OBES SURG (2015) 25:2106–2111
DOI 10.1007/s11695-015-1672-0

ORIGINAL CONTRIBUTIONS

Internal Hernia After Laparoscopic Antecolic Roux-en-Y Gastric Bypass

Mazen R. Al-Mansour[1] · Romie Mundy[1] · James M. Canoy[2] · Kal Dulaimy[2] · Jay N. Kuhn[1] · John Romanelli[1]

Published online: 3 June 2015

Abstract
Background We evaluated the incidence and presentations of internal hernias (IH) after laparoscopic antecolic Roux-en-Y gastric bypass (RYGB) at our institution.
Methods We retrospectively reviewed the records of 594 patients who underwent laparoscopic antecolic RYGB at our institution between December 2004 and December 2010.
Results Five hundred ninety-four patients underwent laparoscopic antecolic RYGB with a mean follow-up of 50.5 months. Thirty-six patients developed 37 IH (6.2 %) requiring surgical intervention. Mean age of IH patients was 36.9 years. Thirty-one out of 36 were female. Mean preoperative BMI was 44.3 Kg/m^2. The mean time of presentation after their RYGB was 25.9 months. The mean % excess body weight loss at time of presentation was 54.0 %. Twenty-five out of 37 of IH occurred at Petersen's space; 9/37 IH occurred under the jejunojejunostomy; three patients had hernias at both locations. Mesenteric swirling was the most common CT scan finding in 20/36 (55.6 %). Six out of 36 CT were initially read as normal; however, on retrospective review by a radiologist, abnormalities indicating IH were found in 4/6. Patients presented with different degrees of acuity: 6/37 with chronic abdominal pain and 28/37 with acute abdominal pain. Bowel necrosis was found in 3/37.
Conclusion IH is a serious and potentially fatal complication of RYGB. Presentation can vary from chronic abdominal pain to bowel necrosis. CT is helpful in providing diagnosis; however, careful attention to the specific signs of small bowel volvulus, such as mesenteric swirl sign, should be given. IH should be considered in RYGB patients who present with even vague symptoms.

Keywords Bariatric surgery · Gastric bypass · Internal hernia · Morbid obesity · Complications · Petersen

✉ Mazen R. Al-Mansour
mazmansour@yahoo.org

Romie Mundy
romie_mundy@brown.edu

James M. Canoy
jmcanoy1860@msn.com

Kal Dulaimy
kaldulaimy@yahoo.com

Jay N. Kuhn
jay.kuhn@baystatehealth.org

John Romanelli
john.romanelli@baystatehealth.org

[1] Department of Surgery, Baystate Medical Center, Tufts University School of Medicine, Springfield, MA, USA

[2] Department of Radiology, Baystate Medical Center, Tufts University School of Medicine, Springfield, MA, USA

Introduction

Bariatric surgery has emerged as the most reliable method of persistent weight loss [1]. While different operations exist to achieve this goal, Roux-en-Y gastric bypass (RYGB) is considered by many to be the gold standard bariatric operation. It provides substantial weight loss [2] and significant improvement of medical comorbidities [3, 4] with acceptable complication rate.

Internal hernia (IH) resulting in bowel obstruction or intestinal ischemia is a well-described complication of laparoscopic RYGB. We sought to review the frequency of internal hernia in patients treated at Baystate Medical Center (BMC) after laparoscopic antecolic gastric bypass.

Materials and Methods

BMC is a Level 1 Bariatric Surgery Center accredited by the American College of Surgeons Bariatric Surgery Center Network (ACS BSCN). Between December 2004 and December 2010, two bariatric surgeons performed 594 laparoscopic antecolic RYGB at BMC. We utilized the Baystate Weight Loss Surgery Program Prospective Database to look up the patients who underwent surgical intervention for IH in that time period. Thirty-six patients who developed symptomatic IH requiring operative intervention were identified. The charts of these 594 patients were retrospectively reviewed. Approval from our Institutional Review Board was obtained (IRB no. BH-10-136) to perform this study.

Data collected included demographics, weight, and body mass index (BMI) at RYGB and at IH operation, presentation, computed tomography scan (CT) findings as well as operative findings and techniques. Percentage of excess body weight loss (%EBWL) was calculated using the following equations:

$$\%\mathrm{EBWL} = \text{weight at RYGB} - \text{weight at IH operation} / \text{weight at RYGB} - \text{ideal body weight(IBW)} \times 100\%$$

$$\text{Female IBW(lbs)} = [100 + 5 \times (\text{height(in)} - 60)] \times 1.1$$

$$\text{Male IBW(lbs)} = [106 + 6\ (\text{height (in)} - 60)] \times 1.1$$

We used Stata software (ver. 12.1, College Station, TX) for all statistical analysis. Fisher exact testing was used to calculate statistical significance.

Surgical Technique

The two bariatric surgeons performed the laparoscopic gastric bypass operation in a similar manner. An antecolic antegastric formation was utilized. One surgeon used traditional laparoscopic technique while the other used both traditional laparoscopic and robotic techniques.

After establishing laparoscopic entry to the abdomen, the jejunum is divided approximately 40 cm distal to the ligament of Treitz. An approximately 100–120-cm Roux limb is created and aligned with the biliopancreatic limb in preparation for the jejunojejunostomy. A linear stapled side-to-side (functional end-to-side) jejunojejunostomy is then created.

A laparoscopic linear stapling device is used to create the gastric pouch by dividing the stomach starting on the lesser curvature approximately 5 cm distal to the gastroesophageal junction. The Roux limb is then brought in an antecolic antegastric fashion and is aligned with the gastric pouch. Division of the omentum was sometimes performed at the discretion of the operating surgeon, typically using ultrasonic dissection. In the robotic approach, a two-layered hand-sewn gastrojejunostomy was created, while in the traditional laparoscopic approach, a linear stapled side-to-side gastrojejunostomy is created and the common enterotomy is closed in a hand-sewn fashion. Otherwise, the robotic technique did not have any other significant differences compared to the traditional laparoscopic technique.

The mesenteric defect underneath the jejunojejunostomy was routinely closed using a running 2-0 silk suture. However, the surgeons only started to close Petersen's space defect during the course of the study period. 2-0 silk suture in a continuous fashion was used for Petersen's space closure.

Results

The 594 patients who underwent laparoscopic antecolic RYGB had a mean (±SD) follow-up of 50.5 (±9.2) months. Of these, 36 patients developed 37 IH requiring surgical intervention during the study time period with an incidence of 6.2 %. The patient population had a mean age of 36.9 (±10.4) years; 31/36 (86.1 %) of the patients were women, and the mean preoperative BMI was 44.3 (±3.5) Kg/m^2. We analyzed the annual distribution of IHs over the 6 years of the study period (Table 1). No statistically significant difference in internal hernia distribution over time was noted.

The mean time between the laparoscopic RYGB procedure and the operation for IH was 25.9 (range 3 to 86) months. The mean % excess body weight loss at the time of operation for IH was 54.0 % (±11.8). In the majority of patients, the IH was only found at Petersen's space 25/37 (67.6 %). The hernia was found only at the jejunojejunostomy site in 9/37 (24.3 %) patients and three patients IHs at both locations (8.1 %). One patient was admitted twice with abdominal pain requiring operative exploration; an IH was found at each operation, one at the jejunojejunostomy location, and the second at Petersen's space (Table 2).

Patient presentation at the time of IH operation varied. We found that some patients, 6/37 (16.2 %), presented with chronic abdominal pain and had a semi-elective laparoscopic exploration looking for IH. Twenty-eight out of 37 (75.7 %) patients had acute abdominal pain presenting in the emergency room at our institution or necessitating transfer from a nearby

Table 1 Annual IH distribution over study period

2005	4.91 %
2006	6.67 %
2007	8.70 %
2008	5.22 %
2009	9.33 %
2010	4.48 %
Total	6.23 %

Fischer's exact test ($p<0.69$)

Table 2 Characteristics of the internal hernias

Mean time from RYGB to operation for IH, months (range)	25.9 (3–86)
Mean %EBWL (± SD)	54.0 (±11.8)
Location	
Petersen's space	25/37 (67.6 %)
Jejunojejunostomy	9/37 (24.3 %)
Both locations	3/37 (8.1 %)
Presentation	
Chronic abdominal pain	6/37 (16.2 %)
Acute abdominal pain	28/37 (75.7 %)
Bowel necrosis	3/37 (8.1 %)

RYGB Roux-en-Y gastric bypass, *SD* standard deviation, *%EBWL* percentage estimated body weight loss

facility. Necrotic bowel was encountered on operative exploration in 3/37 (8.1 %) patients.

With the exception of one patient who had peritonitis and therefore underwent immediate exploration, all other patients had an abdominal CT scan (Table 3). The most common CT finding was the mesenteric swirl sign, defined as twisting pattern of the mesenteric vessels indicating midgut volvulus (Fig. 1). Other findings included small bowel dilation, mesenteric edema, free abdominal fluid, mushrooming of the mesentery, and small bowel intussusception. In 6/36 (16.7 %) patients, no abnormality was identified on CT scan. Of these 6 patients, 5 had acute presentation including a patient who had necrotic bowel.

When a board certified radiologist (K.D.) was asked to retrospectively review the CT scans that were initially interpreted as normal, the read was changed to reflect a possible internal hernia in 4/6 cases.

Laparotomy and bowel resection was performed in all patients who had necrotic bowel. One patient had a short segment resection and had an excellent postoperative course. However, in the other two, extensive resection was performed (one requiring multiple operations) and both developed enterocutaneous fistulas requiring elective reoperation. All patients eventually were able to tolerate oral diet, and no mortalities were noted. In these three patients, only the jejunojejunostomy mesenteric defect (but not Petersen's space defect) was closed during the index RYGB. All three patients

Table 3 CT scan findings

Mesenteric swirl	20/36 (55.6 %)
Bowel dilation/obstruction	9/36 (25 %)
Mesenteric edema	4/36 (11.1 %)
Free abdominal fluid	4/36 (11.1 %)
Other	6/36 (16.7)
No abnormal findings	6/36 (16.7)

Fig. 1 Mesenteric swirl sign

had internal herniation of the bowel through Petersen's defect. One patient had herniation of small bowel through the jejunojejunostomy defect as well (herniation through both defects). In all but two of the patients who did not have necrotic bowel, reduction of the IH and closure of the mesenteric defect were performed laparoscopically.

Data on closure of the mesenteric defects were recorded in 590 operative reports. The jejunojejunostomy defect was closed in all cases. Both surgeons started to routinely close the Petersen's space defect during the course of the study period. Therefore, this was performed in 153/590 (25.9 %). The incidence of IH in patients who underwent closure of both mesenteric defects (5.9 %) was not statistically different from patients who underwent closure of the jejunojejunostomy defect alone (6.6 %; $p=0.85$). The mean (SD) of follow-up was 19.4 (11.1) and 28.3 (21.4) months. Out of the 153 patients who had closure of both mesenteric defects, only 6 developed IH. Two out of these 6 patients (33.3 %) patients developed IH at Petersen's space defect. On the other hand, of the 337 patients who had closure of the jejunojejunostomy defect alone, 31 developed IHs. Twenty-six out of these 31 patients (83.9 %) developed an IH at Petersen's space defect.

One hundred thirty-two patients (of the total 594) had robotic RYGB. The incidence of IH in robotic RYGB (6.8 %) was not different from the incidence in standard laparoscopic RYGB (6.0 %; $p=0.69$). The mean (SD) follow-up period for robotic RYGB was 21.7 (14.1) months.

Discussion

Roux-en-Y gastric bypass (RYGB) has established itself as a very effective weight loss operation (with % excess body weight loss (%EBWL) of up to 74 %) with acceptable morbidity [2]. With the breakthrough of laparoscopic surgery, a noticeable increase in the rate of bariatric operations was noticed. When compared to the open technique, laparoscopic RYGB is associated with a lower incidence of wound complications, ventral hernia formation, and a shorter hospital stay [5–7]. On the other hand, several reports have suggested that the laparoscopic approach is associated with a higher incidence of internal hernia formation, likely due to reduced postoperative adhesions [8, 9]. IH is the most common and most frequently missed cause of small bowel obstruction after laparoscopic RYGB [10, 11]. IH can be a life-threatening complication if it resulted in bowel obstruction or bowel ischemia.

Several reports have investigated the location of the alimentary limb as a contributing factor to the development of IH. Most notable is the location of the alimentary limb relative to the transverse colon (antecolic vs. retrocolic). While the antecolic approach eliminates a potential site for IH, i.e., the transverse mesocolic defect, the data on which direction the alimentary limb should follow have been controversial [12–17]. Conversely, the hernia behind the Roux limb (commonly referred to as Petersen hernia) is more likely to occur in the antecolic approach.

In this study, we review the incidence and pattern of presentation of internal hernias requiring operative intervention at our institution. The two bariatric surgeons at our institution performed the procedure in an antecolic fashion. Our incidence of IH was 6.2 % which lies at the higher end of the incidence range reported in the literature (0–6.9 %) [9, 15, 17–29].

The high incidence of IH in our population was surprising to us especially that the incidence did not change after adding routine closure of the Petersen's space defect. Many bariatric surgeons recommend routine closure of the mesenteric defects. Rodriguez et al. studied two groups of laparoscopic antecolic antegastric RYGB patients. In group 1 (2004–2006), the jejunal mesentery was widely divided and Petersen's space was left open. In group 2 (2004–2006), the jejunal mesentery was only minimally divided and Petersen's space was closed routinely. The incidence of small bowel obstruction (including IH) was much higher in group 1 (14.4 %) as compared to group 2 (1.1 %). The study's limitations included the retrospective nature and the significant difference in mean follow-up duration between the two groups (36 months (group 1) versus 26 months (group 2)) [30]. Madan et al. reviewed 54 patients who underwent reoperation (for different indications) after prior laparoscopic antecolic antegastric RYGB without closure of the mesenteric defects. The mean follow-up was 24 months. During reoperation, careful search for mesenteric defect identified patent defects in only two patients and none of these patients had a symptomatic IH [31]. We included only the patients who received their reoperation at our institution; while we are unaware of patients operated on elsewhere from this series, it is possible that the actual incidence of IH might actually be even higher than what we are reporting.

While the incidence of IH did not change when we instituted routine closure of Petersen's space defect, the location of the IH seems to have changed. Routine closure of Petersen's space defect reduced the percentage of patients with Petersen hernias from 83.9 to 33.3 %. We do believe that closure of Petersen's space defect has the potential to reduce the incidence of IH after RYGB. While our series does not yet support this finding, we believe that the shorter duration of follow-up and the small number of IHs that developed in patients who had closure of Petersen's space defect may explain our findings. A newer technical innovation that one of the surgeons now routinely employs is to tie the sutures of both mesenteric closures together. Given that the mesentery of the Roux limb and the mesentery of the biliopancreatic limb used to be the same structure, they lie in close proximity once the procedure is completed. Tying the closure sutures together means both suture lines would have to breakdown for an incarcerated hernia to form. We do not yet have data on whether or not this will ultimately reduce IH rate.

Abdominal pain is the most common symptom of IH [11]. The acuity of the pain varies from chronic intermittent abdominal pain that represents intermittent self-limited herniation of small bowel through a mesenteric defect, to acute abdominal pain with or without bowel obstruction, to bowel strangulation and necrosis due to closed loop obstruction or more commonly volvulus with twisting and occlusion of the mesenteric vascular pedicle. The most common presentation in our series was acute abdominal pain without strangulation/bowel necrosis. Garza et al., found that intermittent postprandial abdominal pain and/or nausea/vomiting was the most common complaint of IH [23]. The incidence of bowel necrosis in our series was 8.1 %. These patients did not have specific signs of bowel necrosis on CT imaging. Clinical assessment of these patients with low threshold for abdominal exploration is key to prevent delay in diagnosis and surgical management, which may result in substantial morbidity and mortality risk.

Multi-detector abdominal CT is among the most commonly obtained imaging studies in patients with RYGB who present with abdominal pain. All but one of the IH patients in our study had a CT scan. 16.7 % of these were falsely negative. However, a retrospective review by our radiologist identified an abnormality suggestive of IH in two thirds of the studies previously interpreted as normal. Of the patients who had a normal initial interpretation of the abdominal CT, 5/6 had acute presentation and one had necrotic bowel. This highlights the need for an experienced radiologist who is able to take into consideration the altered anatomy and subtleness of IH findings in these patients. Surgeons who are taking care of RYGB patients should also be familiar with the cross-sectional imaging of these patients and have a low threshold to proceed with operative exploration.

The false negative rate of CT in our study is consistent with previous reports that show a false negative rate of 13.5–17.8 % [11, 32]. The mesenteric swirl sign was the most common CT finding in our patients. Lockhart et al. retrieved the CT scans of 18 patients with surgically proven IH and had these CT scans retrospectively reviewed by three radiologists. Mesenteric swirl sign was shown to be the best single predictor of IH with a sensitivity of 61–83 % and a specificity of 67–94 % [33].

Our study has multiple limitations. The most notable is the retrospective nature of this study. There was also no consistent differentiation upon review of the operative reports if the bowel was seen herniating through a mesenteric defect or if a widely patent mesenteric defect was found. This might have contributed to the high incidence of IH in our series.

In conclusion, IH is common complication of laparoscopic RYGB procedure. Radiologists and surgeons should entertain this diagnostic possibility in all patients with a history of RYGB who present with abdominal pain. The presentation of these patients can be variable, and diagnostic delays can result in substantial morbidity or mortality. CT scan can be helpful in confirming the diagnosis, but a low threshold for operative exploration should be maintained.

Acknowledgments The authors thank Mr. Paul Visintainer, PhD for his assistance in performing the statistical analysis of the data.

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

Ethical Approval Statement 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

Informed Consent Statement For this type of study, formal consent is not required.

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