Obesity Surgery (2019) 29:1922–1931
https://doi.org/10.1007/s11695-019-03793-9

ORIGINAL CONTRIBUTIONS

Comparison of Non-routine Healthcare Utilization in the 2 years Following Roux-En-Y Gastric Bypass and Sleeve Gastrectomy: A Cohort Study

Richard L. Seip[1] · Kyle Robey[1] · Andrea Stone[1] · Geneth Chin[1] · Ilene Staff[2] · Tara McLaughlin[1,3] · Darren Tishler[1] · Pavlos Papasavas[1]

Published online: 6 March 2019

Abstract

Background Patients undergoing Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) have different healthcare needs after surgery. Our aim was to quantify non-routine healthcare utilization after RYGB vs. SG.

Methods We compared non-routine (NR) visits made and associated services provided up to 2 years post-surgery for patients undergoing RYGB or SG at a Bariatric Surgery Comprehensive Center between March 2013 and April 2015.

Results A total of 258 and 461 patients had primary RYGB and SG, respectively. Successful follow-up rates at one (76.2%) and 2 years post-surgery (52.6%) did not differ between groups. Rates for all NR visits, expressed as the number per 100 patients, were 68.6 in RYGB vs. 35.4 in SG patients ($p < 0.0001$). Emergency department visits with subsequent admission (EDA) or without subsequent admission (ED-only) and outpatient visits (OPV) were more frequent in RYGB vs. SG: EDA, 14.7 vs. 8.0 ($p = 0.0076$); ED-only, 17.8 vs. 7.6 ($p = 0.0001$); and OPV, 29.8 vs. 14.1 ($p < 0.0001$). RYGB required more services per 100 patients than SG, 120.9 vs. 75.3, respectively ($p < 0.0001$). Imaging was the resource most often used overall. Surgery type (RYGB) significantly predicted healthcare utilization even after controlling for gender, ethnicity, and other variables. Healthcare utilization peaked at 1 to 6 months post-surgery, driven by patients who underwent RYGB.

Conclusions RYGB required twice as many non-routine follow-up visits and 1.6 times greater use of healthcare services relative to SG. Computer-assisted tomography imaging and endoscopies showed the greatest differences. Peak healthcare utilization for RYGB occurred between 1 and 6 months following surgery.

Keywords Follow-up · Healthcare services · Non-routine visits · Imaging · Bariatric surgery

✉ Tara McLaughlin
Tara.Mclaughlin@hhchealth.org

Richard L. Seip
Richard.Seip@hhchealth.org

Kyle Robey
Robey@uchc.edu

Andrea Stone
Andrea.Stone@hhchealth.org

Geneth Chin
Chin.Geneth18@gmail.com

Ilene Staff
Ilene.Staff@hhchealth.org

Darren Tishler
Darren.Tishler@hhchealth.org

Pavlos Papasavas
Pavlos.Papasavas@hhchealth.org

[1] Hartford Healthcare Surgical Weight Loss Center, Hartford, CT 06102, USA

[2] Hartford Hospital Research Program, Hartford, CT 06102, USA

[3] Department of Surgery, Hartford Healthcare Medical Group, 85 Seymour Street, Hartford, CT 06106, USA

Introduction

Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) together account for more than 70% of all bariatric surgeries in the USA [1]. RYGB is more efficacious than SG [2–4] but is associated with greater frequency of side effects and complications [5–12]. As surgical procedures, RYGB and SG share common acute complications such as bleeding, leak, and venous thromboembolism, but they differ in rates and types of long-term complications. Patients undergoing RYGB may experience stricture of the gastrojejunostomy, anastomotic ulcers, complications related to the altered anatomy (internal hernia and intussusception), micronutrient deficiencies, reactive hypoglycemia, and kidney stones [11]. Because RYGB is associated with higher complication rates than SG, the characteristics of the follow-up care and services following intervention are expected to differ.

To date, the focus of studies of post-intervention healthcare utilization following bariatric surgery has been limited. The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP®) [13] documents complications during the first 30 days following bariatric surgery, but not all of the services that may have been provided, such as the use and types of imaging deployed. Further, while the MBSAQIP collects readmissions to the hospital related to bariatric surgery beyond the first year, it does not release these data for researchers. There is a need for more thorough examination of healthcare services beyond the first 30 days post-surgery as approximately one third of readmissions to the index institution occur beyond this period [14]. Readmissions, reoperations, and post-operative interventions (endoscopy, percutaneous drain placement, etc.) up to 180 days post-intervention have been documented [15], but beyond 180 days post-surgery, such data are not found. Studies that have documented readmissions up to 1-year post-surgery [16] have focused mainly on the reasons for readmission. To our knowledge, no study extends documentation through the 2 years following intervention and none parses out the details of the visits made and services rendered. There is a need to carefully examine the healthcare services provided in a real-world setting to adequately diagnose and treat patients following SG and RYGB and to better prepare them for the healthcare needs that they may face after these procedures.

The purpose of the current study was to compare the utilization rate of all healthcare services that were related to primary bariatric procedures (SG vs. RYGB) from the time of surgery up to 2 years following surgery at a single accredited surgical weight loss program. We quantified healthcare utilization by counting non-routine visits after bariatric surgery that were judged to be bariatric-related, including emergency department visits, unscheduled office visits, and hospital readmissions and services provided that were triggered by these visits, including radiographic and imaging studies and bariatric-related surgical and non-surgical interventions.

Materials and Methods

Subjects and Study Design This was a retrospective chart review of consecutive patients who underwent RYGB and SG as an initial surgical weight loss procedure at a single site between April 1, 2013 and March 31, 2015. All procedures were performed by two bariatric surgeons using the same laparoscopic technique for sleeve gastrectomy (34F gastric lavage tube) and different techniques for RYGB (laparoscopic retrocolic, retrogastric vs. robotic assisted antecolic antegastric). The study site is accredited by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP). The study was approved by the local Institutional Review Board. Qualified patients in the bariatric clinical registry were identified. Relevant medical history for each patient was extracted from the electronic medical record, de-identified, and compiled in a secure, HIPAA-compliant research database.

Measures

Patient Clinical Characteristics Age, height, body mass index (BMI), comorbidities present, and other relevant clinical data collected before surgery were used to characterize patient groups.

Healthcare Visits All non-routine follow-up visits within 2 years of surgery were identified and clinician notes were interrogated for relevance to bariatric surgery treatment. A non-routine (NR) visit was defined as a visit to the surgical weight loss center, to the emergency department, or to another healthcare facility that was not previously scheduled as part of the standard of care after bariatric surgery and was needed in order to address a side effect, symptom, or complication judged by the investigators to be related to the index bariatric procedure. A visit or service was counted if a connection to bariatric surgery was inferred by the investigators based on the clinical documentation, or if subsequent work-up revealed that the problem in question was related to the index bariatric procedure. In cases where a connection to bariatric surgery was questionable, the research team reviewed the case and arrived at a consensus. Visits and services for treatment of medical problems that were not related to bariatric surgery treatment were excluded. Examples of excluded visits and services were elective surgeries such as knee replacement, visits to the ED due to injuries on the job, and outpatient visits for conditions such as hemorrhoids. Each included visit was categorized as one of the following: (1) an emergency

department visit with subsequent hospital admission (EDA), (2) an emergency department visit without subsequent hospital admission (ED-only), (3) an inpatient admission not immediately preceded by an emergency department visit (IPV), or (4) an outpatient visit (OPV).

Healthcare Services Healthcare service utilization was quantified by tabulating the number of tests, procedures, and services related to the index bariatric surgery. These are detailed below. Intraoperative services were not counted. A service received during the initial hospitalization was counted if it was considered as non-routine or not part of the post-operative standard of care pathway. Imaging services included computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), and X-ray, usually of the abdomen, chest, or pelvis. Non-imaging services included endoscopies (diagnostic or therapeutic), visits for rehydration, blood transfusions, and endoscopic retrograde cholangiopancreatography (ERCP). All surgical procedures performed to address a bariatric-related complication or symptom were recorded including all laparoscopic cholecystectomies.

Hospital Length of Stay The duration of the initial hospital stay and any subsequent readmission was recorded in days. A day was counted if it was accompanied by an overnight stay in the hospital.

Follow-up Documentation of a measured body weight in the medical record within ± 6 months of the 1- and 2-year time points served as an indicator that the patient was seen at our surgical weight loss center and represented a surrogate for successful follow-up to that date. Additionally, any bariatric-related healthcare services were documented and used in the analyses, even for patients who were lost to follow-up based on the unavailability of a documented body weight in the medical record.

Data Analysis

We first tested for group differences in rates of total NR visits (or services) per 100 patients using a comparison of rates test [17]. To assess whether the effects were driven by a small number of patients with multiple visits, we performed additional analyses excluding patients with more than two visits or more than five visits. To further avoid any bias created by patients with multiple uses having a disproportionate effect on analyses and to comply with statistical rules of independence, we compared proportion of patients with one or more NR visit (or used an associated service) using chi-square test of proportions or Fisher's exact test. For differences in clinical characteristics, chi-square tests of proportion or Fisher's exact test were used to detect group differences in proportions, as cell size demanded. For continuous variables, we employed independent group *t* tests or Wilcoxon rank-sum tests as appropriate based on underlying distributions. Logistic regression was used to assess whether type of surgery predicted the need for one or more NR visit, or associated services, independent of other potentially influential factors. Variables that were found in univariate analyses to be associated with NR visits or services at $p < 0.20$ were included in two separate logistic regressions. For all tests, significance was set at $p < 0.05$. MedCalcv13.1.2 was used to test for the difference of rates; SPSSv21 was used for all other tests.

Results

Numbers of surgeries performed by each surgeon The numbers for each type of surgery performed were, for surgeon 1, 134 RYGB + 225 SG = 359 total and surgeon 2, 124 RYGB + 236 SG = 360 total ($\chi^2 = 0.649$; $p = 0.421$, NS).

Pre-operative and surgical characteristics A total of 258 and 461 consecutive patients underwent RYGB and SG, respectively, during the study period. The mean age for the entire cohort of 719 patients was 45.7 ± 12.0 years; 78.6% were women; 65.5% were Caucasian, 17.9% were Latino, 15.4% were African-American, and 1.1% reported another ethnogeographic origin or declined to report. Pre-operative and surgical characteristics are presented in Table 1. Patients undergoing SG vs. RYGB differed significantly on BMI and body weight. Those undergoing RYGB had significantly higher rates of some comorbidities, greater surgical risk, and a duration of surgery that was nearly double that of the SG group.

Outcomes and Follow-up One-year follow-up weights were available for 548 patients (76.2% of the total sample), and 2-year follow-up weights were available for 378 (52.6% of the total sample) (Table 1). By surgery type, the follow-up rates at 1- and 2-year time points did not differ significantly and were 75.0% for SG and 78.3% for RYGB patients and 51.2% and 55%, respectively. RYGB patients had greater weight loss relative to SG (Table 1).

Reasons for Non-routine Visits and Services Abdominal pain was the most common complaint, occurring at least once in 22.1% of the RYGB and 11.1% of the SG patients ($p < 0.002$). Abdominal pain, dysphagia, dehydration, nausea, and vomiting comprised the top five symptoms/reasons, occurring in the RYGB group at rates more than double those in SG (Table 2). Notably, rates of GERD were higher in SG compared to RYGB (Table 2).

Visits Patients who experienced at least one NR visit comprised 32.6% of RYGB compared to 18.4% of SG ($p < 0.001$; Table 3). Among subcategories, the rates of EDA

Table 1 Characteristics of all patients before surgery and characteristics of those with data at 1 and 2 years after surgery

Characteristic	Sleeve gastrectomy	Roux-en-Y gastric bypass	Test	*p* value
Pre-surgery				
N (women, men)	461 (359, 102)	258 (206, 52)	A	0.537
Ethnicity[†]				
Caucasian	66.8% (308/461)	63.2% (163/258)		0.108
African-American	16.3% (75/461)	14.0% (36/258)	A[#]	
Latino	15.8% (73/461)	21.7% (56/258)		
Other or not available	1.1% (5/461)	1.2% (3/258)		
Age	46.0 ± 12.3 (n = 461)	45.2 ± 11.6 (n = 258)	B	0.365
Height (inches)	65.1 ± 3.8 (n = 461)	65.1 ± 3.4 (n = 258)	B	0.953
Weight (lbs)	268.8 ± 58.2 (n = 461)	278.1 ± 55.6 (n = 258)	C	0.005*
BMI (kg/m^2)	44.4 ± 7.6 (n = 461)	45.9 ± 7.5 (n = 258)	C	0.0001*
Comorbidities present, % (n/total)				
Diabetes			A	0.00003*
Yes, insulin dependent	8.5% (39/461)	18.2% (47/258)		
Yes, non-insulin dependent	16.9% (135/461)	22.1% (57/258)	A,3way	0.0001*
Not present	74.6% (344/461)	59.7% (154/258)		
Gastroesophageal reflux disease	28.2% (130/461)	42.6% (110/258)	A	0.00008*
Hyperlipidemia	28.2% (130/461)	28.3% (73/258)	A	0.978
Hypertension	44.4% (205/461)	51.6% (133/258)	A	0.068
Sleep apnea	50.8% (234/461)	58.5% (151/258)	A	0.045*
Smoker	9.8% (45/461)	8.1% (21/258)	A	0.470
Chronic obstructive pulmonary			A	0.469
Disease (COPD)	0.7% (3/461)	1.2% (3/258)		
Mobility device	1.7% (8/461)	1.9% (5/258)	A	0.845
ASA class			A	0.004*
I	0.2% (1/461)	0% (0/258)		
II	33.6% (155/461)	21.3% (55/258)		
III	64.9% (299/461)	77.9% (201/258)		
IV	1.3% (6/461)	0.8% (2/258)		
Characteristics related to hospitalization				
Surgery duration (min)	66 ± 19 (n = 461)	121 ± 30 (n = 258)	A	0.00001*
Robotic approach	0.0 (0/461)	50.0% (129/258)	A	<0.001
Length of hospital stay (days)	2.2 ± 0.7 (n = 461)	2.1 ± 0.6 (n = 258)	C	0.367
One year post-surgery				
N (women, men)	346 (202, 76)	202 (162, 40)	A	0.550
Weight loss (lbs)	55.7 ± 29.2 (n = 346)	84.8 ± 32.7 (n = 202)	B	0.00001*
Total weight loss (%)	20.8 ± 9.3 (n = 346)	30.6 ± 9.4 (n = 202)	B	0.00001*
BMI decrease (kg/m^2)	9.3 ± 4.5 (n = 346)	14.1 ± 5.2 (n = 202)	B	0.00001*
Two years post-surgery				
N (women, men)	236 (188, 48)	142 (111, 31)	A	0.571
Weight loss (lbs)	50.8 ± 30.1 (n = 236)	82.9 ± 41.2 (n = 142)	B	0.00001*
Total weight loss (%)	19.2 ± 10.2 (n = 236)	29.9 ± 11.3 (n = 142)	B	0.00001*
BMI decrease (kg/m^2)	8.5 ± 4.9 (n = 236)	13.7 ± 6.7 (n = 142)	B	0.00001*

A chi-square, *B* Student's *t* test, *C* Wilcoxon rank-sum test

[†] Five patients who underwent SG and three patients who underwent RYGB did not report ethnicity

[#] "Other or not available" group was not included in statistical testing

*Significant difference between groups

or ED-only and OPV were essentially doubled in the RYGB group (Table 4).

Services Patients who received at least one NR healthcare service comprised 40.7% of RYGB compared to 29.9% of SG ($p = 0.003$; Table 3). The overall rate of healthcare service utilization was 1.6× higher in the RYGB group compared to the SG group (Table 4). The exclusion of patients who made many repeated NR visits reduced, but did not eliminate, the greater utilization of healthcare services by RYGB patients (Table 3). The use of all imaging services (Table 4) was 26.2% higher ($p = 0.0169$) in RYGB, driven by a 90.8% higher usage of CT imaging in this group ($p = 0.0003$). The rate of all surgical procedures was different between groups (4.3 per 100 vs. 1.1 per 100, $p = 0.0061$). Endoscopies were performed four times more frequently, rehydration services administered nearly twice as frequently, and red blood cell transfusions occurred nearly four times more frequently in RYGB compared to SG (Table 4).

Table 2 Rates of the most frequently cited reasons for non-routine healthcare (visits and services) listed in order of overall frequency. Data are rates per 100 patients calculated from counts (in parentheses) as *n* of counts / *n* of patients × 100. The rate difference represents the rate for RYGB rate minus the rate for SG. Listed below the table are reasons for visits that occurred infrequently (< 1 per 100 patients), with corresponding counts for each

Reasons	All patients $n = 719$	SG $n = 461$	RYGB $n = 258$	Rate difference, confidence interval	*p* value
Abdominal pain	26.7 (192)	17.8 (82)	42.6 (110)	24.9 16.7 to 32.5	<0.0001*
Dysphagia	6.4 (46)	2.4 (11)	13.6 (35)	11.1 7.3 to 15.0	<0.0001*
Dehydration	6.1 (44)	4.6 (21)	8.9 (23)	4.4 0.6 to 8.1	0.0234*
Nausea	6.0 (43)	3.9 (18)	9.7 (25)	5.8 2.1 to 9.5	0.0023*
Vomiting	3.6 (26)	2.0 (9)	6.6 (17)	4.6 1.7 to 7.5	0.0017*
GERD	2.4 (17)	3.3 (15)	0.8 (2)	−2.5 −4.8 to −1.4	0.0382*
Constipation	1.1 (8)	0.9 (4)	1.6 (4)	0.7 −0.9 to 2.2	0.4052

Reasons reported at rates less than 1.0 per 100 patients (data are counts): melena, 6; shortness of breath, 6; weight gain, 6; diarrhea, 5; syncope, 3; chest pain, 3; fever, 2; dizziness, 2; hematemesis, 1; swelling, 1; malnutrition, 1; pain in throat, 1; drainage from wound, 1; dyspepsia, 1; fatigue, 1; hematuria,1; lower extremity pain, 1; hemoptysis, 1; numbness, 1; and weakness, 1

GERD gastroesophageal reflux disease

Trends in NR Visits and Services by Interval Post-surgery RYGB patients made significantly more NR visits than SG patients at almost every interval post-surgery (Fig. 1a). For SG patients, the rate of NR visits steadily declined over the 24 months post-surgery (Fig. 1a). For healthcare services, the groups did not differ in the first 30 days. However, from 1 to 6 months post-surgery and over the 24 months after surgery, RYGB patients received NR healthcare services at least twice as often than SG patients (Fig. 1b).

Factors Predicting Non-routine Healthcare Utilization Table 5 indicates that nine variables were associated with at least one NR visit or service at $p < 0.20$ in univariate analyses. Multivariate logistic regression (Table 6) indicated that surgery

Table 3 Proportions of surgery groups who made one or more non-routine visits or received one or more non-routine services, and comparison of rates by surgery type in all patients, and in subgroups formed after excluding 5 patients who made more than 5 non-routine visits, and excluding 42 who made more than 2 non-routine visits. Rates are determined from counts as in Table 2

	All Patients	SG	RYGB	Rate difference, confidence interval	p value
Proportions					
	n719	n461	n258		
Patients Making ≥ 1 NR visit	23.5% (169)	18.4% (85)	32.6% (84)	-	<0.001*
Receiving ≥ 1 NR service	33.8% (243)	29.9% (138)	40.7% (105)	-	<0.003*
Rate per 100 patients					
In All Patients	n719	n461	n258		
Visits	45.9 (330)	35.4 (153)	68.6 (177)	35.4 [25.1 to 45.7]	<0.0001*
Services	91.5 (659)	75.3 (347)	120.9 (312)	45.7 [31.1 to 60.3]	<0.0001*
Excluding patients with > 5 NR visits	n714	n460	n254		
Visits	40.9 (292)	31.7 (146)	57.5 (146)	25.7 [15.9 to 35.5]	<0.0001*
Services	78.0 (557)	68.3 (314)	95.7 (243)	27.4 [13.9 to 40.9]	<0.0001*
Excluding patients with > 2 NR visits	n677	n443	n234		
Visits	24.1 (163)	19.4 (86)	32.9 (77)	13.5 [5.7 to 21.3]	0.0007*
Services	53.6 (363)	49.2 (218)	62.0(145)	12.8 [1.2 to 24.3]	0.031*

Table 4 Visit rates and rates of services utilized during the 2 years following surgery. Rates are determined from counts as in Table 2

Visit or service	All patients $n = 719$	SG $n = 461$	RYGB $n = 258$	Rate difference, confidence interval	p value
All visits	46.0 (331)	33.4 (154)	68.6 (177)	35.2 24.9 to 45.5	< 0.0001*
ED + admission	10.7 (77)	8.2 (38)	15.1 (39)	6.9 1.9 to 11.9	0.0069*
ED + discharge	11.4 (81)	7.6 (35)	17.8 (46)	10.2 5.1 to 15.4	0.0001*
Admission (no preceding ED visit)	4.3 (31)	3.5 (16)	5.8 (15)	2.3 0.8 to 5.5	0.1467
Outpatient	19.7 (142)	14.1 (65)	29.8 (77)	15.8 9.0 to 22.5	< 0.0001*
All services	91.5 (659)	75.3 (347)	120.9 (312)	45.7 31.1 to 60.3	< 0.0001*
Imaging					
All imaging	60.6 (436)	55.5 (256)	69.8 (180)	14.2 2.4 to 26.1	0.0169*
Computed tomography	17.2 (124)	13.0 (60)	24.8 (64)	11.8 5.5 to 18.1	0.0003*
Ultrasound	5.8 (42)	6.1 (28)	5.4 (14)	− 0.6 − 4.3 to + 3.0	0.7305
X-ray	36.5 (263)	36.0 (166)	37.6 (97)	1.6 − 7.6 to 10.8	0.7356
Magnetic resonance imaging	1.0 (7)	0.4 (2)	1.9 (5)	1.5 0.1 to 3.0	0.0499*
Surgical procedures					
All surgical procedures related to bariatric surgery‡	2.2 (16)	1.1 (5)	4.3 (11)	3.2 − 0.9 to 5.5	0.0061
Laparoscopic cholecystectomy	3.3 (24)	3.3 (15)	3.5 (9)	0.2 − 2.5 to 3.0	0.8688
Total	5.6 (40)	4.3 (20)	7.8 (20)	3.4 − 0.2 to 7.0	0.0627
Other					
Endoscopy	14.9 (107)	7.2 (33)	28.7 (74)	21.5 15.7 to 27.4	< 0.0001*
Visit for rehydration	7.9 (56)	5.9 (27)	11.2 (29)	6.5 1.5 to 11.4	0.0103*
Red blood cell transfusion	1.4 (10)	0.7 (3)	2.7 (7)	5.4 1.1 to 9.6	0.0131*

Admission refers to a hospital admission

ED emergency department

‡ Surgical procedures for RYGB included the following: diagnostic laparoscopy for bowel obstruction (5), abdominal pain (3), bleeding (1), open gastric bypass reversal (1), and laparoscopic transgastric ERCP (1). Surgical procedures for SG included the following: diagnostic laparoscopy for bleeding (3), laparoscopic placement of jejunostomy tube (1), and laparoscopic reduction of intrathoracic stomach (1)

type and hospital LOS both independently and significantly predicted at least one NR visit even after controlling for other factors (age, ethnicity, use of robotic approach, and history of GERD). Ethnic group and history of GERD also independently and significantly predicted at least one NR visit. Surgery type and hospital LOS both independently predicted the use of at least one service even after controlling for other factors in the equation (gender, ethnicity, and use of robotic approach).

Discussion

The current study compared the number of non-routine healthcare visits and services that were related to problems arising from primary surgical procedures in 258 RYGB patients and 461 SG patients, from immediate post-surgery to 2 years following surgery at a single MBSAQIP accredited surgical weight loss program. Notably, patients who underwent RYGB experienced significantly higher rates of non-routine events (visits to undergo medical evaluation and treatment of bariatric surgery related problems, and associated services) in the 24 months following surgery than did those who underwent SG. Regarding non-routine medical visits, 32.6% of the RYGB patients required at least one such visit, compared to 18.4% of the SG patients. When all such visits (including multiple visits made by some patients) were counted, the RYGB visit rate was 2.1 times greater than that of the SG sample. This difference

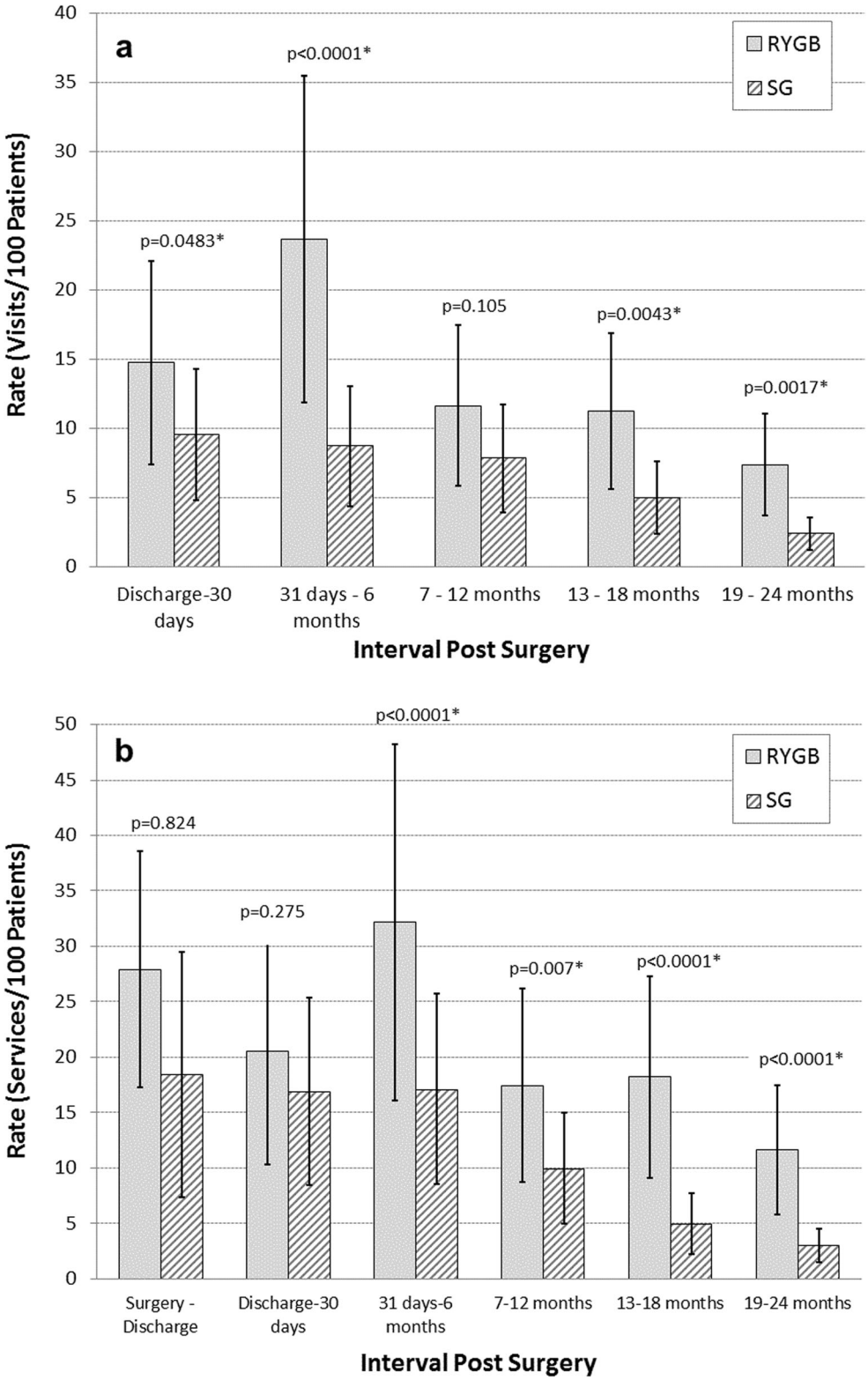

Fig. 1 Timing of non-routine visits made and services utilized in designated intervals relative to the surgery date following primary RYGB and SG surgery. Data are rates per 100 patients. Error bars represent 95% confidence intervals. **a** Non-routine visits. **b** Healthcare services utilized. RYGB Roux-en-Y gastric bypass, SG sleeve gastrectomy

was driven by outpatient visits and ED visits, with or without subsequent hospital admission. Collectively outpatient visits and ED visits were twice as common after RYGB compared to SG. Surgery type remained a significant predictor of healthcare utilization even after controlling for other factors; patients who had RYGB had significantly higher odds of at least one NR visit and use of at least one associated service relative to those who had SG.

Table 5 Differences in demographics, processes, and comorbidities according to non-routine utilization of healthcare

Category	Variable or factor	Made at least one non-routine visit			Received at least one non-routine service		
		Yes	No	*p* value	Yes	No	*p* value
Demographic	Gender (*N* of women/total)	86.0% (145/169)	76.4% (420/550)	*0.009*	82.3% (200/243)	76.7% (420/476)	*0.082*
	Age	46.3 (35.1–54.1)	45.6 (37.0–54.1)	*0.149*	47.1 (36.0–54.5)	45.1 (36.5–54.2)	0.969
	Ethnicity						
	Caucasian	56.2% (95/168)	69.2% (376/543)	*0.005*	62.2% (150/241)	68.3% (321/470)	
	African-American	17.8% (30/168)	14.9% (81/543)		16.2% (39/241)	15.3% (72/470)	*0.189*
	Latino	26.0% (44/168)	15.8% (86/543)		21.6% (52/241)	16.4% (77/470)	
	Height (inches)	64 (62–66)	65 (63–67)	*0.031*	64 (62–67)	65 (63–67)	*0.014*
	Weight, pre	259 (231–296)	265 (233–297)	0.406	259 (229–293)	267 (236–298)	*0.167*
	BMI	43.0 (40.0–49.1)	43.4 (39.4–48.4)	0.638	43.1 (40.0–48.0)	43.4 (39.4–48.6)	0.997
Process	Robotic surgery	25.4% (43/169)	15.7% (86/550)	*0.004*	20.6% (50/243)	16.6% (79/476)	*0.188*
	Length of stay > 2 days	24.6% (42/169)	17.1% (94/550)	*0.024*	32.1% (78/243)	12.2% (58/476)	*0.000*
	LOS in days	2.0 (2.0–2.5)	2.0 (2.0–2.0)	*0.005*	2.0 (2.0–3.0)	2.0 (2.0–2.0)	*0.000*
Comorbidity or health status–related	ASA score	3 (2–3)	3 (2–3)	0.304	3 (2–3)	3 (2–3)	0.541
	Mobility device required	1.2% (2/169)	4.6% (11/550)	0.486	2.1% (4/243)	1.9% (9/476)	0.816
	Diabetes present	28.4% (48/169)	31.5% (173/550)	0.452	26.2% (78/243)	30.0% (143/476)	0.572
	Diabetes severity						
	No diabetes	71.6% (121/169)	68.5% (377/550)	0.567	67.9% (165/243)	70.0% (333/476)	0.633
	Diabetes treated with oral med	16.0% (27/169)	19.6% (108/550)		18.5% (45/243)	18.9% (90/476)	
	Diabetes treated with insulin	12.4% (21/169)	11.8% (65/550)		13.6% (33/243)	10.9% (53/476)	
	Gastroesophageal reflux disease	40.2% (68/169)	31.3% (172/550)	*0.031*	36.2% (88/243)	31.9% (152/476)	0.250
	Hypertension	43.8% (74/169)	48.0% (264/550)	0.337	47.3% (114/243)	47.1% (224/476)	0.971
	Hyperlipidemia	26.0% (44/169)	28.9% (159/550)	0.468	30.0% (73/243)	27.7% (130/476)	0.442
	Chronic obstructive pulmonary disease	0.6% (1/169)	0.9% (5/550)	0.692	0.8% (2/243)	0.8% (4/476)	0.981
	Sleep apnea	52.1% (88/169)	54.0% (297/550)	0.660	54.7% (133/243)	51.9% (252/476)	0.649
	Smoking	7.7% (13/169)	9.6% (53/550)	0.444	8.2% (20/243)	9.7% (46/476)	0.529

Data are percentages calculated from (counts), or medians (25th–75th percentile). Italicized *p* values indicate significant difference ($p < 0.20$) between groups; these variables were included in logistic regression

With respect to medical services associated with the visits, 40.7% of RYGB patients received at least one non-routine healthcare service in the 2 years following surgery compared to 29.9% of the SG patients. Of particular interest is the use of imaging. In the present study, RYGB patients used 25% more imaging services than SG patients. These high usage rates correspond to a recent study by Haddad et al. (2017) [18] who reported 907 non-routine abdominal and pelvic imaging studies in 578 RYGB and SG patients over a 5-year follow-up period for a calculated 5 year rate of 157.9 per 100 patients. In the present study, CT scans were used overall at a rate of 17.4 per 100 patients, with the rate being 1.88-fold greater in RYGB compared to SG. This is not surprising, given that the abdominal symptoms occur more often following RYGB vs. SG (Table 2, see discussion below), and in light of the greater frequency of surgical complications some of which are unique to gastric bypass (internal hernia, bowel obstruction) [19]. The Clinical Issues Committee of ASMBS in collaboration with the American College of Emergency Physicians has created an interactive online tool to assist ED physicians with bariatric examination, assessment, and management [20]. Our results support the use of this tool in RYGB cases and argue perhaps for further research into its use and how it may inform a more judicious use of CT for bariatric patients.

Our study revealed generally higher rates of various symptoms or complaints in RYGB patients. Abdominal pain was the most common reason that patients sought medical care, with 22% of RYGB patients compared to 11% of SG patients reporting at least one sequel. Counting all instances of abdominal symptoms, including multiple instances within unique patients, the population rate of abdominal symptoms was 2.37 times higher in RYGB compared to SG. Similarly, dysphagia was 5.7 times more frequent, dehydration was 1.93 times more frequent, nausea was 2.49 times more frequent,

Table 6 Results of multivariate logistic regression predicting non-routine healthcare utilization

Dependent variable	Factor (reference group)	Odds ratio	95% CI for OR	*p* value
Made at least one non-routine visit	RYGB surgery (sleeve gastrectomy)	*1.95*	*1.24–3.09*	*0.004**
	Extended length of stay (within 2 days)	1.55	1.00–2.40	0.050*
	History of GERD (no history)	1.46	1.01–2.17	0.046*
	Female (male)	1.45	0.78–2.71	0.240
	Ethnicity (Caucasian)			0.067
	African-American	1.39	0.85–2.28	0.193
	Latino	1.68	1.06–2.68	0.028*
	Robotic procedure (laparoscopic)	1.18	0.69–2.02	0.648
	Age (continuous—per year)	0.99	0.97–1.01	0.219
	Height (continuous—per inch)	0.98	0.91–1.04	0.976
Used at least one non-routine service	Extended length of stay (within 2 days)	3.39	2.27–5.06	< 0.001*
	RYGB surgery (sleeve gastrectomy)	*1.86*	*1.22–2.86*	*0.004**
	Ethnicity (Caucasian)			0.560
	African-American	1.06	0.67–1.67	0.814
	Latino	1.26	0.83–1.93	0.282
	Pre-surgical weight (continuous—per lb.)	1.00	0.99–1.002	0.277
	Height (continuous—per inch)	0.98	0.91–1.04	0.454
	Robotic procedure (laparoscopic)	0.95	0.57–1.60	0.854
	Female (male)	0.93	0.55–1.58	0.797

Data corresponding to the surgery type is italicized for emphasis

and vomiting was 3.30 times more frequent in RYGB vs. SG. These results are not unexpected in light of the reports of higher complication rates in RYGB vs. SG [11]. Only gastro-esophageal reflux occurred at a higher rate in SG (3.3 per 100) compared to RYGB (0.8 per 100).

Timing RYGB patients had higher rates of non-routine visits and services throughout the 2-year span. For bypass patients, the significantly greater rate of visits and services provided within 6 months of surgery is not surprising in view of the higher rate of surgical complications reported with RYGB surgery during this timeframe [11]. The NR visit and service rates in Fig. 1 were calculated using the full quota of patients who originally underwent surgery as the denominator, not the subset of patients that was available at any given time for follow-up (an unknown number). Although patient follow-up was less than 100% for both groups, the rates at one and 2-year follow-up did not differ. Therefore, we believe the comparisons that show large differences between groups in visits and services 1 to 6 months post-surgery and also the differences noted, thereafter, are valid.

Limitations The present study had several limitations. (1) This was not a randomized design; however, we do not feel that bias due to surgeon preference was a problem. Surgeries were performed in numbers that did not differ by surgeon, and post-operatively, the surgeons followed standard, established institutional clinical pathways to evaluate patient complaints post-intervention. Post-operative complaints were handled by either of the surgeons who cross-cover each other's cases and routinely consult each other on the management of these complaints. (2) While we were able to access data from within our healthcare system and we were also able to access data from some external facilities, we were not able to access data from every patient's visit to every external healthcare facility. Thus, we cannot be certain that we have captured all instances of NR healthcare utilization for this sample. (3) The collection of data at single site limits the generalizability of the results to other sites. (4) Despite the best efforts of staff to contact patients to schedule follow-up visits, about 23% of the patients were lost to follow-up at 1 year and 47% at 2 years, based on the presence of a body weight in the patients' medical records. Thus, the rates per patient reported for unscheduled visits and diagnostic imaging tests represent estimates calculated using the pre-surgery sample sizes as the denominator. (5) Our tracking of healthcare services and visits stopped at 2 years post-surgery. Further research should track healthcare utilization over a longer time period to determine whether RYGB patients require non-routine services for a longer period post-surgery relative to SG patients.

Conclusion

This study provides insight into the differential burdens placed on the healthcare system after the two most common bariatric procedures indicating that healthcare systems, and providers

should be prepared to provide non-routine services to bariatric patients within the first 2 years after surgery.

Compliance with Ethical Standards The study site is accredited by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP). The study was approved by the local Institutional Review Board.

Conflict of Interest DT served as a consultant for Olympus and Medtronic. PP served as a consultant for Olympus.

Statement of Informed Consent This study was approved by the Hartford Hospital Institutional Review Board (HHC-2017-0077) with a waiver of informed consent.

Ethical Approval This study was approved by the Hartford Hospital Institutional Review Board (HHC-2017-0077). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

1. Al-Khyatt W, Ryall R, Leeder P, et al. Predictors of inadequate weight loss after laparoscopic gastric bypass for morbid obesity. Obes Surg. 2016.
2. Lee JH, Nguyen QN, Le QA. Comparative effectiveness of 3 bariatric surgery procedures: Roux-en-Y gastric bypass, laparoscopic adjustable gastric band, and sleeve gastrectomy. Surg Obes Relat Dis. 2016;12:997–1002.
3. Zhang C, Yuan Y, Qiu C, et al. A meta-analysis of 2-year effect after surgery: laparoscopic Roux-en-Y gastric bypass versus laparoscopic sleeve gastrectomy for morbid obesity and diabetes mellitus. Obes Surg. 2014;24:1528–35.
4. Li J, Lai D, Wu D. Laparoscopic Roux-en-Y gastric bypass versus laparoscopic sleeve gastrectomy to treat morbid obesity-related comorbidities: a systematic review and meta-analysis. Obes Surg. 2016;26:429–42.
5. Bohdjalian A, Langer FB, Shakeri-Leidenmuhler S, et al. Sleeve gastrectomy as sole and definitive bariatric procedure: 5-year results for weight loss and ghrelin. Obes Surg. 2010;20:535–40.
6. Langer FB, Bohdjalian A, Shakeri-Leidenmuhler S, et al. Conversion from sleeve gastrectomy to Roux-en-Y gastric bypass–indications and outcome. Obes Surg. 2010;20:835–40.
7. Toussi R, Fujioka K, Coleman KJ. Pre- and postsurgery behavioral compliance, patient health, and postbariatric surgical weight loss. Obesity (Silver Spring). 2009;17:996–1002.
8. Elms L, Moon RC, Varnadore S, et al. Causes of small bowel obstruction after Roux-en-Y gastric bypass: a review of 2,395 cases at a single institution. Surg Endosc. 2014;28:1624–8.
9. Lee WJ, Pok EH, Almulaifi A, et al. Medium-term results of laparoscopic sleeve gastrectomy: a matched comparison with gastric bypass. Obes Surg. 2015;25:1431–8.
10. Zaveri H, Dallal RM, Cottam D, et al. Indications and operative outcomes of gastric bypass reversal. Obes Surg. 2016;26:2285–90.
11. Li JF, Lai DD, Lin ZH, et al. Comparison of the long-term results of Roux-en-Y gastric bypass and sleeve gastrectomy for morbid obesity: a systematic review and meta-analysis of randomized and nonrandomized trials. Surg Laparosc Endosc Percutan Tech. 2014;24:1–11.
12. Carlin AM, Zeni TM, English WJ, et al. The comparative effectiveness of sleeve gastrectomy, gastric bypass, and adjustable gastric banding procedures for the treatment of morbid obesity. Ann Surg. 2013;257:791–7.
13. Hutter JCMM. The MBSAQIP (Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program) Comprehensive Bariatric Program (MBSAQIP-ASMBS/ACS). The SAGES Manual of Bariatric Surgery; 2017. p. 185–90.
14. Garg T, Rosas U, Rogan D, et al. Characterizing readmissions after bariatric surgery. J Gastrointest Surg. 2016;20:1797–801.
15. Hutter MM, Schirmer BD, Jones DB, et al. First report from the American College of Surgeons Bariatric Surgery Center Network: laparoscopic sleeve gastrectomy has morbidity and effectiveness positioned between the band and the bypass. Ann Surg. 2011;254:410–20. discussion 20-2
16. Mora-Pinzon MC, Henkel D, Miller RE, et al. Emergency department visits and readmissions within 1 year of bariatric surgery: a statewide analysis using hospital discharge records. Surgery. 2017;162:1155–62.
17. Sahai H, Kuhurshid A. Statistics in epidemiology: methods, techniques, and applications. Boca Raton: CRC Press, Inc.; 1996.
18. Haddad D, David A, Abdel-Dayem H, et al. Abdominal imaging post bariatric surgery: predictors, usage and utility. Surg Obes Relat Dis. 2017;13:1327–36.
19. Li K, Gao F, Xue H, et al. Comparative study on laparoscopic sleeve gastrectomy and laparoscopic gastric bypass for treatment of morbid obesity patients. Hepatogastroenterology. 2014;61:319–22.
20. American College of Emergency Physicians. Bariatric examination, assessment and management. Avaliable at https://www.acep.org/patient-care/beam/#sm.00ik7too14bwfhg10x718i2hytwr1. Accessed 15 Oct 2018.