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Original article

Effect of the COVID-19 pandemic on bariatric surgery in North America: a retrospective analysis of 834,647 patients

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Abstract

Background: COVID-19 has transformed surgical care, yet little is known regarding implications for bariatric surgery.
Objective: We sought to characterize the effect of COVID-19 on bariatric surgery delivery and outcomes.
Setting: The Metabolic and Bariatric Accreditation and Quality Improvement Program (MBSAQIP) collects data from 885 centers in North America.
Methods: The MBSAQIP database was evaluated with 2 cohorts described: the COVID-19 and the pre–COVID-19, with patients receiving surgery in 2020 and 2015–2019, respectively. Yearly operative trends were characterized, and bivariate analysis compared demographics and postoperative outcomes. Multivariable modeling evaluated 30-day readmission, reintervention, and reoperation rates and factors associated with undergoing Roux-en-Y gastric bypass.
Results: We evaluated 834,647 patients, with 155,830 undergoing bariatric surgery during the 2020 pandemic year. A 12.1% reduction in total cases (177,208 in 2019 versus 155,830 in 2020; $P < .001$) and 13.8% reduction in cases per center occurred (204.2 cases per center in 2019 versus 176.1 cases per center in 2020; $P < .001$). Patients receiving bariatric surgery during the pandemic were younger and had fewer co-morbidities. Use of sleeve gastrectomy increased (74.5% versus 72.5%; $P < .001$), and surgery during COVID-19 was associated with reduced Roux-en-Y gastric bypass procedure selection (odds ratio = .83; 95% CI: .82–.84; $P < .001$). Length of stay decreased significantly (1.4 ± 1.4 days versus 1.6 ± 1.4 days; $P < .001$), yet postoperative outcomes were similar. After adjusting for co-morbidities, patients during COVID-19 had decreased 30-day odds of readmission and reintervention and a small increase in odds of reoperation.
Conclusion: The COVID-19 pandemic dramatically changed bariatric surgery delivery. Further studies evaluating the long-term effects of these changes are warranted. (Surg Obes Relat Dis 2022;18:803–811.) © 2022 American Society for Bariatric Surgery. Published by Elsevier Inc. All rights reserved.

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

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The COVID-19 pandemic has drastically transformed delivery of surgical care worldwide [1]. With concerns regarding hospital resources and COVID-19 perioperative morbidity and mortality, millions of surgical procedures were canceled in 2020 [1–3]. In response, patient selection, surgical techniques, and postoperative care have been affected, with substantial changes across every area of general surgery [1,4–12]. These changes are expected to have pervasive long-term health and care delivery effects [13–15]. Despite substantial evidence across various surgical subspecialties, a multicenter international evaluation of the effect that COVID-19 has had on bariatric surgery has not been well characterized. This scarcity of evidence has occurred despite patients with obesity being disproportionately affected by COVID-19, alongside concerns that obesity treatments may be overlooked because of obesity stigma as we recover from the COVID-19 pandemic [16–19].

Early studies evaluating the effect of COVID-19 on bariatric surgery have reported a substantial reduction in procedures performed [16]. Unfortunately, delaying bariatric surgery because of COVID-19 has shown deleterious weight gain and psychological patient effects [20]. Other groups, including our own, have reported ongoing bariatric care delivery with careful patient selection to enable early patient discharge and limit the effect on hospital resources [21,22]. The largest study evaluating bariatric surgery patients during the COVID-19 pandemic has reported similar postoperative outcomes to historic studies but unfortunately did not characterize differences in delivery or patient selection [18]. Better understanding of the consequences of COVID-19 on bariatric surgery is required to optimize future delivery during the ongoing COVID-19 waves and potentially after if COVID-19 cannot be limited or eradicated.

Here, we report the largest multicenter international retrospective cohort study of prospectively collected data evaluating the effect of COVID-19 on the delivery of bariatric surgery care in North America. The Metabolic and Bariatric Accreditation and Quality Improvement Program (MBSAQIP) database was used to describe surgical volume, patient demographics, operative technique, and postoperative outcomes for patients undergoing bariatric surgery in accredited North American centers.

Materials and Methods

Data source

The 2015–2020 MBSAQIP database was queried to collate data for this study. This data registry prospectively collects key preoperative, operative, and early postoperative information on patients undergoing bariatric surgery from 885 centers in the United States and Canada. Data within the registry are collected based on well-defined, standardized variables, and data integrity and collection practices are subject to frequent review [23]. This study was exempt from research ethics board review.

Study design, patient population, and variable definitions

This is a retrospective cohort study of prospectively collected MBSAQIP data. The study's primary objective was to characterize bariatric surgery delivery, including case volume, during the COVID-19 pandemic compared with before the pandemic. Secondary outcomes involved ascertainment of trends in demographics, surgical technique, and postoperative outcomes for patients undergoing bariatric surgery in North America during the COVID-19 pandemic compared with those before COVID-19.

Patients receiving bariatric surgery during the COVID-19 pandemic included any bariatric surgery occurring during the 2020 MBSAQIP year. Patients who underwent surgery before COVID-19 were categorized by bariatric surgery before 2020 and after 2015, when the MBSAQIP database began collecting data. Only patients receiving elective sleeve gastrectomy (SG) or Roux-en-Y gastric bypass (RYGB) were included because they represent the majority of bariatric procedures performed [24]. Patients with a history of a previous bariatric surgery and those in whom the index procedure represented emergency surgery were excluded.

Demographic data were obtained for all patients and included sex, race, and preoperative body mass index. The pulmonary co-morbidities evaluated were sleep apnea, active smoking, and chronic obstructive pulmonary disease. The cardiac co-morbidities evaluated were hypertension, hyperlipidemia, previous myocardial infarction (MI), previous cardiac surgery, and previous percutaneous coronary intervention. Other co-morbidities evaluated were history of venous thromboembolism, gastroesophageal reflux disease, diabetes, venous stasis, renal insufficiency, dialysis dependency, therapeutic anticoagulation, and chronic steroid use. Information regarding the surgical technique included the operative procedure (SG versus RYGB) and operative time.

Postoperative outcomes evaluated length of inpatient hospital stay after bariatric surgery and 30-day readmissions to hospital, reoperations, and reinterventions based on MBSAQIP definitions [23]. Additionally, infectious complications such as the rate of urinary tract infection, deep and superficial surgical site infection, wound disruption, pneumonia, and sepsis are reported. Other postoperative complications evaluated include unplanned intubation, acute renal failure (described as any renal failure requiring dialysis), MI, cerebral vascular accidents, and mortality.

Statistical analysis

All statistical analyses were completed using STATA 17 statistical software (StataCorp, College Station, TX, USA). Categorical data were expressed as absolute values with percentages, whereas continuous data were expressed as a weighted mean ± standard deviation. Between-group differences were evaluated using χ^2 tests for categorical data and analysis of variance for continuous data. Trends were analyzed over time, with demographics and surgical technique reported for each year from 2015 to 2020. Given the MBSAQIP's large data set, many statistically significant outcomes occurred; therefore, results presented here are those with substantial differences and clinical significance. Specific cases where statistical significance occurred without clinical significance are also highlighted.

To determine independent predictors of postoperative complications, including 30-day readmissions, reinterventions, and reoperations, a nonparsimonious multivariable logistic regression model was developed using a hypothesis-driven purposeful selection methodology. Bivariate analysis of variables with a P value $<.1$ or from variables previously deemed clinically relevant to our primary outcome were used to generate a preliminary main effects model. Significant variables in the multivariable model were then identified (Wald test $P < .05$), and linear assumption of continuous variables and multicollinearity were checked using the variance inflation factors. Variables with variance inflation factors >10 were explored using collinearity diagnostic tests and excluded from the final model if they were collinear. The Brier score and the receiver operating characteristic curve were used to assess goodness of fit. This model included the pandemic as an independent variable to assess its effect on postoperative outcomes. A multivariable model also was developed in a similar fashion to evaluate factors independently associated with undergoing RYGB to assist with characterizing delivery of bariatric surgery during COVID-19.

Results

Patient demographics

Patients undergoing elective bariatric surgery during the COVID-19 pandemic were marginally younger (44.0 ± 11.9 years COVID-19 versus 44.7 ± 12.0 years pre–COVID-19; $P < .001$) and were more likely to be female (81.6% COVID-19 versus 80.2% pre–COVID-19; $P < .001$) (Table 1). Notably, there was a large decrease in White patients receiving bariatric surgery during the COVID-19 pandemic (67.1% COVID-19 versus 71.7% pre–COVID-19; $P < .001$), with an ensuing increase in Black patients (19.7% COVID-19 versus 18.2% pre–COVID-19; $P < .001$) (Table 1).

With regard to metabolic co-morbidities, patients during the COVID-19 pandemic were less likely to have hypertension (44.4% COVID-19 versus 47.1% pre–COVID-19; $P < .001$) or dyslipidemia (22.4% COVID-19 versus 23.2% pre–COVID-19; $P < .001$) and were more likely to not require medication for diabetes (77.2% COVID-19 versus 74.6% pre–COVID-19; $P < .001$). They also had fewer systemic co-morbidities, including less sleep apnea (36.9% COVID-19 versus 37.4% pre–COVID-19; $P = .002$), and fewer cardiac co-morbidities such as prior MI, prior cardiac surgery, or prior percutaneous coronary intervention (Table 1).

In terms of operative technique, SG was performed in a higher proportion of patients during the COVID-19 pandemic (74.5% COVID-19 versus 72.5% pre–COVID-19; $P < .001$; Table 1). Despite this change, operative duration was shorter before the COVID-19 pandemic by 3.2 minutes (89.9 ± 54.5 minutes COVID-19 versus 86.7 ± 49.8 minutes pre–COVID-19; $P < .001$).

Trends in operative volume over time

A total of 834,647 patients were evaluated, with 155,830 (18.7%) receiving bariatric surgery during the COVID-19 pandemic. Despite an increasing number of MBSAQIP-accredited centers in 2020 (n = 885 centers), the number of elective bariatric surgery cases completed during the COVID-19 pandemic decreased by 21,359 (12.1%) compared with 2019 (n = 868 centers; Fig. 1). The number of cases per MBSAQIP center showed a 13.8% decreased during the COVID-19 pandemic from 204.2 cases per center in 2019 to 176.1 cases per center in 2020 ($P < .001$).

Changes in patient selection and operative procedure over time

Patient selection from 2015 to 2020 demonstrates a trend toward bariatric surgery for patients with diet-controlled or no diabetes from 74.0% in 2015 to 77.2% in 2020 (Table 2). Similarly, there has been a trend toward selecting fewer patients with hypertension (48.9% in 2015 versus 44.4% in 2020). For both diabetes and hypertension, patients receiving bariatric surgery during the COVID-19 pandemic (i.e., 2020) had the lowest rates since MBSAQIP began collecting data (Table 2). In terms of operative selection, there has been an increasing use of SG from 70.2% in 2015 to 74.5% in 2020, again with 2020 representing the greatest proportion of SGs ever reported in the MBSAQIP data.

Bivariate analysis of postoperative outcomes comparing pandemic and nonpandemic cohorts

During the COVID-19 pandemic, length of inpatient hospital stay was significantly reduced compared with previously (1.4 ± 1.4 days COVID-19 versus 1.6 ± 1.4 days pre–COVID-19; $P < .001$). Patients undergoing bariatric surgery during the COVID-19 pandemic experienced similar postoperative outcomes to those having surgery before the pandemic. Reoperation rates within 30 days were statistically similar (1.3% COVID-19 versus 1.3% pre–COVID-19; $P = .142$), and both reinterventions (1.0% COVID-19 versus 1.2% pre–COVID-19; $P < .001$) and

Table 1
Patient characteristics comparing patients who received elective bariatric surgery during the COVID-19 pandemic with those who received elective bariatric surgery before the COVID-19 pandemic

Characteristic	Bariatric surgery before COVID-19 (n = 678,817), n (%)	Bariatric surgery during COVID-19 (n = 155,830), n (%)	P value*
Age (y), mean ± SD	44.7 ± 12.0	44.0 ± 11.9	<.001
<18	1246 (.2)	214 (.1)	<.001
18–29	77,324 (11.4)	15,533 (10.0)	
30–39	172,641 (25.4)	37,297 (23.9)	
40–49	198,416 (29.2)	45,633 (29.3)	
50–59	149,958 (22.1)	36,779 (23.6)	
≥60	79,244 (11.7)	20,394 (13.1)	
Sex			<.001
Female	544,084 (80.2)	127,095 (81.6)	
Male	134,591 (19.8)	28,691 (18.4)	
Nonbinary	—	44 (.03)	
BMI (kg/m^2), mean ± SD	45.0 ± 7.8	44.8 ± 7.8	<.001
<35	29,092 (4.3)	11,592 (7.6)	<.001
35–39	155,489 (23.1)	34,471 (22.5)	
40–45	342,772 (50.9)	74,548 (48.5)	
45–50	114,297 (17.0)	25,442 (16.6)	
50–60	25,575 (3.8)	5754 (3.8)	
>60	6381 (1.0)	1772 (1.2)	
Race			
White	486,444 (71.7)	104,570 (67.1)	<.001
American Indian or Alaska native	2911 (.4)	763 (.5)	
Asian	3528 (.5)	894 (.6)	
Black or African American	123,326 (18.2)	30,748 (19.7)	
Native Hawaiian or other Pacific Islander	1885 (.3)	415 (.3)	
Race combinations*	—	83 (.1)	
Other	—	698 (.5)	
Not reported	60,723 (9.0)	17,659 (11.3)	
Smoker	55,356 (8.2)	10,693 (6.9)	<.001
Diabetes			
No or diet controlled	506,599 (74.6)	120,266 (77.2)	<.001
Non–insulin dependent	117,853 (17.4)	25,484 (16.4)	
Insulin dependent	54,365 (8.0)	10,080 (6.5)	
Hypertension	319,802 (47.1)	69,229 (44.4)	<.001
GERD	210,785 (31.1)	49,719 (31.9)	<.001
COPD	10,358 (1.5)	1896 (1.2)	<.001
Hyperlipidemia	157,651 (23.2)	34,927 (22.4)	<.001
Chronic steroid use	12,272 (1.8)	3338 (2.1)	<.001
Renal insufficiency	4195 (.6)	900 (.6)	.064
Dialysis dependent	2116 (.3)	496 (.3)	.647
History of DVT	11,345 (1.7)	2755 (1.8)	.007
History of PE	8374 (1.2)	2115 (1.4)	<.001
Venous stasis	6200 (.9)	1104 (.7)	<.001
Preoperative therapeutic anticoagulation	19,581 (2.9)	4514 (2.9)	.733
Sleep apnea	253,535 (37.4)	57,557 (36.9)	.002
History of MI	8308 (1.2)	1647 (1.1)	<.001
Previous major cardiac surgery	7088 (1.0)	1431 (.9)	<.001
Previous PCI	12,601 (1.9)	2332 (1.5)	<.001
SG	492,070 (72.5)	116,090 (74.5)	<.001
RYGB	186,753 (27.5)	39,753 (25.5)	<.001
Operative time (min), mean ± SD	86.7 ± 49.8	89.9 ± 54.5	<.001

SD = standard deviation; BMI = body mass index; GERD = gastroesophageal reflux disease; COPD = chronic obstructive pulmonary disease; DVT = deep vein thrombosis; PE = pulmonary embolism; MI = myocardial infarction; PCI = percutaneous coronary intervention; SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass.

* Data on race combinations or other race were not captured in the Metabolic and Bariatric Accreditation and Quality Improvement Program database before 2020. *P* values were determined using χ^2 analysis for categorical data and analysis of variance for continuous data.

readmissions (3.5% COVID-19 versus 3.8% pre–COVID-19; $P < .001$) were clinically similar despite statistical difference. Overall, none of the postoperative complications had a difference >.4% and are unlikely to be clinically significant when comparing those undergoing bariatric surgery during COVID-19 with prior patients (Table 3).

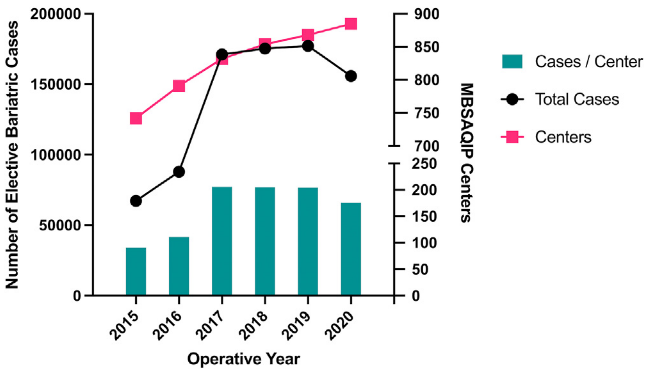

Fig. 1. Total number of elective bariatric surgeries, Metabolic and Bariatric Accreditation and Quality Improvement Program (MBSAQIP) reporting centers, and elective bariatric surgeries per center over time.

Multivariable logistic regression of factors associated with postoperative complications

Undergoing bariatric surgery during the COVID-19 pandemic was associated with a minor decrease in 30-day readmissions (odds ratio [OR] = .93; 95% CI: .91–.96; $P < .001$) and reinterventions (OR = .86; 95% CI: .82–.91; $P < .001$) and a small increase in odds of 30-day reoperation (OR = 1.07; 95% CI: 1.02–1.13; $P = .001$) (Table 4). These differences, while statistically significant, are unlikely to represent clinically significant changes over time. The most significant independent factors associated with increased odds of 30-day readmission, reoperation, and reintervention were undergoing RYGB as opposed to SG, gastroesophageal reflux disease, chronic obstructive pulmonary disease, prior MI, prior deep vein thrombosis, and preoperative anticoagulation (Table 4). The models for readmission, reintervention, and reoperation had receiver operating characteristic curve areas of .64, .67, and .68, and Brier scores of .036, .012, and .017, respectively.

Multivariable logistic regression evaluating predictors of procedural selection

When evaluating predictors of undergoing RYGB as opposed to SG, we see few independent predictors (Table 5). However, undergoing bariatric surgery during the COVID-19 pandemic was independently associated with a reduced likelihood of receiving RYGB (OR = .83; 95% CI: .82–.84; $P < .001$). The only patients with a greater reduction in RYGB likelihood were those with renal insufficiency and those who were dependent on dialysis (Table 5). The model was accurate with a receiver operating characteristic curve area of .76 and a Brier score of .16.

Discussion

During the COVID-19 pandemic, there was a 12.1% decrease in total elective bariatric surgery cases and a 13.8% decrease in cases per MBSAQIP-accredited center. Less metabolically co-morbid patients were selected for elective surgery, and there was a greater shift toward SG selection at the expense of RYGB delivery. While unadjusted outcomes were similar between cohorts, multivariable analysis revealed small differences in 30-day readmission, reintervention, and reoperation.

Beyond the overall reduction in operative volume, patient selection and operative techniques were the most drastic changes during the COVID-19 pandemic. These outcomes partly contradict the recommendations initially proposed by Rubino et al. [19], who suggested that patients with severe obesity, substantial co-morbidities, and risk of deterioration from obesity-related complications should be prioritized for bariatric surgery. Regardless, both the trend toward SG and less co-morbid patient selection appears to have begun before the COVID-19 pandemic but was emphasized during the pandemic. It is likely that recent data showing favorable outcomes and long-term benefits in patients with obesity but without co-morbidities led to selection of these patients during the pandemic, considering the limited operative time, hospital occupancy, and postoperative follow-up [16,21]. Similarly, favorable outcomes, shorter hospital stays, and reduced postoperative complications with SG in the recently published The Swiss Multicenter Bypass or Sleeve Study and Sleeve vs Bypass trials likely explain its increased use during the COVID-19 pandemic [25–27]. The advent and success of bariatric day surgery, again before the COVID-19 pandemic, have also likely contributed to these findings [28,29]. In contrast, the reason for the increased proportion of surgeries being performed on Black patients during the COVID-19 pandemic is unclear. This may represent a change over time with increased recognition of bariatric surgery benefits for Black individuals or another factor not measured within this study. Future studies evaluating the effect of COVID-19 on bariatric surgery access related to ethnicity may be of interest. Overall, limited acute care resources during the COVID-19 pandemic likely contributed to surgeons and centers directing delivery toward patients more likely to be fit for day or short-stay surgery.

Fortunately, despite changes in delivery, bariatric surgery procedures during the COVID-19 pandemic did not appear to have substantially worse outcomes. However, when adjusting for co-morbidities, COVID-19 was associated with decreased odds of readmission and reintervention and a small increase in the odds of reoperation. While our study design does not allow us to evaluate reasons for these findings, a potential reason could be earlier discharge during COVID-19 and increased postoperative management of non–life-threatening complications via telehealth solutions [30,31]. Overall, outcomes during the COVID-19 pandemic were similar to those before the pandemic, which is in keeping with the largest international retrospective study by Singhal et al. [18]. This study and ours support continuation of bariatric surgery during the COVID-19 pandemic with

Table 2
Five-year demographic and operative characteristics for patients who received elective bariatric surgery during the COVID-19 pandemic versus those who received elective bariatric surgery before the COVID-19 pandemic

Characteristic	2015	2016	2017	2018	2019	2020
SG	47,176 (70.2)	64,089 (72.9)	125,515 (73.3)	128,207 (73.1)	127,077 (71.7)	116,077 (74.5)
RYGB	20,029 (29.8)	23,832 (27.1)	45,649 (26.7)	47,112 (26.9)	50,131 (28.3)	39,753 (25.5)
Total elective bariatric surgeries	67,205	87,921	171,164	175,319	177,208	155,830
Centers reporting MBSAQIP data	742	791	832	854	868	885
Elective bariatric surgeries per MBSAQIP center	90.6	111.2	205.7	205.3	204.2	176.1
BMI (kg/m^2)						
<35	2793 (4.2)	3592 (4.1)	7209 (4.2)	7444 (4.3)	8054 (4.6)	11,592 (7.6)
35–39	14,834 (22.3)	19,863 (22.8)	39,287 (23.1)	40,943 (23.5)	40,562 (23.1)	34,471 (22.5)
40–45	33,221 (49.9)	44,178 (50.8)	86,978 (51.1)	88,779 (50.9)	89,616 (51.1)	74,548 (48.5)
45–50	12,028 (18.1)	15,027 (17.3)	28,806 (16.9)	29,213 (16.8)	29,223 (16.7)	25,442 (16.6)
50–60	2690 (4.0)	3524 (4.1)	6378 (3.8)	6574 (3.8)	6436 (3.7)	5754 (3.8)
>60	1003 (1.5)	778 (.9)	1523 (.9)	1487 (.9)	1590 (.9)	1772 (1.2)
Diabetes						
No or diet controlled	49,728 (74.0)	65,438 (74.4)	127,758 (74.6)	130,893 (74.7)	132,791 (74.9)	120,280 (77.2)
Non–insulin dependent	11,602 (17.3)	15,234 (17.3)	29,665 (17.3)	30,407 (17.3)	30,947 (17.5)	25,485 (16.4)
Insulin dependent	5878 (8.8)	7249 (8.2)	13,746 (8.0)	14,022 (8.0)	13,471 (7.6)	10,085 (6.5)
Hypertension	32,888 (48.9)	42,107 (47.9)	80,922 (47.3)	81,976 (46.8)	81,914 (46.2)	69,245 (44.4)
GERD	20,775 (30.9)	27,654 (31.6)	53,161 (31.1)	53,694 (30.6)	55,508 (31.3)	49,727 (31.9)

SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; MBSAQIP = Metabolic and Bariatric Accreditation and Quality Improvement Program; BMI = body mass index; GERD = gastroesophageal reflux disease.
Data are presented as n (%) or n.

careful patient selection in order to provide care for patients with obesity who also happen to be at substantial risk of morbidity and mortality from COVID-19 [17,32]. Long-term outcomes are warranted, and careful scrutiny of these practices is encouraged, especially considering the ongoing trend toward use of SG despite novel studies suggesting that RYGB outperforms SG in terms of long-term weight loss and co-morbidity resolution, particularly in patients with super obesity [25,33–37].

Considering the decrease in bariatric surgeries performed, the COVID-19 pandemic has created a substantial deficit in care for thousands of patients with obesity. Further, considering the shift toward selecting less co-morbid patients who can successfully be managed with SG, patients with super obesity or substantial co-morbidities are likely at a further deficit. Unfortunately, it is these patients who also stand to benefit most from bariatric intervention [37–39]. We hypothesize that as COVID-19 is eliminated or becomes

Table 3
Thirty-day postoperative outcomes for patients who received elective bariatric surgery during the COVID-19 pandemic versus those who received surgery before the COVID-19 pandemic

Outcome	Bariatric surgery before COVID-19 (n = 678,817), n (%)	Bariatric surgery during COVID-19 (n = 155,830), n (%)	*P* value
Length of stay (d)	1.6 ± 1.4	1.4 ± 1.4	<.001
Reoperation	8791 (1.3)	2081 (1.3)	.205
Reintervention	8236 (1.2)	1587 (1.0)	<.001
Readmission	25,600 (3.8)	5449 (3.5)	<.001
UTI	2291 (.3)	523 (.3)	.908
Superficial SSI	2838 (.4)	569 (.4)	.022
Deep SSI	435 (.06)	118 (.08)	.381
Wound disruption	391 (.06)	87 (.06)	.001
Pneumonia	1401 (.2)	357 (.2)	.134
Sepsis	770 (.1)	226 (.2)	.001
Unplanned intubation	870 (.1)	250 (.2)	.002
Acute renal failure	453 (.07)	147 (.1)	<.001
MI	168 (.02)	47 (.03)	.181
Cerebral vascular accidents	92 (.01)	27 (.02)	.261
Mortality	595 (.09)	196 (.13)	<.001

UTI = urinary tract infection; SSI = surgical site infection; MI = myocardial infarction.

Table 4
Multivariable logistic regression for 30-day postoperative readmission, reoperation, reintervention, and death after elective bariatric surgery

Risk factor	30-day readmission			30-day reoperation			30-day reintervention		
	Odds ratio	95% CI	*P* value	Odds ratio	95% CI	*P* value	Odds ratio	95% CI	*P* value
COVID-19 pandemic	.93	.91–.96	<.001	1.07	1.02–1.13	.004	.86	.82–.91	<.001
Age	.96	.95–.97	<.001	1.08	1.06–1.10	<.001	.96	.94–.98	<.001
RYGB	1.53	1.49–1.57	<.001	1.85	1.77–1.92	<.001	2.05	1.96–2.14	<.001
GERD	1.35	1.32–1.39	<.001	1.30	1.25–1.35	<.001	1.36	1.30–1.42	<.001
Male sex	.84	.82–.87	<.001	1.03	.98–1.09	.98	.86	.81–.90	<.001
BMI	1.01	1.00–1.02	.046	.96	.95–.98	<.001	.99	.98–1.01	.227
Hypertension	1.09	1.06–1.12	<.001	1.06	1.01–1.10	.015	1.09	1.04–1.14	<.001
Hyperlipidemia	1.08	1.05–1.11	<.001	.98	.93–1.03	.434	1.00	.95–1.05	.961
Diabetes									
Non–insulin dependent	.94	.91–.97	<.001	.92	.87–.97	.001	.93	.88–.98	.011
Insulin dependent	1.30	1.25–1.36	<.001	.94	.87–1.00	.068	1.08	1.00–1.56	.038
Previous DVT	1.48	1.38–1.59	<.001	1.41	1.25–1.59	<.001	1.24	1.10–1.41	—
Preoperative therapeutic anticoagulation	1.62	1.53–1.71	<.001	1.31	1.19–1.45	<.001	1.74	1.58–1.92	<.001
Operative duration	1.00	1.00–1.00	<.001	1.00	1.00–1.01	<.001	1.00	1.00–1.00	<.001
History of MI	1.32	1.21–1.43	<.001	1.24	1.08–1.43	.002	1.64	1.44–1.88	<.001
Renal insufficiency	1.53	1.37–1.71	<.001	1.48	1.23–1.78	<.001	1.21	.99–1.49	.067
Dialysis	1.75	1.52–2.02	<.001	2.16	1.71–2.73	<.001	1.98	1.53–2.54	<.001
Smoker	1.14	1.09–1.18	<.001	1.23	1.55–1.32	<.001	1.18	1.10–1.27	<.001
COPD	1.41	1.31–1.51	<.001	1.40	1.24–1.58	<.001	1.25	1.09–1.42	<.001
Sleep apnea	1.01	.99–1.04	.285	.98	.94–1.02	.238	1.02	.98–1.07	.395

CI = confidence interval; RYGB = Roux-en-Y gastric bypass; GERD = gastroesophageal reflux disease; BMI = body mass index; DVT = deep vein thrombosis; MI = myocardial infarction; COPD = chronic obstructive pulmonary disease.

endemic, a transition back to operating on patients with increased co-morbidities may occur. Studies evaluating delivery of bariatric surgery care in the next year will be critical to further evaluate the long-term effect of COVID-19. This would further characterize trends that are specific to COVID-19 and others that have occurred secondary to bariatric surgery optimization over time. Regardless, while surgical delays and deficits are often discussed in the oncologic setting, a similar call to action to prioritize surgical care of patients with obesity is needed considering the social, financial, and functional benefits offered with these interventions [40–43].

Limitations of this study are primarily related to its retrospective nature and data limitations from MBSAQIP. In this study, the COVID-19 pandemic cohort was defined by any surgery occurring during the 2020 MBSAQIP data collection year. However, as we have all experienced, waves of the pandemic have differed drastically, and the effect on

Table 5
Multivariable logistic regression evaluating predictors of procedural selection (RYGB versus SG)

Risk factor	Odds ratio	95% CI	*P* value
COVID-19 pandemic	.83	.82–.84	<.001
Age	.94	.94–.95	<.001
Male sex	.77	.76–.78	<.001
GERD	1.36	1.34–1.37	<.001
BMI	1.03	1.03–1.04	<.001
Hypertension	1.01	.98–1.02	.108
Hyperlipidemia	1.06	1.04–1.07	<.001
Diabetes: non–insulin dependent; insulin dependent	.98; 1.27	.80–1.20; 1.02–1.58	.869; .032
Previous DVT	1.03	.98–1.07	.269
Preoperative therapeutic anticoagulation	.86	.83–.89	<.001
History of MI	1.03	.98–1.08	.189
Renal insufficiency	.82	.76–.88	<.001
Dialysis	.45	.40–.50	<.001
COPD	.91	.87–.95	<.001
Sleep apnea	1.07	1.05–1.08	<.001

CI = confidence interval; GERD = gastroesophageal reflux disease; BMI = body mass index; DVT = deep vein thrombosis; MI = myocardial infarction; COPD = chronic obstructive pulmonary disease.

bariatric surgery delivery likely also varied during that time. Similarly, the COVID-19 pandemic has had variable effects on different countries, regions, and municipalities; because center-specific data are not collected, the variability of those effects could not be evaluated. Additionally, because the COVID-19 pandemic began in 2019, some of the reported patients from 2019 may also have received bariatric surgery during the pandemic. In contrast, the beginning of 2020 had fewer cases, restrictions, and healthcare effects than other periods of the year, and this temporal variability is summarized as an average throughout the year in this study. Comparing patients receiving bariatric surgery during COVID-19 with all patients from 2015 to 2019 also presents substantial limitations considering changes that occurred over time; to limit this effect we presented all operative trends by year in order to put differences in context. Finally, as detailed earlier, the MBSAQIP database does not characterize outpatient management or other changes that likely occurred during the COVID-19 pandemic, which may represent substantial confounders in this study. Data from this study are also limited to 30 days after operation. Studies evaluating the effect of COVID-19 on outpatient management of bariatric surgery patients and long-term outcomes after bariatric surgery during the COVID-19 pandemic are warranted. Despite these limitations, this study characterizes important trends and effects on bariatric surgery in North America secondary to the COVID-19 pandemic that will prove useful in evaluation of next steps as we continue to improve surgical care in the setting of healthcare resource limitations.

Understanding the effect that COVID-19 has elicited on bariatric surgery delivery in North America is crucial to evaluating future patient and technique selection. This is especially true as subsequent waves of the COVID-19 pandemic occur. During the COVID-19 pandemic, patients undergoing bariatric surgery have had fewer metabolic comorbidities and received SG at an unprecedented rate. It remains uncertain whether these changes will continue in the future and how these changes will affect future bariatric surgery care. Regardless of COVID-19's trajectory, a growing trend toward SG has been hastened by the COVID-19 pandemic, and ongoing evaluations of long-term outcomes as well as the socioeconomic consequences of this affected delivery are warranted.

Conclusion

The COVID-19 pandemic has dramatically changed the landscape of bariatric surgery delivery in North America. During the COVID-19 pandemic, there was a 13.8% decrease in elective bariatric surgery cases despite the increased number of reporting centers. Patients receiving surgery were less co-morbid and more likely to receive SG, whereas outcomes were similar to before the pandemic. Future studies evaluating persistent changes that occur after the COVID-19 pandemic and further work characterizing the long-term effect of the COVID-19 pandemic on outcomes and the socioeconomic consequences of this affected delivery are warranted.

Disclosures

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