Internal Hernia Following Roux-en-Y Gastric Bypass Surgery for Morbid Obesity: Evaluation of Radiographic Findings at Small-Bowel Examination

| Purpose: | To characterize features of internal hernia (IH) at small-bowel follow-through (SBFT) following Roux-en-Y gastric bypass procedure (RYGBP) for morbid obesity. |
| Materials and Methods: | The institutional review board approved this HIPAA-compliant retrospective study; informed consent was waived. Radiologic database review revealed 1655 SBFT studies over 6 years in 1282 patients after RYGBP. IH was suggested on 24 studies in 23 patients. Studies were analyzed for atypical bowel configuration, change in bowel or suture position, and obstruction. Chart review was performed to determine clinical course, treatment, and outcome. Studies from a control group of 21 RYGBP patients were similarly analyzed. Statistical comparison was performed with the Fisher exact test. |
| Results: | Clinical and/or surgical evidence of IH was found following 21 SBFT studies in 20 of 1282 patients (1.6%). Atypical bowel configuration with clustered small bowel was identified on all studies. Cluster location was lateral to descending colon ($n=10$), left upper quadrant ($n=6$), left upper and mid abdomen ($n=3$), right midabdomen ($n=2$), under the gastric pouch ($n=1$), and right lower quadrant ($n=1$). For two studies, two locations of clustered bowel were identified. Change in jejunojejunal suture position occurred in all cases with radiopaque suture ($n=15$). Other signs of IH included displaced colon ($n=19$), visible entrance and exit limbs into the hernia ($n=17$), stasis in clustered bowel ($n=16$), densely matted bowel ($n=12$), and a straight left lateral border of clustered bowel ($n=10$). Partial obstruction occurred in 16 patients. Findings of atypical bowel configuration, clustered bowel, and staple line change were significant when compared with the control. |
| Conclusion: | IH following RYGBP is a rare but potentially fatal complication. Radiologists must be aware of this complication and its diagnostic features at SBFT. |

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Supplemental material: http://radiology.rsna.org/cgi/content/full/2513081544/DC1
Obesity is increasing in prevalence in the United States; more than 50% of adults are overweight or obese, as defined by a body mass index of greater than 25 kg/m², and occurrence of obesity has increased by approximately 74% from 1991 to 2001 (1–6). Nonsurgical treatments for morbid obesity have limited long-term success and bariatric surgery has become a popular treatment option (1,7–9). The highest long-term success rates have been reported with the Roux-en-Y gastric bypass procedure (RYGBP) (1,7–16).

Materials and Methods

This study was conducted according to all guidelines set forth by the institutional review board and was Health Insurance Portability and Accountability Act compliant. Given the retrospective nature of the study, the requirement for informed consent was waived. Radiologic database review at our institution revealed 1655 SBFT studies performed in 1282 patients following RYGBP over a 6-year period. In the database, 844 patients underwent initial open RYGBP and 438 underwent laparoscopic RYGBP. Review of SBFT reports revealed findings suggestive of IH on 24 studies in 23 patients.

Patients with Possible IH

Findings in reports from 24 SBFT studies performed in 23 patients following RYGBP suggested a diagnosis of IH; surgery was performed following 23 of those studies.

Implication for Patient Care

- Radiologists must be aware of the expected anatomy following RYGBP, the potential complications of IH, and the constellation of findings that may be seen at SBFT to make the diagnosis of IH.
Clinical and/or surgical evidence of IH was found in 21 instances in 20 (1.6%) of 1282 patients following RYGBP. One patient was diagnosed with IH after review of two studies performed 3 years apart and surgical confirmation was obtained in each instance. Three additional patients were excluded from the study owing to lack of definitive surgical proof of IH (IH or mesenteric defect was not specifically mentioned in the surgical report). Our study group therefore consisted of 20 patients (mean age, 38 years at initial IH diagnosis; range, 23–58 years), including 17 women (mean age, 38 years; range, 23–58 years) and three men (mean age, 39 years; range, 35–45 years), who were suspected of having IH at SBFT. Initial surgery was performed laparoscopically in five patients and as open surgery in 15. SBFT was performed at a mean of 3.9 years following surgery (range, 26 days to 10 years).

Control Group

Our control group was randomly selected from the same radiologic database of SBFT studies performed following RYGBP over a 6-year period and consisted of 21 studies performed in 21 patients (mean age, 43 years; range, 25–61 years), including 18 women (mean age, 43 years; range, 25–61 years) and three men (mean age, 44 years; range, 40–48 years). Initial surgery was performed laparoscopically in 11 patients and as open surgery in 10. SBFT was performed at a mean of 2.4 years following surgery (range, 27 days to 10 years). The subjects in the control group had no other known small-bowel disease.

SBFT Technique

Following preliminary supine radiography, SBFT examinations were initially performed in five patients and as open surgery in 15. SBFT was performed at a mean of 3.9 years following surgery (range, 26 days to 10 years).

Image Analysis

SBFT examinations performed on 20 study and 21 control patients were analyzed in consensus by two abdominal radiologists (L.R.C. and M.A.T., with 11 and over 25 years experience with SBFT, respectively). The observers were blinded to the surgical diagnosis at the time of the review. SBFT studies from the study and control group patients were reviewed separately. Studies were analyzed for atypical bowel configuration (eg, clustered, displaced small-bowel loops) and location, change in the position of bowel and/or sutures from prior studies and during the study; and stasis of contrast material within clustered

Figure 1

Figure 1: Normal postoperative anatomy and potential mesenteric defects for IH following RYGBP. (a) Diagram of expected anatomy following RYGBP shows small gastric pouch (P), Roux jejunal limb (J), and jejunojejunal anastomosis (arrowhead). Potential mesenteric defects (yellow arrows) for development of IH are defect through transverse mesocolon with retrocolic Roux limb (TM), defect for small-bowel anastomosis (SB), and retro-Roux defect (Petersen defect, RR). (b) Supine overhead radiograph from SBFT shows postoperative anatomy following RYGBP and expected course of small bowel. Arrow = gastrojejunal anastomosis.
bowel segments as the major bolus progresses distally, displacement of bowel owing to clustered segments of bowel, bowel dilatation, and obstruction.

**Clinical Chart Review**

Chart review was performed to assess clinical presentation, time of diagnosis following initial surgery, surgical procedures performed, treatment, and patient outcome. Surgical reports were reviewed to determine findings at the initial procedure and follow-up surgery.

**Statistical Methods**

SBFT findings from the study and control groups were compared with the Fisher exact test.

**Results**

**SBFT Findings**

All SBFT images evaluated for this study were adequate for diagnosis.

*Study group.*—The study group consisted of 21 SBFT studies performed on 20 patients. For all SBFT studies, there was an interval change in the bowel configuration and/or suture position in comparison with a previous study, where available (n = 16). For all 21 studies, an atypical bowel configuration was identified with clustered small-bowel loops. The location of clustered small bowel is shown in Table 1. The most common locations for clustered bowel were the left midabdomen, lateral to the descending colon in 10 (48%) of 21 studies (Fig 2) and the left upper quadrant under the diaphragm, cephalad into the gastric pouch, in six (29%) (Fig 3). Larger hernias involved clustered bowel in the left upper and mid abdomen in three (14%) studies (Fig 4). Overall, clustered small bowel was identified in the left upper and/or left midabdomen in 19 (90%) of 21 studies. On one study, clustered bowel was located in the midabdomen under the gastric pouch. This clustered segment was fixed, persisting in the upright position (Fig E1 [http://radiology.rsna.jnl.org/cgi/content/full/2513081544/DC1]).

More atypical locations for clustered bowel were the right midabdomen (Fig 5) and right lower quadrant (Fig E2 [http://radiology.rsna.jnl.org/cgi/content/full/2513081544/DC1]). In two cases each, two different locations for clustered bowel were identified. A change in location of the jejunojejunal anastomotic suture or staple line from the location noted at postoperative imaging was identified on all.

**Table 1**

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<th>Cluster Location</th>
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<td>Left mid abdomen, lateral to descending colon</td>
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<td>Left upper quadrant, under diaphragm</td>
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<td>Left upper and lateral mid abdomen</td>
<td>3 (14)</td>
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<td>Right mid abdomen</td>
<td>2 (10)</td>
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<tr>
<td>Under gastric pouch</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Right lower quadrant</td>
<td>1 (5)</td>
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</table>

Note.—Numbers in parentheses are percentages.

* On two studies each, two cluster locations were identified.

**Figure 2**

IH with clustered small bowel in left midabdomen. Supine overhead radiograph from SBFT shows contrast material densely matted in clustered small-bowel loops in left midabdomen. Small bowel is displaced, extending to left lateral abdominal wall, lateral to descending colon. Clustered small bowel is dilated. J = Roux jejunal limb, arrow = proximal descending colon.

**Figure 3**

IH with clustered small bowel displaced into left upper quadrant, under diaphragm. (a) Supine and (b) upright overhead radiographs from SBFT show persistent matted small-bowel loops (arrows) clustered and displaced into left upper quadrant, under diaphragm and cephalad to gastric pouch (P). Small bowel is mildly dilated and fixed in this location in upright position (b). Roux limb is superimposed on gastric pouch. Small-bowel loops are clustered, tethered, and angulated.
studies in which a radiopaque staple line was seen on the scout film (n = 15). On 11 (73%) of 15 studies, the staple line was displaced cephalad into the left upper quadrant. For two additional studies, the staple line was displaced laterally to the left. For two other studies, the staple line was displaced to the right (Fig E3 [http://radiology.rsna.org/cgi/content/full/2513081544/DC1]). For one of these two studies, the staple line was initially displaced into the right abdomen and intermittently shifted into the left midabdomen during the study.

Additional SBFT findings identified in the study group are listed in Table 2. Clustered small bowel displaced the colon in 19 (90%) of 21 studies: Descending colon was displaced medially by lateral extension of the small bowel on 11 (52%) studies, and the transverse colon and splenic flexure were displaced inferiourly on eight (38%). On 17 (81%) studies, small-bowel limbs could be seen entering and exiting the clustered segment (Fig 6). Stasis of contrast material in the clustered segment was found on 16 (76%) studies (Fig 7). The clustered segment was densely opacified and matted on 12 (57%) studies, and on 10 (48%), there was a straight margin of the left lateral border of clustered small bowel (Fig 4).

Partial small-bowel obstruction was diagnosed on 16 (76%) of 21 studies. Obstruction was mild in two, moderate in nine, and severe in five. Five (31%) of 16 patients with obstruction had dilated bowel proximal and distal to the clustered segment of bowel with a more distal transition point (Figs 6, 7). In five cases, no bowel dilatation was noted. The clustered bowel appeared angulated or tethered on all 21 studies.

Control group.—SBFT findings in the control group of 21 RYGBP patients are shown in Table 3. No patient in the control group had a displaced visible distal staple line (visible in 16 control group patients) and none had obstruction. In two of 21 control patients, there was an atypical small-bowel configuration with clustered small bowel. At further inspection, in one of these two patients, clustered small bowel was located within a ventral hernia documented in the lateral position at SBFT. The second patient had tethered, angulated small bowel in the left midabdomen; however, there was no stasis of contrast material in these loops. A different patient had a straight left lateral border of small bowel on a single overhead film. However, there was no clustering of bowel and this configuration changed during the study. The difference between the study and control groups was significant for each of the five findings (Table 3). No other SBFT finding associated with IH was found in the control group.

Clinical Symptoms of IH

Patients experienced abdominal pain in all 21 instances of IH in the 20 study group patients. Pain location was epigastric in 10, umbilical in three, diffuse in six, and lower abdominal in two. Pain was described as crampy or colicky in 13 and radiating in eight patients. Pain increased after eating in eight patients. Pain was intermittent with progressive exacerbations occurring over days (n = 9), weeks (n = 7), or months (n = 5). Nausea and vomiting occurred in 14 patients. Fever was documented in three patients.

Clinical Chart Review

A diagnosis of IH was made following 21 SBFT studies in 20 patients. IH was di-

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Table 2

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<td>Displaced colon</td>
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<td>17 (81)</td>
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<td>Contrast material stasis in cluster</td>
<td>16 (76)</td>
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<tr>
<td>Dense, matted cluster</td>
<td>12 (57)</td>
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<tr>
<td>Straight left lateral border</td>
<td>10 (48)</td>
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</table>

Note.—Numbers in parentheses are percentages.
diagnosed at a mean of 3.9 years (range, 26 days to 10 years) after initial surgery. One case was diagnosed within 1 month postoperatively, with a total of five cases diagnosed within the 1st year. Sixteen (76%) of 21 cases were diagnosed more than 2 years following surgery. IH was diagnosed at a mean of 1.3 years (range, 26 days to 4.6 years) following laparoscopic surgery and a mean of 4.7 years (range, 3 months to 10 years) following open surgery.

Clinical evidence of IH was found following 21 SBFT studies in 20 patients. Surgery was performed and confirmed a diagnosis of IH following 20 of 21 studies (19 patients). One of these patients was diagnosed with IH following two SBFT studies performed 3 years apart, and surgical confirmation was obtained following each study. One additional patient with a high index of clinical and radiologic suspicion for IH refused surgical treatment and left the hospital against medical advice, with no follow up.

Surgical reports described 13 specific mesenteric defects in 10 patients. In the remaining 11 cases, IH was found but the specific defect was not documented in the surgical record. The most common defect documented was of the transverse mesocolon in six (46%) of 13 defects. This was followed by four (31%) defects at the jejunojejunal anastomosis and three (23%) Petersen defects. Three patients each had two defects consisting of a Petersen defect in combination with a defect through the transverse mesocolon (n = 2) or at the jejunojejunal anastomosis (n = 1). One patient had IH documented on two occasions with a 3-year interval: The first was through a defect at the jejunojejunal anastomosis; and in the second instance, the specific defect was not documented in the surgical record. In all cases with specific defects documented, displaced clustered bowel was located in the left upper and/or left mid abdomen at SBFT. No bowel necrosis was identified at surgery and no death occurred related to IH.

**Discussion**

IH is a potentially fatal complication of RYGBP, occurring in 20 (1.6%) patients in our study. Prompt diagnosis is desirable, as further drastic complications may occur, including bowel strangulation and infarction, and urgent surgical intervention is often necessary. RYGBP patients with abdominal pain and possible obstruction are often radiologically evaluated. However, IH remains a diagnostic challenge to radiologists interpreting CT and SBFT studies. To date, the literature predominantly discusses CT findings of IH following RYGBP and suggests a high degree of overlap between findings of IH and adhesions (18–21,25,31,32,40–43,45). SBFT findings of IH after RYGBP have not been well described in the literature and patients with presumptive symptoms of IH may undergo surgery on the basis of clinical findings. Urgent surgery performed on the basis of clinical findings alone may result in unnecessary procedures, especially since clinical findings are often nonspecific. A more accurate diagnostic test may diminish the need for additional surgery or may lead to more timely and appropriate surgical management.

From our retrospective review, we found several characteristic findings of IH at SBFT, including abnormal bowel configuration with clustered small-bowel loops and displacement of bowel and suture line. Clustered small bowel is most often in the left upper and/or mid abdomen (19 [90%] of 21 cases); however, it can be located anywhere. As in our control group, clustered bowel may also be within a ventral hernia. Routine assessment for ventral hernia should be performed in the lateral position during SBFT following RYGBP to help make this distinction. As clustered small bowel migrates into an atypical configuration in IH, colon is displaced in 90% (19 of 21) of cases. Small-bowel loops may be seen entering and exiting the clustered bowel segment at SBFT in 17 (81%) cases. It is important to follow the bowel to the right colon at SBFT, as even distal ileum may be located within an IH; and with a large IH, the pattern may not become apparent until the terminal ileum is opacified. In comparison with available prior studies, all patients had a change in bowel configuration and a change in jejunojejunal suture location was found in all cases in which it was visible in our series. SBFT findings of IH in our study were significant when compared with those of the control group. Further prospective evaluation of these findings is indicated.

SBFT provides a potential advantage over CT, as it is performed over time, often several hours. Small bowel can be observed as it is opacified with contrast material at fluoroscopy. SBFT allows for observing stasis of contrast material in clustered bowel as the major bulus progresses distally and changes in bowel configuration over time, including migration of clustered bowel or the jejunojejunal anastomosis during the study.
indicating intermittent IH. SBFT may more readily help depict entrance and exit limbs of small bowel into IH, compared with CT, as well. However, CT can often be performed and subsequently interpreted faster and may be more readily available after hours and in the emergency room.

IH is considered a delayed complication of RYGBP, occurring more than 1 month postoperatively in 93% of patients (18,21,24,26,42,43). Our study also found delayed postoperative occurrence of IH, with 20 (95%) of 21 occurring more than 1 month and 16 (76%) occurring more than 2 years postoperatively (mean, 3.9 years). However, IH can occur at any time following RYGBP (11,24) and even in the relatively acute postoperative course, IH should be a diagnostic consideration.

IH is much more common following laparoscopic RYGBP compared with open surgery (11,17,18,22–24,26,33,34,36,45). The lack of adhesions following laparoscopic surgery is thought to allow more bowel mobility and increase the potential for IH (17,22–24,26). The reported incidence of IH following laparoscopic RYGBP is 1.6%–5% (10,11,17,21–24,26,33,34,36,42,46). However, this incidence may be underestimated owing to limited long-term follow-up for laparoscopic RYGBP and a result of difficulty in making an accurate diagnosis (20,21,34). Even at surgery, IH may be overlooked owing to spontaneous reduction and difficulty performing a thorough exploration of the entire peritoneal cavity, especially in larger patients (19,20,27). In addition, IH may be transient.

Our study included patients who had undergone laparoscopic and open RYGBP. In our database of 1282 patients following RYGBP, 844 (66%) underwent open surgery and 438 (34%) underwent laparoscopic RYGBP. Although considered rare following open RYGBP (23,43), in our study, 75% (five of 20) of IH patients underwent open surgery with a mean time of diagnosis of 4.7 years following surgery. The mean time of diagnosis of IH following laparoscopic surgery was 1.3 years. These findings are, at least in part, likely related to longer follow-up for open RYGBP compared with laparoscopic RYGBP, as IH can occur at any time postoperatively. IH requires a mesenteric defect and weight loss presumably causes expansion of mesenteric

Table 3

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<th>Control Group</th>
<th>Fisher P Value</th>
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<td>Atypical bowel configuration</td>
<td>21/21 (100)</td>
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<td>Clustered small bowel</td>
<td>21/21 (100)</td>
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<td>Staple line change (radiopaque staple line)</td>
<td>15/15 (100)</td>
<td>0/16 (0)</td>
<td>&lt;.001</td>
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<tr>
<td>Partial small-bowel obstruction</td>
<td>16/21 (76)</td>
<td>0/21 (0)</td>
<td>&lt;.001</td>
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<tr>
<td>Straight left lateral border</td>
<td>10/21 (48)</td>
<td>1/21 (5)</td>
<td>.0036</td>
</tr>
</tbody>
</table>

Note.—Numbers in parentheses are percentages.
defects (17,21,26,30,46). These factors are also found following open RYGBP and IH should be a diagnostic consideration following this procedure. Also, IH has become a more recognized potential complication in recent years as laparoscopic surgery has become a popular option.

Small-bowel obstruction has a similar incidence following open and laparoscopic RYGBP, occurring in up to 5% of patients (18,33,36,37,45,47,48). IH should be considered as an etiology for obstruction following RYGBP and is reportedly the most common cause of obstruction following laparoscopic RYGBP (19,21,22,24–26,32,36,37,48). However, IH may occur without bowel dilatation or obstruction (24) or obstruction may be intermittent (31). In 24% (five of 21) of cases in our series, there was no bowel dilatation. In addition, in five (31%) of 16 patients with obstruction in our study group, the transition point was distal to the clustered bowel within the IH. This may be related to overall changes in bowel configuration and function related to the internal hernia.

During RYGBP, mesenteric defects are routinely created and IH may occur through any defect. The most common sites are through the transverse mesocolon, at the jejunojejunal anastomosis and posterior to the Roux limb (Petersen defect) (17–26). Although documentation of the surgical defect was incomplete in our retrospective study, the transverse mesocolon defect was the most common documented (six [46%] of 13 defects and six [60%] of 10 patients). There was no association between the defect at surgery and the location of clustered small bowel seen at SBFT in our series. Also, 30% (three of 10) of patients with documented defects had a defect at more than one site. This emphasizes the importance of careful inspection for this complication at the time of reoperation.

In our study, IH occurred in 1.6% (20 of 1282) of RYGBP patients, lower than reported in many prior studies (10,11,17,21–24,26,33,34,36,42,46). Our study included only patients who underwent SBFT. Other patients may have undergone surgery on the basis of clinical suspicion or patients may have undergone only CT imaging. Our study was limited by its retrospective nature. In addition, it was limited because of selection bias; only RYGBP patients undergoing SBFT were included and patients were selected from a radiologic database. Furthermore, because our study group was selected on the basis of radiologic findings, patients with IH who may have been misdiagnosed at initial SBFT imaging may not have been included in our study group. Also, patients with abnormal findings were more likely to be included in our study group.

It is important for radiologists to recognize IH as a potential complication following RYGBP for morbid obesity and to be aware of diagnostic features of IH seen on SBFT studies. This evaluation requires knowledge of the expected postoperative anatomy and thorough fluoroscopic and overhead radiographic evaluation with SBFT. Although IH is most often a delayed complication, it can occur at any time following RYGBP, and radiologists must maintain a high index of suspicion for the diagnosis.

References


40. Blachar A, Federle MP. Bowel obstruction following live transplantation: clinical and CT findings in 48 cases with emphasis on internal hernia. Radiology 2001;218:384–388.


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