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ORIGINAL CONTRIBUTIONS

Gastroesophageal Reflux Predicts Utilization of Dehydration Treatments After Bariatric Surgery

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Abstract

Background Dehydration treatments (DT) provide intravenous fluids to patients in the outpatient setting; however, the utilization of DT is not well-described. We characterize the cohort receiving DT, the first year it was recorded in a bariatric-specific database.

Setting A retrospective cohort analysis of patients undergoing bariatric surgery between January 1, 2016, and December 31, 2016, in 791 centers in the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program data file.

Methods Patients ≥ 18 years with a body mass index (BMI) ≥ 35 kg/m^2 who underwent laparoscopic adjustable gastric band (LAGB), sleeve gastrectomy (LSG), Roux-en-Y gastric bypass (LRYGB), and biliopancreatic diversion with duodenal switch (LBPD/DS) were identified. Unadjusted and adjusted rates of DT were analyzed. In addition, adjusted rates and indication for readmission were reviewed.

Results The overall rate of dehydration treatments was 3.5% for the 141,748 bariatric surgery cases identified. Patient comorbidities of gastroesophageal reflux (GERD) (odds ratio (OR) 1.49; 95% CI, 1.40–1.59), insulin-dependent diabetes (OR = 1.19; 95% CI, 1.07–1.33), and LRYGB (OR = 1.45; 95% CI, 1.36–1.54) were associated with higher odds of DT. DT only had the highest odds of readmission (OR = 6.22; 95% CI, 5.55–6.98) compared to other outpatient visits. Nausea and vomiting, or fluid, electrolyte, or nutritional depletion was the most common indication for readmission in all groups.

Conclusions Patients with GERD utilized dehydration treatments after bariatric surgery. DT was highly associated with readmissions, and a better understanding of the clinical application of DT will allow bariatric centers to develop programs to further optimize outpatient treatments.

Keywords Gastroesophageal reflux · Diabetes · Dehydration treatments · Bariatric surgery · Readmission · Outpatient visits · Gastric bypass · Duodenal switch

Introduction

The Hospital Readmissions Reduction Program introduced by the Centers for Medicare and Medicaid Services in 2012 reduced reimbursement to hospitals with high readmission rates [1]. Prevention of unplanned readmission was the focus of quality improvement programs [2–4] with the challenge to decrease readmission rates that range from 4.4 to 5.3% [5–8]. Strategies to reduce unplanned readmissions after surgery emphasize coordinated, safe, and efficient care for patients. Goldfield described four benchmarks to prevent readmission: (1) exceptional inpatient care, (2) appropriate discharge planning, (3) coordination of care between inpatient and outpatient centers, and (4) adequate outpatient follow-up [9].

The Decreasing Readmissions through Opportunities Provided (DROP) program applied these tenets to improve patient education, create standardized inpatient care pathways, and coordinate care after discharge [2]. Specifically, pathways focused on fluid management, access to outpatient services, and 23-h stays for dehydration [2]. In July 2014, the initial

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implementation of DROP included 128 bariatric centers with an average readmission rate of 4.79%. Readmission at these centers decreased by 14% within 6 months, and further implementation of this initiative was enacted in July 2015 [10].

DT is an opportunity to identify patients who required outpatient care and mitigate a preventable readmission. Limited information exists about the cohort that utilized DT, including incidence and risk factors. DT was first recorded in the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) data file in 2016. The objective of this study is to describe the group of patients who utilized DT after primary bariatric surgery. Furthermore, the association of DT and readmission has not been described.

Methods

Data Source and Population

After Institutional Review Board approval, a retrospective review of prospectively collected data was conducted using the 2016 MBSAQIP participant use data file (PUF). This is a multi-institutional dataset including data on patient characteristics, operative details, and 30-day outcomes from 791 participating sites with 186,772 cases collected between January 1, 2016, and December 31, 2016. The readmission data file was linked by case identification number for information regarding indication for readmission, days from operation, days from discharge, and length of stay (LOS) for readmission.

Patients included in the cohort were ≥ 18 years of age with BMI ≥ 35 kg/m^2 and underwent primary laparoscopy using Current Procedural Technology (CPT) codes: laparoscopic adjustable gastric band (LAGB) (43770), laparoscopic sleeve gastrectomy (LSG) (43775), and LRYGB (43644, 43645) with modifier of approach to include laparoscopy: conventional laparoscopy, laparoscopic-assisted, and robotic-assisted. Laparoscopic biliopancreatic diversion with duodenal switch (LBPD/DS) was included and defined by CPT 43845 and laparoscopic approach similar to a previous study with LSG [11]. Procedures were performed by a general surgeon or metabolic and bariatric surgeon.

One hundred twenty-eight patients were excluded from the cohort for death < 30 days. These patients likely were seriously ill or had a catastrophic event after surgery and are not the group of patients represented in a study to examine outpatient care. Also, erroneous values, example LOS > 30 days, were excluded.

Variable Definitions

Characteristics compared were sex, age, race, ethnicity, and comorbid conditions: gastroesophageal reflux disease (GERD), history of myocardial infarction (MI), hypertension, BMI, renal insufficiency, therapeutic anticoagulation, diabetes, smoking status, functional health status, chronic obstructive pulmonary disease (COPD), and chronic steroids. Intraoperative variables included assistant training level, conversion to open approach, American Society of Anesthesiologists (ASA) class, transfusion, and LOS. Subgroups created for the training level of assistant were attending (other and weight loss surgeon), trainee (resident PGY 1–5+ and minimally invasive fellow), and physician assistant (PA)/scrub (no assist or scrub tech/RN only and PA/nurse practitioner/registered nurse first assist). Age, BMI, and LOS were analyzed both as continuous and as categorical variables.

Outcomes and Modeling

The primary outcome was DT and defined as outpatient treatment providing intravenous fluids to treat nausea, vomiting, or fluid or nutritional deficiencies < 30 days after surgery. Secondary outcomes were LOS, number of DT, emergency department visit (EDV), number of EDV, readmission, and indication for readmission. EDV was an evaluation in the ED < 30 days after surgery that did not result in admission to an acute care center. Readmission was as an inpatient acute care bed within 30 days of index surgery or outpatient care that covered two midnights.

Statistical Analysis

Demographics, comorbid conditions, operative technique, and postoperative variables were considered for two separate comparisons. First, the DT group was compared to the group that did not receive DT (NoDT). Next, the cohort with a 30-day all-cause readmission was contrasted to those without readmission. Continuous variables were compared using Student's t tests for normally distributed variables and Kruskal–Wallis for variables that were not normally distributed. Categorical variables were compared using Pearson's chi-square tests or Fisher's exact tests for small groups.

A covariate-adjusted analysis of DT and readmission was performed with clinically relevant variables for each outcome. Factors included in the dehydration model were sex, age, race, Hispanic, BMI groups, ASA class, GERD, hypertension, renal insufficiency, diabetes, functional health status, assistant training level, approach converted, type of surgery, prolonged LOS, and transfusion. Prolonged LOS was defined as > 4 days to incorporate the average 4.1 days LOS after LBPD/DS [12]. Due to clinical relevance and previous research [5, 7, 13, 14], the readmission analysis also included smoking history, COPD, history of MI, chronic steroids, and therapeutic anticoagulation. In addition, a subgroup of outpatient visits was described as no visit, DT, EDV, or both (DT + EDV). LSG has low morbidity and increased frequency of use and was the reference procedure for the analysis. Backward elimination procedures were used to select the key variables in prediction of each of the two models. Logistic regression was performed with a Bonferroni correction for multiple testing. The inclusion criterion for the risk factors in these models was $P < .05$. Analysis was performed with SAS version 9.4 (SAS Institute, Cary, NC).

Results

From January 1, 2016, to December 31, 2016, 141,756 primary, laparoscopic bariatric surgery cases in the MBSAQIP data file met the inclusion criteria. The cohort consisted of 100,203 LSG (70.7%), 37,950 LRYGB (26.8%), 2521 LAGB (1.8%), and 1074 LBPD/DS (0.8%) (sFig. 1). Furthermore, 4968 (3.5%) patients received DT.

Dehydration Treatment

Unadjusted demographics and baseline characteristics of patients who received DT are shown in Table 1. The mean age was 41.8 years ± 11.5 years compared to 44.6 ± 11.9 years in the NoDT group ($P < .001$). Adjusted analysis showed that a preoperative diagnosis of GERD was associated with DT (odds ratio (OR) = 1.49; 95% confidence interval (CI), 1.40 to 1.59) (Table 2). Additional factors that increased odds of DT were age, female, Black, non-Hispanic, hypertension, diabetes, and training level of the assistant. LRYGB had a higher likelihood of DT (OR 1.45; 95% CI, 1.36 to 1.54) compared to LSG. No significant association existed among BMI, ASA class, functional status, renal insufficiency, approach converted, and transfusion.

Readmission

Of the 5360 readmitted patients, 383 (7.1%) had both (DT + EDV), while 412 (7.7%) had DT only, 631 (11.8%) had EDV only, and the majority of readmitted patients 3934 (73.4%) had no visit (Fig. 1). In adjusted analysis, DT only was associated with higher odds (OR = 6.22; 95% CI, 5.55 to 6.98) of readmission, along with both DT + EDV (OR 4.87; 95% CI, 4.34 to 5.47) and EDV only (OR 3.28; 95% CI, 2.99 to 3.59) when compared to no visit (Table 3). LRYGB (OR 1.73; 95% CI, 1.63 to 1.83) and LBPD/DS (OR 1.96; 95% CI 1.52 to 2.52) had increased odds of readmission compared to LSG. Factors associated with readmission were GERD, insulin-dependent diabetes, and LOS > 4 days. Furthermore, none of the levels of the variables of age and assistant training level was significant, though type 3 tests of these variables were significant.

Indication for Readmissions

Of the 5360 patients with a 30-day readmission, a total of 5932 reported readmission events occurred. The top 20 reasons for readmission were stratified by outpatient visit (Table 4). Nausea, vomiting, and fluid, electrolyte, and nutritional depletion were the most common indication for readmissions in all groups ($P < .001$).

Time to Readmission

The earliest readmission after discharge occurred at a median of 10 days in the no visit group (interquartile range 13) compared to 14 days (interquartile range 15) in both (DT + EDV) (Table 5). DT only had the shortest length of readmission with a mean 3.5 days (standard deviation 3.3) compared to other groups ($P = .014$).

Discussion

Using prospectively collected data from 141,756 procedures performed in 791 centers in the 2016 MBSAQIP data registry, a total of 4968 (3.5%) patients received DT. The all-cause readmission rate was 3.8% and the odds of readmission increased with all outpatient visits, especially DT only. Nausea, vomiting, and dehydration were the most common cause of readmission.

Patients utilizing DT were younger, carried a preoperative diagnosis of GERD or insulin-dependent diabetes, and underwent LRYGB. Our study is similar to Telem et al.'s report that younger age was predictive of increased unplanned visitation to the ED within 30 days from bariatric surgery [15]. Patients with GERD and insulin-dependent diabetes may carry an underlying functional or motility disorders, e.g., gastroparesis or functional reflux, that impede adequate oral intake. Just as studies extensively analyzed the impact of "de novo" GERD after LSG with a preoperative workup of upper endoscopy, esophageal manometry, barium swallow, 24-h pH study, and hiatal hernia repair [16, 17], an area of future research includes objective evaluation of the interplay of GERD and insulin-dependent DM with motility and esophageal function to identify the impact on postoperative hydration status. In our study, more patients with a preoperative diagnosis of GERD underwent LRYGB 38.3%, compared to 32.9% LBPD/DS, 28.3% LSG, and 25.1% LAGB ($P < .05$). DT after all procedures had rates of 4.6% LRYGB, 3.9% LBPD/DS, 3.1% LSG, and 1.0% LAGB. Furthermore, LRYGB was associated with increased DT utilization compared to LSG. While mechanical obstructions such as strictures or kinking, along with non-mechanical reasons, e.g., dysfunctional eating or neurohormonal interruption, may result in persistent nausea and vomiting after all types of bariatric surgery, further

Table 1 Patient characteristics by dehydration treatment

	No DT (*N* = 136,780)	DT (*N* = 4968)	Total (*N* = 141,748)	*P* value
Sex				< .001[1]
Female	107,887 (78.9%)	4400 (88.6%)	112,287 (79.2%)	
Male	28,896 (21.1%)	568 (11.4%)	29,464 (20.8%)	
Age				< .001[2]
N	136,780	4968	141,748	
Mean (SD)	44.6 (11.9)	41.8 (11.5)	44.5 (11.9)	
Median (IQR)	44.2 (35.6, 53.3)	40.8 (33.0, 49.8)	44.1 (35.5, 53.2)	
Range	(18.0–79.9)	(18.0–76.9)	(18.0–79.9)	
Age groups (years)				< .001[1]
18–29	16,147 (11.8%)	832 (16.7%)	16,979 (12.0%)	
30–39	35,501 (26.0%)	1535 (30.9%)	37,036 (26.1%)	
40–49	39,603 (29.0%)	1370 (27.6%)	40,973 (28.9%)	
50–64	38,476 (28.1%)	1075 (21.6%)	39,551 (27.9%)	
≥ 65	7053 (5.2%)	156 (3.1%)	7209 (5.1%)	
Race/ethnicity				< .001[1]
White	100,166 (73.2%)	3456 (69.6%)	103,622 (73.1%)	
Black	24,003 (17.5%)	1182 (23.8%)	25,185 (17.8%)	
Other	12,611 (9.2%)	330 (6.6%)	12,941 (9.1%)	
Hispanic				< .001[1]
No	106,418 (77.8%)	4117 (82.9%)	110,535 (78.0%)	
Unknown	13,459 (9.8%)	338 (6.8%)	13,797 (9.7%)	
Yes	16,903 (12.4%)	513 (10.3%)	17,416 (12.3%)	
BMI group				< .001[1]
≤ 35–39	31,766 (23.2%)	1010 (20.3%)	32,776 (23.1%)	
40–49	72,693 (53.1%)	2649 (53.3%)	75,342 (53.2%)	
50–59	25,141 (18.4%)	1006 (20.2%)	26,147 (18.4%)	
≥ 60	7180 (5.2%)	303 (6.1%)	7483 (5.3%)	
ASA class				.212[1]
Missing	831 (0%)	62 (0%)	893 (0%)	
1–2	30,693 (22.6%)	1056 (21.5%)	31,749 (22.5%)	
3	100,636 (74.0%)	3677 (74.9%)	104,313 (74.1%)	
4–5	4620 (3.4%)	173 (3.5%)	4793 (3.4%)	
GERD				< .001[1]
No	94,905 (69.4%)	3016 (60.7%)	97,921 (69.1%)	
Yes	41,875 (30.6%)	1952 (39.3%)	43,827 (30.9%)	
Hypertension				.032[1]
No	70,921 (51.9%)	2653 (53.4%)	73,574 (51.9%)	
Yes	65,859 (48.1%)	2315 (46.6%)	68,174 (48.1%)	
Renal insufficiency				.483[1]
No	135,900 (99.4%)	4932 (99.3%)	140,832 (99.4%)	
Yes	880 (0.6%)	36 (0.7%)	916 (0.6%)	
Diabetes				< .001[1]
Insulin	11,483 (8.4%)	463 (9.3%)	11,946 (8.4%)	
No	100,997 (73.8%)	3713 (74.7%)	104,710 (73.9%)	
Non-insulin	24,300 (17.8%)	792 (15.9%)	25,092 (17.7%)	
Functional status				.955[1]
Independent	135,337 (98.9%)	4916 (99.0%)	140,253 (98.9%)	
Partially/totally dependent	1443 (1.1%)	52 (1.0%)	1495 (1.1%)	
Training level of assistant groups				< .001[1]
Attending	27,969 (20.4%)	798 (16.1%)	28,767 (20.3%)	
Trainee	35,762 (26.1%)	1335 (26.9%)	37,097 (26.2%)	

Table 1 (continued)

	No DT (*N* = 136,780)	DT (*N* = 4968)	Total (*N* = 141,748)	*P* value
PA/scrub	73,049 (53.4%)	2835 (57.1%)	75,884 (53.5%)	
Approach converted				.347[1]
No	136,600 (99.9%)	4959 (99.8%)	141,559 (99.9%)	
Yes	180 (0.1%)	9 (0.2%)	189 (0.1%)	
Type of surgery				< .001[1]
LSG	97,053 (71.0%)	3150 (63.4%)	100,203 (70.7%)	
LRYGB	36,200 (26.5%)	1750 (35.2%)	37,950 (26.8%)	
LBPD/DS	1032 (0.8%)	42 (0.8%)	1074 (0.8%)	
LAGB	2495 (1.8%)	26 (0.5%)	2521 (1.8%)	
Length of stay				< .001[2]
N	136,780	4968	141,748	
Mean (SD)	1.7 (1.1)	1.9 (1.2)	1.7 (1.1)	
Median (IQR)	2.0 (1.0, 2.0)	2.0 (1.0, 2.0)	2.0 (1.0, 2.0)	
Range	(0.0–30.0)	(0.0–28.0)	(0.0–30.0)	
LOS > 4 days				< .001[1]
No	134,912 (98.6%)	4836 (97.3%)	139,748 (98.6%)	
Yes	1868 (1.4%)	132 (2.7%)	2000 (1.4%)	
Transfusion initiated				.002[1]
No	135,989 (99.4%)	4922 (99.1%)	140,911 (99.4%)	
Yes	791 (0.6%)	46 (0.9%)	837 (0.6%)	

DT dehydration treatment, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *GERD* gastroesophageal reflux disease, *LRYGB* laparoscopic Roux-en-Y gastric bypass, *LAGB* laparoscopic adjustable gastric banding, *LSG* laparoscopic sleeve gastrectomy, *LBPD/DS* laparoscopic biliopancreatic diversion with duodenal switch, *PA* physician assistant, *LOS* length of stay

[1] Chi-square

[2] Kruskal–Wallis

investigation should evaluate the indication for DT to understand the impact of preoperative conditions and surgical technique. Identification of patients at risk for 30-day utilization of DT allows for expansion of prehospital education and enhancement of care pathways to further optimize outpatient care and reduce readmissions.

The 3.8% readmission rate after primary, laparoscopic bariatric surgery was reduced from the rate of 4.4% in 2014 [8]. Borza et al. described an 11% reduction in readmission in the Medicare population after non-bariatric surgery with increased utilization of observation stays [18]. DT as an outpatient treatment of intravenous fluids, along with implementation of multifaceted initiatives, resulted in a reduction of readmissions in 2016. However, understanding the association of DT with readmission requires more in-depth understanding of technical complications and administrative policies that define outpatient and inpatient care. First, readmission rates are associated with the administrative complexity of "observation" status. Outpatient treatments performed under observation status lack uniformity in payor, state, and institutional guidelines. In particular, patients under "observation status" are subject to readmission based on time (> 23 h or 2 midnights) or complexity of disease [4]. Second, dehydration has non-specific laboratory values and physical exam findings of weight loss, tachycardia, orthostatic hypotension, dry mucous membranes, decreased urine output, and elevated creatinine [19]. These diagnostic parameters are present during medical and surgical complications and may obscure the evaluation. DT may be a "gateway" for initial treatment and evaluation of patients with postsurgical complications; however, temporal order could not be created. Further research at the institutional level will provide more granularity to the application and order of DT visits, outpatient stay, and surgical complications.

Our study reported that prolonged LOS was associated with higher rates of DT and is similar to studies that show this is predictive of readmission [8, 20]. A prolonged LOS represents a complex intraoperative case or postsurgical course and identified patients who required outpatient visits, including readmission. Currently, DT lacks standardization for pre-treatment evaluation, protocols for implementation, or designation of location and thus may occur in inpatient units, observation care areas, ED, home infusion, or other monitored settings [21]. The lack of uniformity or location of intervention is an opportunity

Table 2 Factors associated with 30-day dehydration treatments

Variable	Odds ratio (95% CI)	*P* value
Sex		
Female	Reference	
Male	0.52 (0.48–0.57)	< .001
Age groups (years)		
18–29	Reference	
30–39	0.78 (0.72–0.85)	< .001
40–49	0.60 (0.55-0.67)	< .001
50–64	0.45 (0.41-0.50)	< .001
≥ 65	0.37 (0.31–0.44)	< .001
Race		
White	Reference	
Black	1.35 (1.23–1.45)	< .001
Other	0.86 (0.76–0.97)	.017
Hispanic		
No	Reference	
Yes	0.83 (0.75–0.91)	< .001
Unknown	0.73 (0.65-0.83)	< .001
GERD		
No	Reference	
Yes	1.49 (1.40–1.59)	< .001
Hypertension		
No	Reference	
Yes	1.12 (1.05–1.20)	< .001
Diabetes		
No	Reference	
Non-insulin	0.93 (0.86–1.01)	.09
Insulin	1.19 (1.07–1.33)	.001
Training level of assistant group		
Attending	Reference	
PA/scrub	1.29 (1.19–1.39)	< .001
Trainee	1.21 (1.11–1.33)	< .001
Type of surgery		
LSG	Reference	
LRYGB	1.45 (1.36–1.54)	< .001
LBPD/DS	1.21 (0.88–1.66)	.243
LAGB	0.32 (0.21–0.47)	< .001
LOS		
≤ 4 days	Reference	
> 4 days	1.83 (1.53–2.20)	< .001

c-index: 0.644

Variables considered but not significant for the model: BMI groups, ASA class group, functional status, renal insufficiency, approach converted, and transfusion

to optimize patient-centered care plans. By the same token, Jalilvand et al. created Bariatric Care Coaching plans for postoperative nausea and vomiting that successfully

Table 3 Factors associated with all-cause 30-day readmission

Variable	Odds ratio	*P* value
Race		
White	Reference	
Black	1.44 (1.35–1.55)	< .001
Other	1.00 (0.90–1.11)	.970
Age groups (years)		
18–29	Reference	
30–39	0.92 (0.84–1.01)	.090
40–49	0.87 (0.79–0.95)	.004
50–64	0.86 (0.77–0.95)	.002
≥ 65	0.92 (0.79–1.06)	.244
ASA class group (vs)		
1–2	Reference	
3	1.13 (1.05–1.22)	.001
4–5	1.46 (1.23–1.68)	< .001
GERD		
No	Reference	
Yes	1.27 (1.19–1.34)	< .001
Renal insufficiency		
No	Reference	
Yes	1.77 (1.40–2.24)	< .001
Diabetes		
No	Reference	
Non-insulin	0.96 (0.89–1.04)	.327
Insulin	1.28 (1.17–1.40)	< .001
Functional status		
Independent	Reference	
Partially/totally dependent	1.71 (1.40–2.09)	< .001
Chronic steroids		
No		
Yes	1.31 (1.09–1.57)	.004
COPD		
No	Reference	
Yes	1.42 (1.20–1.67)	< .001
Approach converted		
No	Ref	
Yes	1.88 (1.20–2.96)	.006
Type of procedure		
LSG	Reference	
LRYGB	1.73 (1.63–1.83)	< .001
LBPD/DS	1.96 (1.52–2.52)	< .001
LAGB	0.77 (0.58–1.02)	.071
LOS		
≤ 4 days	Reference	
> 4 days	2.58 (2.24–2.97)	< .001
Transfusion		
No	Reference	
Yes	2.34 (1.89–2.91)	< .001
Therapeutic anticoagulation		
No	Reference	

Table 3 (continued)

Variable	Odds ratio	*P* value
Yes	1.81 (1.59–2.06)	< .001
DT or EDV groups		
No visit	Ref	
DT only	6.22 (5.55–6.98)	< .001
EDV only	3.28 (2.99–3.59)	< .001
Both (DT + EDV)	4.87 (4.34–5.47)	< .001

c statistic: 0.705

Variables considered but not significant for the model: sex, Hispanic, BMI groups, hypertension, smoker, and previous MI

reduced LOS [3]. Furthermore, an ongoing review of these initiatives allows for dynamic adjustment to provide efficient outpatient care.

Nausea, vomiting, and dehydration were the most common causes of readmission in all groups, especially those with DT only. Our results are consistent with several previous studies that revealed the indication for readmission was nausea and vomiting in up to 35.4% of readmissions [5, 6, 8]. Once admitted, the DT only group had a shorter LOS compared to those without an outpatient visit. Outpatient hydration clinics combat poor oral intake and dehydration with a goal to decrease these unplanned readmissions [5, 7, 22]. Similarly, enhanced recovery protocols incorporated multimodal analgesia to target postoperative nausea and reported low readmission rates after adoption [23]. Partial implementation of best practices impacts readmission rates [24], and an ongoing review of initiatives that target postoperative nausea and dehydration allows us to provide effective patient-centered care in the outpatient setting.

Limitations

There are several limitations to our study. First, postoperative complications predict readmission [11, 25]; however, 30-day complications were not included in the adjusted models because temporal order could not be defined. This has been accounted for in future PUF but not at the initial recording of DT. Next, there is inherent selection bias among patients and surgeons to type of procedure. In the univariate associations, patients with GERD and insulin-dependent diabetes underwent intestinal bypass procedures (LRYGB and LBPD/DS) more often than LSG or LAGB and subsequent pairwise comparisons were performed. In the pairwise comparison of LAGB versus LSG, the results remained the same for both of these variables; in the comparison of LRYGB versus LBPD/DS, insulin-dependent diabetes was slightly higher in LRYGB (13.6% vs 13.3%, $P = .20$) and not statistically significant. Further, the LBPD/DS is often excluded from studies due to limited volume and limitations of data entry. Modifications to the DS have emerged that merit inclusion of LBPD/DS [12, 26]; however, staged procedures or those performed under CPT 43659 were not captured in this study. Finally, social determinants of health and psychological conditions may influence postoperative recovery and warrant evaluation; however, these were not available in the 2016 MBSAQIP PUF.

Conclusions

Younger patients and those with a preoperative diagnosis of GERD and insulin-dependent diabetes more frequently utilized DT after primary bariatric surgery. LRYGB is associated with an increased likelihood of DT compared

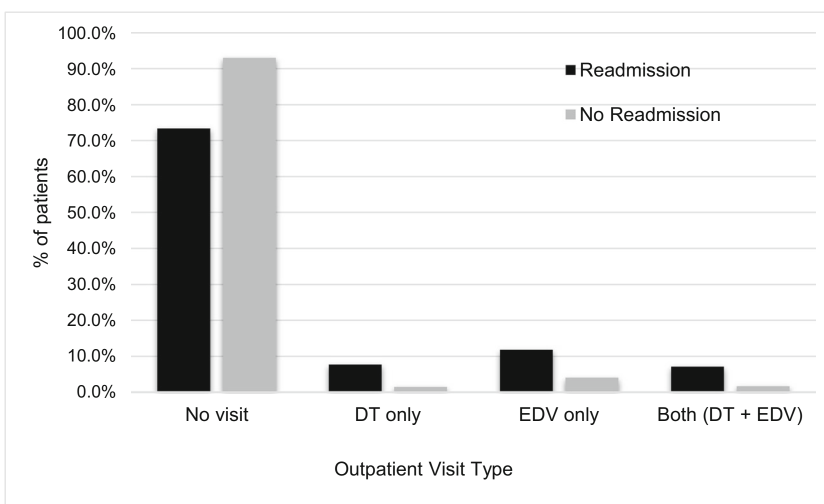

Fig. 1 Composition of readmitted patients stratified by 30-day outpatient visit; DT, dehydration treatment; EDV, emergency department visits

Table 4 Top 20 indications for readmission by outpatient visit type

		Outpatient visit				
	All readmissions $N = 5932$	No visit $N = 4338$	DT only $N = 448$	Both (DT + EDV) $N = 436$	EDV only $N = 710$	P value
1. Nausea and vomiting, and fluid, electrolyte, or nutritional depletion	1954 (32.9)	1246 (28.7)	277 (61.8)	243 (55.7)	188 (26.5)	< .001
2. Other	777 (13.1)	612 (14.1)	34 (7.6)	26 (6.0)	105 (14.8)	< .001
3. Abdominal pain, not otherwise specified	762 (12.8)	560 (12.9)	31 (6.9)	47 (10.8)	124 (17.5)	< .001
4. Bleeding	276 (4.7)	221 (5.1)	10 (2.2)	11 (2.5)	34 (4.8)	< .001
5. Anastomotic/staple line leak	238 (4.0)	187 (4.3)	12 (2.7)	12 (2.8)	27 (3.8)	< .001
6. Vein thrombosis requiring therapy	220 (3.7)	178 (4.1)	14 (3.1)	7 (1.6)	21 (3)	< .001
7. Intestinal obstruction	203 (3.4)	164 (3.8)	10 (2.2)	10 (2.3)	19 (2.7)	< .001
8. Other abdominal sepsis	174 (2.9)	125 (2.9)	5 (1.1)	19 (4.4)	25 (3.5)	< .001
9. Pulmonary embolism	152 (2.6)	126 (2.9)	2 (0.4)	3 (0.7)	21 (3)	< .001
10. Wound infection/evisceration	141 (2.4)	106 (2.4)	6 (1.3)	8 (1.8)	21 (3)	< .001
11. Pneumonia	118 (2.0)	90 (2.1)	5 (1.1)	4 (0.9)	19 (2.7)	< .001
12. Infection/fever	106 (1.8)	88 (2.0)	4 (0.9)	6 (1.4)	8 (1.1)	< .001
13. Strictures/stomal obstruction	99 (1.7)	69 (1.6)	9 (2.0)	11 (2.5)	10 (1.4)	< .001
14. Gallstone disease	96 (1.6)	71 (1.6)	3 (0.7)	6 (1.4)	16 (2.3)	< .001
15. Chest pain	83 (1.4)	68 (1.6)	3 (0.7)	3 (0.7)	9 (1.3)	< .001
16. Shortness of breath	75 (1.3)	63 (1.5)	3 (0.7)	2 (0.5)	7 (1)	< .001
17. Anastomotic ulcer	67 (1.1)	53 (1.2)	4 (0.9)	4 (0.9)	6 (0.8)	< .001
18. Cardiac, not otherwise specified	61 (1)	53 (1.2)	3 (0.7)	0 (0)	5 (0.7)	< .001
19. Renal insufficiency	49 (0.8)	38 (0.9)	3 (0.7)	0 (0)	8 (1.1)	< .001
20. Nephrolithiasis	39 (0.7)	24 (0.6)	3 (0.7)	4 (0.9)	8 (1.1)	< .001

DT dehydration treatment, *EDV* emergency department visits

to LSG. Nausea, vomiting, and dehydration remain the most common indications for readmission after bariatric surgery. The increased association of DT with readmission requires more granularity around implementation of

Table 5 Time to readmission by outpatient visit type

	No visit $N = 131{,}142$	DT only $N = 2379$	EDV only $N = 6121$	Both (DT + EDV) $N = 2678$	P value
Days from surgery to readmission					
Mean (SD)	13.2 (8.2)	14.5 (8.4)	14.6 (8.2)	15.9 (8.4)	< .001
Median (Q1, Q3)	12 (6, 20)	14 (7, 21)	14 (7, 22)	16 (8, 23)	
Range	(0, 30)	(1, 30)	(1, 30)	(0, 30)	
Days from original discharge to readmission					
Mean (SD)	11 (8.1)	12.3 (8.3)	12.4 (8.1)	13.8 (8.4)	< .001
Median (Q1, Q3)	10 (4, 17)	12 (5, 19)	12 (5, 19)	14 (6, 21)	
Range	(0, 29)	(0, 29)	(0, 29)	(0, 29)	
Length of stay of readmission					
Mean (SD)	4.3 (5.7)	3.5 (3.3)	4.0 (4.8)	4.1 (4.7)	.014
Median (Q1, Q3)	3 (2, 5)	3 (2, 4)	3 (2, 4)	3 (2, 5)	
Range	(0, 93)	(0, 26)	(0, 65)	(0, 47)	

DT dehydration treatment, *EDV* emergency department visits, *SD* standard deviation best practices and standardization of protocols for hydration interventions. Further utilization of DT in bariatric centers should evaluate institutional protocols to optimize postoperative care.

Compliance with Ethical Standards

Conflict of Interest Maragatha Kuchibhatla was a consultant to Aniara Diagnostica. The other authors have no conflicts of interest to declare.

Informed Consent Informed consent does not apply.

Human and Animal Rights/Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors. For this type of study, formal consent is not required.

Abbreviations DT, dehydration treatments; MBSAQIP, Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program; BMI, body mass index; LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; LRYGB, laparoscopic Roux-en-Y gastric bypass; LBPD/DS, laparoscopic biliopancreatic diversion with duodenal switch; GERD, gastroesophageal reflux; DROP, Decreasing Readmissions through Opportunities Provided; PUF, participant use data file; LOS, length of stay; CPT, Current Procedural Technology; MI, myocardial infarction; COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists; PA, physician assistant; EDV, emergency department visit; NoDT, no dehydration treatment

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