Surgical Endoscopy (2023) 37:1213–1221
https://doi.org/10.1007/s00464-022-09651-7

ORIGINAL ARTICLE

Body mass index and risk of mortality in patients undergoing bariatric surgery

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Received: 13 February 2022 / Accepted: 13 September 2022 / Published online: 26 September 2022

Abstract

Background Prior literature has demonstrated that bariatric surgery is a safe approach for patients with morbid obesity. However, the relationship between body mass index (BMI) and risk of mortality in these patients has not been fully elucidated. Primary objective of this study was to evaluate the relationship between BMI and risk of mortality using data obtained from a national database, with a special focus on patients with BMI ≥ 70.0 kg/m^2.

Methods A retrospective cohort study of patients with morbid obesity (BMI ≥ 40 kg/m^2) undergoing first-time bariatric surgery between 2015 and 2018 was performed using data from the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program. Primary outcome was intra-operative death or death within 30 days post-operatively. Patients were categorized into quartiles according to BMI. Multivariable analysis was performed to evaluate the association of BMI with risk of mortality. Relative risk (RR) and 95% confidence interval (CI) are provided as measures of strength of association and precision, respectively.

Results A total of 463, 436 patients were included with a 30-day mortality rate of 0.11%. Mean BMI (SD) was 48.2 (7.3) kg/m^2; 1.5% of patients had BMI ≥ 70.0 kg/m^2. On multivariable analysis, highest quartile patients had a significantly higher risk of mortality than lowest quartile patients. For patients with BMI ≥ 70.0 kg/m^2, the risk of mortality was more pronounced with an eightfold increase compared to the lowest quartile. In patients with BMI ≥ 70.0 kg/m^2, although sleeve gastrectomy (SG) was the most common procedure, the risk of mortality was significantly higher in patients undergoing Roux-en-Y gastric bypass (RYGB).

Conclusions BMI is associated with increased risk of 30-day mortality. The effect of BMI is more pronounced in patients with BMI ≥ 70.0 kg/m^2. In these patients, RYGB is associated with increased risk of mortality compared to SG.

This study was presented as a poster presentation at the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Meeting 2021, September, 2021, Las Vegas, NV, USA.

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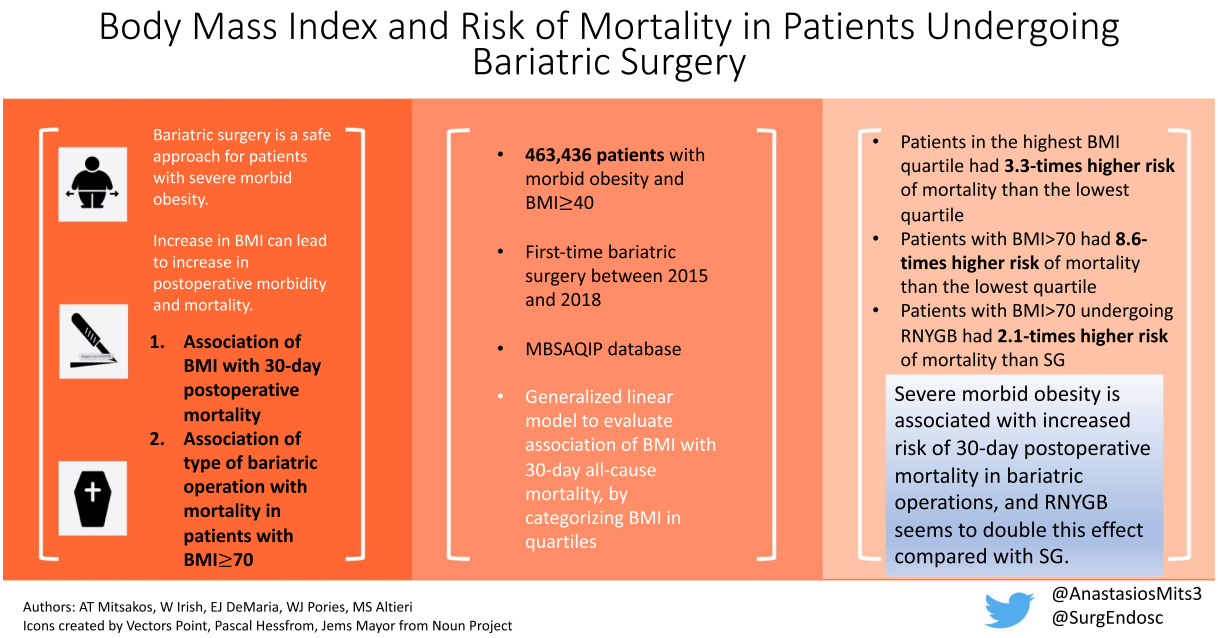
Graphical abstract



Keywords Body mass index · Morbid obesity · Post-operative mortality · Sleeve gastrectomy · Roux-en-Y gastric bypass

Since its initiation more than 60 years ago, bariatric surgery has evolved into the evidence-based treatment of choice for obesity and metabolic syndrome, with major effect on weight loss and comorbidity reduction and with an associated low risk of peri-operative morbidity and mortality [1–7]. While the research on elucidating the metabolic and cellular pathways involved in its efficacy is ongoing, the severity of morbid obesity in the United States and worldwide keeps increasing. Despite numerous studies having shown its clinical efficacy and cost-effectiveness for patient care and for the health system in its entirety, bariatric surgery unfortunately remains underutilized both as a referral and as an operative tool in the management of patients with morbid obesity and obesity related comorbidities [8–11].

Along with the demographic increase in the incidence of severe comorbid obesity in the United States, the relative percentage of patients with progressively higher body mass index (BMI) and more comorbidities also keeps increasing [10]. Previous literature has demonstrated that higher BMI is associated with a plethora of worse perioperative outcomes for most major operations, including bariatric operations [12–14]. As older data initially encouraged staged or open operations to decrease postoperative morbidity in these high-risk patients, it is currently established clinical practice to perform minimally invasive bariatric operations, with the most common procedures being laparoscopic sleeve gastrectomy and laparoscopic Roux-en-Y gastric bypass [12, 14–17].

Thus, with the progressive increase of morbid obesity in the general population and with the increasing confidence of the bariatric surgical community in operating on such patients to improve their long-term comorbidities and weight loss, the association between very high BMI and short-term postoperative mortality remains unclear. The choice of operative approach is still in debate, but the sleeve gastrectomy has increased in popularity due to its theoretically safer profile. The primary aim of this study was to evaluate the association between BMI and risk of all-cause 30-day mortality in patients undergoing a bariatric operation for the first time, with a specific focus on patients with BMI ≥ 70 kg/m^2. A secondary objective of this study was to evaluate the association between type of surgical operation performed and all-cause 30-day mortality in that subgroup of patients (BMI ≥70 kg/m^2).

Materials and methods

Data source

The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) is a single unified, nationally validated, risk-adjusted program designed

to achieve one national accreditation standard for bariatric surgery centers, and collects data to promote quality analysis in surgical care, including 30-day morbidity and mortality. It was developed as a combined collaboration of the respective national bariatric surgery accreditation programs of the American College of Surgeons (ACS) and the American Society for Metabolic and Bariatric Surgery (ASMBS). A bariatric surgical center achieves accreditation following a rigorous review process during which it proves that it can maintain certain physical resources, human resources, and standards of practice. All accredited centers report their outcomes to the MBSAQIP database. The MBSAQIP provides Health Insurance Portability and Accountability Act (HIPAA) compliant, patient-level, aggregate data but does not provide hospital or provider-specific data [18]. For this study period (2015–2018), the MBSAQIP Participant User Data File included data from approximately 200,000 bariatric surgical procedures per year from more than 200 participating hospital centers per year.

For this retrospective cohort study, prospectively collected data from the MBSAQIP data file from 2015 to 2018 were used to include adult patients (age > 18 years) with BMI ≥40.0 kg/m2 undergoing primary bariatric surgery. Revisions or reversal procedures and records without enough information were excluded from analysis. This study was reviewed by the Institutional Review Board and was determined to be exempt.

Variables and outcomes

Patient demographic and clinical variables assessed included age, sex, race, BMI, diabetes mellitus, American Society of Anesthesiologists (ASA) class, renal insufficiency, end-stage renal disease (ESRD) undergoing or requiring dialysis, functional health status, hypertension, and hyperlipidemia. The total cohort was divided in quartiles according to BMI, with an additional 5th subcohort identified and separated for patients with BMI ≥70.0, with the goal of assessing differences in variables and in outcomes as the BMI increases.

Intra-operative variables included the type of the bariatric operation performed, with the two most common operations being laparoscopic sleeve gastrectomy and laparoscopic Roux-en-Y gastric bypass. The rest of the operations performed were classified as Other due to small sample size (5.1%, $N = 23{,}459$). The major outcome of interest was 30-day postoperative all-cause mortality. This was defined as intra-operative death or as death from any etiology within 30 days after the bariatric operation.

Statistical analysis

Continuous data were compared using t-test or Wilcoxon's rank sum and categorical data were compared by chi-squared analysis. In order to control for confounding factors associated with 30-day postoperative all-cause mortality, a multivariable logistic regression model was used. Variables included in the regression model were selected a priori and were based on the available demographic and clinical data as described above. Specifically, they included age, sex, race, BMI, diabetes mellitus, ASA class, renal insufficiency, ESRD undergoing or requiring dialysis, functional health status, hypertension, hyperlipidemia, and type of bariatric operation performed. Further multivariable statistical analysis was performed, taking into consideration only the most highly clinically and statistically relevant variables of all the ones that had been included in the initial model, in order to more accurately identify the relative risk of all-cause 30-day postoperative mortality of these patients. In this secondary analysis model, only age, sex, race, BMI, and diabetes mellitus were included. All tests were two-tailed; those with a p-value of < 0.05 were considered statistically significant. Statistical analysis was performed using SAS® software. Copyright © 2019 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

Results

Demographics

A total of 463,436 patients with BMI ≥40.0 kg/m^2 who underwent a bariatric operation for the first time were identified from the MBSAQIP database from 2015 to 2018. These patients were initially categorized in four quartiles according to their BMI. The 1st quartile consisted of patients with $40.0 \leq \text{BMI} < 42.9$ kg/m^2 ($N = 115{,}609$), the 2nd quartile of patients with $42.9 \leq \text{BMI} < 46.3$ kg/m^2 ($N = 115{,}842$), the 3rd quartile of patients with $46.3 \leq \text{BMI} < 51.5$ kg/m^2 ($N = 115{,}968$), and the 4th quartile of patients with BMI ≥ 51.5 kg/m^2 ($N = 116{,}017$). In order to analyze the subcategory of patients with BMI ≥70.0 kg/m^2 separately, these patients were placed in a 5th category ($N = 6{,}793$), thus leaving the patients with $51.5 \leq \text{BMI} > 70.0$ kg/m^2 as the finalized 4th quartile ($N = 109{,}224$) (Table 1).

Age at presentation was similar among the BMI subgroups, with most patients presenting at their early 40 s. More than 75% of the patients undergoing bariatric operation in this study were female, however there appeared to be a trend of increasing male patients in the two highest BMI subgroups. The majority of patients were White, but there was an increase of the percentage of Black patients as the BMI increased. The majority of patients had hyperlipidemia and approximately half of them had hypertension, while a quarter were diagnosed with diabetes mellitus. Almost all of the patients in the cohort were functionally independent and

Table 1 Sociodemographic and Clinical Characteristics by Body Mass Index (BMI)

	Total cohort *N* = 463,436 (100.0%)	40.0 ≤ BMI < 42.9 *N* = 115,609 (24.9%)	42.9 ≤ BMI < 46.3 *N* = 115,842 (25.0%)	46.3 ≤ BMI < 51.5 *N* = 115,968 (25.0%)	51.5 ≤ BMI > 70.0 *N* = 109,224 (23.6%)	BMI ≥ 70.0 *N* = 6,793 (1.5%)
Age						
Mean years (± SD)	43.5 (± 11.9)	44.6 (± 11.9)	44.0 (± 12.0)	43.4 (± 12.0)	42.3 (± 11.6)	39.9 (± 10.4)
Sex						
Male	99,726 (21.5%)	20,787 (18.0%)	23,109 (20.0%)	25,603 (22.1%)	28,145 (25.8%)	2,082 (30.6%)
Female	363,710 (78.5%)	94,822 (82.0%)	92,733 (80.0%)	90,365 (77.9%)	81,079 (74.2%)	4,711 (69.4%)
Race						
White	329,810 (71.2%)	85,093 (73.6%)	83,820 (72.4%)	82,263 (70.9%)	74,471 (68.2%)	4,163 (61.3%)
Black	89,988 (19.4%)	18,713 (16.2%)	20,778 (17.9%)	23,018 (19.9%)	25,394 (23.2%)	2,085 (30.7%)
Other	43,638 (9.4%)	11,803 (10.2%)	11,244 (9.7%)	10,687 (9.2%)	9,359 (8.6%)	545 (8.0%)
Diabetes mellitus						
No	346,014 (74.7%)	89,335 (77.3%)	87,612 (75.6%)	85,595 (73.8%)	78,551 (71.9%)	4,921 (72.4%)
Yes	117,422 (25.3%)	26,274 (22.7%)	28,230 (24.4%)	30,373 (26.2%)	30,673 (28.1%)	1,872 (27.6%)
ASA classification**						
I	1,561 (0.3%)	521 (0.5%)	410 (0.4%)	362 (0.3%)	252 (0.2%)	16 (0.2%)
II	86,587 (18.8%)	29,465 (25.6%)	24,833 (21.5%)	19,597 (17.0%)	12,169 (11.2%)	523 (7.7%)
III	353,105 (76.5%)	83,024 (72.1%)	87,103 (75.5%)	90,566 (78.4%)	87,524 (80.5%)	4,888 (72.2%)
IV	20,190 (4.4%)	2,062 (1.8%)	3,029 (2.6%)	4,932 (4.3%)	8,828 (8.1%)	1,339 (19.8%)
ESRD on or requiring dialysis						
No	461,933 (99.7%)	115,249 (99.7%)	115,432 (99.7%)	115,570 (99.7%)	108,903 (99.7%)	6,779 (99.8%)
Yes	1,503 (0.3%)	360 (0.3%)	410 (0.3%)	398 (0.3%)	321 (0.3%)	14 (0.2%)
Renal insufficiency						
No	460,342 (99.3%)	114,994 (99.5%)	115,066 (99.3%)	115,159 (99.3%)	108,379 (99.2%)	6,744 (99.3%)
Yes	3,094 (0.7%)	615 (0.5%)	776 (0.7%)	809 (0.7%)	845 (0.8%)	49 (0.7%)
Functional health status						
Independent	458,146 (98.9%)	114,784 (99.3%)	114,881 (99.2%)	114,801 (99.0%)	107,278 (98.2%)	6,402 (94.3%)
Partially dependent	3,488 (0.7%)	394 (0.3%)	546 (0.5%)	761 (0.7%)	1,466 (1.3%)	321 (4.7%)
Totally dependent	1,802 (0.4%)	431 (0.4%)	415 (0.4%)	406 (0.3%)	480 (0.4%)	70 (1.0%)
Hypertension						
No	243,405 (52.5%)	66,485 (57.5%)	63,531 (54.8%)	59,759 (51.5%)	50,703 (46.4%)	2,927 (43.1%)
Yes	220,031 (47.5%)	49,124 (42.5%)	52,311 (45.2%)	56,209 (48.5%)	58,521 (53.6%)	3,866 (56.9%)

Table 1 (continued)

	Total cohort $N=463,436$ (100.0%)	$40.0 \leq BMI < 42.9$ $N=115,609$ (24.9%)	$42.9 \leq BMI < 46.3$ $N=115,842$ (25.0%)	$46.3 \leq BMI < 51.5$ $N=115,968$ (25.0%)	$51.5 \leq BMI > 70.0$ $N=109,224$ (23.6%)	$BMI \geq 70.0$ $N=6,793$ (1.5%)
Hyperlipidemia						
No	362,466 (78.2%)	89,756 (77.6%)	90,088 (77.8%)	90,382 (77.9%)	86,619 (79.3%)	5,621 (82.7%)
Yes	100,970 (21.8%)	25,853 (22.4%)	25,754 (22.2%)	25,586 (22.1%)	22,605 (20.7%)	1,172 (17.3%)
Operation performed						
Laparoscopic sleeve gastrectomy	316,337 (68.2%)	83,067 (71.9%)	80,939 (69.9%)	77,823 (67.1%)	70,060 (64.1%)	4,448 (65.5%)
Laparoscopic Roux-en-Y gastric bypass	123,640 (26.7%)	27,445 (23.7%)	29,951 (25.8%)	32,338 (27.9%)	32,131 (29.4%)	1,775 (26.1%)
Other	23,459 (5.1%)	5,097 (4.4%)	4,952 (4.3%)	5,807 (5.0%)	7,033 (6.5%)	570 (8.4%)
30-Day postoperative mortality						
No	462,919 (99.89%)	115,537 (99.94%)	115,764 (99.93%)	115,830 (99.88%)	109,026 (99.82%)	6,762 (99.54%)
Yes	517 (0.11%)	72 (0.06%)	78 (0.07%)	138 (0.12%)	198 (0.18%)	31 (0.46%)

*_BMI_ Body Mass Index, _ASA_ American society of anesthesiologists, _ESRD_ End-stage renal disease

**Frequency missing 1993, thus total cohort for this category was 461,443

did not have any major renal issues. The majority of patients (94.9%) underwent either laparoscopic sleeve gastrectomy or laparoscopic Roux-en-Y gastric bypass, with the former being the predominant most common operation (68.2%) (Table 1).

30-Day postoperative mortality

The unadjusted all-cause 30-day postoperative mortality was 0.11% for the total cohort ($N=517$). The mortality rate increased slowly with the progression in the BMI quartile subgroups, and it reached its peak at the 5th subgroup consisting of patients with BMI $\geq$70.0 kg/m^2 (0.06% for the 1st quartile, 0.07% for the 2nd quartile, 0.12% for the 3rd quartile, 0.18% for the 4th quartile, and 0.46% for the patients with BMI $\geq$70.0 kg/m^2), thus showing an eightfold increase in mortality for the patients with BMI $\geq$70.0 kg/m^2 compared to patients with $40.0 \leq BMI < 42.9$ kg/m^2 (Table 1).

On multivariable regression analysis, taking into consideration all the demographic and clinical variables as described earlier, the relative risk of 30-day postoperative mortality increased progressively in the higher BMI quartile subgroups. Older age, male sex, Black race, and chronic renal disease with or without dialysis, were all associated with a statistically significant increase in the risk of mortality in the intra-operative and postoperative period. In addition, the performance of laparoscopic Roux-en-Y gastric bypass was associated with higher relative risk of mortality in comparison to laparoscopic sleeve gastrectomy (Table 2).

On multivariable regression analysis with adjustment only for the most clinically and statistically significant variables of the model (BMI, age, sex, race, diabetes mellitus), there was still noted a progressive increase in the relative risk of 30-day mortality as the BMI increased, with patients in the BMI $\geq$70.0 kg/m^2 subgroup having an 8.6-times higher risk than patients in the 1st BMI quartile subgroup (RR 8.61, 95% CI 5.63–13.17). In the same model, older age, male sex, Black race, and diabetes mellitus are all associated with an increase in 30-day mortality risk, but to a lower extent than the increase in BMI (Table 2). In a graphical depiction, as the BMI increases, the increase in the 30-day mortality risk starts as linear but evolves in an exponential fashion in the 4th BMI quartile subgroup and even more pronounced at the subgroup of patients with BMI $\geq$70.0 kg/m^2 (Fig. 1).

Subgroup analysis of patients with BMI $\geq$ 70.0

For the subgroup of patients with BMI $\geq$70.0, a similar multivariable regression model analysis was performed, adjusting for type of bariatric operation performed, age, sex, race, and diabetes mellitus. These patients were found to have a more than twofold increase in their relative risk of 30-day all-cause mortality when undergoing a laparoscopic Roux-en-Y gastric bypass in comparison with laparoscopic sleeve gastrectomy (RR 2.11, 95% CI 1.04–4.27). Male sex

Table 2 Multivariable analysis—relative risk of 30-day postoperative mortality (Adjusted only for BMI, Age, Sex, Race, Diabetes Mellitus)

	30-Day postoperative mortality	
	Relative Risk	95% CI
BMI (ref. = 40.0 ≤ BMI < 42.9)		
42.9 ≤ BMI < 46.3	0.53	0.43–0.65
46.3 ≤ BMI < 51.5	0.90	0.76–1.06
51.5 ≤ BMI > 70.0	1.31	1.13–1.52
BMI ≥ 70.0	3.08	2.27–4.18
Operation performed (ref. = laparoscopic sleeve gastrectomy)		
Laparoscopic Roux-en-Y gastric bypass	1.78	1.47–2.14
Other	2.38	1.78–3.18
Age		
Per year increase	1.05	1.04–1.06
Sex (ref. = female)		
Male	1.42	1.30–1.56
Race (ref. = white)		
Black	1.54	1.30–1.82
Other	0.71	0.56–0.91
Diabetes mellitus (ref. = no)		
Yes	1.06	0.96–1.17
ASA classification (ref. = I)		
II	0.61	0.35–1.07
III	1.04	0.63–1.73
IV	1.68	0.99–2.87
ESRD on or requiring dialysis (ref. = no)		
Yes	1.48	1.04–2.10
Renal insufficiency (ref. = no)		
Yes	1.36	1.06–1.74
Functional health status (ref. = independent)		
Partially dependent	1.51	1.05–2.18
Totally dependent	1.18	0.69–2.04
Hypertension (ref. = no)		
Yes	1.08	0.96–1.20
Hyperlipidemia (ref. = no)		
Yes	1.11	1.01–1.23
BMI (ref. = 40.0 ≤ BMI < 42.9)		
42.9 ≤ BMI < 46.3	1.07	0.78–1.48
46.3 ≤ BMI < 51.5	1.90	1.43–2.53
51.5 ≤ BMI > 70.0	3.01	2.29–3.95
BMI ≥ 70.0	8.61	5.63–13.17
Age		
Per year increase	1.06	1.05–1.07
Sex (ref. = female)		
Male	2.16	1.81–2.58
Race (ref. = white)		
Black	1.72	1.40–2.10
Other	0.80	0.55–1.16
Diabetes mellitus (ref. = no)		
Yes	1.43	1.20–1.71

**BMI* Body Mass Index, *ASA* American society of anesthesiologists, *ESRD* End-stage renal disease

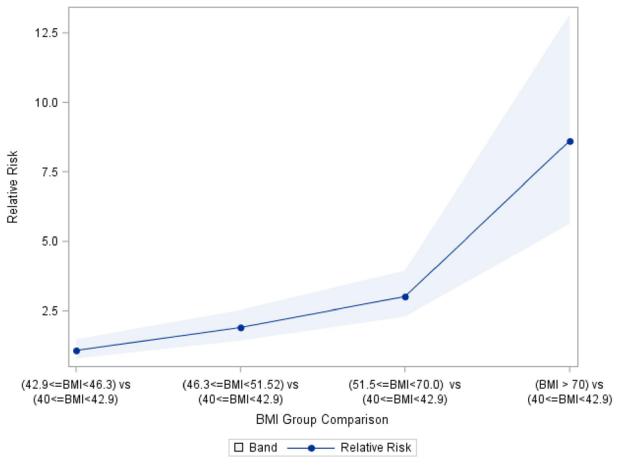


Fig. 1 Relative risk of 30-day mortality and 95% Confidence Interval by Body Mass Index (kg/m^2) group comparison

and Black race were again associated with higher mortality, however the relative increase in mortality for patients of older age and with diabetes mellitus did not reach statistical significance (Table 3).

Discussion

In this study, 463,436 patients with BMI ≥40.0 kg/m^2 who underwent a bariatric operation for the first time were identified from the MBSAQIP database from 2015 to 2018. The risk for combined all-cause peri-operative and 30-day postoperative mortality increased exponentially as the BMI increased to levels of severely morbid obesity. Patients with BMI ≥70.0 kg/m^2 had a more than eightfold higher risk in

Table 3 Multivariable analysis—relative risk of 30-day postoperative mortality in the subgroup of patients with BMI > 70.0 (Adjusted only for operation performed, age, sex, race, diabetes mellitus)

	30-Day postoperative mortality	
	Relative risk	95% CI
Operation performed (ref. = laparoscopic sleeve gastrectomy)		
Laparoscopic Roux-en-Y gastric bypass	2.11	1.04–4.27
Age		
Per year increase	1.03	0.99–1.06
Sex (ref. = female)		
Male	1.49	1.04–2.12
Race (ref. = white)		
Black	1.87	1.03–3.39
Other	0.81	0.31–2.09
Diabetes mellitus (ref. = no)		
Yes	1.38	0.97–1.98

comparison with patients in the 1st BMI quartile subgroup. In addition, the subgroup of these patients with BMI ≥ 70.0 kg/m^2 had a more than twofold increase in their risk of early mortality when undergoing laparoscopic Roux-en-Y gastric bypass versus laparoscopic sleeve gastrectomy. Previous retrospective single-institution and national database studies have indeed demonstrated that higher BMI, male gender, and more advanced age all play an independent role as risk factors for early mortality in patients undergoing a bariatric operation [12, 13]. However, the specific functional association of the increase in BMI with the increase in early mortality in patients with severe morbid obesity has not been clearly defined. To our knowledge, this is the first and largest retrospective national study to investigate the association between BMI and all-cause combined intra-operative and 30-day postoperative mortality in patients undergoing a bariatric operation.

The effect of obesity as an independent risk factor on peri-operative morbidity, mortality, and overall outcomes for the broad range of surgical procedures has been well described in the literature. Wound dehiscence, surgical site infections, and postoperative hernias are some of the most feared complications for surgeons of all specialties when operating on high-risk patients in the emergency and in the elective setting [19–23]. A recent retrospective study evaluating patients undergoing bariatric surgery from the National Registry of Bariatric Surgery in Israel found an increased risk of all-cause 3.5-year mortality in patients with higher BMI, advanced age, and male gender [12]. Our study evaluated the association between BMI and peri-operative and early post-operative mortality in a large-scale national retrospective cohort, but most importantly it was able to show the exponential increase in the relative risk of mortality as the BMI increases to ≥50.0, and in an even more pronounced fashion as it increases to ≥ 70.0, something that has not been studied in the literature.

Another finding of major significance in this study is the fact that laparoscopic Roux-en-Y gastric bypass is associated with an increased relative risk in all-cause intra-operative and 30-day postoperative mortality in comparison with laparoscopic sleeve gastrectomy, a risk that is accentuated to a more than twofold increase in patients with BMI ≥70.0 kg/m^2, as shown in the multivariable analysis. The literature is replete of comprehensive reviews addressing the historical efficacy and safety of laparoscopic bariatric operations, both Roux-en-Y gastric bypass and sleeve gastrectomy, as treatment of severe morbid obesity [16, 24–27]. However, the decision as to which operation to perform on which patients remains debatable and has to be made in an individualized basis after taking into consideration patient demographic and clinical variables, as well as personal preference. A retrospective study from Italy and Switzerland assessed 581 patients who underwent either laparoscopic Roux-en-Y gastric bypass or laparoscopic sleeve gastrectomy and found decreased early postoperative complication rate but also decreased 1-year weight loss in patients who underwent sleeve gastrectomy [17]. A single institution study from the University of Illinois at Chicago evaluated 89 patients with BMI ≥60.0 and found significantly higher 1- and 2-year weight loss for the patients undergoing Roux-en-Y gastric bypass, but no statistically significant differences in postoperative complications or length or stay [28]. Last, a more recent retrospective study from France followed 210 patients with BMI ≥60.0 who underwent one of the two aforementioned operations over the span of 6 years and concluded that patients undergoing Roux-en-Y gastric bypass suffer from increased postoperative complications but have improved mid- and long-term weight loss in comparison to patients undergoing sleeve gastrectomy [14]. While our study did not evaluate long-term outcomes, the findings support an increased, albeit still relatively low, early postoperative mortality rate for patients with severe morbid obesity undergoing laparoscopic Roux-en-Y gastric bypass in comparison to sleeve gastrectomy.

There are several limitations to this study. First, this is a retrospective study and is limited by the quality of the data abstraction and chart review by MBSAQIP registrars. Second, MBSAQIP includes 30-day postoperative data only; therefore, this study was not designed to evaluate any mid- or long-term outcomes associated with bariatric operations. This could potentially limit the extent in which the results of this study can be interpreted, when informed decision making process is performed for an individualized patient case; for example, even though a patient with BMI ≥70.0 kg/m^2 does have an increased risk of early mortality if they undergo a Roux-en-Y gastric bypass in comparison with a sleeve gastrectomy, this increased risk will have to be balanced by the potentially improved mid- and long-term effect of that operation on their weight loss and overall comorbidities, something that was not assessed in this study. Third, MBSAQIP participating institutions are per definition nationally accredited bariatric centers, thus the results might not be representative of and generalizable to all facilities at which bariatric operations are performed. Subsequently, extrapolation of findings to other non-accredited facilities should be performed with caution. Finally, no data was collected regarding the individual cause of intra- and early postoperative mortality for the patients in this study, therefore presenting an unknown parameter in the data interpretation.

Conclusions

In this retrospective observational study of patients with morbid obesity and BMI ≥40.0 kg/m^2 undergoing a first-time bariatric operation in the MBSAQIP database between

2015 and 2018, higher BMI was directly associated with higher risk of all-cause intra-operative and 30-day postoperative mortality. This risk increased exponentially with the increase in BMI above 50 kg/m^2, reaching a peak of eightfold increase for patients with BMI ≥70.0 kg/m^2, and having an additional twofold increase for these patients undergoing laparoscopic Roux-en-Y gastric bypass compared to laparoscopic sleeve gastrectomy. These findings should be taken into account when counseling patients before undergoing a bariatric operation, as they could play a significant role in the informed decision making, which eventually should happen on an individualized basis with all demographic and clinical information available.

Author contributions ATM: Conception, design, data acquisition, analysis, manuscript preparation, critical revision, and final approval for study submission. WI: Conception, design, data acquisition, analysis, manuscript preparation, critical revision, and final approval for study submission. EJDM, WJP, MSA: Conception, design, data acquisition, analysis, manuscript preparation, critical revision, and final approval for study submission.

Funding This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations

Disclosures Drs. Anastasios T Mitsakos, William Irish, Eric J DeMaria, Walter J Pories, and Maria S Altieri, have no conflict of interest or financial ties to disclose.

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