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Original article

Postoperative pneumonia after bariatric surgery during the COVID-19 pandemic: a National Surgical Quality Improvement Program study

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Abstract

Background: During the COVID-19 pandemic, surgical centers had to weigh the benefits and risks of conducting bariatric surgery. Obesity increases the risk of developing severe COVID-19 infections, and therefore, bariatric surgery is beneficial. In contrast, surgical patients who test positive for COVID-19 have higher mortality rates.

Objective: This study investigates the national prevalence of postoperative pneumonia during the COVID-19 pandemic in the bariatric surgery population.

Setting: The American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) database.

Methods: This is a cross-sectional study using the ACS-NSQIP database. The population of concern included patients who underwent sleeve gastrectomy and Roux-en-Y gastric bypass procedures. Information was extracted on rate of postoperative pneumonia and other 30-day complications between 2018 and 2020.

Results: All baseline characteristics were similar among patients who underwent bariatric surgery between 2018 and 2020. However, there was a 156% increase in postoperative pneumonia in 2020 compared with the previous year. Furthermore, despite the similar postoperative complication rates across the years, there was a statistically significant increase in all-cause mortality in 2020. The multivariate analysis showed that having surgery in 2020 was a statistically significant risk factor for pneumonia development postoperatively.

Conclusions: This study showed a statistically significant increase in the prevalence of postoperative pneumonia during the COVID-19 pandemic among bariatric surgery patients. Surgical centers must continuously evaluate the risks associated with healthcare-associated exposure to COVID-19 and weigh the benefits of bariatric surgery. (Surg Obes Relat Dis 2022;18:1239–1245.) © 2022 Published by Elsevier Inc. on behalf of American Society for Bariatric Surgery.

Keywords: Bariatric surgery; Roux-en-Y gastric bypass; Gastric bypass; Sleeve gastrectomy; COVID-19; NSQIP

The coronavirus disease 2019 (COVID-19) pandemic has had an unprecedented impact on global surgical practices [1]. From the initial shutdown of elective surgery in early 2020 to the gradual resumption of operative interventions, leaders of each surgical field have weighed the patients' and healthcare workers' risks and benefits of offering the full range of operative services [2]. It has been shown that surgical patients who test positive for COVID-19 suffer higher rates of mortality from surgery [3]. In contrast, rates of hospital-acquired COVID-19 infection reached up to 44% hospital outbreaks early

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in the pandemic [4]. The resumption of elective surgery, namely any surgery not offered in the emergent or urgent setting, has been particularly controversial because the risks of COVID-19 exposure are weighed against the lifelong benefits of these procedures to the patients [5]. Because there is a multimillion-case backlog of operations canceled throughout the pandemic, there is a pressing need to catch up on these procedures [6].

The decision to reinstate bariatric surgery during the pandemic required careful consideration of both the health of patients with obesity and the relative burden of bariatric surgery and perioperative care on the healthcare system [7]. Because bariatric surgery provides both sustained weight loss and amelioration of obesity-related co-morbid conditions, the expeditious resumption of bariatric surgery during the pandemic was pressing [8]. Obesity increases the risk for developing a severe COVID-19 infection [9]. Furthermore, studies have shown that a history of bariatric surgery may be protective against severe COVID-19 infection [10,11]. Therefore, the surgical community largely supported the resumption of bariatric surgery during the pandemic by offering guidelines on safe surgical practices for both patients and providers [7,12]. These recommendations also stress the importance of evaluating each patient on a case-by-case basis to consider the risks and benefits of each procedure [13]. Studies describing single-center surgical experiences during the COVID-19 pandemic have reported that bariatric and metabolic surgery can be performed safely under appropriate guidelines [14,15].

As the pandemic has evolved with the emergence of new COVID-19 variants, there has been a global movement toward increased availability of vaccines and better care practices. Similarly, there is a need for surgical guidelines to continuously adapt and improve. During this third year of the pandemic, we can now analyze our practices and outcomes in the hope of informing future practices. During the initial months of the pandemic, data showed a 10% risk of developing COVID-19 in the perioperative period [16]. Therefore, we sought to study the prevalence of COVID-19 infections in this surgical population nationally. While data specifically on perioperative COVID-19 infections were not available in a national database, we sought to study the prevalence of other postoperative complications, especially respiratory infections, in the bariatric surgical population. Because these data are available in different multi-institutional databases, we chose to use the American College of Surgeons National Surgical Quality Improvement Project (NSQIP) database because it draws cases from a range of clinical settings that will provide nuance on the risks of bariatric surgery during the pandemic for providers in both accredited and nonaccredited bariatric centers [17].

Methods

Study design

This was a cross-sectional study using the NSQIP database, a nationwide registry that has been validated for surgical outcomes research. It contains >300 variables, including preoperative, intraoperative, and 30-day postoperative data from centers around the United States. Data are collected using a systematic sampling process by trained surgical clinical reviewers. Institutional review board approval was not needed given the nature of the study and its data.

Population

All patients who underwent primary sleeve gastrectomy (SG) or Roux-en-Y gastric bypass (RYGB) from 2018 to 2020 were included. Specifically, we included patients with primary Current Procedural Terminology (CPT) codes 43775, 43644, or 43645. Patients with primary CPT codes 43644 (proximal gastric bypass with Roux limb of 150 cm or less) and 43645 (distal gastric bypass with Roux limb of >150 cm) were combined and both considered to have undergone RYGB. The ACS-NSQIP database does not include patients younger than 18 years of age, and therefore, they were not included in this study. It is important to note that the sampling process does not allow the inclusion of more than 3 procedures during an 8-day period.

Definitions and primary outcome

The primary outcome assessed was the rate of postoperative pneumonia, which ACS-NSQIP defines as "an infection of one or both lungs caused by bacteria, viruses, fungi, or aspiration" based on (1) radiologic examination demonstrating infiltrate, consolidation, opacity, cavitation, pneumonia, or the diagnosis rendered by an attending physician or (2) signs, symptoms, and laboratory data as stated in the variable definition booklet. These criteria must be met within 30 days of the primary procedure. An increase in the baseline rate of pneumonia was considered to be an indirect measure of the development of SARS-CoV-2 infection. As a control, other 30-day complications that could not be directly attributed to SARS-CoV-2 were compared.

Statistical analysis

All statistical analyses were performed with SAS version 9.4 (SAS, Cary, NC, USA). The χ^2 test was used to evaluate the association between year of the operation and the primary and secondary outcomes. The development of pneumonia was assessed in a univariate analysis using the Student t test and χ^2 test for continuous and categorical variables, respectively. The Fischer exact test was used for categorical variables when an observed value was <5. Statistical significance was considered at $P < .05$. Variables

with statistical significance in the univariate analysis were included in a logistic regression model to generate a multivariate analysis. Unless otherwise indicated, results are reported as total and percentages for categorical variables, means and standard deviations for continuous variables, and odds ratio (OR) and 95% confidence intervals (95% CI).

Results

According to the ACS-NSQIP database, in 2020, there were 7847 patients who underwent bariatric surgery compared to 12,202 in 2019 and 19,226 in 2018. Each year, approximately 80% of the patients were female and 20% were male. Preoperatively, most patients were classified as American Society of Anesthesiologist (ASA) class 3 or higher, with specific percentages being 76% in 2018, 76% in 2019, and 79% in 2020. Each year's cohort had similar percentages of patients diagnosed with non–insulin-dependent diabetes and insulin-dependent diabetes, with 17% and 8% in 2018, 18% and 8% in 2019, and 17% and 7% in 2020, respectively. Similar percentages of patients had chronic obstructive pulmonary disease (COPD), with 1.54% in 2018, 1.54% in 2019, and 1.27% in 2020. Similar percentages of patients were former or current smokers, with 8% in 2018, 7% in 2019, and 6% in 2020. In all years, <1% of patients had congestive heart failure, renal failure, or required hemodialysis (Table 1).

In terms of the types of procedures that patients underwent, the breakdown between SG and RYGB was 67% and 33% in 2018, 64% and 36% in 2019, and 60% and 40% in 2020, respectively. Mean lengths of stay were 1.7 days in 2018, 1.6 days in 2019, and 1.6 days in 2020 (Table 1).

Table 1
Baseline demographics

Factor	2018, n = 19,226	2019, n = 12,204	2020, n = 7847
Age (yr)	44 ± 12	44 ± 12	44 ± 12
BMI (kg/m^2)	45 ± 8	44 ± 8	45 ± 8
Operative time (min)	98 ± 54	100 ± 56	105 ± 56
LOS (d)	1.7 ± 3.3	1.6 ± 3.3	1.6 ± 3.1
	n (%)	**n (%)**	**n (%)**
Female	15,419 (80)	9849 (81)	6412 (82)
Male	3807 (20)	2353 (19)	1435 (18)
Race			
Native American	89 (.46)	65 (.53)	34 (.43)
Asian	179 (.93)	300 (2.46)	204 (2.60)
Black	3146 (16.36)	1635 (13.40)	1217 (15.51)
Other	60 (.31)	19 (.16)	16 (.20)
Unknown	3341 (17.38)	2238 (18.34)	1771 (22.57)
White	12,411 (64.55)	7947 (65.12)	4605 (58.68)
Ethnicity			
Hispanic	2527 (13)	1411 (12)	933 (12)
ASA			
ASA classes 1 and 2	4672 (24)	2892 (24)	1668 (21)
ASA classes 3, 4, and 5	14,554 (76)	9312 (76)	6179 (79)
Hypertension	8518 (44)	5441 (45)	3303 (42)
Diabetes			
No insulin	3217 (17)	2190 (18)	1317 (17)
Insulin	1516 (8)	939 (8)	542 (7)
Dyspnea	2002 (10)	1022 (8)	584 (7)
Smoke	1507 (8)	873 (7)	506 (6)
Dependent	119 (.62)	80 (.66)	57 (.73)
COPD	297 (1.54)	188 (1.54)	100 (1.27)
Ascites	2 (.01)	0 (0)	2 (.03)
CHF	83 (.43)	70 (.57)	41 (.52)
Renal failure	3 (.02)	3 (.02)	11 (.14)
Dialysis	79 (.41)	50 (.41)	34 (.43)
Cancer	8 (.04)	10 (.08)	2 (.03)
Steroid use	371 (1.93)	255 (2.09)	161 (2.05)
Procedure			
SG	12,907 (67)	7787 (64)	4691 (60)
RYGB	6319 (33)	4417 (36)	3156 (40)

BMI = body mass index; LOS = length of stay; ASA = American Society of Anesthesiologist; COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure; SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass.

Table 2
Complications by year

Complication	2018, n = 19,226	2019, n = 12,204	2020, n = 7847	% change*	*P* value
Pneumonia	.25%	.16%	.41%	156.25%	**.004**
Septic shock	.12%	.07%	.14%	100.00%	.22
Sepsis	.27%	.23%	.38%	65.22%	.12
Mortality	.08%	.07%	.11%	57.14%	**.001**
Transfusions	.78%	.68%	.99%	45.59%	**.05**
Fail to wean ventilator	.11%	.09%	.13%	44.44%	.73
Deep vein thrombosis	.36%	.28%	.40%	42.86%	.32
Unplanned intubation	.13%	.12%	.17%	41.67%	.7
Organ space SSI	.44%	.39%	.54%	38.46%	.35
Reoperation	1.37%	1.35%	1.84%	36.30%	**.008**
Pulmonary embolism	.15%	.20%	.27%	35.00%	.13
Cardiac arrest requiring CPR	.06%	.07%	.09%	28.57%	.65
Clostridium difficile	.15%	.12%	.15%	25.00%	.82
Progressive renal insufficiency	.06%	.07%	.08%	14.29%	.85
Readmission	3.55%	3.94%	4.03%	2.28%	.08
Stroke	.02%	.01%	.01%	.00%	.85
Acute renal failure	.09%	.05%	.05%	.00%	.27
Urinary tract infection	.53%	.64%	.56%	–12.50%	.42
Superficial SSI	.79%	.84%	.62%	–26.19%	.21
Deep SSI	.06%	.08%	.05%	–37.50%	.68
Myocardial infarction	.06%	.06%	.03%	–50.00%	.54
Dehiscence	.07%	.06%	.01%	–83.33%	.16

SSI = surgical site infection; CPR = cardiopulmonary resuscitation.
Bold indicates statistically significant.
* 2020 compared to the prior year.

Postoperative complications by year are shown in Table 2. There was a 156% increase in the rate of postoperative pneumonia, with .25% in 2018, .16% in 2019, and .41% in 2020 ($P = .004$). In terms of other outcomes, there were statistically significant differences in the rates of reoperation, with 1.37% in 2018, 1.35% in 2019, and 1.84% in 2020 ($P = .008$). Importantly, the all-cause mortality rate was statistically significant different between years, .08% in 2018, .07% in 2019, and .11% in 2020 ($P = .001$). A deeper analysis of the increased postoperatively morbidity in 2020 revealed that postoperative complication rates were comparable between groups for thromboembolic events (including deep vein thrombosis, pulmonary embolism, and stroke), cardiac events (including arrest and myocardial infarction), and renal complications. In terms of infectious complications, there were no major differences in surgical-site infections, sepsis, *Clostridium difficile* infections, and urinary tract infections. In terms of respiratory complications, there were no differences in rates of failed extubation or unplanned intubation.

In the univariate analysis (Table 3) for the development of postoperative pneumonia, pneumonia was found to be associated with the following baseline characteristics: diabetes (36.63% versus 24.72%; $P = .006$), dependent status (3.96% versus 0.64%; $P = .004$), baseline dyspnea (18.81% versus 9.16%), COPD (4.95% versus 1.48%; $P = .02$), cancer (0.99% versus 0.05%; $P = .05$), older age (50 versus 44 years of age; $P = .001$), and lower body mass index (43 versus 45 kg/m^2; $P = .05$). In terms of interventions, it was also associated with undergoing RYGB (62.38% versus 35.3%; $P = .001$), longer operative times (148 versus 100 minutes; $P = .001$), and having surgery in 2020 (.41% versus .22%; $P = .003$). Reoperation was also associated with postoperative pneumonia (.17% versus 5.93%; $P = .001$). In addition, in the univariate analysis, both reoperation (.06% versus 2.09%; $P = .001$) and pneumonia (.08% versus 2.97%; $P < .001$) were associated with mortality.

In the multivariate analysis (Table 4), having surgery in 2020 remained a risk factor for the development of pneumonia (OR = 1.71; 95% CI: 1.11–2.64), as well as reoperation (OR = 24.11; 95% CI: 15.35–37.86) and longer operative time (OR = 1.00; 95% CI: 1.00–1.01). Increasing age also was a risk factor for the development of pneumonia (OR = 1.02; 95% CI: 1.01–1.04). The absence of dyspnea (OR = .56; 95% CI: .32–.98) was a protective factor. Diabetes mellitus, body mass index, COPD, functional status, type of procedure, and disseminated cancer did not reach statistical significance.

Discussion

As the COVID-19 pandemic continues to evolve with the emergence of new variants, it is crucial to analyze surgical practices and outcomes to inform future practices. In this study, we found that during the first year of the pandemic, there were statistically significant increases in the rate of postoperative pneumonia, reoperation, and mortality among bariatric patients within 30 days of their procedures

Table 3
Univariate analysis

Factor	No pneumonia (n = 39,176), n (%)	Pneumonia (n = 101), n (%)	*P* value
2020	7815 (19.95)	32 (31.68)	**.003**
2018–2019	31,361 (80.05)	69 (68.32)	
Female	31,601 (80.66)	79 (78.22)	.82
Male	7573 (19.33)	22 (21.78)	
Native American	188 (.48)	0 (0)	.99
Asian	681 (1.74)	2 (1.98)	
Black	5979 (15.26)	19 (18.81)	
Other	95 (.24)	0 (0)	
Unknown	7332 (18.72)	18 (17.82)	
White	24,901 (63.56)	62 (61.39)	
Hispanic	4860 (12.41)	11 (10.89)	.9
Hypertension	17,210 (49.93)	52 (51.49)	.13
Diabetes	9684 (24.72)	37 (36.63)	**.006**
Dependent	252 (.64)	4 (3.96)	**.004**
Dyspnea	3589 (9.16)	19 (18.81)	**.001**
ASA classes 1 and 2	9215 (23.52)	17 (16.83)	.11
ASA classes 3, 4, and 5	29,961 (76.48)	84 (83.17)	
SG	25,347 (64.70)	38 (37.62)	**.001**
RYGB	13,829 (35.30)	63 (62.38)	
Smoke	2874 (7.34)	12 (11.88)	.08
COPD	580 (1.48)	5 (4.95)	**.02**
Ascites	4 (.01)	0 (0)	.99
CHF	192 (.49)	2 (1.98)	.09
Renal failure	17 (.04)	0 (0)	.99
Dialysis	162 (.41)	1 (.99)	.34
Cancer	19 (.05)	1 (.99)	**.05**
Steroid	785 (2.00)	2 (1.98)	.99
	Mean ± SD	**Mean ± SD**	
LOS (d)	1.6 ± 3.1	4.2 ± 21.4	.22
Operating room time (min)	100 ± 55	148 ± 84	**.001**
Age (y)	44 ± 12	50 ± 12	**.001**
BMI (kg/m^2)	45 ± 8	43 ± 10	**.05**

ASA = American Society of Anesthesiologist; SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure; LOS = length of stay; BMI = body mass index.
Bold indicates statistically significant.

compared with the 2 years prior. In particular, there was a 156% increase in the rate of postoperative pneumonia. This finding was confirmed in a multivariate analysis and found to have independent statistical significance. In our data, both reoperation and pneumonia also were associated with mortality. Reoperations are certainly an increased risk factor for the development of hospital-acquired respiratory infection, and both confer increased risks for mortality [18]. Overall, outcomes were worse during the pandemic for bariatric surgery on several important metrics, including respiratory infections during a pandemic of a respiratory virus as well as reoperations and mortality.

Table 4
Multivariate analysis

Variable	OR	95% CI
Reoperatio	**24.11**	**15.35–37.86**
2020 versus 2018–2019	**1.71**	**1.11–2.64**
Age (y)	**1.02**	**1.01–1.04**
Operating room time	**1.00**	**1.00–1.01**
BMI	.99	.97–1.02
No diabetes versus diabetes	.73	.48–1.12
Sleeve versus RYGB	.65	.41–1.03
No COPD versus COPD	.54	.21–1.42
No dyspnea versus dyspnea	**.56**	**.32–.98**
Independent versus dependent	.35	.11–1.15
No cancer versus cancer	.35	.02–5.13

OR = odds ratio; CI = confidence interval; BMI = body mass index; RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy; COPD = chronic obstructive pulmonary disease.
Bold indicates statistically significant.

These findings dramatically deviate from the trends of the prior 2 years. As demonstrated both by our study and those of others, bariatric surgery has gotten safer as both surgical technique and perioperative management have continued to be optimized [19]. We must therefore consider that these changes may be directly related to the COVID-19 pandemic.

The increased morbidity and mortality related to perioperative COVID-19 have now been well established [20,21]. Patients who underwent surgery in the early days of the pandemic who had COVID-19 infections had high rates of postoperative pulmonary infections, which were associated

with complications and mortality [20]. If our data reflect COVID-19 infections, they closely align with other studies. Because of this, some recommend that elective surgery be postponed at least for 6 weeks following a COVID-19 infection [21]. Additionally, there are reports that during the pandemic, rates of diagnosis of other types of pneumonias decreased, which also would support the idea that our cases could be seen as a surrogate for COVID-19 infection [22]. Overall, if these pneumonias represent COVID-19 infections, they confirm the dangers related to contracting the SARS-CoV-2 virus in the perioperative period because it can cause a clinical pneumonia. Nevertheless, because these data were not available in the NSQIP database, we are unable to validate this conclusion. These data may be forthcoming through national initiatives, such as American College of Surgery COVID-19 Registry, to capture these data [23].

Additionally, we do not have any direct data regarding the rates of COVID-19 testing in the perioperative period of our study population. Therefore, we must also explore the possibility that these pneumonias are not COVID-19 infections but rather infections borne from other sequelae of the pandemic. In this regard, the COVID-19 pandemic has caused massive disruptions in healthcare delivery, including worldwide nursing shortages and burnout, decreased use of emergency services, and decreased cancer screening [24–28]. Patients with chronic respiratory conditions suffered disruptions in both appointments and pulmonary rehabilitation [29,30]. Patient habits changed as well, including increased rates of cigarette use [31]. In the postoperative patient, certain factors are known to be associated with decreased rates of pneumonia, such as early mobilization, which was decreased during the pandemic, and the increase rate of reoperations seen in our study, which was associated with pneumonia development [32,33].

Even though all these factors may explain the increased rate of postoperative pneumonia in our study, it remains as a theory given the nature of a cross-sectional study. Interesting to note is that unplanned intubations, failure to wean, and venous thromboembolism, the last of which is particularly associated with COVID-19 infections, were not statistically significant in our study. This finding also supports the notion that these respiratory infections were not directly related to COVID-19.

Regardless of the etiology, the increased rates of pneumonias in bariatric patients during the pandemic require the bariatric community to counsel patients on the unique risks of undergoing bariatric surgery during a respiratory virus pandemic. As we begin to take note of the changes that occurred during the pandemic peaks, we must continue to investigate the effects and underlying mechanisms of those changes. Further studies can both validate our findings and continue to explore the etiologies. It would be interesting to explore this using a different cohort, such as the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program and National Quality Improvement Program (MBSAQIP) because recent studies suggest that the outcomes of accredited bariatric centers differ from those of centers without accreditation [17].

Our study has limitations inherent to the nature of retrospective studies. One limitation of using the ACS-NSQIP database is the risk of selection bias. This occurs because this database captures a sample of cases done in a specified period of time. This is mitigated by a blinded, random selection of cases within participating institutions. While the NSQIP database has limitations in terms of data granularity and may report higher rates of complications than the MBSAQIP database, as previously stated, we chose to use the database with the broadest scope. This conservative approach will enable our findings to inform practices for all centers performing bariatric surgery regardless of accreditation status.

To our knowledge, this is the first study to explore the national outcomes of bariatric surgery during these challenging times. These findings certainly give us pause regarding continuing all bariatric surgery during the pandemic. Nevertheless, it would certainly be a travesty to adopt blanket restrictions on all healthcare needs unrelated to COVID-19 [5]. Given the increase in the frequency of postoperative pneumonia during the COVID-19 pandemic in bariatric surgery patients, surgeons should pay particular attention to avoid the development of hospital-acquired respiratory infections to offer the best results to their patients. Each center practicing bariatric surgery should analyze its individual rates and adjust its practices to improve the delivery of care.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article. The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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