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Original article

Cost-effectiveness and safety of continuous pulse oximetry for management of undiagnosed obstructive sleep apnea in bariatric surgery: a nationwide cohort study

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Abstract

Background: Undetected obstructive sleep apnea (OSA) is highly prevalent in patients undergoing bariatric surgery and increases perioperative risks. Screening for OSA using preoperative polygraphy (PG) with subsequent continuous positive airway pressure (CPAP) is costly and time-consuming. Postoperative continuous pulse oximetry (CPOX) is less invasive, and is hypothesized to be a safe and cost-effective alternative.
Objectives: This nationwide multicenter prospective observational cohort study compared CPOX monitoring with OSA-screening using PG.
Setting: High-volume bariatric centers.
Methods: Patients were either postoperatively monitored using CPOX without preoperative OSA-screening, or underwent preoperative PG and CPAP treatment when OSA was diagnosed. Cohort placement was based on local hospital protocols. Cost-effectiveness was analyzed using quality

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adjusted life years (QALYs) and healthcare costs. Surgical outcomes were also analyzed. Propensity score matching was used in sensitivity analyses.

Results: A total of 1390 patients were included. QALYs were similar between groups at baseline and 1-year postoperatively. Postoperative complications, intensive care unit (ICU)-admissions and admissions, particularly OSA-related, did not differ between groups. Mean costs per patient/year in the CPOX group was €3094 versus €3680 in the PG group; mean difference €−586 (95% CI €−933–€−242). Following propensity score matching, 1090 of 1390 included patients remained, and similar findings for cost-effectiveness, complications, and ICU admissions were observed.

Conclusion: CPOX monitoring without preoperative OSA-screening was not associated with higher complication or readmission rates compared to PG. CPOX resulted in lower costs from a healthcare perspective and can therefore be considered a cost-effective alternative to routine OSA-screening in patients undergoing bariatric surgery. (Surg Obes Relat Dis 2024;20:1244–1252.)

Keywords: Bariatric surgery; Cost-effectiveness; Continuous pulse oximetry; Obstructive sleep apnea; Polygraphy; Laparoscopic Roux-en-Y gastric bypass; Laparoscopic sleeve gastrectomy; Perioperative care

Obstructive sleep apnea (OSA) is the most prevalent sleep-breathing disorder in patients scheduled for bariatric surgery [1–3]. Obesity and OSA are both associated with significant healthcare costs. Identification of OSA in the general population is recommended because of impaired quality of life (QoL), increased risk of cardiovascular disease, and consequently increased utilization of healthcare resources throughout life [4]. However, these recommendations cannot be extrapolated to the bariatric population in which OSA is expected to reduce in severity or resolve completely following significant weight loss [4–6]. The main challenge concerning OSA in patients who undergo bariatric surgery is that the majority is undiagnosed and thus untreated, which increases the risk of cardiopulmonary and thromboembolic complications [7,8].

Most bariatric guidelines advocate preoperative OSA assessment using sleep studies such as polysomnography or polygraphy (PG). If moderate or severe OSA is diagnosed, continuous positive airway pressure (CPAP) therapy is advised to prevent perioperative OSA-related complications. These guideline recommendations are mainly based on low-quality evidence, or are only consensus-based [9,10]. Because sleep studies are costly, time-consuming, and frequently limited in availability, OSA screening questionnaires have been developed. Unfortunately, these questionnaires lack sufficient sensitivity and specificity in patients scheduled for bariatric surgery [11,12]. Another option is postoperative monitoring with continuous pulse oximetry (CPOX) and noninvasive supplementation of oxygen, without any form of OSA assessment before surgery. This strategy focusses on the early postoperative phase and oxygenation, and the termination of singular, long-lasting apneas that are feared by some clinicians [13].

To date, no high-quality comparative studies are available that have evaluated the efficacy or cost-effectiveness of these perioperative strategies in patients who undergo bariatric surgery with undetected OSA. Because OSA-related complications are potentially life-threatening but rarely occur, this creates a difficult discussion whether an invasive and expensive perioperative strategy is required.

We hypothesized that postoperative CPOX with supplemental oxygen can prevent desaturations leading to OSA-related complications, and would therefore be more cost-effective compared to preoperative screening of patients underoing bariatric surgery with PG and consequential CPAP therapy.

Methods

Study design

This is a prospective, multicenter, observational cohort study that was conducted in 7 bariatric centers in the Netherlands. Patients were eligible if they had no prior OSA diagnosis and fulfilled the criteria to undergo bariatric surgery (body mass index (BMI) $\geq$40 kg/m^2, or BMI $\geq$35 kg/^{2} in presence of obesity-related comorbidity) [14]. Exclusion criteria were previous bariatric surgery, the inability to speak the Dutch language, or concomitant procedures during bariatric surgery that could increase the risk of complications, such as hiatal hernia repair, or cholecystectomy. The study design has been previously described [15]. All patients provided written informed consent and the study was performed in accordance with the Declaration of Helsinki [16].

Treatment allocation

Patients were placed in a cohort based on local protocols of their respective hospital. Patients in the CPOX group underwent postoperative monitoring with CPOX immediately after return to the surgical ward, with additional oxygen supplied via a nasal cannula (2L/min SpO_2). Nurses were alarmed when saturation levels dropped <92% SpO_2, during at least 10 seconds, to perform a clinical evaluation and prevent long-lasting apnea's by awaking the patient, or by providing additional supplemental oxygen. When indicated, clinical evaluation was performed by the attending physician.

All patients in the PG group underwent an ambulant, preoperative PG to assess complete and partial cessations of breathing, respectively called apneas and hypopneas. The OSA diagnosis was defined by the apnea or hypopnea index (AHI); an AHI <5/hour excluded OSA, and mild, moderate or severe OSA was diagnosed with an AHI of >5/hour, 15-30/hour and >30/hour, respectively. Patients with moderate or severe OSA started CPAP therapy, and were required to use CPAP after surgery. In case a patient with moderate or severe OSA did not tolerate CPAP treatment, the patient was admitted to the intensive care unit (ICU) for postoperative monitoring.

In this study, only laparoscopic Roux-en-Y gastric bypass and laparoscopic sleeve gastrectomy were performed. All participating hospitals based their anesthetic regime on the principles of early recovery after bariatric surgery (ERABS). This included the minimization of opioids and other intraoperative drugs that could influence postoperative oxygenation. All centers used propofol for initial sleep induction, while using rocuronium as muscle relaxant. Some hospitals also used propofol as maintenance of anesthesia. At the end of the surgical procedure, all centers measured residual relaxation related to neuromuscular blockade with train-of-four count, and applied reversal drugs, such as Sugammadex/Bridion, if indicated. In the postoperative phase, all centers administered low-molecular-weight heparin (nadroparin) to all patients to prevent thrombosis.

Outcomes

The primary outcome was cost-effectiveness of CPOX compared with PG from a societal perspective; evaluating health care costs made from baseline (i.e., start of bariatric care) until 1 year after surgery. QoL was measured as quality-adjusted life years (QALYs, using EuroQol 5 Dimensions – 3 level (EQ-5D-3L) questionnaires at several time-points; preoperatively, and 1, 3, 6, and 12 months after surgery [17]. Healthcare costs were derived from hospital records and trial registration. Additionally, patients reported medical costs outside the hospital (e.g., visits to the general practitioner or visits to another hospital) in a medical cost questionnaire. To assess the societal costs related to health, loss of income from a paid job, or productivity loss in unpaid activities, the productivity costs questionnaire (PICQ) was used [18]. When differences in QoL did not exceed the non-inferiority margin of .03, cost-effectiveness outcomes were expressed as incremental costs and no Incremental Cost-Effectiveness Ratio (ICER) was calculated. Robustness of total cost outcomes was assessed using the 95% credibility interval (CI) of the cost difference between both groups. All cost outcomes were analyzed from a societal perspective and a healthcare perspective. The healthcare perspective excluded productivity costs.

Secondary outcomes included complications until 30 days postoperatively, in particular cardiopulmonary and thromboembolic complications, as they can be the result of untreated OSA. In addition, admissions to the intensive or medium care unit (respectively ICU and MCU) were reported, length of stay, readmission, and reoperations. Outcomes of PG were also documented, with AHI, oxygen desaturation index (ODI), and indication for CPAP treatment. Secondary outcome data were prospectively collected from electronic health records.

Because we observed significant differences between baseline characteristics that are known confounders (i.e., age, hypertension, and dyslipidemia) in the initial analyses of this study with a nonrandomized design, propensity score-matched groups were compared in sensitivity analyses. In the logistic regression to form propensity scores, we used known risk factors for OSA prevalence: gender, BMI, age, hypertension, diabetes, hypercholesterolemia, alcohol consumption, and smoking. We performed 1:1 nearest neighbor matching with a .1-width caliper.

Sample size calculation

This study had a noninferiority design to assess whether postoperative CPOX without a PG was noninferior to preoperative PG in patients who undergo bariatric surgery. Sample size calculation was based on QALYs reported in a study comparing CPAP to best supportive care alone (e.g., advice on sleep hygiene) in patients with OSA. The mean QALY in the CPAP group was .68 (95% CI .64–.72) [19]. We predefined a noninferiority margin of .03 on the EQ-5D score, meaning that the upper boundary of the 95% CI of the absolute difference between the primary endpoint (i.e., the EQ-5D score) in the 2 study groups would be lower than .03. Calculating with 80% power to detect the predefined noninferiority margin at a one-sided level of .05, 621 patients would be needed in each study group. Assuming a loss to follow up of 10%, the total study population was set at 1380 patients (690 per arm).

Statistical analysis

Data were analyzed using SPSS 25.0 for Windows R (4.4) packages mice (3.14.0). Data were expressed as mean ± standard deviation, or median with interquartile ranges, based on normality. Baseline characteristics and complication parameters were compared between the two groups with an unpaired t test for continuous data or a chi-squared test for binary data. A *P*-value of <.05 was considered significant. The 95% credibility interval was calculated using Monte Carlo simulations.

Health economic analysis

Data regarding QoL and hospital costs were analyzed from the inclusion date until 1 year after surgery. Data from the medical cost questionnaire and productivity losses were measured from the surgery date until 1-year of follow-up. Unit costs of both healthcare costs and societal costs were translated into the year 2020 euros, using the Dutch consumer price index (Supplementary Materials, Tables S1–S3, and Table 2). Missing data were imputed using 20 imputation sets. Next, the mean of the imputation sets was used as an outcome measure. Monte Carlo bootstrap simulation was performed 5000 times by randomly (with replacement) selecting patients and randomly (without replacement) selecting 20 out of 200 imputation sets. Again, the mean of both groups was calculated. The 95% credibility interval was assessed using the percentile method on the simulation mean outcomes for both total costs and total QoL. As a sensitivity analysis, these analyses were repeated in the total number of included patients (N = 1390), and in all complete cases analysis. Study conduct and reporting adhered to the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist for economic evaluations [20].

Results

Between April 2018 and February 2020, 1390 patients were included, 699 in the CPOX cohort and 691 in the PG cohort. Patients' mean age was 45 years, median BMI 42.2 kg/m^2, and 79.2% were female (Table 1). In the PG cohort, 338 patients (48.9%) had moderate or severe OSA and started CPAP treatment. Several differences in baseline characteristics existed between these groups; i.e., age, gender, hypertension, hypercholesterolemia, and several comorbidities (Table 1).

Cost-effectiveness

At baseline, there were EQ-5D scores of the CPOX and PG group were .77 and .76, respectively (Table 2). One year postoperatively, both groups had significantly improved in QoL to .873 QALY in the CPOX group, and .874 QALY in the PG group (difference .001, 95% CI of the difference −.013 to .009).

The total mean cost per patient from a healthcare perspective was lower in the CPOX group (€3094) versus the PG group (€3680), with a mean difference of €−586 (95% CI €−933–€−242) (Table 2). This difference mainly originated in the absence of sleep studies, no initiation of CPAP treatment, and no OSA-related outpatient clinic visits in the CPOX group.

Costs from a societal perspective were less clearly pronounced and favored the PG group. The total per-patient costs were estimated at €8251 versus €8630 in the CPOX group (mean difference €−379, 95% CI €−1318–€450). The cost differences were explained by higher observed productivity losses in the CPOX group, mainly caused by a small group of patients reporting higher productivity losses in day-to-day activities, such as caregiving for family members.

We did not calculate Incremental Cost Effectiveness Ratio's (ICERs), as no clinically relevant differences between QALY outcomes occurred between groups. We performed a budget impact analysis based on the Dutch health care system. Annually, 12,000 bariatric procedures are performed in the Netherlands, and approximately 10% of these patients have a medical history of OSA. It is our estimation that approximately half of all Dutch patients undergo polygraphy before bariatric surgery. Due to the lower costs of the CPOX group (€−586) per patient, we therefore expect a potential cost saving of €2, 7 to 3 million per year in the Netherlands, from a healthcare perspective.

Surgical outcomes

The incidence of overall postoperative complications was 6.6% in the CPOX group, and 7.7% in the PG group, P = .430 (Table 3). Fatalities within 30 days of surgery only occurred in the CPOX group: one patient with refractory septic shock due to anastomotic leakage. OSA-related complications were not significantly different between the groups. In the CPOX group, seven patients experienced cardiopulmonary or thromboembolic events, compared with eight patients in the PG group (1.0% versus 1.2%, P = .983). Other types of complications, i.e., staple line leakage or bleeding, were also similar between groups. The severity of complications, based on the Clavien Dindo Classification, did not significantly differ in minor complications (class ≤2; 5.0% versus 4.1%, P = .440), while it was significantly different in major complications (class ≥3A; 1.6% versus 3.6%, P = .016).

Total ICU admissions were significantly different between groups, with a lower ICU admission rate in the CPOX versus PG group (.1% versus 1.9%, P = .001). However, this difference did not remain significant after the distinction between scheduled and unscheduled ICU admissions was made (Table 3). Nine PG patients had scheduled ICU admissions due to CPAP intolerance. Of these, 3 had moderate OSA, and two had severe OSA, both with AHI >60/hour. Another patient was scheduled for ICU due to an AHI>100, despite well tolerated CPAP. MCU admissions, length of stay, readmissions, and reoperations were similar in both groups.

Sensitivity analysis

For sensitivity analysis, propensity score matching was performed and 545 patients per cohort could be matched

Table 1
Baseline characteristics

Variable	CPOX (n = 699)	PG (n = 691)	*P*-value
Female gender (n, %)	571 (81.7)	530 (76.7)	.025
Age, in years (mean, SD)	44.4 (±12.1)	46.2 (±11.5)	.004
BMI, in kg/m2 (median, IQR)	42.5 (39.8–46.8)	42.0 (39.8–45.8)	.081
Waist circumference, in cm (mean, SD)	128.5 (±14.2)	128.6 (±13.9)	.937
Comorbidities (n, %)			
Hypertension	253 (36.2)	293 (42.4)	.018
Type 2 diabetes	114 (16.3)	132 (19.1)	.262
NIDDM	67 (9.6)	85 (12.3)	
IDDM	47 (6.7)	47 (6.8)	
Dyslipidemia	143 (20.5)	207 (30.0)	<.001
GERD	199 (28.5)	211 (30.5)	.411
Osteoarthritis	333 (47.6)	385 (55.7)	.003
Hypothyroidism	71 (10.2)	75 (10.9)	.726
Asthma	91 (13)	81 (11.7)	.371
COPD	20 (2.9)	17 (2.5)	.620
AF	13 (1.9)	10 (1.4)	.675
HF	5 (.7)	3 (.4)	.726
CAD	16 (2.3)	15 (2.2)	.881
OHS	0 (0)	2 (.3)	.248
DVT	38 (5.7)	22 (3.4)	.035
Myocardial infarction	17 (2.4)	21 (3.0)	.514
History of psychiatric disorder	133 (19.0)	218 (29.1)	.001
History of carcinoma	41 (5.9)	31 (4.5)	.278
CVA	8 (1.1)	6 (.9)	.790
Smoking (n, %)			.307
Active smoker	58 (8.3)	45 (6.5)	
Former smoker	212 (30.3)	229 (33.1)	
Alcohol (n, %)	234 (33.5)	366 (53)	<.001
Sleep study outcomes (median, IQR)			
AHI	N/A	11.3 (5.1–23.2)	N/A
AHI supine	N/A	12.5 (4.0–31.6)	N/A
ODI	N/A	12.3 (5.4–24.6)	N/A
TST supine in min	N/A	144 (63.5–239.2)	N/A
Average Sp02	N/A	94 (92–95)	N/A
Lowest SpO2	N/A	84 (78–88)	N/A
No. episodes Sp02 <90%	N/A	13 (1–46)	N/A
Total desaturation time in sec	N/A	221 (20–1506)	N/A
No. episodes SpO2 4% below baseline saturation	N/A	59.5 (6.5–146.3)	N/A
OSA diagnosis + CPAP treatment (n, %)	N/A	338 (48.9)	N/A
Drug use (n, %)			
Oral antidiabetic agents	102 (14.6)	116 (16.8)	.269
Insulin	49 (7.0)	46 (6.7)	.832
Antihypertensive agents	244 (34.9)	273 (39.5)	.070
Lipid lowering agents	124 (17.7)	121 (17.5)	.888
Daily painkillers	140 (20.0)	122 (16.2)	.070
Of which: opioids	43 (6.2)	35 (5.1)	.415
Anticoagulants	63 (9.0)	52 (7.5)	.330
Type of procedure (n, %)			.053
LRYGB	556 (79.5)	516 (74.7)	
LSG	143 (20.5)	175 (25.3)	

AF = atrial fibrillation; AHI = apnea hypopnea index; BMI = body mass index; CAD = coronary artery disease; CDC = Clavien Dindo classification; CPAP = continuous positive airway pressure; CPOX = continuous pulse oximetry; CVA = cerebrovascular accident; DVT = deep venous thrombosis; GERD = gastroesophageal reflux disease; HF = heart failure; IQR = interquartile range; LRYGB = laparoscopic Roux-en-Y gastric bypass; LSG = laparoscopic sleeve gastrectomy; (N)IDDM = (non)insulin dependent diabetes mellitus; ODI = oxygen desaturation index; OHS = obesity hypoventilation syndrome; OSA = obstructive sleep apnea; PG = polygraphy; PSM = propensity score matched, SD = standard deviation; TST = total sleep time.

Table 2
Cost-effectiveness outcomes, expressed in QALYs and costs from healthcare and societal perspective

QALY	CPOX (n = 699)	PG (n = 691)	Difference	95% CI
	Mean EQ5D score	Mean EQ5D score		
Pre-operative	.77	.76	.002	
1 mo	.86	.86	.001	
3 mo	.88	.87	.004	
6 mo	.88	.88	−.009	
12 mo	.89	.89	.002	
Total 1 yr follow-up	**.873 (SD: .13)**	**.874 (SD: .14)**	**−.001**	**(−.013 to .009)**

Healthcare costs	Unit cost	Mean cost	Mean cost	Difference	95% CI
Trial reported preoperative cost					
Polygraphy	133	0	133	−133	
Polygraphy follow-up consult	98	0	74	−74	
CPAP treatment	512	0	251	−251	
Trial reported follow-up costs					
No. PG during follow-up	133	0	20	−20	
Follow-up healthcare costs in operation hospital					
Consultations	98	493	369	124	
Online consultations	98	60	50	9	
Day treatment	299	16	19	−2	
Emergency visits	280	59	67	−8	
ICU	2179	0	196	−196	
Ward days	515	1459	1514	−54	
Self-reported costs at other healthcare providers					
General practitioner	36	116	112	3	
Dietitian	32	66	79	−13	
Company Doctor	71	54	44	10	
Home care	NA*	251	256	−5	
Emergency visits	280	96	84	13	
Ambulance	557	50	43	7	
Consultations	98	67	69	−2	
Inpatient days	515	306	300	6	
Total cost healthcare perspective	**3094**		**3680**	**−586**	**(€−933–€−242)**
Unpaid productivity					
Unpaid productivity losses month 3	16	532	659	−127	
Unpaid productivity losses month 12	16	1869	1402	467	
Paid productivity losses month 3	41	1210	1127	83	
Paid productivity losses month 12	41	1546	1762	−216	
Total productivity losses	**5157**		**4950**	**207**	**(€−600–€927)**
Total cost societal perspective	**8251**		**8630**	**−379**	**(€−1318–€450)**

CPAP = continuous positive airway pressure; CPOX = continuous pulse oximetry; ICU = intensive care unit; QALY = quality adjusted life year.
* Home care consisted of a mix of domestic help (€108 per week), home care (€395 per wk) and personal care at home (€270 per week). Sources for unit cost: Table S1 (for CPAP and PG).

pairwise, resulting in 1090 patients (Supplementary Materials, Table S4). Findings were similar to the main cohort: QALYs did not differ between the CPOX and PG group (.87 versus .88) (Supplementary Materials, Table S2). CPOX was cost-effective from a healthcare perspective compared to PG; €−534 (95% CI: €−896–€−137). From a societal perspective, PG was favored by €134, 95% CI €−877–€1063, similar to the main analysis. In another sensitivity analysis, only using data of patients with complete case records in all 247 data points to calculate cost-effectiveness (n = 709), the health care costs for CPOX were € −724 compared with PG, and from a societal perspective, CPOX was unfavorable compared with the PG group by € −692 (Supplementary Materials, Table S3) Monte Carlo bootstrap simulations were performed using all included patients (n = 1390), and the propensity score matched group (n = 1090) for cost-effectiveness analysis from a healthcare and societal perspective, and re-established our previous findings (Supplementary Materials, Figures S1–S4).

Secondary outcomes of the propensity score matched group were similar to the all included patients, except for

Table 3
Surgical outcomes

	CPOX		PG		*P*-value	PSM
	All (n = 699)	PSM (n = 545)	All (n = 691)	PSM (n = 545)	All	
Complications (n, %)	46 (6.6)	32 (5.9)	53 (7.7)	43 (7.9)	.430	.188
OSA-related complications	7 (1.0)	6 (1.1)	8 (1.2)	8 (1.5)	.983	.789
Pulmonary	6 (.9)	5 (.9)	6 (.9)	6 (1.1)		
Cardiac	1 (.1)	1 (.2)	2 (.3)	2 (.4)		
Thromboembolic	0	0	0	0		
Bleeding	17 (2.4)	11 (2.0)	20 (2.9)	15 (2.8)	.592	.552
Anastomotic leakage	1 (.1)	1 (.2)	3 (.4)	2 (.4)	.380	.739
GJ stenosis	5 (.7)	4 (.7)	8 (1.2)	8 (1.5)	.535	.476
Wound infection	1 (.1)	1 (.2)	4 (.6)	4 (.7)	.223	.289
Postoperative pain	3 (.4)	2 (.4)	3 (.4)	2 (.4)	.858	.761
UTI	5 (.7)	3 (.6)	3 (.4)	2 (.4)	.343	.417
Other*	7 (1.0)	4 (.7)	4 (.6)	2 (.4)	.134	.230
Severity of complications						
Minor (CDC ≤2)	35 (5.0)	22 (4.0)	28 (4.1)	24 (4.4)	.392	.440
Major (CDC ≥3A)	11 (1.6)	10 (1.8)	25 (3.6)	19 (3.5)	.016	.065
ICU admission (n, %)	1 (.1)	1 (.2)	13 (1.9)	9 (1.7)	.001	.021
Scheduled	0	0	9 (1.3)	6 (1.1)	.002	.031
Unscheduled	1 (.1)	1 (.2)	4 (.6)	3 (.6)	.216	.624
MCU admission (n, %)†	6 (.9)	5 (.9)	1 (.1)	1 (.2)	.124	.124
Readmission (n, %)	27 (3.9)	20 (3.6)	25 (3.6)	19 (3.5)	.639	.870
Reoperation (n, %)	7 (1.0)	6 (1.1)	15 (2.2)	11 (2.0)	.134	.328
Length of stay, in days (median, IQR)	1 (1–2)	1 (1–2)	1 (1–1)	1 (1–2)	.051	.321

CDC = Clavien Dindo classification; CPOX = continuous pulse oximetry; GJ = gastrojejunal; ICU = intensive care unit; IQR = interquartile range; MCU = medium care unit; OSA = obstructive sleep apnea; PG = polygraphy; PSM = propensity score matched; UTI = urinary tract infection.

* CPOX: fever without focus (3), internal herniation (1), kidney stones (1), incisional hernia (1), constipation (1). PG: Postoperative urinary retention (1), incisional hernia (1), postoperative hyperglycemia (2).

† All admissions to MCU were unscheduled.

the incidence of major complications, which was significantly different in the main analyses, but disappeared in the propensity score matched cohort analysis (CPOX 1.8% versus PG 3.5%, $P = .065$) (Table 3).

Discussion

This study compared 2 perioperative care strategies for patients who undergo bariatric surgery with no previous OSA diagnosis, and showed that postoperative CPOX without preoperative OSA-screening is safe and cost-effective from a healthcare perspective compared with routine PG and CPAP treatment. No difference in QoL was seen between groups, while costs from a healthcare perspective were lower in the CPOX group. In addition, secondary outcomes such as complications and unanticipated ICU admissions were similar between groups. Hence, these data provide evidence that CPOX is a safe and cost-effective alternative in the perioperative management of patients undergoing bariatric surgery who have no prior OSA diagnosis.

To our knowledge, this is the first study that compared postoperative outcomes in patients undergoing bariatric surgery who either had routine OSA screening or had no OSA screening in the preoperative setting. Previous studies have mainly evaluated OSA in preselected high-risk patient groups, or compared different types of care for patients with known OSA. For example, Shearer et al. reported that postoperative ICU admission is unnecessary in patients with OSA following bariatric surgery, as these patients can be safely managed at a general surgery ward [21]. More recently, several studies found no consistent or significant outcomes in patients with mild or moderate OSA who undergo bariatric surgery without additional measures, when compared with patients with severe OSA with perioperative CPAP treatment [22,23]. However, the intervention and control groups in these studies were not comparable in disease-severity or a priori risk of complications. Additionally, ERABS protocols are increasingly becoming standard care. Consequently, risks of developing cardiopulmonary complications are potentially reduced, although this has not yet been established specifically for patients with OSA [24]. In our cohort of 1390 patients, major complication rates were significantly different between the cohorts, in favor of CPOX. This difference disappeared after propensity score matching, making the clinical significance dubious, as many OSA-related baseline characteristics were different which are known to influence risk of complications.

Studies on costs related to sleep breathing disorders such as OSA in patients who undergo bariatric surgery show conflicting results. Mokhlesi et al. reported shorter hospital stay and reduced costs for patients with OSA compared with patients without OSA diagnosis, which meant these latter patients did not have an ICD code for a sleep-breathing disorder, but the diagnoses were not specifically excluded by sleep studies [25]. A study in patients who underwent laparoscopic gastric banding found that OSA was a predictive factor for readmission, which resulted in substantial increased costs [26]. Our data did not show an increased risk of readmission or difference in hospital stay in the CPOX patients compared with the PG patients.

In addition, some authors advocate less invasive management of potentially undiagnosed OSA in patients undergoing bariatric surgery as many of these will only benefit from postoperative CPAP treatment for several months before weight-loss induces remission or reduction of OSA [27]. However, it has been shown that CPAP treatment is not tolerated by all patients, or is insufficiently used to ensure its clinical benefits, such as reduction of day-time sleepiness or counteract the cardiovascular effects of OSA [28].

Some limitations of this study should be acknowledged. First, the initial study design in which all patients were preoperatively screened for OSA with PG and subsequently randomly assigned to either CPAP or no treatment, resulted in ethical objections regarding patient safety. Consequently, we chose to perform a prospective cohort study with propensity score matching analysis. However, due to the nonrandomized design the groups were not comparable for several baseline characteristics that are relevant in OSA prevalence. In the propensity score matching analysis we were unable to correct for neck-circumference, which is a well-known risk factor of OSA, due to incomplete data. This may have had an effect on comparability and preprobability of OSA between the two groups. However, we believe that we have formed 2 comparable groups based on the other confounders in the propensity score matching. Second, cost-effectiveness analyses are dependent on the type of data used for analyses. In this study, we used declaration data from hospital databases, which is less susceptible to human-errors than using clinical data directly gained from the trial. However, the pitfall of this type of data is that health care utilization should be billed properly in hospital databases. An example of missing data is visible in Table 2, where no expenses are presented for ICU admissions for the intervention group, even though one CPOX patient was admitted to the ICU (Table 3). The actual impact on costs would have been .75 euro per patient, which is rather minimal. Although a minor limitation, it is essential to be mentioned as this should be kept in mind when interpreting cost-benefit analyses. Third, in calculating the propensity score in logistic regression for propensity score matching, we did not include a history of thromboembolic events in patients at baseline. One could argue this may have influenced the risk of developing another thromboembolic event in the postoperative phase and therefore should have been included in our propensity score matching. However, as no thromboembolic events occurred in either the matched cohort or the total number of included patients, we believe this did not influence the outcomes.

With rising popularity of fast-track and day-care bariatric surgery, we underline that certain precautions are necessary to prevent rare, but severe OSA-induced complications [29]. In addition, general surgery patients are likely to become heavier as the worldwide obesity rates continue to rise. Undiagnosed OSA will also become more prevalent in the general population. Hence, the results of this study could be extrapolated to other types of surgery that include general anesthesia with breathing-depressing drugs. It is of importance that future studies focus on the least invasive, safest and most cost-effective type of perioperative care of patients potentially at risk for OSA-related complications.

Conclusion

This nationwide cohort study shows that CPOX is a safe strategy in the perioperative management of patients who undergo bariatric surgery with no prior OSA diagnosis. CPOX was similar in effectiveness, was not associated with a higher complication or readmission rates and has lower costs from a healthcare perspective compared with PG and CPAP therapy. Therefore, postoperative CPOX can be considered a cost-effective alternative for routine preoperative OSA screening in the bariatric population.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

Supplementary data

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.soard.2024.06.009.

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