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SSAT PLENARY PRESENTATION

Post-Operative Complications and Readmissions Associated with Smoking Following Bariatric Surgery

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Abstract

Background The link between smoking and poor postoperative outcomes is well established. Despite this, current smokers are still offered bariatric surgery. We describe the risk of postoperative 30-day complications and readmission following laparoscopic sleeve gastrectomy and laparoscopic Roux-En-Y gastric bypass in smokers.

Methods The National Surgical Quality Improvement Program database was queried to identify patients who underwent laparoscopic sleeve gastrectomy and Roux-En-Y gastric bypass from 2012 to 2017. Patient outcomes were compared based on smoking status. Primary outcomes included 30-day readmission and death or serious morbidity. Secondary outcomes included wound and respiratory complications. Multivariable logistic regression was used to determine the association between smoking status and measured outcomes.

Results Of the 133,417 patients who underwent bariatric surgery, 12,424 (9.3%) were smokers. Smokers more frequently experienced readmission (4.9% v 4.1%, $p < 0.001$), death or serious morbidity (3.8% v 3.4%, $p = 0.019$), wound complications (2% v 1.4%, $p < 0.001$), and respiratory complications (0.8% v 0.5%, $p < 0.001$). The likelihood of death or serious morbidity (OR 1.13, 95% CI 1.01–1.26), readmission (OR 1.21, 95% CI 1.10–1.33), wound (OR 1.44, 95% CI 1.24–1.68), and respiratory complications (OR 1.69, 95% CI 1.34–2.14) were greater in smokers. The adjusted ORs remained significant on subgroup analysis of laparoscopic sleeve gastrectomy and Roux-En-Y gastric bypass patients, with the exception of death or serious morbidity in laparoscopic Roux-En-Y gastric bypass (OR 1.04, 95% CI 0.89–1.24).

Conclusions Smokers undergoing bariatric surgery experience significantly worse 30-day outcomes when compared with non-smokers. There should be a continued emphasis on perioperative smoking cessation for patients being evaluated for bariatric surgery.

Keywords Bariatric surgery · Outcomes · Smoking

Abbreviations

LSG	Laparoscopic sleeve gastrectomy
LRYGB	Laparoscopic Roux-En-Y gastric bypass

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Introduction

Bariatric surgery remains one of the most effective methods of achieving sustained long-term weight loss and improvement in obesity-related comorbidities.[1,2] The rigorous preoperative evaluation process, consisting of appropriate screening for medical and psychological comorbidities, has made bariatric surgery an especially safe procedure.[3,4] This is particularly notable, given the inherently higher risk of complications associated with operating on morbidly obese patients. However, areas for improvement in outcomes following bariatric surgery remain. One key risk factor for poor surgical outcomes is smoking. The link between smoking and poor postoperative outcomes has been well established. Smoking represents an independent predictor of postoperative complications and is

associated with higher healthcare costs.[5–9] Despite this, current smokers continue to be offered elective bariatric surgery.

Smoking cessation prior to surgery has been associated with a significant improvement in both postoperative outcomes and healthcare expenditures.[8,10] To date, the association between smoking and postoperative outcomes following bariatric surgery has only been explored in the context of limited case series.[11–13] However, the generalizability of these studies has been limited by their small sample size and inclusion of only single institution or single state cohorts. In addition, the single national study evaluating the association between smoking and outcomes following bariatric surgery was performed using data prior to the adoption of laparoscopic sleeve gastrectomy (LSG).[11] As a result, the impact of smoking on one of the most common bariatric procedures currently performed is poorly understood.

As bariatric surgery, in particular LSG, continues to serve a key role in the treatment of obesity, it is important to evaluate the association between the modifiable risk factor of smoking and postoperative outcomes. In this retrospective cohort study, data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) was used to describe the risk of postoperative 30-day complications and readmission following LSG and laparoscopic Roux-En-Y gastric bypass (LRYGB) in smokers.

Materials and Methods

Data Source

Data from the 2012–2017 ACS NSQIP was used to identify all laparoscopic sleeve gastrectomy (LSG) and laparoscopic Roux-en Y gastric bypass (LRYGB) patients. ACS NSQIP sampling strategy, data abstraction, variables collected, and outcomes are detailed elsewhere.[14,15] Briefly, the ACS NSQIP database maintains prospectively collected data on several clinical and pathological characteristics. These include patient demographics, comorbidities, operative details, and 30-day postoperative outcomes. Data are collected by highly trained surgical clinical reviewers in a standardized fashion. This study was deemed exempt by the Institutional Review Board of Northwestern University.

Study Population

Current Procedural Terminology (CPT) codes were used to identify patients who underwent LSG or LRYGB in the ACS NSQIP database (CPT codes 43644 and 43775). Patients who underwent revision surgery ($n = 1016$), were classified as emergent ($n = 1737$), or had an American Society of Anesthesiologist (ASA) class of V or missing were excluded ($n = 117$). Smoking status was determined based on patient self-report of smoking cigarettes within the last year and coded as "current smoker" vs "non-smoker." ACS NSQIP does not collect data regarding patients who were "former" smokers.

Outcomes

The primary outcomes studied include 30-day readmission and death or serious morbidity (DSM). DSM included death, deep surgical site infection, organ space surgical site infection, wound dehiscence, pneumonia, reintubation, pulmonary embolism, acute kidney injury, myocardial infarct, cardiac arrest, sepsis, septic shock, return to OR, deep venous thrombosis, requiring ventilator support for 48 h, or bleeding requiring transfusion. Secondary outcomes included wound (defined as superficial, deep, and organ space surgical site infection [SSI]) and respiratory (pneumonia, reintubation, and failure to wean from mechanical ventilation within 48 h) complications.

Covariates

Patient-specific demographic (age, sex, race/ethnicity), comorbidities (diabetes, hypertension, chronic obstructive pulmonary disease [COPD], dyspnea, steroid use, and functional status), and operative characteristics (ASA, wound class, and operative time) were available within the dataset.

Statistical Analysis

Bivariate associations between demographic characteristics and smoking status were evaluated using descriptive statistics. Categorical variables were evaluated using chi-squared tests, while continuous variables were evaluated with either a Student *t* test or Mann-Whitney test. The incidence of postoperative readmission and complications by smoking status was evaluated with chi-squared test. Multivariable logistic regression was used to assess for associations between the outcomes of interest and smoking status. The multivariable model adjusted for age, sex, race (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other/Unknown), BMI, and pre-existing comorbidities (diabetes, hypertension, COPD, and dyspnea). Subgroup analyses, evaluating LSG and LRYGB individually, were performed to assess for differential associations based on type of surgery. All tests were two sided and the level of significance was set at 0.05. Statistical analysis was performed using STATA v15.1 (College Station, TX).

Results

Among 133,417 patients who underwent bariatric surgery from 2012 to 2017, 12,424 (9.3%) self-reported as smokers

Table 1 Demographic characteristics of elective bariatric surgery patients by smoking status

	Smoking status		*p* value[a]
	Current smoker	Non-smoker	
	N (%)		
Total	12,424 (9.3)	120,993 (90.7)	
Age, year, mean (SD)	24.3 (10.7)	27.9 (11.9)	< 0.001[b]
Sex			
Female	9750 (78.5)	96,441 (79.7)	0.001
Male	2674 (21.5)	24,552(20.3)	
Race			
Non-Hispanic White	8175 (65.8)	75,600 (65.8)	< 0.001
Non-Hispanic Black	1784 (14.4)	19,235 (15.9)	
Hispanic	1316 (10.6)	13,229 (10.9)	
Other/unknown	1149 (9.3)	12,929 (10.7)	
BMI, mean (SD)	46.2 (8.2)	45.5 (8.0)	< 0.001[c]
Comorbidities			
Diabetes	2904 (23.4)	32,785 (27.1)	< 0.001
Hypertension	5343 (43.0)	59,402 (49.1)	< 0.001
COPD	480 (3.9)	1822 (1.5)	< 0.001
Dyspnea (moderate exertion/rest)	1946(15.6)	14,800 (12.2)	< 0.001
Steroid use	199 (1.6)	2193 (1.8)	0.092
Functional status			
Dependent	83 (0.7)	881 (0.7)	0.451
Independent	12,341 (99.3)	120,112 (99.3)	
ASA**			
I/II	3257 (26.2)	32,194 (26.6)	0.356
III/IV	9153 (73.6)	88,701 (73.4)	
Wound classification			
I/II	12,326 (99.2)	120,108 (99.3)	0.477
III/IV	98 (0.8)	885 (0.7)	
Operative time, min, mean (SD)	103 (52.8)	103 (53.2)	0.392[b]
Surgery type			
Laparoscopic Roux-En-Y gastric bypass	4770 (38.4)	47,250 (39.1)	0.152
Laparoscopic sleeve gastrectomy	7654 (61.6)	73,743 (60.9)	

[a] Chi-squared test

[b] Two sided *t* test

[c] Mann-Whitney test

(Table 1). Current smokers were more likely to be younger (24.3 v 27.9 years old, $p < 0.001$), male (21.5% v 20.3%, $p = 0.001$), have a higher BMI (46.2 v 45.5, $p < 0.001$), have COPD (3.9% v 1.5%, $p < 0.001$), and experience dyspnea with moderate exertion or at rest (15.6% v 12.2%, $p < 0.001$). Current smokers were less likely to have diabetes (23.4% v 27.1%, $p < 0.001$) and hypertension (43.0% v 49.1%, $p < 0.001$). There were no significant differences between type of bariatric surgery and smoking status.

The overall rate of DSM following bariatric surgery was 3.5% while the overall rate of 30-day readmission was 4.2%. On unadjusted analysis, a total of 608 (4.9%) current smokers were readmitted within 30 days, compared with 4934 (4.1%) non-smokers ($p < 0.001$; Table 2). Rates of DSM were higher in current smokers (475 [3.8%] v 4136 [3.4%], $p = 0.019$). Current smokers were also more likely to experience wound (251 [2.0%] v 1712 [1.4%], $p < 0.001$) and respiratory (95 [0.8%] v 622 [0.5%], $p < 0.001$) complications when compared with non-smokers. Analysis of individual complications revealed no differences in the rates of septic complications, venous thromboembolism, cardiac complications, or transfusion requirements. Similar trends were noted on subgroup analysis of LSG and LRYGB patients.

Following adjustment for patient demographic, clinical factors, and surgery type, current smokers were more likely to experience DSM (odds ratio [OR] 1.13, 95% confidence interval [CI] 1.01–1.26) and 30-day readmission (OR 1.21, 95% CI 1.10–1.33; Table 3). In addition, current smokers were more likely to experience wound (OR 1.44, 95% CI 1.24–1.68) and respiratory (OR 1.69, 95% CI 1.34–2.14) complications. However, current smokers were no more likely to return to the operating room (OR 1.15, 95% CI 0.98–1.34) when compared with non-smokers. The adjusted ORs remained significant on subgroup analysis of LSG and LRYGB patients, with the exception of death or serious morbidity in LSG (OR 1.04, 95% CI 0.89–1.24).

Discussion

In this study, a national cohort of patients undergoing elective bariatric surgery was analyzed to compare outcomes between smokers and non-smokers. Smoking was associated with increased DSM and 30-day readmission following surgery after adjusting for patient comorbidities. Patients who were smokers were particularly more likely to experience wound and respiratory complications. Similar findings were noted when evaluating LSG and LRYGB individually.

The association between smoking and poor postoperative outcomes is well established. Previous studies have shown smokers undergoing major oncologic, cardiovascular, or thoracic operations to have higher rates of infectious, wound, and pulmonary complications.[7,16] Similarly, recent work by our group has demonstrated that smokers undergoing even minor elective operations, such as hernia repairs, also experience worse postoperative outcomes when compared with nonsmokers.[17] The results of this study similarly demonstrate the adverse impact of smoking at the time of bariatric surgery in a large-scale, national patient cohort. While previous studies have evaluated the association between smoking and bariatric surgery outcomes, they have been limited by small sample size, single institutions or state cohorts, or the lack of data on the most common bariatric surgery currently performed. Thus, the current study provides the most generalizable results reported to date by using a national cohort consisting of patients who underwent either LSG or LRYGB. In particular, we found that smokers undergoing LSG experience higher rates of DSM and readmission when compared with smokers undergoing LRYGB.

Table 2 Incidence of postoperative complications and readmission following elective bariatric surgery by smoking status

	Total			LSG			LRYGB		
	Current smoker	Non-smoker	*p* value [a]	Current smoker	Non-smoker	*p* value[a]	Current smoker	Non-smoker	*p* value[a]
	N (%)			*N* (%)			*N* (%)		
DSM	475 (3.8)	4136 (3.4)	0.019	198 (2.6)	1834 (2.5)	0.594	277 (5.8)	2302 (4.9)	0.005
Readmission	608 (4.9)	4934 (4.1)	< 0.001	280 (3.7)	2236 (3.1)	0.003	238 (6.9)	2698 (5.7)	0.001
Death	13 (0.1)	117 (0.1)	0.787	8 (0.1)	56 (0.1)	0.396	5 (0.1)	61 (0.1)	0.653
Return to OR	227 (1.8)	1939 (1.6)	0.059	87 (1.1)	750 (1.0)	0.323	140 (2.9)	1189 (2.5)	0.081
Wound complication	251 (2.0)	1712 (1.4)	< 0.001	107 (1.4)	656 (0.9)	< 0.001	144 (3.0)	1056 (2.2)	0.001
Superficial SSI	148 (1.2)	988 (0.8)	< 0.001	58 (0.8)	352 (0.5)	0.001	90 (1.9)	636 (1.3)	0.002
Deep SSI	14 (0.1)	110 (0.1)	0.448	5 (0.1)	32 (0.1)	0.392	9 (0.2)	78 (0.2)	0.704
Organ space SSI	89 (0.7)	592 (0.5)	0.001	44 (0.6)	252 (0.3)	0.001	45 (0.9)	340 (0.7)	0.086
Dehiscence	11 (0.1)	74 (0.1)	0.249	1 (0.1)	30 (0.1)	0.239	10 (0.2)	44 (0.1)	0.017
Respiratory complication	95 (0.8)	622 (0.5)	< 0.001	38 (0.5)	261 (0.3)	0.040	57 (1.2)	361 (0.7)	0.001
Pneumonia	57 (0.5)	374 (0.3)	0.005	26 (0.3)	153 (0.2)	0.019	31 (0.7)	221 (0.4)	0.084
Reintubation	39 (0.3)	238 (0.2)	0.006	15 (0.2)	106 (0.1)	0.259	34 (0.5)	132 (0.3)	0.007
Failure to wean from vent	33 (0.3)	194 (0.2)	0.007	9 (0.1)	72 (0.1)	0.598	24 (0.5)	122 (0.3)	0.002
Sepsis	47 (0.4)	364 (0.3)	0.138	17 (0.2)	166 (0.2)	0.958	30 (0.6)	198 (0.4)	0.036
Septic shock	20 (0.2)	160 (0.1)	0.406	9 (0.1)	56 (0.1)	0.220	11 (0.2)	104 (0.2)	0.883
Pulmonary embolism	27 (0.2)	201 (0.2)	0.188	15 (0.2)	103 (0.1)	0.218	12 (0.3)	98 (0.2)	0.527
Deep venous thrombosis	34 (0.3)	361 (0.3)	0.629	16 (0.2)	242 (0.3)	0.078	18 (0.4)	119 (0.2)	0.107
Cardiac arrest	9 (0.1)	76 (0.1)	0.685	5 (0.1)	36 (0.1)	0.540	4 (0.1)	40 (0.1)	0.986
Myocardial infarct	7 (0.1)	90 (0.1)	0.477	5 (0.1)	50 (0.1)	0.937	2 (0.1)	40 (0.1)	0.322
Transfusion	133 (1.1)	1232 (1.0)	0.581	54 (0.7)	544 (0.7)	0.754	79 (1.7)	688 (1.5)	0.274

[a] Chi-squared test

Table 3 Associations between smoking and 30-day postoperative complications as well as readmission by surgery type†

	Nonsmoker	Any bariatric procedure	LSG	LRYGB
	Adjusted odds ratio (95% CI)*			
DSM	REF	1.13 (1.01–1.26)**	1.04 (0.89–1.24)	1.19 (1.03–1.37)**
Readmission	REF	1.21 (1.10–1.33)**	1.18 (1.02–1.36)**	1.24 (1.09–1.40)**
Wound complication	REF	1.44 (1.24–1.68)**	1.53 (1.20–1.93)**	1.39 (1.14–1.69)**
Respiratory complication	REF	1.69 (1.34–2.14)**	1.62 (1.11–2.34)**	1.74 (1.29–2.36)**
Return to OR	REF	1.15 (0.98–1.34)	1.09 (0.85–1.40)	1.18 (0.98–1.43)

† All odds ratios presented are for smokers, non-smokers represent the reference group within the logistic regression model

*Logistic regression model adjusted for gender, age, race, BMI, surgery type, and comorbidities

**$p < 0.05$

While complications following bariatric surgery are rare, the number of bariatric surgical procedures performed each year in the USA continues to increase.[18] Therefore, even a small reduction in postoperative complications and readmissions related to smoking would represent an important opportunity to improve patient outcomes and reduce healthcare costs. Along these lines, certain insurance policies mandate that patients remain nicotine free during the preoperative period. Furthermore, past work has shown that the likelihood of sustained abstinence from smoking at 1 year was greatest if performed preoperatively.[19–21] The extended preoperative workup associated with bariatric surgery provides a unique opportunity for surgeons to target a modifiable risk factor. Despite these findings, several studies have shown surgeons are less likely to address smoking cessation preoperatively.[22,23] Therefore, this study adds to the body of literature indicating that surgeons should take a leading role in addressing smoking cessation.

This study should be interpreted within the context of the following limitations. First, for data collection purposes, NSQIP classifies smokers as any patient who reported smoking within the past year even if they may have quit within that time frame. While this produces a broad definition of "smoker," the resulting decrease in effect size indicates that the estimated association between smoking and outcomes of interest would be biased towards the null hypothesis. Second, the NSQIP definition of smoking also does not take into account previous history of smoking. Several studies have shown that those with a history of smoking have higher risks for postoperative complications when compared with patients who have never smoked. As in the previous case, this limitation would likely produce a conservative estimate of the association between smoking and outcomes of interest. Third, NSQIP only gathers outcomes up to 30 days following surgery. This precludes any evaluation of long-term associations between smoking and postoperative outcomes.

Conclusion

Smokers undergoing bariatric surgery experience significantly worse 30-day outcomes when compared with non-smokers. These findings further underscore the importance of smoking cessation counseling prior to bariatric surgery. Given the large volume of bariatric procedures performed annually, counseling regarding preoperative smoking cessation process may decrease poor postoperative outcomes, reduce healthcare costs, and encourage patients to sustain smoking cessation.

Author Contributions TKY, RK: data analysis, interpretation of results, writing.

NJS, ESH, APN, ENT, KYB, DDO: conceptualization, interpretation of results, methodology, writing, editing.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Disclaimer Views expressed in this work represent those of the authors only.

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