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ORIGINAL CONTRIBUTIONS

Trends in Drain Utilization in Bariatric Surgery: an Analysis of the MBSAQIP Database 2015–2017

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Abstract

Background Laparoscopic Roux-en-Y gastric bypass (LRYGB) and sleeve gastrectomy (SG) are the two most common bariatric operations. With the implementation of enhanced recovery protocols, the use of drains should decrease.

Methods The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program database was queried for the years 2015–2017. Our inclusion criteria included all patients undergoing a primary LRYGB, SG, and revisions. We examined demographics, operative characteristics, the use of drains, and postoperative complications. Continuous variables were summarized using means and standard deviations (SD). Categorical variables were summarized using frequencies and proportions. Student's *T* test (Wilcoxon sum rank test in the case of skewed data) and chi-squared analysis were used to assess the baseline differences in drain utilization.

Results From 2015 to 2017, there were 388,239 bariatric cases performed without drains and 100,221 performed with drains. Twenty-nine percent of LRYGB patients had a drain placed but only 16.7% of SG patients. The percentage of LRYGB that had a drain dropped from 33.1 to 24.6% during the study period and that of SG dropped from 20.3 to 13.6%. Patients that had drains placed were more likely to have a provocative test at the time of surgery (prevalence ratio (PR) 2.24) and to have a postoperative swallow study (PR 1.93).

Conclusions Drains are still commonly used in bariatric patients. Over the study period, there was a decrease in the use of drains in both bypass and sleeve patients. Patients with a drain were more likely to have had a provocative test and a swallow study and have a higher rate of complications and mortality.

Keywords Abdominal drains · MBSAQIP · Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program · Bariatric surgery

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Introduction

Laparoscopic Roux-en-Y gastric bypasses (LRYGB) and sleeve gastrectomy (SG) are the two most common bariatric operations. The most far-reaching advance in bariatric surgery was the introduction of laparoscopic surgery, with widespread adoption by the mid-1990s [1, 2]. Wittgrove and Clark performed the first laparoscopic gastric bypass in 1993, and by the turn of the century, bariatric surgery became almost exclusively performed using the laparoscopic technique [3]. This has led to decreased length of stay, rare utilization of intensive care units for the standard bariatric operation, and a progression towards enhanced recovery methods [4, 5]. With the implementation of enhanced recovery protocols, surgeons tend to use less invasive methods of perioperative management. This includes decrease in urinary catheterization and the use of nasogastric tubes and abdominal drains (referred to as drains hereafter). Despite the guidelines provided by the American Society of Metabolic and Bariatric Surgeons in 2009, there is still controversy about the routine use of drains and indications for drain placement [6]. As practice patterns change and enhanced recovery protocols are adopted, the use of drains should decrease.

The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) of the American College of Surgeons (ACS) is a nationwide prospective database that contains data from every accredited center for bariatric surgery in the USA and Canada [7]. This database includes patients that underwent metabolic or bariatric surgery and reports 30-day outcomes. The Participant Use Data File (PUF) has been completed and made available for study for the years 2015–2017. The use of drains has been evaluated in the database by Doumouras et al. in their seminal article evaluating the PUF for the year 2015 [8]. They showed that the overall drainage rate was 24.4%. They looked at 5 major outcomes: leak, reoperation, morbidity, readmission, and mortality. They found that the use of a drain increased the odds of a leak by 30%. There was also an increase in reoperation, morbidity, and readmission, but there was no difference in mortality. They concluded that routine abdominal drainage should not be used because it "increased the rate of all-cause morbidity, reoperations, and anastomotic leaks...." Despite this conclusion, we felt that abdominal drainage was not the cause of increased complications and proposed building on this work but including 3 years of MBSAQIP data. We wanted to see if we could find common preoperative characteristics that might have led to drains being placed, operative variables that were associated with drain placement, and differences in postoperative complications in those patients receiving drains. This can be summed up by two questions: what are the characteristics of patients that have drains placed, and what are the outcomes of those patients? Our secondary outcomes of interest were trends in drain utilization in bariatric surgery for the years 2015–2017.

Methods

Database

We queried the MBSAQIP database for the years 2015–2017. This database is the largest bariatric-specific registry in the USA and contains Health Insurance Portability and Accountability Act (HIPAA)-compliant patient level data on more than 160,000 patients that are operated on yearly. This database includes patients that underwent metabolic or bariatric surgery and reports 30-day outcomes. The ACS and Metabolic Bariatric Surgery Accreditation and Quality Improvement Program and the centers participating in the ACS MBSAQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors. Our institutional review board deemed this study exempt.

Patient Population

Our inclusion criteria included all patients undergoing surgery that are reported in the MBSAQIP database. Eligibility criteria included patients over the age of 18, Current Procedural Terminology (CPT) codes of 43644, 43645, 43775. We also included revisions as a subgroup, which were the cases that were marked as Revision/Conversion. Exclusion criteria were patients over 75 years of age and patients with incomplete data.

Outcome Measures

The preoperative characteristics of patients with and without drainage were examined. These included demographics and preoperative comorbidities. Operative variables were also examined including type of operation, operative time, approach, techniques such as staple line reinforcement, blood loss, provocative testing, and drain placement. Provocative testing is defined in the MBSAQIP as "insufflation of air through an endoscope or nasogastric tube with the anastomosis under saline to look for bubbles" or "the instillation of methylene blue under pressure." Postoperatively, we examined if the drain was present at 30 days, if there was a postoperative swallow study performed, and length of hospital stay. Postoperative 30-day outcomes for complications were also examined: death/mortality, morbidity (defined as any complication occurring within 30 days after the operation), readmission, reoperation, reintervention, unplanned admission to the intensive care unit (ICU), deep postoperative skin and soft tissue infection (SSI), intra- or postoperative myocardial infarction, unplanned postoperative ventilation, ventilator > 48 h, organ space infection, pneumonia, progressive renal insufficiency, pulmonary embolism (PE), sepsis, transfusion, unplanned intubation, postoperative urinary tract infection

(UTI), acute renal failure, SSI present at time of surgery, peripheral nerve injury, UTI present on admission, postoperative vein thrombosis requiring therapy, wound disruption, coma > 24 h, intraoperative or postoperative cardiac arrest requiring CPR, and stroke/cerebral vascular accident.

Statistical Analysis

Quantitative variables were summarized using means and standard deviations (SD). Categorical variables were summarized using frequencies and proportions. Student's T test (Wilcoxon sum rank test in the case of skewed data) and chi-squared analysis were used to assess the baseline differences in drain utilization. Unadjusted and adjusted association of drain usage with selected outcomes of interest were assessed using the generalized linear models (GLM) with family Poisson and link log. These relative risk measures were reported as the prevalence ratio (PR) along with the 95% confidence interval (CI). For outcomes of length of stay and operative length, linear regression models were used to assess the unadjusted and adjusted associations of drain usage and further reported using regression coefficients (RC) along with their 95% CI. p values less than 5% were considered statistically significant. All analyses were carried out using STATA V15.

Results

Total Population and Demographics

In 2015–2017, there were 488,460 bariatric cases performed. Of that, 388,239 patients did not have drains (ND) placed and there were 100,221 with drains (WD). Over the study period, the use of drains decreased. In 2015, 36.4% of patients had drains placed; in 2016, it was 33.6%, and by 2017, only 30.0% of patients underwent drainage (Fig. 1). Table 1 shows the demographics and preoperative and operative characteristics of the patients studied. The average age of the patients was 44.9 (standard deviation (SD), 11.9), with patients undergoing drainage having a slightly greater age than ND [45.7 (SD, 11.8) vs 44.8 (SD, 11.9), $p < 0.001$]. Overall, 80% of the patients were female. The most common race was white at 73.3% followed by black or African–American at 17.6% with significant differences between groups ($p < 0.001$). Our study was comprised of a majority of non-Hispanics (78%), with Hispanics being less likely to receive a drain placed (PR, 0.82; 95% CI, 0.81–0.84).

Preoperative Comorbidities and Operative Characteristics in Patients with Drain Placement

Table 1 is a summary descriptive for the entire cohort and lists the preoperative and operative characteristics by WD and ND patients. Preoperative characteristics of patients that were more likely to have drains are listed in detail in Table 1.

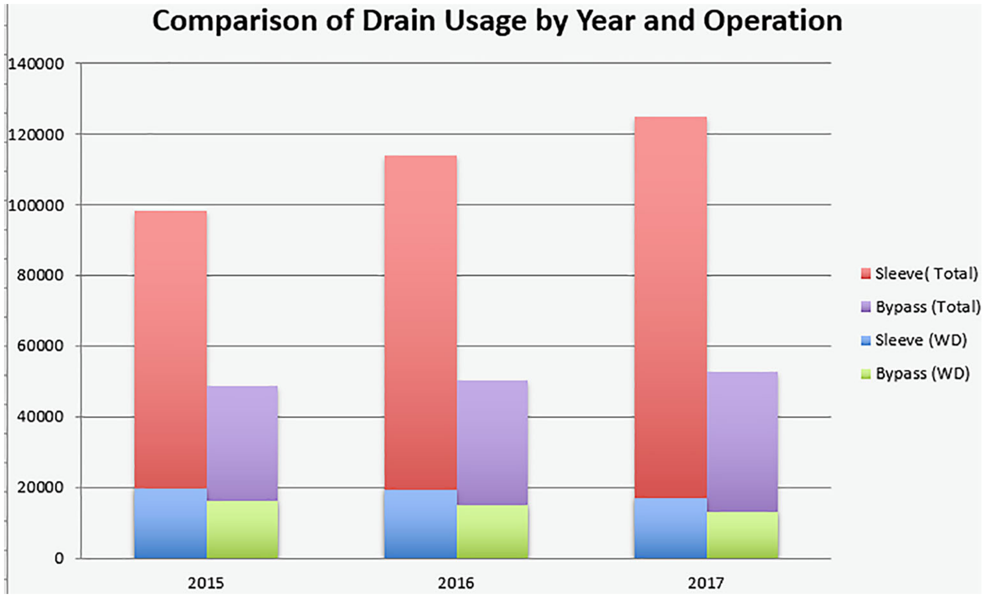
Patients that had a drain placed had longer operative times than patients with no drain (86 min vs 104 min, $p < 0.001$). The laparoscopic approach was the most common (88.7%); 7.0% of patients underwent a robotic-assisted approach, and open surgery was rare with less than 0.1% of patients undergoing this technique, but patients who had open surgery had a higher rate of drain placement (PR 2.16, 95% CI 1.95–2.41, $p < 0.001$) compared to patients who underwent the conventional laparoscopic approach. If the procedure was converted to the open approach, the risk of a drain increased (PR 1.55, 95% CI 1.22–1.97, $p < 0.001$). Patients undergoing staple line reinforcement (SLR) had a decreased risk of having a drain (PR 0.84, 95% CI 0.83–0.85, $p < 0.001$). A swallow study was not performed in 63.8% of patients. WD patients underwent a provocative test to check the anastomosis/staple line more frequently (PR 2.24, 95% CI 2.2–2.29, $p < 0.001$). They also had an increased risk of 1.93 (95% CI 1.91–1.95, $p < 0.001$) for having a swallow study. Only 1.1% of patients still had a drain at 30 days.

Table 2 describes the complications of the ND vs WD patients. Patients who had a drain placed had statistically significant differences in death, readmission, reoperation, reintervention, and serious morbidity, as described by Brethauer et al. [9]. Table 3 describes the outcomes for WD and ND patients when adjusted for patient and operative characteristics. Patients with drains had a higher risk of mortality (PR 1.25, 95% CI 1.01–1.55, $p < 0.038$) and a higher risk of morbidity (PR 1.35, 95% CI 1.30–1.41, $p < 0.001$). WD patients had an increased risk for developing leaks (PR 1.11, 95% CI 1.11,−1.12, $p < 0.001$), and there was a higher risk of readmission (PR 1.13, 95% CI 1.09–1.17, $p < 0.001$) and reoperation (PR 1.18, 95% CI 1.11–1.25, $p < 0\ .001$). Patients who died were more likely to be in the drain group (PR 1.47, 95% CI 1.29–1.69, $p < 0.001$).

Gastric Bypasses Vs Sleeve Gastrectomy

For the study period, 29% LRGYB patients had a drain placed vs 16.7% of SG patients. The risk of having a drain placed in SG was 0.57 (95% CI 0.57–0.58, $p < 0.001$). The percentage of LRYGB that had a drain dropped from 33.1 to 24.6% during the study period. The percentage of SG undergoing drainage dropped from 20.3% in 2015 to 17% in 2016 to 13.6% in 2017. The operative time was longer WD (118 min) compared to ND (110 min, $p < 0.001$). SG patients with drains had a significantly longer operative time (72 min vs 65 min, $p < 0.001$) and were discharged more often on postoperative day 2. Routine swallow studies were performed on LRYGB patients WD 41.9% of the time, compared to 21% of the time in patients ND ($p < 0.001$). Routine swallow studies were performed on SG patients WD 56.7% of the time, compared to 34.5% of the time in patients ND ($p < 0.001$). The anastomosis was also more frequently checked in WD vs ND (93.1% vs 85.9%, $p <$

Fig. 1 Comparison of drain usage by year and operation



0.001). Gastric bypass patients WD had a higher rate of reoperation (PR 1.28) and readmission (PR 1.19). The anastomosis was also more frequently checked in SG WD vs ND (85.9% vs 70.1%, $p < 0.001$). There was no statistically significant difference in death rates between the two groups ($p = 0.99$). Supplemental Table 4 shows complication rates by procedure.

Revisions

Supplemental Table 5 shows the pre- and perioperative characteristics of revisional bariatric patients WD vs ND. Revisions were the third most common operation with 43,913 cases in the study period. Drains were left in 32.8% of cases in 2015, 31.1% in 2016, and 27.7% in 2017. We did not examine the exact type of revisions as this was not one of the main outcomes of this paper but did analyze the cases in the PUF that were listed as revisions. Patients undergoing revisions were more likely to have a routine swallow study (WD 47.8% vs ND 30.6%, $p < 0.001$), have the anastomosis checked more (WD 85.9% vs ND 69.5%), and had a statistically significant increase in the rates of death, reoperation, and readmission ($p < 0.001$).

Discussion

The questions we wanted to answer were what kind of patients get drains placed and why? Our findings indicate patients with higher BMI, serious comorbidities, higher ASA status, and previous foregut surgery, and patients undergoing revisions or conversions were more likely to have a drain placed. Patients that had longer operative times and provocative anastomotic testing were more likely to have a drain placed as well as patients that were converted to open. Once the drain was placed, those patients had a higher rate of swallow studies and longer length of stay. Complications were more likely in the drain group as was the risk of reoperation, readmission, and death. Drainage may reflect the surgeon's intraoperative evaluation of the difficulty of the case or the value assigned to the likelihood of a postoperative complication, but this cannot be proved with the MBSAQIP database. There is also no way to determine from the MBSAQIP database what kind of drain was used. This could range from a simple silastic drain to a closed suction drain. As a suction drain could theoretically cause a leak, this is potentially important information lacking in this dataset.

Our findings show that the use of drains is decreasing with time. This is the largest series published to date looking at the use of abdominal drainage after bariatric surgery. The MBSAQIP database has once again proved an invaluable resource for looking at short-term outcomes in bariatric surgery. The operation that most commonly had drains used were revisions with 30% followed by the LRYGB with 29% of the patients over the 3-year period. SG patients had a lower rate of drainage at 16.7%.

Dourmouras et al. wrote the first analysis of drain usage using the MBSAQIP database. We too found an increased relative risk of complications in patients that had abdominal drainage [8]. They used a regression analysis to look at the five outcomes of interest to come to this conclusion. There was an increased risk of having these outcomes in patients who underwent drainage in their study. As noted in the "Introduction, " they felt that routine abdominal drainage was possibly harmful to the patient, and noted an increased risk of all-cause morbidity, reoperations, and anastomotic leaks. The MBSAQIP database does not have the ability to differentiate between statistical association and causality. A randomized controlled trial would be able to do this, but an

Table 1 Summary descriptive for the entire cohort, and by drain placement

Factor	Entire cohort	Drain placed? No	Drain placed? Yes		
N	488,460	388,239	100,221	PR (95% CI)	*p* value
Demographics					
Age, mean (SD)	44.94 (11.9)	44.75 (11.9)	45.69 (11.8)	1.01 (1, 1.01)	< 0.001
Pre-op BMI closest to bariatric surgery, mean (SD)	44.86 (8.5)	44.76 (8.3)	45.26 (9.2)	1.01 (1, 1.01)	< 0.001
Pre-op albumin lab value, mean (SD)	3.66 (1.3)	3.67 (1.2)	3.61 (1.3)	0.97 (0.97, 0.97)	< 0.001
Pre-op hematocrit lab value, mean (SD)	39.45 (8.1)	39.58 (7.8)	38.95 (9.3)	0.99 (0.99, 0.99)	< 0.001
Sex					0.002
Female	390,788 (80.0%)	310,961 (80.1%)	79,827 (79.7%)	Reference	
Male	97,672 (20.0%)	77,278 (19.9%)	20,394 (20.3%)	1.02 (1.01, 1.04)	
Race					< 0.001
American Indian or Alaska Native	1891 (0.4%)	1563 (0.4%)	328 (0.3%)	Reference	
Asian	2305 (0.5%)	1884 (0.5%)	421 (0.4%)	1.05 (0.92, 1.2)	0.439
Black or African American	85,824 (17.6%)	68,940 (17.8%)	16,884 (16.8%)	1.13 (1.03, 1.25)	0.013
Native Hawaiian or other Pacific Islander	1319 (0.3%)	1082 (0.3%)	237 (0.2%)	1.04 (0.89, 1.21)	0.648
Unknown/not reported	38,977 (8.0%)	31,883 (8.2%)	7094 (7.1%)	1.05 (0.95, 1.16)	0.349
White	358,144 (73.3%)	282,887 (72.9%)	75,257 (75.1%)	1.21 (1.1, 1.34)	< 0.001
Hispanic ethnicity					< 0.001
No	382,118 (78.2%)	303,294 (78.1%)	78,824 (78.7%)	Reference	
Unknown	46,862 (9.6%)	35,587 (9.2%)	11,275 (11.3%)	1.17 (1.15, 1.19)	
Yes	59,480 (12.2%)	49,358 (12.7%)	10,122 (10.1%)	0.82 (0.81, 0.84)	
Operation info					
Operation length (min), median (IQR)	79.00 (56.00, 113.00)	76.00 (55.00, 108.00)	89.00 (60.00, 130.00)	1 (1, 1)	< 0.001
Operation length (min), mean (SD)	89.61 (51.2)	85.88 (47.48)	104.07 (61.49)		< 0.001
Days to discharge from hospital admit, median (IQR)	2.00 (1.00, 2.00)	2.00 (1.00, 2.00)	2.00 (1.00, 2.00)	1.04 (1.03, 1.04)	< 0.001
Year of operation					< 0.001
2015	146,768 (30.0%)	110,744 (28.5%)	36,024 (35.9%)	Reference	
2016	163,987 (33.6%)	129,719 (33.4%)	34,268 (34.2%)	0.85 (0.84, 0.86)	< 0.001
2017	177,705 (36.4%)	147,776 (38.1%)	29,929 (29.9%)	0.69 (0.68, 0.7)	< 0.001
Procedure					< 0.001
Bypass	151,562 (31.0%)	107,565 (27.7%)	43,997 (43.9%)	Reference	
Sleeve	336,898 (69.0%)	280,674 (72.3%)	56,224 (56.1%)	0.57 (0.57, 0.58)	
Revision/conversion flag					< 0.001
No	444,547 (91.0%)	357,465 (92.1%)	87,082 (86.9%)	Reference	
Yes	43,913 (9.0%)	30,774 (7.9%)	13,139 (13.1%)	1.53 (1.5, 1.55)	
Procedure converted to another approach					< 0.001
No	487,288 (99.8%)	387,537 (99.8%)	99,751 (99.5%)	Reference	
Yes	1172 (0.2%)	702 (0.2%)	470 (0.5%)	1.96 (1.83, 2.1)	
If approach was converted, what was the final operative approach?					< 0.001
Conventional laparoscopic (thoracoscopic)	160 (13.65)	109 (15.53)	51 (10.85)	Reference	
Hand assisted	13 (1.11)	7 (1)	6 (1.28)	1.45 (0.77, 2.72)	0.249
Laparoscopic assisted (thoracoscopic assisted)	33 (2.82)	24 (3.42)	9 (1.91)	0.86 (0.47, 1.56)	0.611
Open	772 (65.87)	390 (55.56)	382 (81.28)	1.55 (1.22, 1.97)	< 0.001
Robotic assisted	160 (13.65)	149 (21.23)	11 (2.34)	0.22 (0.12, 0.4)	< 0.001
Single incision	34 (2.9)	23 (3.28)	11 (2.34)	1.01 (0.59, 1.74)	0.957
Surgical approach					< 0.001
Conventional laparoscopic (thoracoscopic)	433,354 (88.7%)	342,836 (88.3%)	90,518 (90.3%)	Reference	
Hand assisted	296 (0.1%)	238 (0.1%)	58 (0.1%)	0.94 (0.74, 1.18)	0.587
Laparoscopic assisted (thoracoscopic assisted)	17,037 (3.5%)	13,650 (3.5%)	3387 (3.4%)	0.95 (0.92, 0.98)	0.002
N.O.T.E.S. (natural orifice transluminal endoscopic surgery)	1531 (0.3%)	1285 (0.3%)	246 (0.2%)	0.77 (0.69, 0.86)	< 0.001
Open	418 (0.1%)	229 (0.1%)	189 (0.2%)	2.16 (1.95, 2.41)	< 0.001
Robotic assisted	34,372 (7.0%)	28,713 (7.4%)	5659 (5.6%)	0.79 (0.77, 0.81)	< 0.001
Single incision	1452 (0.3%)	1288 (0.3%)	164 (0.2%)	0.54 (0.47, 0.62)	< 0.001
First assist training level					< 0.001
Attending—other	26,853 (5.5%)	18,855 (4.9%)	7998 (8.0%)	Reference	
Attending—weight loss surgeon	74,886 (15.3%)	57,908 (14.9%)	16,978 (16.9%)	0.76 (0.74, 0.78)	< 0.001
Minimally invasive surgery fellow	43,562 (8.9%)	35,000 (9.0%)	8562 (8.5%)	0.66 (0.64, 0.68)	< 0.001
None (no assist or scrub tech/RN only)	71,667 (14.7%)	56,275 (14.5%)	15,392 (15.4%)	0.72 (0.7, 0.74)	< 0.001
	184,555 (37.8%)	146,782 (37.8%)	37,773 (37.7%)	0.69 (0.67, 0.7)	< 0.001

Table 1 (continued)

Factor	Entire cohort	Drain placed? No	Drain placed? Yes		
Physician assistant/nurse practitioner/registered nurse first assist					
Resident (PGY 1–5+)	86,937 (17.8%)	73,419 (18.9%)	13,518 (13.5%)	0.52 (0.51, 0.53)	< 0.001
Emergency case					< 0.001
No	486,357 (99.6%)	386,787 (99.6%)	99,570 (99.4%)	Reference	
Yes	2103 (0.4%)	1452 (0.4%)	651 (0.6%)	1.51 (1.42, 1.61)	
Sleeve staple line reinforcement					< 0.001
No	111,148 (22.8%)	90,345 (23.3%)	20,803 (20.8%)	Reference	
Yes	225,745 (46.2%)	190,326 (49.0%)	35,419 (35.3%)	0.84 (0.83, 0.85)	< 0.001
Unknown	151,567 (31.0%)	107,568 (27.7%)	43,999 (43.9%)	1.55 (1.53, 1.57)	< 0.001
Stapling procedure					< 0.001
No	10,869 (2.2%)	9205 (2.4%)	1664 (1.7%)	Reference	
Yes	477,589 (97.8%)	379,032 (97.6%)	98,557 (98.3%)	1.35 (1.29, 1.41)	< 0.001
Unknown	2 (< 1%)	2 (< 1%)	0 (0.0%)	0 (0, 0)	< 0.001
Sleeve over sew					< 0.001
No	262,316 (53.7%)	223,336 (57.5%)	38,980 (38.9%)	Reference	
Yes	74,577 (15.3%)	57,335 (14.8%)	17,242 (17.2%)	1.56 (1.53, 1.58)	< 0.001
Unknown	151,567 (31.0%)	107,568 (27.7%)	43,999 (43.9%)	1.95 (1.93, 1.98)	< 0.001
Discharge destination					< 0.001
Expired	165 (< 1%)	103 (< 1%)	62 (0.1%)	Reference	
Facility which was home	521 (0.1%)	396 (0.1%)	125 (0.1%)	0.64 (0.5, 0.82)	< 0.001
Home	485,854 (99.5%)	386,429 (99.5%)	99,425 (99.2%)	0.54 (0.45, 0.66)	< 0.001
Rehab	315 (0.1%)	198 (0.1%)	117 (0.1%)	0.99 (0.77, 1.26)	0.926
Separate acute care	403 (0.1%)	308 (0.1%)	95 (0.1%)	0.63 (0.48, 0.82)	0.001
Skilled care, not home	629 (0.1%)	379 (0.1%)	250 (0.2%)	1.06 (0.85, 1.32)	0.615
Unknown	309 (0.1%)	174 (< 1%)	135 (0.1%)	1.16 (0.92, 1.47)	0.206
Unskilled facility not home	264 (0.1%)	252 (0.1%)	12 (< 1%)	0.12 (0.07, 0.22)	< 0.001
Operative drain still present at 30 days					< 0.001
No	486,947 (99.7%)	387,868 (99.9%)	99,079 (98.9%)		
Yes	1513 (0.3%)	371 (0.1%)	1142 (1.1%)		
Drain placed at the time of the initial operation					
No	388,239 (79.5%)				
Yes	100,221 (20.5%)				

SD standard deviation, *PR* prevalence ratio, *CI* confidence interval, *GERD* gastroesophageal reflux disease, *PE* pulmonary embolism, *ASA* American Society of Anesthesiologists, *IQR* interquartile range, *UTI* urinary tract infection, *ICU* intensive care unit, *PCI* previous percutaneous coronary intervention, *COPD* chronic obstructive pulmonary disease, *IVC* inferior vena cava filter, MI myocardial infarction

observational trial can only outline an association. However, the conclusions we draw from this data provided by the MBSAQIP are very different. An alternate view, espoused by the authors of this study, is that drains were used selectively in what surgeons perceived as high-risk patients. This of course leads to a selection bias, which can make it appear as if drains are the problem. But some patients without drains still developed leaks and other complications. Although patients in the ND group still had routine and selective swallow studies postoperatively, there was a PR of 1.9 and 1.8, respectively, for the WD group. WD patients also had a more than double rate of having a provocative leak test (PR = 2.24). While the MBSAQIP database does not provide the granularity to examine individual surgeon preferences, we feel it is a safe inference that those surgeons were worried enough to perform not only a provocative test at the time of the operation on patients they drained, but also to order a swallow study postoperative. Thus, it is reasonable based on these findings, to draw the opposite conclusion from the previous authors, namely that the drain is a "symptom" of a higher-risk patient, not a "cause" of complications and increased morbidity.

The MBSAQIP database was also studied by Alizadeh et al. regarding the risk factors for gastrointestinal leak after bariatric surgery. They used the 2015 PUF and looked at SG and GB patients. Among other risk factors, patients with a drain had a higher leak rate of 1.6% vs. 0.4% in patients with no drain [10]. They noted the association of leakage to drain placement and provocative testing with an adjusted prevalence ratio (APR) of 3.46 and 1.41, respectively. They felt the provocative testing could have been performed in an aggressive manner with a nasogastric tube, thereby causing the leak, and preferred using an endoscope. There is no way to tease this data out of the PUF, as the technique used is not specified. Alizadeh et al. felt the APR for leaks with drainage was likely a selection bias, which is supported by the current paper.

Table 2 Postoperative complications

		Drain placed?			
	Entire cohort 488,460	No 388,239	Yes 100,221	PR (95% CI)	*p* value
Outcome					
Swallow study performed day of or day after procedure					< 0.001
No	311,506 (63.8%)	263,647 (67.9%)	47,859 (47.8%)	Reference	
Yes, routine	169,644 (34.7%)	119,360 (30.7%)	50,284 (50.2%)	1.93 (1.91, 1.95)	
Yes, selective	7310 (1.5%)	5232 (1.3%)	2078 (2.1%)	1.85 (1.78, 1.92)	
Swallow study performed day of or day after procedure					< 0.001
No	311,506 (63.77)	263,647 (67.91)	47,859 (47.75)	Reference	
Yes	176,954 (36.23)	124,592 (32.09)	52,362 (52.25)	1.93 (1.91, 1.95)	
Death during operation (intra-op death) or post-op death within 30 days of procedure					< 0.001
No	487,967 (99.9%)	387,895 (99.9%)	100,072 (99.9%)	Reference	
Yes	493 (0.1%)	344 (0.1%)	149 (0.1%)	1.47 (1.29, 1.69)	
At least one reoperation within 30 days of op					< 0.001
No	481,482 (98.6%)	383,186 (98.7%)	98,296 (98.1%)	Reference	
Yes	6978 (1.4%)	5053 (1.3%)	1925 (1.9%)	1.35 (1.3, 1.4)	
At least one readmission within 30 days of op					< 0.001
No	468,239 (95.9%)	373,119 (96.1%)	95,120 (94.9%)	Reference	
Yes	20,221 (4.1%)	15,120 (3.9%)	5101 (5.1%)	1.24 (1.21, 1.27)	
At least one intervention within 30 days of op					< 0.001
No	481,134 (98.5%)	382,965 (98.6%)	98,169 (98.0%)	Reference	
Yes	7326 (1.5%)	5274 (1.4%)	2052 (2.0%)	1.37 (1.32, 1.42)	
Morbidity					< 0.001
No	474,293 (97.1%)	378,405 (97.5%)	95,888 (95.7%)	Reference	
Yes	14,167 (2.9%)	9834 (2.5%)	4333 (4.3%)	1.51 (1.47, 1.55)	
Unplanned admission to ICU within 30 days					< 0.001
No	484,750 (99.2%)	385,676 (99.3%)	99,074 (98.9%)		
Yes	3710 (0.8%)	2563 (0.7%)	1147 (1.1%)		
Number of post-op deep incisional SSI					< 0.001
0	488,065 (99.9%)	388,021 (99.9%)	100,044 (99.8%)		
1+	395 (0.1%)	218 (0.1%)	177 (0.2%)		
Deep incisional SSI PATOS					< 0.001
No	488,434 (100.0%)	388,229 (100.0%)	100,205 (100.0%)		
Yes	26 (< 1%)	10 (< 1%)	16 (< 1%)		
Intra-op or post-op myocardial infarction					0.48
No	488,302 (100.0%)	388,117 (100.0%)	100,185 (100.0%)		
Yes	158 (< 1%)	122 (< 1%)	36 (< 1%)		
Number of on ventilator > 48 h occurrences					< 0.001
0	488,003 (99.9%)	387,935 (99.9%)	100,068 (99.8%)		
1+	457 (0.1%)	304 (0.1%)	153 (0.2%)		
Ventilator > 48 h PATOS					< 0.001
No	488,439 (100.0%)	388,230 (100.0%)	100,209 (100.0%)		
Yes	21 (< 1%)	9 (< 1%)	12 (< 1%)		
Number of post-op organ/ space SSI occurrences					< 0.001
0	487,029 (99.7%)	387,340 (99.8%)	99,689 (99.5%)		
1+	1431 (0.3%)	899 (0.2%)	532 (0.5%)		

Table 2 (continued)

	Entire cohort 488,460	Drain placed? No 388,239	Drain placed? Yes 100,221	PR (95% CI)	*p* value
Organ/space SSI PATOS					< 0.001
No	488,309 (100.0%)	388,190 (100.0%)	100,119 (99.9%)		
Yes	151 (< 1%)	49 (< 1%)	102 (0.1%)		
Number of post-op pneumonia occurrences					< 0.001
0	487,306 (99.8%)	387,466 (99.8%)	99,840 (99.6%)		
1+	1154 (0.2%)	773 (0.2%)	381 (0.4%)		
Pneumonia PATOS					< 0.001
No	488,422 (100.0%)	388,219 (100.0%)	100,203 (100.0%)		
Yes	38 (< 1%)	20 (< 1%)	18 (< 1%)		
Peripheral nerve injury					0.23
No	488,433 (100.0%)	388,215 (100.0%)	100,218 (100.0%)		
Yes	27 (< 1%)	24 (< 1%)	3 (< 1%)		
Progressive renal insufficiency					< 0.001
No	488,129 (99.9%)	388,019 (99.9%)	100,110 (99.9%)		
Yes	331 (0.1%)	220 (0.1%)	111 (0.1%)		
Pulmonary embolism					< 0.001
No	487,910 (99.9%)	387,834 (99.9%)	100,076 (99.9%)		
Yes	550 (0.1%)	405 (0.1%)	145 (0.1%)		
Number of post-op sepsis occurrences					< 0.001
0	487,754 (99.9%)	387,797 (99.9%)	99,957 (99.7%)		
1+	706 (0.1%)	442 (0.1%)	264 (0.3%)		
Sepsis PATOS					< 0.001
No	488,376 (100.0%)	388,217 (100.0%)	100,159 (99.9%)		
Yes	84 (< 1%)	22 (< 1%)	62 (0.1%)		
Number of post-op septic shock occurrences					< 0.001
0	488,074 (99.9%)	387,982 (99.9%)	100,092 (99.9%)		
1+	386 (0.1%)	257 (0.1%)	129 (0.1%)		
Septic shock PATOS					< 0.001
No	488,406 (100.0%)	388,218 (100.0%)	100,188 (100.0%)		
Yes	54 (< 1%)	21 (< 1%)	33 (< 1%)		
Number of post-op superficial incisional SSI					< 0.001
0	486,113 (99.5%)	386,686 (99.6%)	99,427 (99.2%)		
1+	2347 (0.5%)	1553 (0.4%)	794 (0.8%)		
Superficial incisional SSI PATOS					0.021
No	488,424 (100.0%)	388,216 (100.0%)	100,208 (100.0%)		
Yes	36 (< 1%)	23 (< 1%)	13 (< 1%)		
Transfusion intra-op/post-op (72 h of surgery start time)					< 0.001
No	484,870 (99.3%)	385,787 (99.4%)	99,083 (98.9%)		
Yes	3590 (0.7%)	2452 (0.6%)	1138 (1.1%)		
Number of units transfused (1–200), median (IQR)	0.06 (0.46)	0.05 (0.44)	0.08 (0.53)		< 0.001
Number of units transfused (1–200)					< 0.001
0	145,602 (29.8%)	110,009 (28.3%)	35,593 (35.5%)		
1	727 (0.1%)	505 (0.1%)	222 (0.2%)		
2	1798 (0.4%)	1232 (0.3%)	566 (0.6%)		
3+	1052 (0.2%)	707 (0.2%)	345 (0.3%)		
Unknown	339,281 (69.5%)	275,786 (71.0%)	63,495 (63.4%)		

Table 2 (continued)

	Entire cohort 488,460	Drain placed? No 388,239	Yes 100,221	PR (95% CI)	*p* value
Unplanned intubation					< 0.001
No	487,694 (99.8%)	387,701 (99.9%)	99,993 (99.8%)		
Yes	766 (0.2%)	538 (0.1%)	228 (0.2%)		
Number of post-op UTI occurrences					< 0.001
0	486,656 (99.6%)	386,868 (99.6%)	99,788 (99.6%)		
1+	1804 (0.4%)	1371 (0.4%)	433 (0.4%)		
Urinary tract infection PATOS					0.25
No	488,312 (100.0%)	388,127 (100.0%)	100,185 (100.0%)		
Yes	148 (< 1%)	112 (< 1%)	36 (< 1%)		
Post-op vein thrombosis requiring therapy					0.095
No	487,578 (99.8%)	387,558 (99.8%)	100,020 (99.8%)		
Yes	882 (0.2%)	681 (0.2%)	201 (0.2%)		
Wound disruption					0.84
No	488,184 (99.9%)	388,021 (99.9%)	100,163 (99.9%)		
Yes	276 (0.1%)	218 (0.1%)	58 (0.1%)		
Unplanned admission to ICU within 30 days					< 0.001
No	484,750 (99.2%)	385,676 (99.3%)	99,074 (98.9%)		
Yes	3710 (0.8%)	2563 (0.7%)	1147 (1.1%)		
Acute renal failure					< 0.001
No	488,092 (99.9%)	387,992 (99.9%)	100,100 (99.9%)		
Yes	368 (0.1%)	247 (0.1%)	121 (0.1%)		
Intra-op or post-op cardiac arrest requiring CPR					0.027
No	488,246 (100.0%)	388,082 (100.0%)	100,164 (99.9%)		
Yes	214 (< 1%)	157 (< 1%)	57 (0.1%)		
Coma > 24 h					0.58
No	488,449 (100.0%)	388,231 (100.0%)	100,218 (100.0%)		
Yes	11 (< 1%)	8 (< 1%)	3 (< 1%)		
Stroke/cerebrovascular accident					0.81
No	488,405 (100.0%)	388,196 (100.0%)	100,209 (100.0%)		
Yes	55 (< 1%)	43 (< 1%)	12 (< 1%)		

PR prevalence ratio, *CI* confidence interval, *IQR* interquartile range, *UTI* urinary tract infection, *ICU* intensive care unit, *SSI* skin and soft tissue infection, *PATOS* present at time of surgery, *MI* myocardial infarction, *CPR* cardiopulmonary resuscitation

So, what is the benefit of drainage? This data, and the referenced literature, do not show a clear benefit. Drains can be used to detect bleeding and also leaks. Some surgeons have advocated sending the drain fluid for amylase, which has been shown to be sensitive for a leak [11]. Others recommend having the patient drink methylene blue and assessing the drain output for any blue discoloration [12]. Postoperative hemorrhage can also be detected by intra-abdominal drainage [13]. Drains may facilitate early detection of leak or bleeding, leading to a shorter time for definitive surgical care. Bariatric surgeons must be ever vigilant to these complications and should not be distracted by the presence or absence of a drain and must be careful to evaluate the entire clinical picture. In cases of uncertainty and/or an unstable patient, prompt operative exploration is paramount.

Gastric Bypass and Drains

The use of drains over the study period in patients undergoing gastric bypass decreased over time. We found that the significant complications that occurred were consistent throughout the study period despite the decrease in drainage. Routine drainage after LRYGB has been demonstrated as unnecessary. There are multiple reports in the literature that show drainage is not useful for detecting leaks, and some authors recommend abandoning drains altogether. Kavuturu et al. published results

Table 3 Adjusted associations

	Entire cohort (n = 392,135) PR (95% CI), p value	Sleeve* (n = 271, 654) PR (95% CI), p value	Bypass (n = 120,546) PR (95% CI), p value	Conversion (n = 35,187) PR (95% CI), p value
LOS: RC (95% CI)	0.35 (0.34, 0.37) < 0.001	0.22 (0.21, 0.24) < 0.001	0.52 (0.49, 0.55) < 0.001	0.78 (0.71, 0.85) < 0.001
Operation length: RC (95% CI)	10.29 (9.96, 10.62) < 0.001	8.58 (8.22, 8.93) < 0.001	10.65 (9.96, 11.33) < 0.001	21.96 (20.53, 23.39) < 0.001
Mortality	1.25 (1.01, 1.55) 0.038	1 (0.69, 1.44) 0.995	1.48 (1.12, 1.95) 0.005	1.37 (0.85, 2.2) 0.192
Morbidity	1.35 (1.3, 1.41) < 0.001	1.2 (1.12, 1.28) < 0.001	1.47 (1.4, 1.54) < 0.001	1.82 (1.67, 1.98) < 0.001
Swallow study	1.62 (1.6, 1.63) < 0.001	1.52 (1.5, 1.53) < 0.001	1.85 (1.82, 1.89) < 0.001	1.55 (1.51, 1.59) < 0.001
Leak	1.11 (1.11, 1.12) < 0.001	1.18 (1.17, 1.18) < 0.001	1.04 (1.04, 1.04) < 0.001	1.09 (1.08, 1.1) < 0.001
Readmission	1.13 (1.09, 1.17) < 0.001	1.1 (1.04, 1.16) 0.001	1.15 (1.1, 1.21) < 0.001	1.26 (1.16, 1.37) < 0.001
Intervention	1.19 (1.13, 1.26) < 0.001	1.12 (1.02, 1.23) 0.023	1.28 (1.19, 1.37) < 0.001	1.6 (1.42, 1.81) < 0.001
Reoperation	1.18 (1.11, 1.25) < 0.001	1.15 (1.04, 1.27) 0.008	1.19 (1.11, 1.28) < 0.001	1.4 (1.25, 1.58) < 0.001

Adjusted for age, body mass index, albumin, hematocrit, gender, race, Hispanic, diabetes, preoperative hypertension, gastroesophageal reflux disease, hyperlipidemia, history of pulmonary embolism, pulmonary embolism, sleep apnea, smoker, steroid use, American Society of Anesthesiologists classification, myocardial infarction all history, percutaneous coronary intervention, previous percutaneous coronary intervention, hypertensive meds, history of deep vein thrombosis, therapeutic anticoagulation, previous surgery, functional health status, chronic obstructive pulmonary disease, oxygen dependent, inferior vena cava filter, operative year, procedure type, surgical approach, assistant training level, priority, *staple line reinforcement, stapling procedure*, *oversew. (* = indicates variables only adjusted in sleeve procedures)

PR prevalence ratio, *CI* confidence interval, *RC* regression coefficient, *LOS* length of stay

of 272 patients with drainage vs 483 patients without and found no benefit in leak detection by routine drainage [14]. Computed tomography was found to be more useful than any other modality for detecting leaks. Regardless of these findings, the overall clinical picture of the patient is paramount to the prompt recognition and treatment of any complication. Rare complications, such as small bowel obstruction, directly caused by drains were also reported in their paper. Those reported results were regarding routine drain placement, but selected usage of drains may be necessary in some cases. Other authors have reached the same conclusions [15, 16]. Our findings support this, but one limitation of the MBSAQIP PUF is that although swallow studies have an option of "no," "yes routine," or "yes selective," the options for drain placement are a "yes" and "no" choice. If surgeons had the same option for drains, this could clarify what is selection bias for high-risk patients vs drainage that is routinely performed in all cases for that specific surgeon. With data accumulated on 488,000 patients, the question on drainage could be answered definitively.

Gastric Sleeve and Drains

Sleeves are now the most commonly performed bariatric operation in the USA. In the 2015–2017 PUF data, SG made 69% of all bariatric cases. There was a decrease in the rate of drainage in SG patients over the 3-year period. Drain placement had a lower rate in SG patients vs LRYGB patients with an overall rate of 16.7% vs 29% over the 3-year study period. SG patients with SLR had a lower risk of having a drain placed, which may indicate that the surgeons using SLR are less concerned about complications. The complications that were statistically significant were consistent in the study period, similar to what was found in the LRYGB patients.

The specific question of whether drains are useful to facilitate detection of leaks or bleeding after SG was studied by Curro et al. They examined 100 SG patients with intra-abdominal drainage and nasogastric drainage and 100 patients without. They found no difference between the groups [17]. This study is limited by its small sample size but adds to the growing body of literature. Albanopoulos et al. also studied drainage in primary and revisional SG. They found that in primary SG, the drain did not aid in the detection of a leak, an abscess, or bleeding but that drains may be helpful in patients undergoing conversion of lap banding to SG [18].

Revisions and Drains

The rate of drainage in revisions in the MBSAQIP was essentially equivalent to the rate of drainage in LRYGB but remained more consistent over the study period. An interesting finding about these cases is that patients undergoing revisions had a higher rate of anastomotic provocative testing and postoperative studies. These patients also had higher complication rates. Drainage in these cases may indicate that the reason for the drain is surgeon concern. The drain was left in response to this and is probably not the cause of morbidity.

Limitations and Strengths

There are several limitations to this study. The MBSAQIP database is subject to variations in data collection and reporting and may have incomplete or missing data. It only captures data from accredited bariatric centers and therefore may not accurately depict the true incidence of complications in the whole population of bariatric patients. The database is non-randomized, so the comparison is retrospective between cohorts. Also, individual surgeon outcomes are not obtainable from this database, and there is no way to account for the variable results of different accredited centers. This is an especially glaring limitation regarding the questions of drains. We can infer that surgeons left drains in higher-risk patients, but there may be a sizeable percentage of surgeons who routinely leave drains. The strength of this study is the size of this database. It spans 2 countries and collects data on all accredited centers. The data collection process is validated and less subject to bias. The size of our patient population allows some generalizability to the bariatric population at large. We also included emergency cases (n = 2104). This may have skewed our results, but considering that emergency cases only made up 0.43% of the total, it would likely have a small effect.

Conclusions

Drains are still commonly used in bariatric patients. Over the study period, there was a slight decrease in the use of drains in both gastric bypass and sleeve gastrectomy patients. Patients with a drain were more likely to have had a provocative test and a swallow study. They were also more likely to have a readmission, reoperation, or death. The increase in complications in patients with drains does not imply causality, and these results should be interpreted with that in mind.

Compliance with Ethical Standards

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

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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