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Impact of obstructive sleep apnea on postoperative outcomes after SADI-S: a retrospective MBSAQIP database analysis with literature review on behalf of TROGSS - The Robotic Global Surgical Society

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Abstract

Aim: Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) is a hypo-absorptive bariatric procedure with promising weight-loss and metabolic outcomes. The impact of obstructive sleep apnea (OSA), a common obesity-related comorbidity, on surgical outcomes following SADI-S remains underexplored. This study assesses 30-day postoperative outcomes in patients with OSA who underwent SADI-S, utilizing data from the MBSAQIP database (2020-2022).

Methods: Patients undergoing primary SADI-S between January 1, 2020, and December 31, 2022, were identified from the MBSAQIP database. Comparative analyses between patients with and without OSA were conducted using 19 preoperative variables and 17 postoperative outcomes. Continuous variables were analyzed with the Student's *t*-test, and categorical variables using the chi-square test. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated, and multivariate logistic regression models identified independent predictors of OSA. Statistical significance was set at $P < 0.05$.

Results: A total of 1,301 patients were analyzed, with 596 (45.8%) having OSA. OSA patients were older (45.84 ± 10.14 years *vs.* 40.67 ± 10.55 years, $P < 0.001$), had higher body mass index (BMI) (50.57 ± 9.91 kg/m^2 *vs.* 49.05 ± 8.50 kg/m^2, $P = 0.003$), and more comorbidities such as diabetes, hypertension, and hyperlipidemia. OSA was associated with longer operative times (144.30 ± 58.92 min *vs.* 127.41 ± 54.59 min, $P < 0.001$) and increased blood transfusions (1.7% *vs.* 0.3%, $P = 0.009$), but no significant differences in mortality, pulmonary embolism, or readmission rates. Multivariate analysis identified male sex (OR: 3.306, $P < 0.001$), age (OR: 2.077, $P < 0.001$), and higher American Society of Anesthesiologists (ASA) classification (OR: 2.133, $P < 0.001$) as independent predictors of OSA.

Conclusion: Patients with OSA undergoing SADI-S experience longer operative times and an increased risk of blood transfusions, which is primarily an intraoperative or early postoperative event. However, OSA does not significantly impact key short-term postoperative outcomes, such as mortality, pulmonary embolism, or readmission rates. These findings support the safety and efficacy of SADI-S in OSA patients, emphasizing the need for careful intraoperative management while maintaining favorable postoperative outcomes.

Keywords: Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S), obstructive sleep apnea (OSA), postoperative outcomes, MBSAQIP database, bariatric surgery

INTRODUCTION

Obesity and its associated metabolic disorders represent a major global health challenge, with its prevalence rising significantly over the past four decades[1,2]. Metabolic and bariatric surgery (MBS) is widely recognized as an effective intervention for treating obesity and its comorbid conditions, offering sustained weight loss, improved health outcomes, enhanced quality of life, and prolonged survival[1-3]. As surgical techniques continue to evolve, MBS has advanced with the introduction of novel approaches[4].

Single-anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S), first described in 2007, has emerged as a simplified alternative to biliopancreatic diversion with duodenal switch (BPD-DS)[5,6]. SADI-S provides satisfactory long-term weight loss outcomes and facilitates remission of obesity-related diseases[4,6].

Obstructive sleep apnea (OSA), characterized by recurrent episodes of airflow reduction or cessation during sleep, is closely linked to obesity, particularly in patients with severe obesity[7,8]. Diagnosing and managing OSA is a crucial component of the preoperative evaluation for patients undergoing MBS, as it can significantly impact postoperative outcomes[8,9]. Preoperative continuous positive airway pressure (CPAP) therapy can mitigate these risks, enhancing perioperative safety during anesthesia and surgery[6]. Proper preoperative management has been shown to reduce both morbidity and mortality. Untreated OSA is associated with an increased risk of adverse respiratory events and postoperative cardiovascular complications, including atrial fibrillation, emphasizing the importance of effective OSA management[7]. Accurate diagnosis and management of OSA are essential for controlling hypertension, managing cardiovascular disease, and reducing premature mortality in patients undergoing MBS[7,10].

This retrospective comparative analysis, utilizing data from the 2020-2022 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database, addresses the gap in understanding the impact of OSA on patients undergoing SADI-S. The study aims to compare the 30-day postoperative outcomes of SADI-S in patients with OSA versus those without OSA.

METHODS

Study population and data source

This study included patients who underwent primary single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) within the MBSAQIP database from January 1, 2020, to December 31, 2022. Patients were identified using the CPT code 43659 and the variable INIT_PROC_DESC "Single anastomosis duodeno-ileal bypass/Loop duodenal switch".

Patients under 18 and over 65 years of age, as well as those undergoing revision or emergency surgery, were excluded. Data on 30-day readmission, reoperation, and intervention were extracted from separate files by matching unique case identification numbers.

The American College of Surgeons and the American Society for Metabolic and Bariatric Surgery maintain a national standard for accredited centers under the MBSAQIP. The 2020-2022 MBSAQIP participant use files (PUF) were utilized. This database is one of the largest bariatric-specific clinical datasets, including approximately 924 participating MBSAQIP sites across the United States and Canada. Data have been collected annually since 2015, encompassing a wide range of variables related to patient demographics, obesity-related comorbidities, intraoperative details, and 30-day postoperative outcomes.

The MBSAQIP dataset is de-identified, contains no personal health information, and is publicly accessible to surgeons and members of MBSAQIP-accredited centers. As such, it does not fall under the definition of Human Subjects Research per federal regulations. Consequently, this study did not require Institutional Review Board (IRB) approval.

Data assessment and outcome measurements

Patient characteristics collected included sex, age, body mass index (BMI), race, American Society of Anesthesiologists (ASA) score, and histories of pulmonary embolism (PE), myocardial infarction, deep venous thrombosis, smoking status, diabetes mellitus, chronic corticosteroid/immunosuppressive therapy, chronic obstructive pulmonary disease, gastroesophageal reflux disease (GERD), hypertension requiring medication, and hyperlipidemia.

The 30-day outcomes assessed included mortality, PE, deep venous thromboembolism (DVT), blood transfusions, unplanned ICU admissions, reoperations, reinterventions, readmissions, emergency visits, cardiopulmonary complications (cardiac arrest, myocardial infarction, pneumonia, unplanned intubation, or mechanical ventilation for more than 48 h), renal complications (renal failure or dialysis requirement), surgical site infections, operative time, and length of hospital stay. Additionally, three composite outcomes - anastomotic leak, anastomotic ulcer, and anastomotic stricture - were obtained from the files recording suspected causes for reoperation, interventions, and readmissions in the MBSAQIP dataset.

Systematic review

A comprehensive systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P 2020) guidelines. A detailed search strategy was developed to explore multiple databases, including PubMed, Scopus, Web of Science, and ScienceDirect, with the last search conducted on April 2, 2024. Search terms included keywords such as "Obstructive Sleep Apnea" and "Single Anastomosis Duodeno-Ileal Bypass with Sleeve Gastrectomy". Full details of the search strategy can be found in Supplementary Table 1.

The initial search yielded 35 records, and after removing 17 duplicates, 15 records remained for screening. Two independent reviewers screened the titles and abstracts of the identified studies for relevance based on predefined inclusion and exclusion criteria. After this process, 11 records were excluded for not meeting the inclusion criteria. The full texts of the remaining four studies were assessed for eligibility, and all were included in the final synthesis. Any discrepancies between the reviewers were resolved through discussion or consultation with a third reviewer.

The systematic review included cohort, case-control, and cross-sectional studies, as well as randomized controlled trials that reported on adult patients undergoing SADI-S and documented the prevalence of OSA. We excluded abstracts, editorials, reviews, and studies with overlapping populations (e.g., those covering different time periods from the same database). No restrictions were placed on the date of publication or language [Figure 1].

Statistical analysis

Data were analyzed using both descriptive and inferential statistics. Continuous variables were summarized as means and standard deviations, while categorical variables were expressed as frequencies and percentages. Comparisons between patients with and without OSA were performed using the Student's *t*-test for continuous variables and the chi-square test for categorical variables. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to assess the association between OSA and various demographic and clinical variables. Pearson's and Spearman's correlation coefficients were employed to evaluate the relationships between OSA status and continuous variables such as age, BMI, comorbidities, operative time, and length of stay. Multivariate logistic regression models were developed to identify independent predictors of OSA, adjusting for potential confounders such as sex, age, ASA classification, comorbidities, and operative time. *P*-values < 0.05 were considered statistically significant, and all analyses were performed using IBM SPSS Statistics, Version 29.0.

RESULTS

The 2020-2022 MBSAQIP analysis compared 30-day outcomes of 1,301 patients: 596 with OSA and 705 without OSA.

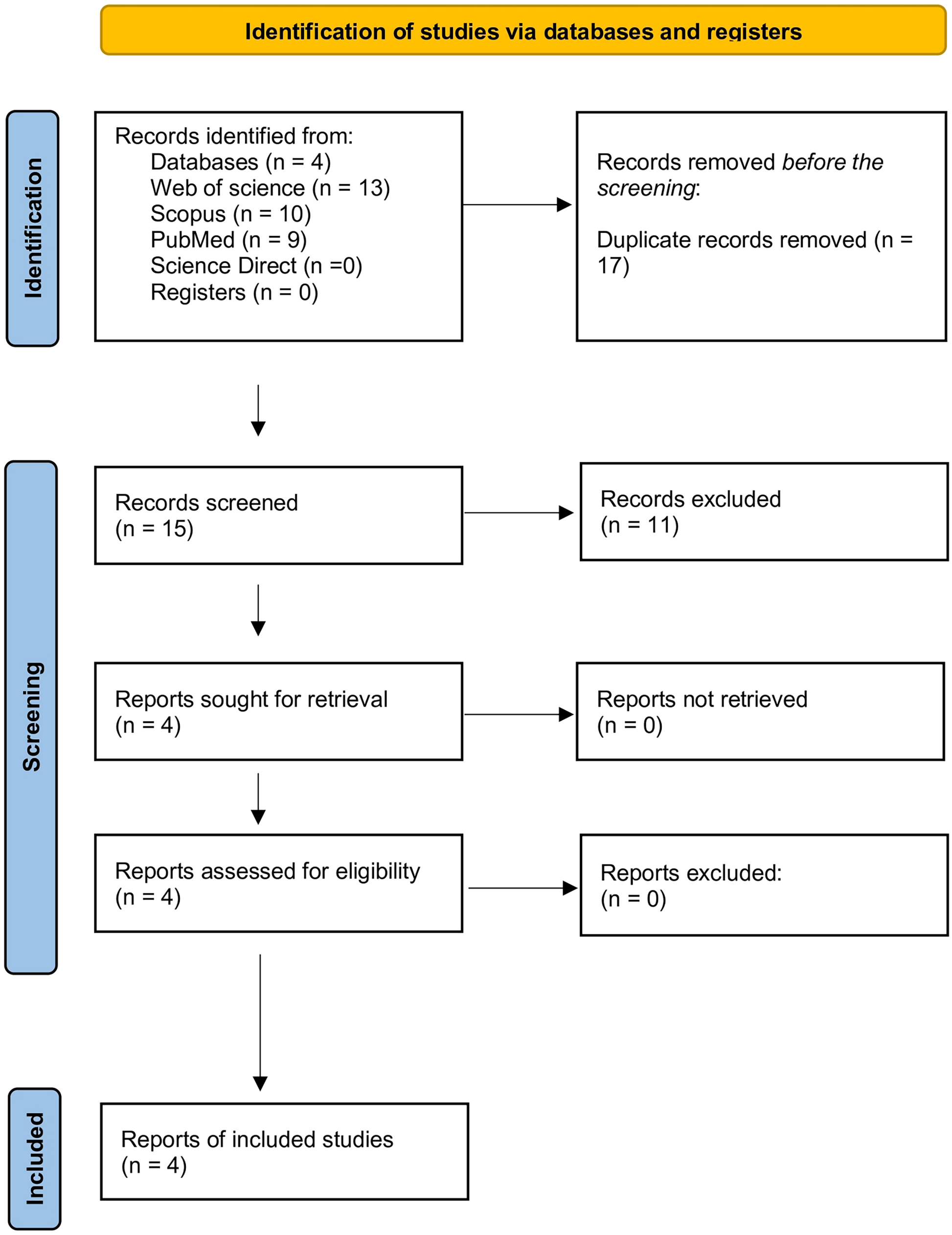

Figure 1. PRISMA flowchart detailing the process of study identification, screening, eligibility, and inclusion in the systematic review.

Patients with OSA were significantly older, with a mean age of 45.84 ± 10.14 years compared to 40.67 ± 10.55 years in the No-OSA group ($P < 0.001$). Similarly, BMI was higher in the OSA group (50.57 ± 9.91 kg/m^2) versus the No-OSA group (49.05 ± 8.50 kg/m^2), with this difference being statistically significant ($P = 0.003$).

In terms of sex distribution, males were significantly more prevalent in the OSA group, representing 32.9% of the cohort, compared to 12.9% in the No-OSA group ($P < 0.001$, OR: 3.306, 95%CI: 2.50-4.36). Conversely, females were significantly more likely to be in the No-OSA group (87.1% *vs.* 67.1%, $P < 0.001$, OR: 0.302, 95%CI: 0.22-0.40), indicating that females had a reduced likelihood of OSA.

Racial differences were also evident, with White patients being more frequent in the OSA group (75.5%) compared to the No-OSA group (68.1%, P = 0.003, OR: 1.445, 95%CI: 1.13-1.84). Black patients, however, were less likely to have OSA (17.3% in the OSA group *vs*. 25.0% in the No-OSA group, P = 0.001, OR: 0.628, 95%CI: 0.47-0.82). There was no significant difference in the proportion of Hispanic patients between the groups (18.8% *vs*. 20.0%, P = 0.583).

Regarding surgical risk as assessed by ASA classification, patients in the OSA group were more likely to be classified as ASA IV-V (14.3% *vs*. 7.2%, P < 0.001, OR: 2.133, 95%CI: 1.47-3.07), while those in ASA class I-II were less likely to have OSA (3.0% *vs*. 9.2%, P < 0.001, OR: 0.307, 95%CI: 0.18-0.52). The distribution of ASA class III was comparable between the two groups (82.7% in OSA *vs*. 83.4% in No-OSA, P = 0.742).

Several comorbidities were more prevalent in the OSA group. Notably, diabetes mellitus was present in 31.5% of the OSA group compared to 21.8% in the No-OSA group (P < 0.001, OR: 1.649, 95%CI: 1.28-2.11). Hypertension was also significantly more common among OSA patients (62.1% *vs*. 40.6%, P < 0.001, OR: 2.399, 95%CI: 1.91-2.99). Hyperlipidemia was more frequent in the OSA group (31.0% *vs*. 17.0%, P < 0.001, OR: 2.194, 95%CI: 1.68-2.85).

In terms of respiratory conditions, chronic obstructive pulmonary disease (COPD) was notably higher among patients with OSA (2.0% *vs*. 0.3%, P = 0.003, OR: 7.223, 95%CI: 1.61-32.4). GERD was also more prevalent in the OSA group (27.9% *vs*. 19.7%, P = 0.001, OR: 1.572, 95%CI: 1.21-2.03). There was no significant difference in the prevalence of smoking (6.2% in the OSA group *vs*. 5.5% in the No-OSA group, P = 0.604) or chronic steroid use (2.7% *vs*. 2.3%, P = 0.630). Detailed baseline characteristics for both groups are presented in Table 1.

Postoperative outcomes

The 30-day postoperative outcomes showed the overall mortality rate was low in both groups, with 0.3% in the OSA group and 0.1% in the No-OSA group, although this difference was not statistically significant (P = 0.468, OR: 2.370, 95%CI: 0.21-26.20). The rates of PE were identical in both groups (0.3%, P = 0.866), and the incidence of deep vein thrombosis (DVT) was slightly lower in the OSA group (0.3% *vs*. 0.6%), but this difference was not significant (P = 0.539, OR: 0.590, 95%CI: 0.10-3.23).

A significant difference was observed in the requirement for blood transfusion, with 1.7% of OSA patients requiring transfusions compared to 0.3% of No-OSA patients (P = 0.009, OR: 5.998, 95%CI: 1.30-27.48). Other outcomes, such as unplanned ICU admissions (1.0% *vs*. 0.7%, P = 0.559), reoperation rates (2.3% *vs*. 2.8%, P = 0.583), and reinterventions (1.3% *vs*. 1.6%, P = 0.744), were not significantly different between groups. Similarly, readmissions within 30 days were comparable (4.7% in the OSA group *vs*. 5.0% in the No-OSA group, P = 0.823).

The rate of anastomotic leak was higher in the OSA group (1.0% *vs*. 0.4%), but this difference did not reach statistical significance (P = 0.208, OR: 2.380, 95%CI: 0.59-9.55). Length of hospital stay was similar between the groups, with a mean duration of 1.78 ± 1.23 days in the OSA group compared to 1.68 ± 2.40 days in the No-OSA group (P = 0.386) [Table 2].

Operative characteristics

Operative time was significantly longer for patients with OSA, with a mean duration of 144.30 ± 58.92 min compared to 127.41 ± 54.59 min for patients without OSA (P < 0.001). This suggests that OSA has an increased likelihood of complications during surgery [Table 2].

Table 1. Characteristics of patients who underwent SADI-S by history of OSA (*n* = 1,301)

Characteristics	No-OSA (*n* = 705)	OSA (*n* = 596)	*P*-value	OR	95%CI
Sex					
Female	614 (87.1)	400 (67.1)	**< 0.001***	0.302	0.22-0.40
Male	91 (12.9)	196 (32.9)		3.306	2.50-4.36
Age, years[a]	40.67 ± 10.55	45.84 ± 10.14	**< 0.001‡**	-	-
Body mass index (kg/m^2)[a]	49.05 ± 8.50	50.57 ± 9.91	**0.003‡**	-	-
Race					
White	480 (68.1)	450 (75.5)	**0.003***	1.445	1.13-0.84
Black	176 (25.0)	103 (17.3)	**0.001***	0.628	0.47-0.82
Hispanic	141 (20.0)	112 (18.8)	0.583*	0.926	0.70-1.22
ASA class					
I-II	65 (9.2)	18 (3)	**< 0.001***	0.307	0.18-0.52
III	588 (83.4)	493 (82.7)	0.742*	0.952	0.71-1.27
IV-V	51 (7.2)	85 (14.3)	**< 0.001***	2.133	1.47-3.07
Comorbidities					
History of PE	10 (1.4)	14 (2.3)	0.273*	1.576	0.69-3.57
History of MI	7 (1)	6 (1)	0.980*	1.014	0.33-3.03
History of DVT	7 (1)	20 (3.4)	**0.003***	3.462	1.45-8.24
Smoker	39 (5.5)	37 (6.2)	0.604*	1.130	0.71-1.79
Diabetes mellitus	154 (21.8)	188 (31.5)	**< 0.001***	1.649	1.28-2.11
Chronic use of steroids	16 (2.3)	16 (2.7)	0.630*	1.188	0.58-2.39
COPD	2 (0.3)	12 (2)	**0.003***	7.223	1.61-32.4
GERD	139 (19.7)	166 (27.9)	**0.001***	1.572	1.21-2.03
Hypertension	286 (40.6)	370 (62.1)	**< 0.001***	2.399	1.91-2.99
Hyperlipidemia	120 (17)	185 (31)	**< 0.001***	2.194	1.68-2.85

*Chi-square; ‡T-Student; [a]Continuous data are shown as the mean ± standard deviation and categorical data as number (%). Bold values are statistically significant. SADI-S: Single anastomosis duodeno-ileal bypass with sleeve gastrectomy; OSA: obstructive sleep apnea; OR: odds ratio; CI: confidence interval; ASA: American Society of Anesthesiologists; PE: pulmonary embolism; MI: myocardial infarction; DVT: deep vein thrombosis; COPD: chronic obstructive pulmonary disease; GERD: gastroesophageal reflux disease.

Correlations and logistic regression analysis

Correlation analyses revealed several significant associations. OSA group patients had a positive correlation with age (ρ = 0.179, P < 0.001), BMI (ρ = 0.061, P = 0.028), and the number of comorbidities (ρ = 0.211, P < 0.001). Additionally, OSA was significantly correlated with operative time (ρ = 0.147, P < 0.001), indicating that patients with OSA tend to have longer surgeries. However, no significant correlation was found between OSA status and length of hospital stay (ρ = 0.024, P = 0.386). Similar results were observed with Spearman's correlation analysis [Table 3].

Logistic regression analyses identified several independent predictors of OSA status. Male sex was a significant predictor, with males being less likely to have OSA (OR: 0.302, 95%CI: 0.229-0.400, P < 0.001). Conversely, females were more likely to have OSA (OR: 3.306, 95%CI: 2.502-4.369, P < 0.001). Higher ASA class (IV-V) was associated with increased odds of OSA (OR: 2.133, 95%CI: 1.479-3.076, P < 0.001), while lower ASA class (I-II) was protective (OR: 0.307, 95%CI: 0.180-5.23, P < 0.001) [Table 4].

Table 2. 30-day outcomes of patients who underwent SADI-S by history of OSA (*n* = 1,301)

	No-OSA (*n* = 705)	OSA (*n* = 596)	*P*-value	OR	94%CI
Outcomes[a]					
Mortality	1 (0.1)	2 (0.3)	0.468[*]	2.370	0.21-26.20
PE	2 (0.3)	2 (0.3)	0.866[*]	1.184	0.16-8.42
DVT	4 (0.6)	2 (0.3)	0.539[*]	0.590	0.10-3.23
Blood transfusion	2 (0.3)	10 (1.7)	**0.009**[*]	5.998	1.30-27.48
Unplanned admission to ICU	5 (0.7)	6 (1.0)	0.559[*]	1.424	0.43-4.68
Reoperation	20 (2.8)	14 (2.3)	0.583[*]	0.824	0.41-1.64
Reinterventions	11 (1.6)	8 (1.3)	0.744[*]	0.858	0.34-2.14
Readmissions	35 (5.0)	28 (4.7)	0.823[*]	0.944	0.56-1.57
ED visit	57 (8.1)	52 (8.7)	0.678[*]	1.087	0.73-1.60
Cardiopulmonary complications	3 (0.4)	1 (0.2)	0.403[*]	0.393	0.04-3.79
Renal complications	2 (0.3)	3 (0.5)	0.523[*]	1.778	0.29-10.67
Anastomotic leak	3 (0.4)	6 (1.0)	0.208[*]	2.380	0.59-9.55
Anastomotic ulcer	0 (0.0)	1 (0.2)	0.277[*]	-	-
Anastomotic stricture	1 (0.1)	0 (0.0)	0.358[*]	-	-
Surgical site infection	1 (0.1)	0 (0.0)	0.358[*]	-	-
Operative time (min)	127.41 ± 54.59	144.30 ± 58.92	**< 0.001**[‡]	-	-
Length of stay (days)	1.68 ± 2.40	1.78 ± 1.23	0.386[‡]	-	-

[*]Chi-square; ‡T-Student; [a]Continuous data are shown as the mean ± standard deviation and categoric data as number (%). Bold values are statistically significant. SADI-S: Single anastomosis duodeno-ileal bypass with sleeve gastrectomy; OSA: obstructive sleep apnea; OR: odds ratio; CI: confidence interval; PE: pulmonary embolism; DVT: deep vein thrombosis; ICU: intensive care unit; ED: emergency department.

Table 3. Pearson's and Spearman's correlation analyses between OSA status and baseline/clinical variables

Pearson's correlation										
OSA status		Gender	BMI	ASA I-II	ASA III	ASA IV-V	Age	Comorbidities	Operative time	Length of stay
	Rho	-0.240	0.082	-0.126	-s0.009	0.114	0.179	0.211	0.147	0.024
	P	**< 0.001**	0.003	**< 0.001**	0.742	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	0.386
	N	1,301	1,301	1,301	1,301	1,301	1,301	1,301	1,301	1,301
Spearman's correlation										
OSA status		Gender	BMI	ASA I-II	ASA III	ASA IV-V	Age	Comorbidities	Operative time	Length of stay
	Rho	-0.240	0.062	-0.126	-0.009	0.114	0.179	0.246	0.154	0.108
	P	**< 0.001**	0.025	**< 0.001**	0.742	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	< 0.001
	N	1,301	1,301	1,301	1,301	1,301	1,301	1,301	1,301	1,301

Bold values are statistically significant. OSA: Obstructive sleep apnea; BMI: body mass index; ASA: American Society of Anesthesiologists; Rho: correlation coefficient.

Age was another important predictor; patients over 45 years of age were more likely to have OSA (OR: 2.077, 95%CI: 1.661-2.596, $P < 0.001$), while those younger than 45 years had a reduced risk (OR: 0.482, 95%CI: 0.385-0.602, $P < 0.001$). Comorbidities were significantly associated with an increased likelihood of OSA (OR: 1.244, 95%CI: 1.183-1.308, $P < 0.001$), and longer operative time also emerged as a significant predictor of OSA (OR: 1.005, 95%CI: 1.003-1.007, $P < 0.001$), though the effect size was small.

Therefore, in conclusion, patients with OSA undergoing SADI-S surgery present with more adverse baseline characteristics, such as older age, higher BMI, and a greater burden of comorbidities (diabetes,

Table 4. Logistic regression using OSA Status CRUDE

Variable	OR	95%CI	*P*-value
Male	0.302	0.229-0.400	< 0.001
Female	3.306	2.502-4.369	< 0.001
Asa I-II	0.307	0.180-5.23	< 0.001
Asa IV-V	2.133	1.479-3.076	< 0.001
Age < 45 years	0.482	0.385-0.602	< 0.001
Age > 45 years	2.077	1.661-2.596	< 0.001
Comorbidities	1.244	1.183-1.308	< 0.001
Operative time	1.005	1.003-1.007	< 0.001

OSA: Obstructive sleep apnea; OR: odds ratio; CI: confidence interval.

hypertension, and hyperlipidemia). Postoperative outcomes such as mortality, ICU admissions, and reoperations were similar between the two groups, although patients with OSA had significantly longer operative times and were more likely to require a blood transfusion. The findings suggest that while OSA does not substantially impact short-term postoperative outcomes, it may complicate the intraoperative course, leading to longer procedures and increased transfusion requirements.

DISCUSSION

Our study revealed that patients with OSA undergoing SADI-S surgery presented with more adverse baseline characteristics, such as older age, higher BMI, and a greater burden of comorbidities (diabetes, hypertension, and hyperlipidemia). Additionally, patients with OSA experienced higher rates of blood transfusions and longer operative times.

In our cohort, the prevalence of OSA was 45.8%, which closely aligns with the 45.5% reported by Marincola *et al.* in patients undergoing SADI-S[11]. While the reported prevalence of OSA in different studies varies (13%-70%), some studies have found rates as high as 70%[12]. In the general adult population, the prevalence of OSA is estimated to range from 15% to 20%, but in candidates for MBS, the prevalence has been reported as significantly higher, ranging from 64% to 97%[13]. This elevated prevalence in MBS candidates is understandable, given that obesity is the most significant risk factor for OSA[13]. Similar to our findings, a higher prevalence of OSA has been observed in men undergoing MBS procedures[14].

Our demographic data revealed that 75.5% of patients with OSA were White, while 25% of those without OSA were African American. Other studies have suggested that African Americans may present with more severe OSA due to a higher respiratory disturbance index (RDI) and more frequent episodes of oxygen desaturation (T90) compared to the White population[15]. However, socioeconomic factors, including higher rates of poverty and limited access to healthcare in this population, may contribute to undiagnosed and untreated OSA, resulting in disparities in the management of the condition[15].

In contrast, our study showed that the majority of patients without OSA were female (87.1%). The Wisconsin Sleep Study estimated the incidence of OSA to be 24% in men and 9% in women[16]. Garvey *et al.* suggested that men are more likely to be referred for OSA screening due to the more classic symptoms, such as loud snoring, which are often reported by their female bed partners[17]. Women, on the other hand, tend to present with more atypical complaints, such as low energy and fatigue, which may lead to an underdiagnosis of OSA. Furthermore, the prevalence of OSA has been found to increase in postmenopausal women, though hormonal replacement therapy may play a protective role against the development of OSA.

Patients with OSA are frequently classified as ASA Class IV-V, likely due to the increased cardiovascular risk factors associated with the condition. OSA can present challenges in perioperative care, including difficulties with mask ventilation, laryngoscopy, and intubation, as well as accelerated arterial desaturation, which complicates postoperative monitoring and discharge[18,19]. Our findings align with these challenges, as patients with OSA in our study had higher rates of DVT, diabetes, COPD, hypertension, and hyperlipidemia, mirroring the findings of other studies examining MBS patients with OSA[20].

Intraoperative complications, reoperations, or deaths were not reported in patients undergoing SADI-S by Qudah *et al.,* with a median follow-up of 4.5 months[21]. Similarly, a cohort of 91 Australian patients undergoing SADI-S had a short-term morbidity rate of 4.3%, with no long-term morbidity[22]. More recent studies have indicated a higher morbidity rate in patients with OSA, including difficult intubation, hypoxemia, pneumonia, PE, atelectasis, cardiac arrhythmias, infarction, and unanticipated ICU admissions[23].

In our study, patients with OSA also had a higher rate of blood transfusions. Given that OSA patients often have multiple obesity-associated conditions, such as hypertension, dyspnea, and metabolic syndrome, perioperative bleeding risk may be elevated[24]. The chronic use of anticoagulants in this population can further increase the risk of bleeding, contributing to the higher rate of blood transfusions observed[25]. These findings are corroborated by a meta-analysis conducted by Sun *et al.*[26].

A meta-analysis conducted by Sun *et al.* concluded that patients with OSA have a higher risk of postoperative bleeding, which leads to an increased rate of blood transfusions[26]. This may be attributed to the higher incidence of coagulation disorders in OSA patients, including hypercoagulability or hypofibrinolysis[27].

Additionally, our study observed a longer operative time in patients with OSA, which was associated with higher BMI[5]. While this has not been explicitly reported for patients undergoing SADI-S, it has been documented in patients undergoing MBS in general[5].

There were no significant differences between the OSA and non-OSA groups regarding mortality, anastomotic leaks, readmissions, reoperations, or unplanned ICU admissions. These findings are consistent with those of Weingarten *et al.*[28]. However, according to a 2023 systematic review and meta-analysis by Katasani *et al.,* patients with OSA are at greater risk of complications after MBS, with a relative risk (RR) of 1.23[29]. Furthermore, Elrashidy *et al.* reported a higher incidence of respiratory complications in patients with OSA following various types of MBS[30].

From the selected studies from systematic review, we extracted various characteristics, including authorship, year of publication, country, study design, evaluation period, number of SADI-S participants, mean age (SD/range), male sex (%), BMI, race, ASA classification, OSA prevalence (%), preoperative comorbidities (e.g., diabetes, hypertension), perioperative technical outcomes, postoperative outcomes, conclusions based on OSA, and length of stay (LOS in days). These details are presented in Table 5.

The findings of our study indicate promising outcomes regarding the resolution of OSA following SADI-S. This is particularly important compared to the established gold standard, Roux-en-Y Gastric Bypass (RYGB) for evaluating surgical interventions aimed at treating obesity and related comorbidities. Nastałek *et al.* (2021) conducted a prospective observational study, which demonstrated a resolution percentage of OSA at approximately 38.6% with RYGB[33].

Table 5. Search results of included studies

Author	Year published	Country	Type of study	Years evaluated	Number of participants with SADI-S	Mean age - (SD/range)	Male sex (%)	BMI	Race	ASA	OSA prevalence (%)	Other preoperative comorbidity (%) (DM, HTN, *etc*)	Perioperative technical outcomes	Postoperative outcomes	Conclusion based on OSA	LOS (days)
Deffain *et al.*[31]	2024	USA	Cohort retrospective	2016-2020	179	44.1-9.5	31 (17.3%)	52.5 (± 9.1)	NR	II 20 (11.1%), III 159 (88.9%)	57.50%	HTN 52%, T2DM 36.3%, DLP 32.4%	Hematoma: 4, Intra-abdominal collections: 4, Sleeve leak: 1, Duodenal leak: 2	No conclusions based on OSA	NR	NR
Ospina Jaramillo *et al.*[12]	2023	USA	Retrospective study	18 months	61	39.8 ± 9.54	34.40%	50 ± 7.1	NR	NR	70.49%	Dyslipidemia 50.82%, Hypertension 34.43%, Type 2 diabetes mellitus 19.67%	NR	Complete remission of type 2 diabetes mellitus 100% at 24 months, Resolution of hypertension 70% at 12 months, Resolution of dyslipidemia 100% at 24 months, Resolution of sleep apnea 25% at 12 months	Effective for weight loss and improving obesity-related comorbidities	2.3 ± 0.8
Holt *et al.*[32]	2023	USA	Prospective single-center study	12 and 24 months	47	44.7 ± 10.1	22.20%	52.2	White (48.6%)	NR	59.50%	Hypertension 51.9%	Mean operating time 93.8 ± 33.6 min, Estimated blood loss 36.6 ± 19.7 mL	35.6% total weight loss at 12 months, 40.4% total weight loss at 24 months, 59.2% resolution of hypertension at 12 months, 64% resolution of OSA at 24 months	SIPS procedure is a safe and effective primary treatment for severe obesity with low complication rates and resolution of metabolic comorbidities	NR
Surve *et al.*[22]	2020	USA	Cohort retrospective	2017-2019	91	46.2 ± 9	30 (32.9%)	43.2 ± 5.7	NR	ASA score > IV (0)	23%	T2D 23%, Hyperlip 29.6%, HTN	Intraoperative complication (0), Open	Resolution for OSA 94.4%, T2D 94.2%,	None	1.4 ± 0.8

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29.6%, GERD 9.8%	conversion (0)	HLD 75%, HTN 68%, GERD 12.5%, Bleeding: 2, Mortality: 0

SADI-S: Single anastomosis duodeno-ileal bypass with sleeve gastrectomy; OSA: obstructive sleep apnea; SD: standard deviation; BMI: body mass index; ASA: American Society of Anesthesiologists; T2DM: type 2 diabetes mellitus; HTN: hypertension; DLP: dyslipidemia; HLD: hyperlipidemia; GERD: gastroesophageal reflux disease; LOS: length of stay; NR: not reported.

Additionally, the comparison with One Anastomosis Gastric Bypass (OAGB) is noteworthy. OAGB has shown similar efficacy in resolving OSA and is associated with shorter operative times compared to SADI-S[34]. This advantage may offer additional considerations for surgical choice in clinical practice, particularly for patients concerned about longer recovery times.

Moreover, another promising alternative is the Single Anastomosis Sleeve Ileal (SASI) bypass, which has reported an impressive OSA remission rate of 81.8%. This outcome underscores the evolving landscape of bariatric surgery techniques, indicating that SADI-S may provide comparable results to both RYGB and SASI while retaining its unique advantages[34].

In summary, our results suggest that SADI-S can be considered a viable option for patients with OSA, demonstrating results that are not only competitive with RYGB but also align with the favorable outcomes seen in emerging procedures like OAGB and SASI. This reinforces the importance of ongoing research and clinical evaluation to further establish the role of SADI-S within the broader spectrum of bariatric surgery interventions.

It should also be emphasized that Obstructive Sleep Apnea Syndrome (OSAS) should ideally be treated prior to surgery to optimize patient outcomes. Preoperative screening for OSAS is crucial, as it is not yet a standard practice globally. Screening questionnaires such as the Berlin, STOP-BANG, or ASA checklist are easy to administer preoperatively and have been shown to identify high-risk patients. Incorporating this step may lead to improved postoperative results, as untreated OSAS can complicate perioperative management and recovery[23].

Moreover, the introduction of robotic-assisted surgery could offer further enhancements in patient outcomes. Robotic platforms allow for greater precision and could enable a reduction in capnoperitoneum pressure, which is particularly beneficial for patients with respiratory comorbidities such as OSAS. In addition to minimizing blood loss and postoperative pain, robotic surgery could also improve recovery times and reduce complications, making it a valuable tool in bariatric surgery, especially for procedures like SADI-S.

Integrating OSAS management and leveraging robotic assistance could thus contribute to further improvements in the success rates of bariatric procedures, underscoring the importance of a multidisciplinary approach in optimizing care for patients with complex comorbidities like OSAS.

While our study focuses on the outcomes of SADI-S, it is important to acknowledge the emergence of other single-anastomosis procedures, such as OAGB and SASI bypass[35]. OAGB has demonstrated similar efficacy in weight loss and OSA resolution while offering a shorter operative time compared to SADI-S, which may be a consideration for surgical choice in select patients. Similarly, SASI has reported an impressive OSA remission rate of 81.8%, highlighting its potential as an alternative intervention[36]. Although SADI-S remains a promising approach with durable weight loss and metabolic benefits, future studies directly comparing these procedures in OSA patients could provide additional insight into optimizing surgical decision making.

It is also worth noting that while OSA has been linked to increased perioperative risks, conflicting evidence exists regarding its role in postoperative inflammation. Some studies suggest that OSA-related intermittent hypoxia may contribute to systemic inflammation through elevated C-reactive protein (CRP) levels and other inflammatory markers, which could influence recovery following bariatric surgery[37,38]. However, our study did not specifically assess inflammatory markers, and the impact of OSA on postoperative inflammation remains an area for further investigation. Future research incorporating inflammatory biomarker analysis may help clarify the extent to which OSA exacerbates postoperative inflammatory responses.

Our study analyzes one of the largest datasets on MBS and is the first to compare the surgical outcomes of patients undergoing SADI-S based on their history of OSA. However, there are inherent limitations to acknowledge. First, our study relies on a secondary retrospective database (MBSAQIP), which only captures 30-day postoperative outcomes. As a result, the evaluation of long-term complications, metabolic changes (e.g., weight fluctuations, diabetes improvement), and OSA recurrence is beyond the scope of this analysis. Future prospective studies with extended follow-up periods are needed to assess these long-term effects.

Second, intraoperative factors such as intubation time, airway management challenges, and intraoperative oxygen desaturation events, which could contribute to longer operative times in OSA patients, are not recorded in the MBSAQIP database. This limits our ability to determine the precise mechanisms underlying prolonged surgical durations. Further studies incorporating detailed intraoperative data are necessary to clarify these associations.

Third, as SADI-S is a relatively new procedure, the sample size in each group is smaller compared to other bariatric surgeries, which may introduce variability in the reported outcomes. While our comparison of ICU admissions did not reveal significant differences, the limited sample size suggests that a larger cohort may provide more conclusive evidence.

Despite these limitations, our study provides important insights into the perioperative risks of SADI-S in OSA patients. Future research should incorporate larger, multicenter cohorts with long-term follow-up and more granular intraoperative data to further refine our understanding of this patient population.

In conclusion, Based on the findings of this study, patients with OSA undergoing SADI-S surgery exhibit more challenging baseline characteristics, including older age, higher BMI, and a higher prevalence of comorbidities such as diabetes mellitus, hypertension, and hyperlipidemia, compared to those without OSA. Intraoperatively, OSA presents significant challenges in patients undergoing SADI-S, including prolonged operative times and increased risk of blood transfusions. Despite these challenges, OSA does not appear to adversely affect key short-term postoperative outcomes, such as mortality, PE, or readmission rates. These findings suggest that while careful intraoperative management is crucial in OSA patients, SADI-S remains a safe and effective bariatric procedure in this population. Perioperative management in patients with OSA is therefore crucial to mitigate intraoperative risks without adversely impacting short-term recovery. Further studies are warranted to explore long-term outcomes and optimize perioperative care for patients with OSA undergoing bariatric surgery.

DECLARATIONS

Authors' contributions

Conceptualization and study design: Chirinos SR, Rivero-Moreno Y, Oviedo RJ
Data acquisition and curation: Chirinos SR, Zevallos A, Goyal A
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All authors contributed significantly to the development and completion of this manuscript.
All authors have read and approved the final version for submission.

Availability of data and materials

The datasets generated and/or analyzed during this study are not publicly available but may be obtained from the corresponding author upon reasonable request.

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None.

Conflict of interest:

Pouwels S is an Editorial Board member of the journal *Metabolism and Target Organ Damage*. Pouwels S is also a Guest Editor for the Special Issue *Clinical Advances in Bariatric Surgery: Current Trends, Outcomes, and Future Perspectives*. Pouwels S was not involved in any steps of editorial processing, notably including reviewer selection, manuscript handling, and decision making. The other authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

The MBSAQIP dataset is de-identified, contains no personal health information, and is publicly accessible to surgeons and members of MBSAQIP-accredited centers. As such, it does not fall under the definition of Human Subjects Research per federal regulations. Consequently, this study did not require Institutional Review Board (IRB) approval.

Consent for publication

Not applicable.

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