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ORIGINAL CONTRIBUTIONS

Post-Operative but Not Pre-Operative COVID-19 Predicts Serious Complications and Mortality Following Elective Bariatric Surgery

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Abstract

Purpose We sought to characterize the prevalence and subsequent impact of pre- and post-operative COVID-19 diagnosis on bariatric surgery outcomes. COVID-19 has transformed surgical delivery, yet little is known regarding its implications for bariatric surgery.

Materials and Methods The Metabolic and Bariatric Accreditation and Quality Improvement Program (MBSAQIP) database was evaluated with three cohorts described: those diagnosed with COVID-19 pre-operatively (PRE), post-operatively (POST), and those without a peri-operative COVID-19 (NO) diagnosis. Pre-operative COVID-19 was defined as COVID-19 within 14 days prior to the primary procedure while post-operative COVID-19 infection was defined as COVID-19 within 30 days after the primary procedure.

Results A total of 176,738 patients were identified, of which 174,122 (98.5%) had no perioperative COVID-19, 1364 (0.8%) had pre-operative COVID-19, and 1252 (0.7%) had post-operative COVID-19. Patients who were diagnosed with COVID-19 post-operatively were younger than other groups (43.0 ± 11.6 years NO vs 43.1 ± 11.6 years PRE vs 41.5 ± 10.7 years POST; $p < 0.001$). Pre-operative COVID-19 was not associated with serious complications or mortality after adjusting for comorbidities. Post-operative COVID-19, however, was among the greatest independent predictors of serious complications (OR 3.5; 95% CI 2.8–4.2; $p < 0.0001$) and mortality (OR 5.1; 95% CI 1.8–14.1; $p = 0.002$).

Conclusions Pre-operative COVID-19 within 14 days of surgery was not significantly associated with either serious complications or mortality. This work provides evidence that a more liberal strategy which employs early surgery after COVID-19 infection is safe as we aim to reduce the current bariatric surgery case backlog.

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

Key Points
- The prevalence of pre- and post-operative COVID less than 1% following elective bariatric surgery.
- Pre-operative COVID was not significantly associated with increased serious complications or mortality.
- Post-operative COVID was among the greatest independent predictors of serious complications.

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Introduction

The coronavirus disease 2019 (COVID-19) virus has, and continues to, drastically impede delivery of bariatric and surgical care worldwide [1–6]. International studies evaluating bariatric surgery in the COVID era have demonstrated a trend toward selection of less metabolically comorbid patients and an increased adoption of sleeve gastrectomy (SG) [2, 3, 7]. Yet, while a number of these studies have demonstrated equivalent pre- and post- pandemic bariatric outcomes [3, 8, 9], limited evidence exists which directly evaluates outcomes with respect to perioperative COVID-19 infection. As we attempt to optimally select patients and reduce the backlog of surgical cases, the effect of recent prior COVID-19 diagnosis on bariatric surgical outcomes has not been elucidated. Evaluation of such outcomes for patients diagnosed with COVID-19 pre-operatively and post-operatively thus remains critical for optimal patient selection, patient prognosis discussions, timing of surgical interventions, and minimizing peri-operative complications.

Currently, bariatric surgical care for patients with peri-operative COVID-19 has been dictated by data extrapolated from a number of landmark non-bariatric surgical studies. For example, compelling work has demonstrated marked increases in pulmonary complications and mortality in patients with a COVID-19 diagnosis within 7 days of surgery and up to 30 days post-operatively [10]. Similar large-scale international work evaluating surgical outcomes after COVID-19 infection has demonstrated adverse outcomes in all patients receiving surgery within 7 weeks of diagnosis [11]. The culmination of these findings, in addition to the recent understanding that metabolic disease burden is associated with poorer COVID prognosis [12, 13], has led to the American Society of Anesthesiologists recommending that wait times from date of COVID-19 diagnosis should be 8 to 10 weeks for symptomatic patients with diabetes and up to 6 weeks for all symptomatic patients. Studies from which these recommendations were developed, however, lack bariatric specific data, and their overgeneralization may pose substantial barriers to implementing strategies to reduce bariatric case backlogs in the post-COVID-19 era.

This study aims to provide the largest multi-centered international retrospective cohort study of prospectively collected data evaluating the impact of peri-operative COVID-19 diagnosis on outcomes following elective bariatric surgery. The Metabolic and Bariatric Accreditation and Quality Improvement Program (MBSAQIP) database was used to compare patients with pre-operative or post-operative COVID-19 diagnosis to those without a peri-operative COVID-19 diagnosis.

Materials and Methods

Data Source

This study analyzes data within the 2021 MBSAQIP database. Only 2021 was included as this was the first year in which data on COVID-19 diagnosis was prospectively collected. The MBSAQIP registry prospectively collects pre-operative, operative, and early (30-day) post-operative outcomes for 211,254 patients undergoing bariatric surgery from 902 accredited centers in the USA and Canada. Data within the registry is collected based on well-defined, standardized variables and is subject to frequent review of data integrity and collection practices. Due to secondary use of data, this study was exempt from ethics board review.

Study Design, Patient Population, and Variable Definitions

This is a retrospective cohort study of prospectively collected data. The study's primary objective was to comparatively evaluate 30-day post-operative bariatric surgery outcomes for patients diagnosed with either pre- or post-operative COVID-19 infection compared to those without peri-operative COVID-19. Secondary outcomes evaluated surgical approach for those patients and independent predictors of serious complications or mortality.

For this analysis, three cohorts of patients are described including those without a peri-operative COVID-19 diagnosis, with a pre-operative COVID-19 diagnosis, and with a post-operative diagnosis of COVID-19. Pre-operative COVID-19 was defined as either a lab-confirmed diagnosis (or ICD-10 code UO7.1) or suspected diagnosis (ICD-10 code U07.2) of COVID-19 within 14 days prior to the primary procedure based on real-time reverse transcription polymerase chain reaction testing. A post-operative COVID-19 infection was defined as either a lab-confirmed diagnosis (or ICD-10 code UO7.1) or suspected diagnosis (ICD-10 code U07.2) of COVID-19 within 30 days after the primary procedure based on real-time reverse transcription polymerase chain reaction testing. As per the MBSAQIP, a positive antibody test alone without a suspected current or active diagnosis was not deemed positive as it could reflect prior infection. Strain-specific COVID-19 data as well as vaccine or prior infection was not captured by the registry.

Included in this study are all patients undergoing elective bariatric surgery within the 2021 MBSAQIP database. Only patients receiving sleeve gastrectomy (SG) or Roux-en-Y gastric bypass (RYGB) were included as the two primary bariatric procedures performed in North-America and to limit heterogeneity [14]. Patients with a history of a previous bariatric or foregut surgery, and those undergoing revisional surgery were excluded.

Patients are described by demographics including sex, age, race, and pre-operative body mass index (BMI). Pulmonary, metabolic, cardiac, and other comorbidities were assessed for each cohort. Pulmonary comorbidities described included smoking status within the past year, pre-operative sleep apnea, and chronic obstructive pulmonary disease (COPD). Metabolic and cardiac comorbidities included diabetes mellitus (DM), hyperlipidemia, hypertension, prior myocardial infarction (MI) or cardiac surgery, and prior percutaneous coronary intervention (PCI). Additionally, we tabulated patient's pre-operative history of venous thromboembolism (VTE), gastroesophageal reflux disease (GERD), venous stasis, renal insufficiency, dialysis dependency, and therapeutic anticoagulation.

Procedural characteristics defined in this study include the operative procedure (SG versus RYGB) and operative time.

Post-operative outcomes evaluated length of hospital stay (LOS) and 30-day reoperation, non-operative reintervention, and readmission based on MBSAQIP definitions. Pulmonary complications evaluated pneumonia and the need for unplanned intubation. Additionally, infectious complications such as deep surgical site infection (SSI), wound disruption, and sepsis are reported. Other post-operative complications evaluated include acute kidney injury, myocardial infarction (MI), and cerebral vascular accidents (CVA). We also defined and evaluated integrated complications including post-operative bleeding, anastomotic leak, and serious complications as defined in the appendix. Finally, mortality differences were presented.

Statistical Analysis

Throughout this study, categorical data were expressed as absolute values with percentages, while continuous data were expressed as weighted mean ± standard deviation unless otherwise specified. Between group differences were evaluated using the Chi-square for categorical data and the Kruskal–Wallis equality-of-populations rank test for continuous data. To control for differences between groups and determine independent predictors of serious complications and mortality, a non-parsimonious multivariable logistic regression model was developed using a hypothesis-driven purposeful selection methodology. Bivariate analysis of variables with a p-value < 0.1 or from variables previously deemed clinically relevant to our primary outcome was used to generate a preliminary main effects model. This model included pre-operative and post-operative COVID-19 diagnosis as an independent variable to assess its effect on post-operative outcomes compared to lack of peri-operative COVID-19. Models were interrogated using the Brier score and the receiver operating characteristic (ROC). Statistical analysis was completed using STATA 17 statistical software (StataCorp, College Station, TX, USA).

Results

Patient Demographics

A total of 176,738 patients were identified, of which 174,122 (98.5%) had no perioperative COVID-19, 1364 (0.8%) had pre-operative COVID-19, and 1252 (0.7%) had post-operative COVID-19.

Compared to patients who were not diagnosed with COVID-19 in the perioperative period (labeled: NO), patients who were diagnosed pre-operatively (labeled: PRE), and post-operative (labeled: POST) had a similar proportion of females (82.5% NO vs 81.8% PRE vs 83.9% POST; $p = 0.4$) and similar pre-operative functional status (Table 1). However, pre-operatively and post-operatively COVID-19 diagnosed patients were more likely to have ASA 3 classification (77.6% NO vs 80.6 PRE vs 80.1% POST; $p = 0.02$). Patients who were diagnosed with COVID-19 post-operatively were younger than other groups (43.0 ± 11.6 years NO vs 43.1 ± 11.6 years PRE vs 41.5 ± 10.7 years POST; $p < 0.001$). Additionally, although statistically different, groups had a clinically similar BMI (45.1 ± 7.6 kg/m^2 NO vs 45.4 ± 7.9 kg/m^2 PRE vs 45.8 ± 8.4 kg/m^2 POST; $p = 0.049$). Patients with pre-operative or post-operative COVID-19 were more likely to be Black or African (20.4% NO vs 21.0% PE vs 23.6% POST; $p < 0.001$).

With regards to metabolic comorbidities, patients diagnosed with COVID-19 were more likely to have medication or insulin-dependent diabetes (NO 22.2% vs. PRE 24.2% vs. POST 24.3%; $p = 0.001$) and were more likely to have GERD (29.8% NO vs 32.8% PRE vs 32.5% POST; $p = 0.006$). There were no significant differences with regards to rates of dyslipidemia, hypertension, or prior cardiac history between cohorts. In terms of pulmonary comorbidities, patients with post-operative COVID-19 were more likely to have sleep apnea and be smokers (Table 1). Notably, patients diagnosed with COVID-19 pre-operatively and post-operatively were more likely to have had prior DVT and be anti-coagulated pre-operatively. Other comorbidities were clinically similar between groups (Table 1).

In terms of operative approach, RYGB was utilized more often in patients with pre-operative and post-operative COVID-19 (26.5% NO vs 27.9% PRE vs 29.5% POST; $p < 0.03$) with 100% of cases performed laparoscopically. Longer operative times were observed in both groups with a perioperative COVID-19 diagnosis (Table 1).

Bivariate Analysis of Post-Operative Outcomes Comparing Patients Without Peri-Operative COVID-19 to Those with Pre- or Post-Operative COVID-19

Patients without COVID-19 had clinically similar outcomes to those with a pre-operative COVID-19 diagnosis for all outcomes (Table 2). On the other hand, patients with post-operative COVID-19 had significantly worse outcomes for nearly all measured domains including important 30-day outcomes such as reoperation (0.9% NO vs 0.8% PRE vs 2.1% POST; $p < 0.001$), reintervention (0.7% NO vs 0.8% PRE vs 1.6% POST; $p < 0.001$), readmission (2.9% NO vs 2.5% PRE vs 13.7% POST; $p < 0.001$), and serious complications (2.8% NO vs 2.3% PRE vs 9.4% POST; $p < 0.001$) (Table 2). Additionally, patients with post-operative COVID-19 had significantly increased rates of pneumonia,

Table 1 Patient characteristics comparing patients without peri-operative COVID-19 diagnosis, with pre-operative COVID-19 diagnosis, and with post-operative COVID-19 diagnosis

	No peri-operative COVID-19 diagnosis $n = 174,122$ *n* (%)	Pre-operative COVID-19 diagnosis $n = 1364$ *n* (%)	Post-operative COVID-19 diagnosis $n = 1252$ *n* (%)	*p*-Value*
Age, years				
mean ± sd	43.0 ± 11.7	43.1 ± 11.6	41.5 ± 10.7	< 0.001
Sex				
Female	143,630 (82.5)	1116 (81.8)	1050 (83.9)	0.4
BMI, kg/m^2				
mean ± sd	45.1 ± 7.6	45.4 ± 7.9	45.8 ± 8.4	0.049
Race				
White	111,640 (64.1)	894 (65.5)	798 (63.7)	< 0.001
American Indian or Alaska Native	928 (0.5)	5 (0.4)	2 (0.2)	
Asian	1016 (0.6)	5 (0.4)	13 (1.0)	
Black or African American	35,433 (20.4)	286 (21.0)	296 (23.6)	
Native Hawaiian or Other Pacific Islander	462 (0.3)	3 (0.2)	6 (0.5)	
Race combinations*	664 (0.4)	3 (0.2)	4 (0.4)	
Other	5370 (3.1)	64 (4.7)	37 (3.0)	
Not reported	18,609 (10.7)	104 (7.6)	96 (7.7)	
Functional Status				0.06
Independent	173,215 (99.6)	1352 (99.3)	1236 (99.1)	
Partially dependent	753 (0.4)	10 (0.7)	11 (0.9)	
Fully dependent	28 (0.2)	0 (0)	0 (0)	
ASA Category				0.02
1–2	32,759 (18.8)	230 (16.9)	211 (16.9)	
3	135,013 (77.6)	1098 (80.6)	1001 (80.1)	
4–5	28 (0.2)	0 (0)	0 (0)	
Smoker	11,494 (6.6)	82 (6.0)	99 (7.9)	< 0.001
Diabetes				
No or diet controlled	135,448 (77.8)	1032 (75.7)	949 (75.8)	0.001
Non-insulin dependent	28,214 (16.2)	217 (15.9)	208 (16.6)	
Insulin dependent	10,460 (6.0)	115 (8.4)	95 (7.6)	
Hypertension	74,903 (43.0)	517 (45.2)	533 (52.6)	0.2
GERD	51,826 (29.8)	447 (32.8)	407 (32.5)	0.006
COPD	1,937 (1.1)	11 (0.8)	12 (1.0)	0.5
Hyperlipidemia	37,744 (21.7)	293 (21.5)	243 (19.4)	0.2
Renal insufficiency	900 (0.5)	11 (0.8)	10 (0.8)	0.1
Dialysis dependent	520 (0.3)	9 (0.7)	6 (0.5)	0.03
History of DVT	2757 (1.6)	30 (2.2)	32 (2.6)	0.005
History of PE	2241 (1.3)	22 (1.6)	22 (1.8)	0.2
Venous stasis	1040 (0.6)	9 (0.7)	14 (1.1)	0.06
Pre-operative therapeutic anticoagulation	4504 (2.6)	67 (4.9)	39 (3.1)	< 0.001
Sleep Apnea	63,384 (36.4)	487 (35.7)	531 (42.4)	< 0.001
History of MI	1641 (0.9)	12 (0.9)	15 (1.2)	0.6
Previous major cardiac surgery	1371 (0.8)	16 (1.2)	16 (1.3)	0.04
Previous PCI	2060 (1.2)	18 (1.3)	15 (1.2)	0.9
SG	128,014 (73.5)	984 (72.1)	883 (70.5)	0.03
RYGB	46,108 (26.5)	380 (27.9)	369 (29.5)	0.03
Operative time, mean ± sd	83.8 ± 48.9	84.5 ± 50.7	90.3 ± 53.1	< 0.001

sd, standard deviation; *BM*I, 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-Y gastric bypass

**p*-Values were determined using the Chi-square analysis for categorical data and the Kruskal–Wallis test for continuous data

Table 2 Thirty-day post-operative outcomes for patients receiving elective bariatric surgery without peri-operative COVID-19 diagnosis, with pre-operative COVID-19 diagnosis, and with post-operative COVID-19 diagnosis

	No peri-operative COVID-19 diagnosis $n = 174{,}122$ *n* (%)	Pre-operative COVID-19 diagnosis $n = 1364$ *n* (%)	Post-operative COVID-19 diagnosis $n = 1252$ *n* (%)	*p*-Value
Length of stay (days)	1.3 ± 1.1	1.4 ± 1.1	1.4 ± 1.2	< 0.001
Reoperation	1613 (0.9)	11 (0.8)	26 (2.1)	< 0.001
Reintervention	1278 (0.7)	11 (0.8)	20 (1.6)	0.002
Readmission	4989 (2.9)	34 (2.5)	172 (13.7)	< 0.001
UTI	545 (0.3)	2 (0.2)	9 (0.7)	0.02
Superficial SSI	567 (0.3)	1 (0.1)	8 (0.6)	0.04
Deep SSI	552 (0.3)	3 (0.2)	13 (1.0)	< 0.001
Wound disruption	82 (0.05)	0 (0)	2 (0.2)	0.137
Sepsis	168 (0.1)	2 (0.2)	7 (0.6)	< 0.001
Pneumonia	278 (0.2)	3 (0.2)	44 (3.5)	< 0.001
Unplanned intubation	137 (0.1)	2 (0.2)	7 (0.6)	< 0.001
VTE	620 (0.4)	3 (0.2)	16 (1.3)	< 0.001
Acute kidney injury	153 (0.1)	2 (0.2)	8 (0.6)	< 0.001
Cardiac events	187 (0.1)	2 (0.2)	2 (0.2)	0.777
Cerebral vascular accidents	27 (0.02)	0 (0)	1 (0.08)	0.176
Leak	394 (0.2)	3 (0.2)	14 (1.1)	< 0.001
Bleed	1525 (0.9)	8 (0.6)	21 (1.7)	0.005
Serious complication	4860 (2.8)	31 (2.3)	117 (9.4)	< 0.001
Mortality	105 (0.06)	2 (0.2)	4 (0.3)	0.001

UTI, urinary tract infection; *SSI*, surgical site infection; *MI*, myocardial infarction; *VTE*, venous thromboembolism

unplanned intubation, and VTE, while patients diagnosed pre-operatively did not demonstrate substantial differences (Table 2). However, all patients with COVID-19 had higher rates of mortality compared to those without COVID (0.06% NO vs 0.2% PRE vs 0.3% POST; $p = 0.001$).

Multivariable Logistic Regression Evaluating Predictors of Serious Complications and Mortality

Two separate multivariable logistic regression models were conducted for serious complications and mortality. With regards to serious complications, pre-operative COVID-19 had no significant association with odds of serious complications while post-operative COVID-19 diagnosis had a near four-fold increased odds of serious complications. Post-operative COVID-19 (OR 3.5; 95% CI 2.8–4.2; $p < 0.0001$) was found to be the greatest independent predictor of serious complications followed by renal insufficiency (OR 2.5; 95% CI 2.0–3.1; $p < 0.0001$) and RYGB procedure (OR 2.0; 95% CI 1.8–2.1; $p < 0.0001$). The only protective factor was female sex (OR 0.89; 95% CI 0.82–0.95; p = 0.001). The Brier score and ROC for the serious complication model were 0.027 and 0.67 respectively (Tables 3 and 4).

Pre-operative COVID-19 also had no significant association with 30-day mortality after adjusting for comorbidities. Overall, the three greatest related predictors of mortality were bleeds (OR 7.2; 95% CI 13.8–3.7; $p < 0.0001$), post-operative COVID-19 (OR 5.1; 95% CI 1.8–14.1; $p = 0.002$), and leaks (OR 4.9; 95% CI 1.46–16.2; $p = 0.01$). Similarly, female sex (0.4; 95% 0.3–0.6; $p < 0.0001$) was the only protective factor for odds of post-operative morality. Interrogation of the mortality model demonstrated a Brier score of 0.0006 and an ROC of 0.83.

Discussion

Using the largest standardized international bariatric registry, we show that post-operative COVID-19 is associated with a large burden of post-operative complications evident across all domains. After adjusting for comorbidities, post-operative COVID-19 infection was among the greatest independent predictors of adverse outcomes with a near four-fold increased odds of serious complications and five-fold increased odds of 30-day mortality. Importantly, pre-operative COVID-19 (within 14 days of surgery) was not significantly associated with either serious complications or mortality, providing evidence that a more liberal surgical booking strategy may be safely implemented as we aim to reduce the current surgical backlog.

Table 3 Multivariable logistic regression evaluating predictors of serious complications

Risk factor	Odds ratio	95% confidence interval	p-Value
COVID-19 diagnosis			
Pre-operative vs. no COVID-19	0.76	0.53–1.09	0.1
Post-operative vs. no COVID-19	3.46	2.84–4.21	< 0.001
Age (per 10 years)	1.05	1.02–1.08	0.002
Female gender	0.89	0.82–0.95	< 0.001
GERD	1.24	1.17–1.32	< 0.001
BMI (per 5 kg/m^2)	0.99	0.97–1.01	0.5
Hyperlipidemia	1.04	0.96–1.12	0.3
Hypertension	1.13	1.06–1.21	< 0.001
Diabetes			
Non-insulin dependent vs. non-diabetic	1.10	0.98–1.22	0.09
Insulin dependent vs. non-diabetic	0.97	0.89–1.05	0.4
Previous DVT	1.61	1.37–1.91	< 0.001
Pre-operative therapeutic anticoagulation	1.89	1.64–2.15	< 0.001
History of MI	1.37	1.11–1.69	0.004
Renal insufficiency	2.48	1.96–3.13	< 0.001
Sleep apnea	1.02	0.96–1.08	0.6
Race category			
Black vs. White	1.33	1.24–1.42	< 0.001
Other vs. White	0.96	0.88–1.04	0.3
RYGB	1.97	1.85–2.11	< 0.001
Functional status			
Partially dependent vs. independent	1.51	1.11–2.04	0.008
Dependent vs. independent	1.55	0.34–7.04	0.6

GERD, gastroesophageal reflux disease; *BMI*, body mass index; *DVT*, deep vein thrombosis; *MI*, myocardial infarction; *RYGB*, Roux-en-Y gastric bypass

To understand the notable differences between our findings and prior studies, it is important to critically appraise the literature from which current guidelines were founded. The COVIDSurg Collaborative landmark international Lancet cohort study, for example, evaluated 1128 patients, with a COVID diagnosis within 7 days of surgery or 30 days after surgery [10]. While significant increases in mortality and pulmonary complications were observed, these outcomes were particularly influenced by males aged 70 years or older and by the nature of surgical indications with almost three quarters of patients undergoing emergency surgery. Furthermore, only 33% of included cases underwent abdominal surgery. Similar outcomes were demonstrated in another recent prospective multicenter study evaluating a total of 1581 patients undergoing surgery with perioperative COVID-19 infection [11]. Significantly higher risks of peri-operative complications were associated with increased age (> 70 years), male sex, malignant pathology, and emergency surgery of which over 1/3 underwent laparotomies. Understandably, these findings led many to conclude that postponement of elective surgeries, when reasonable, should be adopted given the high peri-operative COVID-19 risk.

However, as we argue below, it is difficult to extrapolate such outcomes and recommendations to the current bariatric landscape for a number of important reasons. We postulate that three key contributing factors should be acknowledged when assessing their suitability for bariatric generalizability: vaccine adoption, differences in procedure types, and differences in underlying patient population.

It is well acknowledged that vaccine adoption has markedly altered the trajectory of the COVID-19 disease course in high-risk groups [15]. Recent mathematical modeling based on over 180 countries and territories suggest that an estimated 41% of excess mortality was prevented with vaccinations representing nearly 20 million excess deaths in the first year of COVID-19 vaccination. Although the specific impact of vaccination on peri-operative outcomes has not yet been fully evaluated, it stands to reason that a similar improvement in peri-operative course has also been imparted by vaccination—one potential explanation for the lack of association between adverse outcomes and pre-operative COVID in our study. Recent work by Le et al. using a retrospective study design of 228,913 patients evaluated whether COVID-19 vaccination status influenced peri-operative outcomes in patients infected with COVID-19. Results

Table 4 Multivariable logistic regression evaluating predictors of mortality

Risk factor	Odds ratio	95% confidence interval	*p*-Value
COVID-19 diagnosis			
Pre-operative vs. no COVID	2.27	0.56–9.26	0.3
Post-operative vs. no COVID	5.10	1.85–14.06	0.002
Age (per 10 years)	1.76	1.46–2.13	< 0.001
Female gender	0.41	0.27–0.62	< 0.001
GERD	1.51	1.03–2.23	0.04
BMI (per 5 kg/m^2)	1.36	1.23–1.49	< 0.001
Hyperlipidemia	1.26	0.80–1.98	0.3
Hypertension	0.81	0.52–1.27	0.4
Diabetes			
Non-insulin dependent vs. non-diabetic	1.08	0.58–2.00	0.8
Insulin dependent vs. non-diabetic	1.12	0.70–1.80	0.6
Previous DVT	2.66	1.21–5.81	0.02
Pre-operative therapeutic anticoagulation	0.90	0.44–1.86	0.8
History of MI	3.32	1.54–7.17	0.002
Renal insufficiency	2.59	0.91–7.36	0.07
Bleed	7.15	3.70–13.83	< 0.001
Leak	4.87	1.47–16.15	0.01
Sleep apnea	0.79	0.53–1.18	0.3
Race category			
Black vs. White	1.47	0.93–2.31	0.1
Other vs. White	0.75	0.37–1.50	0.4
RYGB	1.43	0.93–2.18	0.1

GERD, gastroesophageal reflux disease; *BMI*, body mass index; *DVT*, deep vein thrombosis; *MI*, myocardial infarction; *RYGB*, Roux-en-Y gastric bypass

demonstrated that scheduled surgery in fully vaccinated individuals who contracted pre-operative COVID-19 was not associated with higher risks. Together, our findings add to this body of literature by demonstrating the safety of elective bariatric surgery in patients who contracted pre-operative COVID-19 using a large international cohort.

Three other notable contributing factors argue against extrapolation of current COVID-19 elective surgery guidelines to current elective bariatric surgery delivery. The first relates to marked differences between study populations. As mentioned previously, factors demonstrated to be at high-risk of adverse COVID-19 peri-operative outcomes are now well accepted to include male sex, old age (> 70 years), and malignant pathology. Extrapolation of such recommendations to a bariatric population that is predominantly female (> 80%) with a mean age of 40 years undergoing procedures for non-malignant pathology warrants close scrutiny. The second factor regards differences in surgical approaches between studies which captured emergency surgeries, non-abdominal surgeries, and laparotomies of increased operative length. Indeed, generalizing these to elective bariatric procedures performed laparoscopically or robotically with a mean operative time of approximately 80 min makes current recommendations difficult to rationalize. Lastly, with the advent of vaccines, prior-viral exposure, growing community immunity, and ever-evolving COVID-19 strains, it is increasingly difficult to extrapolate outdated guidelines on the dominant strains that we are faced with today [16, 17].

The last important finding of our work is that post-operative COVID-19 poses a significant and markedly increased risk of complications across all domains. While length of stay was comparable between groups, the post-operative COVID-19 cohort had increased rates of 30-day reoperation, reintervention, and readmission. Infectious complications including surgical site infections, urinary tract infections, and sepsis were more than twice more prevalent in patients with post-op COVID-19. Unadjusted rates of pneumonias were over 10 times higher along with increased rates of other important complications like leaks, bleeds, mortality, and overall serious complications. The substantial impact of COVID-19 remained after adjusting for comorbidities with post-operative COVID-19 infection being amongst the greatest independent predictors of both serious complications and mortality. Taken together, this data highlights the dramatic burden of post-operative COVID-19 on elective bariatric outcomes, strongly advocating for close follow-up for newly diagnosed patients as well as renewed multidisciplinary emphasis on peri-operative risk mitigation strategies like vaccination, hand hygiene, and social distancing.

Although our study was not designed to evaluate the underlying pathophysiologic mechanisms responsible for the COVID-19 mediated adverse post-operative outcomes, a number of different processes have been proposed. Work by Amodeo et al. has characterized the peri-operative period of abdominal surgery as one of impaired cell-mediated immune function as evidence by reduction in key cytokines like TNF-a, IL-2, and IFN-g [18]. It is thought that changes in peri-operative cytokine release are then followed by compensatory anti-inflammatory responses predisposing the host to an array of opportunistic infections [19] like COVID-19. Surgery-mediated–cell-mediated dysfunction and cytokine release may serve to further propagate COVID-19 cell-mediated dysfunction like increased macrophage and neutrophil activation thereby inducing early systemic inflammatory responses [20]. Applying these processes together in the context of severe obesity—recently understood to be a disease state characterized by chronic gastrointestinal and systemic inflammation [21]—serves to highlight why COVID-19 infection following bariatric surgery has such a dramatic adverse impact on all captured outcomes.

This study has a number of limitations associated with the nature of retrospective study designs. Perhaps the most important being the inability to control for confounding factors like COVID-19 vaccination or specific impact of viral strain infection limiting our ability to fully explain conflicting difference between our findings and prior landmark studies. To overcome this limitation, future studies evaluating the impact of vaccination on surgical outcomes in this context are warranted. We also could not account for type of COVID-19 therapy received, which itself could increase post-operative outcomes many therapies harbor immunosuppressive side effects. Other factors that we could not account or control for were prior infection, host immunity, disease severity, type of COVID-19 variant infection, and the burden of COVID-19 in the community. Also, we could not adjust for co-viral infection with other viral illnesses like influenza or respiratory syncytial virus nor bacterial pulmonary co-infections. This limits our ability to evaluate for which time of therapy or immune response provides the best protection or is associated with the greatest peri-operative protection with regards to elective metabolic surgery. There is also a selection bias in that sicker patients may be more likely to be tested for COVID-19 while asymptomatic patients may not be tested, resulting in a bias toward more complications in positive patients postoperatively. Pre-operative selection bias may play a larger role as routine pre-operative screening may reveal prior exposure and not necessarily active infection—leading to our lack of adverse findings in this group. Post-operative selection bias may select for more symptomatic active infections in a more at-risk population leading to our positive findings in this group. While we attempted to adjust for differences in populations using regression modeling, differences in bias associated with these groups and the different testing modalities for COVID-19 mean that these results should be interpreted with caution. Additionally, more nuanced information including case, surgeon, and center specific data that would allow for geographical stratification could not be accounted for in the context of the MBSAQIP data registry. This lack of nuanced data limits our ability to assess the potential impact of center-specific practices like mandated vaccine or booster policies. Lastly, there is also the possibility that there may be other factors which we could not fully account for that may ultimately confound our results.

Despite these limitations, our study provides the first characterization of peri-operative COVID-19 and its impact on the elective bariatric setting. Notably, we demonstrate that pre-operative infection is itself not associated with increased odds of complications or mortality, while post-operative infection has a dramatic burden on both serious complications and mortality. Taken together, these findings provide evidence against current guidelines which suggest that elective surgeries should be postponed at least 8 weeks from infection, thus informing bariatric recovery strategies and potentially easing the bariatric backlogs. They also identify a particularly high-risk post-operative period where bariatric patients should be closely monitored, and COVID-19 mitigation strategies should be emphasized if not entirely mandated.

Conclusion

The prevalence of pre- and post-operative COVID 19 is low following elective bariatric surgery, at less than 1%. After adjusting for comorbidities, post-operative COVID-19 infection was amongst the greatest independent predictors of serious complications and mortality. Pre-operative COVID-19 within 14 days of surgery was not significantly associated with either serious complications or mortality, providing evidence that more liberal operative booking strategy may be safely implemented as we aim to reduce current bariatric surgery case backlogs.

Data Availability Requests for reprints should be directed to the corresponding author.

Declarations

Ethical Approval For this type of study, formal consent is not required.

Consent to Participate Informed consent does not apply.

Conflict of Interest The authors declare no competing interests.

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