	43.3 ± 6.4	0.169
Waist circumference, cm (mean, SD)	126.9 ± 12.5	125.9 ± 14.5	0.289
Comorbidities (n, %)			
Hypertension	103 (38)	344 (28.8)	0.003
Dyslipidemia	53 (19.6)	175 (14.7)	0.051
Type 2 diabetes	56 (20.7)	229 (19.2)	0.581
GERD	68 (25.1)	320 (26.8)	0.594
COPD	7 (2.6)	26 (2.2)	0.652
History of CVD	26 (9.6)	76 (6.4)	0.065
Alcohol consumption (n, %)	67 (24.7)	333 (27.9)	0.326
Smoking (n, %)			
Current	44 (16.2)	254 (21.3)	0.078
Former	114 (42.1)	364 (30.5)	< 0.001
Year of sleep study			
2015	59 (13.5)	378 (86.5)	< 0.001
2016	127 (27.0)	343 (73.0)	< 0.001
2017	85 (15.7)	472 (84.7)	< 0.001
Type of procedure (n, %)*			< 0.001
LRYGB	196 (72.3)	813 (68.1)	0.191
LSG	51 (18.8)	232 (19.5)	0.865
One-anastomosis bypass	2 (0.7)	2 (0.2)	0.158
Revisional surgery			
• Conversion LAGB to LRYGB	12 (4.5)	103 (8.6)	0.018
• Conversion LAGB to LSG	2 (0.7)	25 (2.1)	0.207
• Other**	8 (3.0)	18 (1.5)	0.123

BMI body mass index, *COPD* chronic obstructive pulmonary disease, *CVD* cardiovascular disease, *GERD* gastroesophageal reflux disease, *LAGB* laparoscopic adjustable gastric band, *LRYGB* laparoscopic Roux-en-Y gastric bypass, *LSG* laparoscopic sleeve gastrectomy, *PP* portable polygraphy, *PSG* polysomnography

*All procedures were performed laparoscopically

**Other: placement of minimizer-ring, single-anastomosis duodenal ileal bypass, pouch revision, conversion of vertical band gastroplasty to LRYGB, band removal, LSG to LRYGB, elongation of alimentary limb

were treated with CPAP in case of clinically significant deviant PSG or PP metrics, other than AHI, such as time during sleep study that saturation levels were < 90% SpO_2, or in case of reported excessive daytime sleepiness.

Outcomes

The primary outcome is the prevalence of OSA detected by PSG compared to the OSA prevalence detected by PP, expressed as odds ratio (OR) and adjusted odds ratio (aOR). Secondary outcomes were exact outcomes of sleep studies, i.e., AHI and oxygen desaturation index (ODI), the prevalence of consequent initiation of CPAP treatment, and postoperative clinical outcomes within 30 days of surgery, such as general complications and readmissions. Finally, an analysis of specific complications that could be OSA-related, i.e., pulmonary, cardiac or, thromboembolic complications, was performed.

Statistical Analysis

Baseline characteristics were displayed using the number of cases (n) and percentages (%). Normally and non-normally distributed data were described using means with standard deviation (SD) and medians with interquartile range (IQR), respectively. Continuous data were analyzed using independent t-tests, Mann–Whitney U test, or Kruskal–Wallis test, depending on distribution normality. Binary data were analyzed with chi-square analysis or Fishers' exact test, depending on the expected value.

Univariable logistic regression was performed to analyze the odds ratio (OR) for the association of OSA diagnosis and CPAP therapy following PSG or PP tests. To correct for confounders and formulate an adjusted odds ratio (aOR), multivariable logistic regression analysis was performed. All associated factors with a p-value of < 0.1 in univariable analysis were used for multivariable analysis. A p-value of ≤ 0.05 was considered statistically significant. Statistical analyses were performed by using IBM SPSS Statistics, version 25.0 for Windows (SPSS, Chicago, IL).

Results

A total of 1598 patients underwent bariatric surgery during the study period, of which 1464 patients were included in this analysis. Patients were excluded due to previously conducted PSG or PP in other centers ($n = 114$), or because they did not undergo PSG or PP before revisional surgery ($n = 20$). Analysis of these 1464 patients revealed that 271 patients (18.5%) underwent PSG and 1193 patients (81.5%) underwent PP. Patients who underwent PSG were more often male, were older on average, and presented with a higher prevalence of hypertension. These and other baseline characteristics are shown in Table 1.

Table 2 Outcomes of sleep studies and surgery

	PSG $N = 271$	PP $N = 1193$	p-value
P(S)G parameters			
AHI (median, IQR)	15.8 (6.3–32.6)	7.7 (3.2–16.6)	< 0.001
ODI (median, IQR)	17.2 (8.9–29.2)	11.3 (5.4–21.2)	< 0.001
No OSA (AHI < 5) *n*, %	57 (21.0)	429 (36.0)	< 0.001
Overall OSA (AHI ≥ 5) *n*, %	214 (79.0)	764 (64.0)	< 0.001
• Mild (AHI 5–15)	71 (26.2)	440 (36.9)	< 0.001
• Moderate (AHI 15–30)	70 (25.8)	170 (14.2)	< 0.001
• Severe (AHI ≥ 30)	73 (27.0)	154 (12.9)	< 0.001
CPAP implementation (*n*, %)	140 (51.7)	325 (27.2)	< 0.001
Surgical outcomes (*n*, %)			
Complications < 30 days	27 (10.0)	121 (10.1)	0.930
• OSA-related complications*	4 (1.5)	9 (0.8)	0.277
• Pulmonary	3 (1.1)	6 (0.5)	
• Cardiac	1 (0.4)	1 (0.1)	
• Thromboembolic	0	2 (0.2)	
• Bleeding	8 (3.0)	42 (3.5)	0.853
• Anastomotic leakage	6 (2.2)	15 (1.3)	0.254
• GJS stenosis	1 (0.4)	11 (0.9)	0.707
• Wound infection	0	6 (0.5)	-
•Intra-abdominal abscess	0	5 (0.4)	-
•Perforation	0	6 (0.5)	-
•Other**	8 (3.0)	27 (2.3)	0.066
Severity of complications			
• Minor (CDC ≤ 2)	14 (5.2)	59 (5.0)	0.968
• Major (CDC ≥ 3A)	13 (4.8)	61 (5.1)	0.487
Readmission	17 (6.3)	83 (7.0)	0.790

AHI apnea hypopnea index, *CDC* Clavien-Dindo classification, *CPAP* continuous positive airway pressure, *ODI* oxygen desaturation index, *OSA* obstructive sleep apnea, *PP* portable polygraphy, *PSG* polysomnography

*OSA-related complications include, e.g., pneumonia, acute respiratory insufficiency, atrial fibrillation, deep venous thrombosis, and pulmonary embolism

**Other complications include, e.g., gastrointestinal ulcer, internal herniation, postoperative pain, gallstones, gastroesophageal reflux, acute kidney failure, and urinary tract infection

Outcomes of Sleep Studies

Results of sleep studies showed significantly higher median AHI of 15.8 and ODI of 17.2 events/hour in the PSG group, compared to median AHI of 7.7 and median ODI of 11.3 events/hour in the PP group, respectively ($P < 0.001$) (Table 2). Overall, OSA (AHI ≥ 5) was diagnosed in 79% of patients who underwent PSG compared to 64% of patients undergoing PP ($p < 0.001$). Mild OSA was diagnosed in 26% of patients undergoing PSG compared to 37% of PP patients, $p < 0.001$. Moderate and severe OSA was diagnosed in 26% and 27% of PSG patients, compared to 14% and 13% of PP patients, both $p < 0.001$, respectively.

In univariable regression analysis, several significant predictors for OSA prevalence following PSG testing were identified: male gender, age ≥ 50 years, and hypertension. After multivariate analysis, male gender (aOR 13.9) and age ≥ 50 years (aOR 4.0) remained significant.

For OSA prevalence following PP, in univariable analysis male gender, age ≥ 50 years, BMI ≥ 50 kg/m^2, hypertension, dyslipidemia, type 2 diabetes, gastroesophageal reflux disease (GERD), alcohol consumption, and history of cardiovascular disease (CVD) were significant (Table 3). After multivariable logistic regression, the following predictors remained significant: male gender (adjusted odds ratio (aOR) 5.7), age ≥ 50 years (aOR 3.5), BMI ≥ 50 kg/m^2 (aOR 3.1), and hypertension (aOR 2.3).

CPAP Implementation

The disparities of OSA severity between the PSG and PP group were consequently found in CPAP implementation, as 51.7% of PSG patients started CPAP treatment before surgery, compared to 27.2% of PP patients, $p < 0.001$. Patients undergoing PSG had an odds ratio of CPAP implementation of 1.9, compared to patients undergoing PP.

Predictors for CPAP implementation that were significant in the univariable analysis were male gender, age ≥ 50 years, BMI ≥ 50 kg/m^2, PSG as a diagnostic tool (compared to PP), hypertension, dyslipidemia, type 2 diabetes, GERD, alcohol consumption, and history of CVD (Table 3). Predictors for CPAP implementation that remained significant in the multivariable analysis were male gender (aOR 5.15), BMI ≥ 50 (aOR 3.58), PSG as preoperative assessment (aOR 2.74), hypertension (aOR 2.38), and age ≥ 50 years (aOR 1.87).

Surgical Outcomes

Complications within 30 days of surgery occurred in 27 patients who underwent PSG (10.0%) and 121 patients who underwent PP (10.1%), $p = 0.930$ (Table 2). No differences in the type of complications that occurred between groups were found (e.g., anastomotic leakage or bleeding) and no differences in severity of complications, defined as minor or major based on Clavien-Dindo classification, were found. The incidence of readmissions did not differ between groups ($p = 0.790$). OSA-related complications occurred in 11 patients (0.8%), but with no difference between patients who underwent PSG or PP, $p = 0.277$ (Table 2). In the PSG group, these complications were pneumonia ($n = 3$) and cardiac arrhythmias ($n = 1$). In the PP group, the complications were pneumonia ($n = 4$), respiratory failure ($n = 1$), bronchospasm with consequent failed detubation ($n = 1$), atrial fibrillation ($n = 1$), deep venous embolism ($n = 1$), and pulmonary embolism ($n = 1$).

Discussion

The present study found that patients who undergo preoperative PSG prior to bariatric surgery are diagnosed with OSA more frequently than those who underwent preoperative PP. Clinically significant OSA, i.e., moderate or severe OSA, was diagnosed more frequently in patients who underwent PSG than PP. This led to a significant difference in CPAP implementation, and patients who underwent PSG had a 1.9-fold higher odds ratio to receive CPAP treatment before surgery than those that underwent PP. However, OSA-related complications did not differ between both groups.

To our knowledge, this is the first study that compares a large cohort of patients undergoing either PSG or PP testing before bariatric surgery. Oliveira et al. [11] described the diagnostic accuracy of PP monitoring at home for OSA diagnosis and compared it to PSG by performing both sleep studies during preoperative work-up in the same bariatric patient with OSA symptoms. They found a higher diagnostic accuracy when higher AHI cut-off values were used. For AHI ≥ 30, the sensitivity and specificity were 67% and 100%, while for an AHI between 5 and 30, these outcomes were much lower: 40% and 81%, respectively. Due to the small sample size, high drop-out rate (26 of 58 patients, 45%), and a preselected study population with a high pretest probability for OSA, no definitive conclusions could be drawn from their study. Malbois et al. [12] compared nocturnal oximetry to portable OSA monitoring in 68 bariatric patients and found a positive and negative predictive value of 100% and 95%, but they did not conduct PSG for comparison.

Despite a significant difference in perioperative use of CPAP between patients who underwent PSG and PP tests, postoperative complications did not differ between groups. A possible explanation why postoperative outcomes were similar despite a discrepancy in OSA diagnosis and CPAP initiation could be that patients with severe and clinically relevant OSA are identified both by PSG and PP. This is also suggested by the data of the previously mentioned trial

Table 3 Uni- and multivariable logistics regression analysis for predictors of AHI ≥ 5 for PSG patients, AHI ≥ 5 for PG patients, and CPAP initiation combined

Factors	*N* (%)	Univariable OR (95% CI)	*p*	Multivariable aOR (95% CI)	*p*
AHI ≥ 5 for PSG (*n* = 271)					
Gender (male = 1, female = 0)	65 (24.0)	11.47 (2.72–48.48)	0.001	13.93 (3.24–59.79)	< 0.001
Age (≥ 50 = 1 vs. < 50 years)	130 (48.0)	3.64 (1.88–7.04)	< 0.001	4.00 (1.90–3.38)	< 0.001
BMI (≥ 50 = 1 vs. < 50 kg/m^2)	27 (10.0)	1.19 (0.43–3.30)	0.736		
Hypertension (yes = 1, no = 0)	103 (38)	2.19 (1.13–4.24)	0.020	1.24 (0.58–2.67)	0.574
Dyslipidemia (yes = 1, no = 0)	53 (19.6)	1.380 (0.63–3.03)	0.421		
Type 2 diabetes (yes = 1, no = 0)	56 (20.7)	1.29 (0.60–2.74)	0.513		
GERD (yes = 1, no = 0)	68 (25.1)	1.30 (0.641–2.64)	0.468		
COPD (yes = 1, no = 0)	7 (2.6)	1.62 (0.19–13.70)	0.660		
Alcohol consumption (yes = 1, no = 0)	67 (24.7)	1.68 (0.80–3.55)	0.174		
History of CVD (yes = 1, no = 0)	26 (9.6)	1.52 (0.50–4.60)	0.460		
Current smoking (yes = 1, no = 0)	44 (16.2)	1.027 (0.46–2.29)	0.948		
AHI ≥ 5 for PP (*n* = 1193)					
Gender (male = 1, female = 0)	178 (14.9)	6.05 (3.66–10.00)	< 0.001	5.66 (3.31–9.66)	< 0.001
Age (≥ 50 = 1 vs. < 50 years)	419 (35.1)	4.5 (3.36–6.07)	< 0.001	3.50 (2.52–4.87)	< 0.001
BMI (≥ 50 = 1 vs. < 50 kg/m^2)	159 (12.5)	2.47 (1.65–3.72)	< 0.001	3.10 (2.00–4.80)	< 0.001
Hypertension (yes = 1, no = 0)	344 (28.8)	3.83 (2.80–5.24)	< 0.001	2.27 (1.58–3.28)	< 0.001
Dyslipidemia (yes = 1, no = 0)	175 (14.7)	2.86 (1.91–4.28)	< 0.001	1.13 (0.68–1.89)	0.640
Type 2 diabetes (yes = 1, no = 0)	229 (19.2)	2.19 (1.56–3.06)	< 0.001	0.97 (0.64–1.49)	0.899
GERD (yes = 1, no = 0)	320 (26.8)	1.27 (0.97–1.67)	0.083	1.23 (0.91–1.66)	0.170
COPD (yes = 1, no = 0)	26 (2.1)	1.27 (0.55–2.95)	0.578		
Alcohol consumption (yes = 1, no = 0)	333 (27.9)	1.31 (1.00–1.72)	0.047	1.24 (0.92–1.67)	0.164
History of CVD (yes = 1, no = 0)	76 (6.3)	2.62 (1.45–4.74)	0.001	1.15 (0.59–2.25)	0.686
Current smoking (yes = 1, no = 0)	254 (21.3)	0.83 (0.63–1.11)	0.203		
CPAP implementation (*n* = 1464)					
Gender (male = 1, female = 0)	243 (16.6)	5.41 (4.04–7.25)	< 0.001	5.15 (3.72–7.11)	< 0.001
Age (≥ 50 = 1 vs. < 50 years)	549 (37.5)	2.69 (2.14–3.37)	< 0.001	1.87 (1.41–2.48)	< 0.001
BMI (≥ 50 = 1 vs. < 50 kg/m^2)	186 (12.7)	2.50 (1.83–3.41)	< 0.001	3.58 (2.52–5.10)	< 0.001
OSA diagnostic tool (PSG = 1, PP = 0)	271 (18.5)	2.86 (2.18–3.74)	< 0.001	2.74 (2.02–3.72)	< 0.001
Hypertension (yes = 1, no = 0)	447 (30.5)	3.28 (2.59–4.15)	< 0.001	2.38 (1.77–3.21)	< 0.001
Dyslipidemia (yes = 1, no = 0)	228 (15.6)	2.52 (1.89–3.36)	< 0.001	1.13 (0.76–1.69)	0.534
Type 2 diabetes (yes = 1, no = 0)	285 (17.3)	1.96 (1.51–2.56)	< 0.001	0.98 (0.68–1.41)	0.914
GERD (yes = 1, no = 0)	388 (26.5)	1.30 (1.12–1.66)	0.036	1.32 (1.00–1.75)	0.053
COPD (yes = 1, no = 0)	33 (2.3)	1.41 (0.69–2.86)	0.343		
Alcohol consumption (yes = 1, no = 0)	400 (27.3)	1.39 (1.09–1.77)	0.008	1.30 (0.98–1.72)	0.068
History of CVD (yes = 1, no = 0)	102 (7.0)	2.61 (1.74–3.92)	< 0.001	1.34 (0.83–2.17	0.225
Current smoking (yes = 1, no = 0)	298 (20.4)	1.05 (0.80–1.38)	0.734		

AHI apnea hypopnea index, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *CPAP* continuous positive airway pressure, *CVD* cardiovascular disease, *GERD* gastroesophageal reflux disease, *OSA* obstructive sleep apnea, *PP* portable polygraphy, *PSG* polysomnography

by Oliveira et al. [11]. To strengthen this hypothesis, a relationship between OSA severity and OSA-related complications in untreated patients has to be assumed. However, several studies attempted to analyze this relationship, but the outcomes are conflicting. In the largest cohort study, Mutter et al. compared 2640 surgical patients with OSA to 16,220 controls and found a 2.3 odds ratio for patients with severe OSA (AHI ≥ 30) to develop respiratory complications compared to controls [13]. However, in two smaller studies comparing surgical patients with no OSA to known OSA

patients, no correlation between OSA severity and AHI was found [14, 15]. It should be noted that these three studies comprised patients who underwent surgical interventions other than bariatric procedures, and thus are not optimally suited to be compared to bariatric patients. This is because patients undergoing bariatric surgery have a higher probability of undiagnosed OSA, compared with the patient population undergoing general surgery who have a low or intermediate risk of undiagnosed OSA.

The present findings should be interpreted in light of the following limitations. First, the retrospective study design precludes comparing PP and PSG outcomes within the same patient. Second, we did not perform a sample size calculation for the secondary outcome: occurrence of OSA-related complications. Therefore, any interpretation of the prevention of these complications warrants some caution, as cardiopulmonary and thromboembolic complications can result in significant morbidity, or even in fatalities, but are very rare following bariatric surgery. In addition, the percentage of patients using CPAP was different between PSG and PP groups, and this might influence the outcomes as well. Third, extensive preoperative OSA screening has been standard care in many bariatric centers. Historically, like in our hospital, PSG was initially always used as OSA screening due to its status as golden standard diagnostic, but in recent years, a shift towards more ambulatory tests has occurred. This partially explains the uneven distribution of patients in the study groups, as patients who underwent PSG testing only comprised 18.5% of the total cohort. In addition, we observed that patients with a high probability for OSA (e.g., male, older patients with higher prevalence of hypertension) were more likely to undergo PSG than PP, which was most likely a result of selection bias, as patients were referred for PSG or PP at the physician's discretion. Although we attempted to correct for these confounding factors in logistic regression analyses, other factors (such as implicit bias by physicians) may have also played a part in decision-making for either PSG or PP that were not identified as confounders.

A prospective trial that randomized bariatric patients to either PSG or PP prior to surgery would have been ideal. However, by performing univariable and multivariable analysis, we were able to correct for potential confounders, and thus feel able to draw some conclusions from data of this large cohort.

The benefits of extensive preoperative OSA evaluation attempting to prevent postoperative complications should be carefully weighed against the overuse of diagnostic tools and hospital resources. The need to detect undiagnosed severe OSA to avoid preventable complications is paramount, but the results of this study suggest that complications can also be prevented by less invasive diagnostics, despite a lower sensitivity for OSA diagnosis. On the other hand, one could question whether preoperative screening is necessary or not, when alternatives to OSA screening and CPAP treatment would also lead to comparable outcomes. Such an alternative is continuous monitoring of saturation levels in all patients after bariatric surgery to prevent apneas or hypopneas. One argument for this strategy is that up to 93.5% of patient completely resolves their OSA within a year of surgery [16]. A currently active study, the POPCORN study, compares routine preoperative assessment of OSA by performing PP and CPAP initiation to postoperative monitoring with continuous pulse oximetry and supplemental oxygen without preoperative OSA assessment in bariatric patients, with outcome parameters of cost-effectiveness, complications, and quality of life [17]. Future studies should focus on elucidating the balance between safety and invasiveness to optimally manage undiagnosed OSA in bariatric patients in the perioperative period.

Conclusion

Both PSG and PP are feasible options for preoperative diagnosis of OSA in bariatric patients. When PP is performed, some underdiagnosis may occur. Cases of mild OSA might be missed but this seems to be acceptable. However, clinically relevant OSA is detected by both diagnostic tools, and no difference in OSA-related complications was found, taking into consideration that patients were treated with CPAP when OSA was diagnosed. PP is a safe, but less invasive option and can thus be considered as a suitable measure for preoperative assessment of OSA in this population.

Declarations

Ethics Approval This study was approved by the Institutional Review Board of the OLVG.

Statement of Informed Consent Given the retrospective design of this study, informed consent was not required.

Conflict of Interest The authors declare no competing interests.

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