Received:
13 September 2017

Revised:
16 November 2017

Accepted:
01 December 2017

<https://doi.org/10.1259/bjr.20170702>

Cite this article as:

Levy JL, Levine MS, Rubesin SE, Williams NN, Dumon KR. Stenosis of gastric sleeve after laparoscopic sleeve gastrectomy: clinical, radiographic and endoscopic findings. *Br J Radiol* 2018; **91**: 20170702.

THE ROLE OF IMAGING IN OBESITY SPECIAL FEATURE: FULL PAPER

Stenosis of gastric sleeve after laparoscopic sleeve gastrectomy: clinical, radiographic and endoscopic findings

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Objective: To determine the clinical, radiographic, and endoscopic findings of sleeve stenosis after sleeve gastrectomy and to correlate treatment with outcomes.

Methods: We identified 43 patients who underwent barium studies to evaluate upper GI symptoms after laparoscopic sleeve gastrectomy. The clinical, radiographic, and endoscopic findings were reviewed and correlated with treatment and outcomes.

Results: 26 patients (60%) had sleeve stenoses. All stenoses appeared as short segments of smooth, tapered narrowing, with a mean length of 8.0 mm and mean width of 7.5 mm, and 24 (92%) were located in the proximal or distal third of the sleeve. 23 patients (88%) had upstream dilation, and 1 (4%) had retained food proximal to the stenosis. 23 (70%) of 33 patients with obstructive symptoms and 3 (30%) of 10 without obstructive symptoms had sleeve stenoses. Endoscopy revealed sleeve stenosis in 8 (67%) of 12 patients with

radiographic stenosis. Endoscopic dilation resulted in improvement/resolution of symptoms in seven (88%) of 8 patients.

Conclusion: Sleeve stenosis after sleeve gastrectomy was characterized radiographically by a short segment of smooth, tapered narrowing, typically in the proximal or distal third of the sleeve. Approximately, 70% of patients with obstructive symptoms and 30% with non-obstructive symptoms had sleeve stenosis. One-third of radiographically diagnosed stenoses were not seen at endoscopy. The barium study, therefore, is a useful test for sleeve stenosis in patients with obstructive or nonobstructive symptoms after sleeve gastrectomy.

Advances in knowledge: This article describes the appearance and location of sleeve stenoses after laparoscopic sleeve gastrectomy and the clinical presentation and treatment options for these patients.

INTRODUCTION

Laparoscopic sleeve gastrectomy (LSG) is a bariatric procedure in which a major portion of the greater curvature of the fundus and body of the stomach is resected, creating a tubular gastric sleeve. Post-operative weight loss is promoted by the restrictive effect of the sleeve¹ as well as surgical resection of ghrelin-producing fundal cells, with decreased production of ghrelin (a hunger-inducing hormone) and subsequent appetite reduction.² LSG has overtaken gastric bypass as the most popular form of bariatric surgery performed at academic medical centres in the USA.³ The popularity of this procedure can be attributed to excellent weight loss results^{4,5} and fewer complications than laparoscopic Roux-en-Y gastric bypass.^{6,7}

One serious complication of LSG is stenosis of the gastric sleeve, which can result from oedema or ischaemia of the sleeve during the early postoperative period⁸ or from torsion,⁹ kinking,¹⁰ or scarring¹¹ of the sleeve along the staple line months or years after surgery. Patients with sleeve stenosis often develop obstructive symptoms such as nausea, vomiting, and food intolerance.¹² While upper gastrointestinal (GI) contrast studies are not routinely performed immediately after LSG because of the low frequency of leaks during the early postoperative period,¹³ barium studies frequently are employed to evaluate patients who develop obstructive symptoms months or years after surgery to rule out stenosis of the sleeve as the cause of these symptoms. The goals of our investigation are to determine

the findings of stenosis of the gastric sleeve on upper GI barium studies, along with the clinical and endoscopic findings, and to correlate treatment with patient outcome.

METHODS AND MATERIALS

Patient population

A review of electronic medical records at the Hospital of the University of Pennsylvania identified 162 patients who underwent upper GI barium studies to evaluate upper GI symptoms after LSG during a 4.3-year period from January 2011 to April 2016. 15 patients were excluded from analysis because the barium studies were performed to evaluate recurrent weight gain. 33 patients were excluded because the LSG was performed at an outside hospital, so these patients could have had different radiographic and endoscopic findings related to unknown variations in operative technique. 68 patients were excluded because the barium studies were performed less than 4 weeks after surgery (including 43 patients in whom studies were performed within 1 day of surgery to rule out a post-operative leak), so narrowing of the sleeve could have been secondary to acute post-operative oedema or spasm. Finally, three patients were excluded because they underwent limited fluoroscopic studies with water-soluble contrast agents to rule out leaks more than 4 weeks after surgery. The remaining 43 patients constituted our study group. Eight (19%) of these patients were males and 35 (81%) were females. The patients had a mean age of 43 years (range, 17–68 years) and a mean preoperative body mass index of 48 kg m^{-2} (range, $36\text{--}72 \text{ kg m}^{-2}$).

Laparoscopic sleeve gastrectomy technique

All LSGs were performed by experienced bariatric surgeons at the Hospital of the University of Pennsylvania, which is accredited by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program. The surgery was performed under general anaesthesia with endotracheal intubation. All procedures were performed robotically, using the Intuitive Surgical robotic platform (Intuitive Surgical; Sunnyvale, CA), as described previously.¹⁴ Briefly, the short gastric vessels are divided, beginning in the distal gastric antrum. With a bougie placed in the gastric lumen, a linear stapler is used to create the gastric sleeve, with its distal end 5 cm from the pylorus. The sleeve is tested intraoperatively for leaks by administration of indigo blue via a nasogastric tube placed in the lumen. No drains are placed in most cases.

The bougies employed for this surgery were 38 Fr in size in 36 patients (84%), 34 Fr in 2 (5%), 42 Fr in 2 (5%), and 46 Fr in 1 (2%). The size of the bougie was not mentioned in the operative reports for the remaining two patients (5%).

Upper GI barium studies

All of the barium studies were obtained with digital fluoroscopic equipment (Sireskop SD; Siemens, Erlangen, Germany) by residents, fellows, or one of four attending GI radiologists. The studies were performed with a 40% w/v barium suspension (dilute Polibar; Bracco, Princeton, NJ). Fluoroscopic spot images of the gastric sleeve routinely were obtained with the patient in upright, supine, and prone positions to visualize areas of stenosis

while the sleeve was optimally distended. All of the radiographic studies were interpreted by consensus of two GI radiologists (with 35 and 33 years of experience, respectively) who had no knowledge of the clinical or endoscopic findings, treatment, or patient course.

while the sleeve was optimally distended. All of the radiographic studies were interpreted by consensus of two GI radiologists (with 35 and 33 years of experience, respectively) who had no knowledge of the clinical or endoscopic findings, treatment, or patient course.

The studies were reviewed for the presence or absence of stenosis in the gastric sleeve. Stenosis was defined as a fixed area of segmental narrowing in the sleeve that persisted throughout the fluoroscopic examination, whereas spasm was defined as a transient area of narrowing that subsequently was found to distend normally at fluoroscopy. If an area of stenosis was identified, its location in the proximal, middle, or distal third of the sleeve (using the staple line abutting the greater curvature of the sleeve as a frame of reference) as well as the proximal and distal margins (abrupt or tapered), contour (smooth or irregular), and symmetry (symmetric or asymmetric) of the narrowed segment were assessed. The length and width of the stenosis were measured, using a 12 mm in diameter barium tablet placed beside the patient at fluoroscopy as a reference standard to account for radiographic magnification. The presence or absence of dilation and retained food or fluid proximal to the area of stenosis was also recorded. A normal gastric sleeve after LSG is illustrated in Figure 1 for comparison purposes.

The original radiology reports were also reviewed to determine whether gastroesophageal reflux (GER) was present in these patients. The mean interval from the date of surgery to the date of the barium study was 372 days (range, 28–2,453 days).

Variables and outcomes

Electronic medical records for all 43 patients were reviewed to determine the clinical indications for the barium study, the type of treatment (*i.e.* endoscopic dilation, surgery, or conservative management) and patient course (*i.e.* whether obstructive symptoms, if present, remained unchanged or improved/resolved after treatment). Patients were considered to have obstructive symptoms if they presented with nausea, vomiting, regurgitation, and/or early satiety. Conversely, patients were considered to have non-obstructive symptoms if they presented with abdominal pain, reflux symptoms (excluding regurgitation), or other clinical findings in the absence of at least one obstructive symptom. Using these criteria, 33 (77%) of the 43 patients had obstructive symptoms and 10 (23%) had non-obstructive symptoms. 19 (44%) of these 43 patients underwent endoscopy, including 17 (39%) with obstructive symptoms and 2 (4%) with nonobstructive symptoms. Endoscopic reports were reviewed for these 19 patients. The mean interval between the date of the barium study and endoscopy was 27 days (range, 0–321 days). In all patients with radiographically diagnosed stenosis of the gastric sleeve who underwent endoscopy, the endoscopic examination was performed after the barium study, so the endoscopist was aware of the radiographic findings at the time of endoscopy.

The mean length of clinical follow up for these 43 patients from the date of surgery was 498 days (range 48–2563 days). Three patients with less than 60 days of clinical follow up were included in our analysis of the radiographic and endoscopic findings but excluded from analysis of outcome because of inadequate follow up.

Statistical analysis

Continuous variables for patients with and without resolution of symptoms after treatment were compared using an unpaired *t*-test. A Fisher's exact test was used to compare categorical variables. A *p* value < 0.05 was used as the threshold for statistical significance. All tests were performed with Microsoft Excel 2011 (Microsoft; Redmond, WA) or GraphPad QuickCalcs (GraphPad Software; La Jolla, CA).

Institutional review board approval

Our institutional review board approved all aspects of this investigation, which did not require informed consent. This study was also compliant with the Health Insurance Portability and Accountability Act.

RESULTS

Radiographic findings

26 (60%) of 43 patients who underwent barium studies after LSG had radiographic findings compatible with focal stenosis of the gastric sleeve. The stenosis was located in the distal third of the sleeve in 12 (46%) of these 26 patients (Figure 2), the middle third in 2 (8%), and the proximal third in 11 (42%) (Figures 3 and 4). The remaining patient (4%) had two stenotic segments, with one in the proximal third and one in the distal third of the sleeve (Figure 5). In all 26 patients, the stenotic segment had smooth contours and tapered proximal and distal margins (Figures 2–5). The area of stenosis was symmetric in 18 patients (69%) (Figures 2

Figure 2. A 42-year-old female with abdominal pain and vomiting caused by stenosis of the sleeve after laparoscopic sleeve gastrectomy. Prone spot image from a single-contrast examination of the upper GI tract shows a short segment of smooth, symmetric narrowing (*arrow*) with tapered margins in the distal portion of the sleeve. Note upstream dilation of the sleeve and proximal stomach.

and 4) and asymmetric in 8 (31%) (Figure 3). The mean length of the stenotic segment was 8.0 mm (range, 3–14 mm), and the mean width was 7.5 mm (range, 4–15 mm). Upstream dilation of the sleeve (*i.e.*, proximal to the stenotic segment) was present in 23 (88%) of 26 patients with stenosis of the sleeve (Figures 2, 4 and 5) and a conglomerate mass of retained food (*i.e.* a gastric bezoar) was present in 1 (4%) (Figure 4).

GER was present in 21 (81%) of 26 patients with stenosis of the gastric sleeve, absent in 3 (12%), and not mentioned in the radiology reports in the remaining 2 (8%). Similarly, GER was present in 14 (82%) of 17 patients without stenosis of the sleeve, absent in 2 (12%), and not mentioned in the radiology report in the remaining 1 (6%). Thus, there was no difference in the frequency of GER in patients with and without stenosis of the gastric sleeve (*p* = 1.0).

Clinical findings

23 (88%) of 26 patients with stenosis of the gastric sleeve on barium studies had one or more obstructive symptoms and 3 (12%) had non-obstructive symptoms, whereas 10 (59%) of 17 patients without stenosis of the sleeve had one or more obstructive symptoms and 7 (41%) had non-obstructive symptoms (Table 1). Thus, patients with stenosis of the sleeve were significantly more likely to have obstructive symptoms than those without stenosis of the sleeve (*p* = 0.03). Conversely, 23 (70%) of

Figure 3. A 43-year-old male with reflux symptoms, nausea, and vomiting caused by stenosis of the sleeve after laparoscopic sleeve gastrectomy. Prone, right anterior oblique spot image from a single-contrast examination of the upper GI tract shows a short segment of asymmetric narrowing (*arrow*) with smooth contours and tapered margins in the proximal portion of the sleeve.

Figure 4. A 40-year-old female with early satiety caused by stenosis of the sleeve after laparoscopic sleeve gastrectomy. (a) Close-up view of the left upper quadrant from a frontal digital scout image shows a mass of food (*arrow*) outlined by residual gas in the superior portion of the stomach. (b) Steep prone, right anterior oblique spot image from a single-contrast examination of the upper GI tract shows a short segment of relatively symmetric narrowing (*white arrows*) with smooth contours and tapered margins at the proximal end of the sleeve. Note upstream dilation of the stomach. Also, note a large conglomerate mass of food (*black arrows*) in the dilated proximal stomach, with tiny collections of barium trapped in the interstices of the mass. This patient developed a gastric bezoar above the stenosis.

Figure 5. A 66-year-old female with reflux symptoms, nausea, and vomiting caused by two separate areas of stenosis in the sleeve after laparoscopic sleeve gastrectomy. (a) Prone, right anterior oblique spot image from a single-contrast examination of the upper GI tract shows a gastric sleeve with a short segment of narrowing (*arrows*) that has smooth contours and tapered margins at the proximal end of the sleeve. Note considerable upstream dilation of the distal oesophagus above the sleeve. (b) Another spot image with the patient in a prone position shows a second short segment of smooth narrowing (*black arrow*) near the distal end of the sleeve. The more proximal stricture (*white arrow*) is partially visualized in this projection.

33 patients with obstructive symptoms had stenosis of the gastric sleeve and 10 (30%) did not, whereas 3 (30%) of 10 patients with non-obstructive symptoms had stenosis of the sleeve and 7 (70%) did not. Thus, patients with obstructive symptoms were significantly (2.3 times) more likely to have stenosis of the sleeve than those with non-obstructive symptoms ($p = 0.03$).

Endoscopic findings

9 (53%) of 17 patients who underwent endoscopy because of obstructive symptoms had stenosis of the gastric sleeve at endoscopy. The stenotic segment appeared as a focal area of fixed narrowing (the location in the sleeve was not specified in the endoscopic reports) in all nine patients, with associated angulation in five (56%). Neither of two patients who underwent endoscopy for non-obstructive symptoms had stenosis of the gastric sleeve. When correlated with the radiographic findings, stenosis of the sleeve was found at endoscopy in 8 (67%) of 12 patients with stenosis on barium studies and in 1 (14%) of 7 without stenosis on barium studies ($p = 0.06$). Thus, patients with sleeve stenosis on barium studies were more likely to have stenosis of the sleeve on endoscopy than those without sleeve stenosis on barium studies, though this association did not reach statistical significance, presumably because of the small sample size. These findings are summarized in Table 2.

Treatment and patient outcomes

8 (38%) of 21 patients with obstructive symptoms and sleeve stenosis on barium studies who had adequate clinical follow up underwent endoscopic dilation procedures. Five of these eight patients had one dilation, two had two, and one had one dilation followed by surgical revision of the sleeve and gastropexy. None of these eight patients had complications. Seven (88%) of the

Table 1. Clinical findings in 43 patients who underwent upper GI barium studies after laparoscopic sleeve gastrectomy (including 33 patients with obstructive symptoms and 10 patients with non-obstructive symptoms)

Symptoms	No. of pts (%)
Obstructive	33 (77%)
Stenosis of gastric sleeve:	23
Nausea	2
Early satiety	1
Nausea and vomiting	9
Nausea and regurgitation	1
Nausea and abdominal pain	1
Nausea, vomiting, and reflux	2
Nausea, vomiting, regurgitation, and reflux	2
Nausea, vomiting, and abdominal pain	2
Vomiting and abdominal pain	1
Vomiting, dysphagia, and abdominal pain	1
Vomiting, abdominal pain, and reflux	1
No stenosis of gastric sleeve:	10
Vomiting	2
Nausea and vomiting	2
Nausea and abdominal pain	1
Nausea, vomiting, and abdominal pain	1
Nausea, vomiting, and regurgitation	1
Nausea, vomiting, regurgitation, reflux, and abdominal pain	1
Nausea, vomiting, regurgitation, reflux, abdominal pain, and dysphagia	1
Reflux and regurgitation	1
Non-obstructive	10 (23%)
Stenosis of gastric sleeve:	3
Abdominal pain	3
No stenosis of gastric sleeve:	7
Abdominal pain	1
Reflux	2
Abdominal pain and reflux	4

GI, gastrointestinal; No., number; pts, patients.

eight patients with sleeve stenosis who underwent dilation procedures had improvement or resolution of symptoms after dilation and one (12%) did not. Conversely, 13 (62%) of 21 patients with obstructive symptoms and sleeve stenosis on barium studies who had adequate clinical follow up underwent conservative management with small meals and/or soft food diets. 11 (85%) of these 13 patients had improvement or resolution of symptoms and 2 (15%) did not. Thus, there was no significant difference in improvement/resolution of obstructive symptoms for those with sleeve stenosis on barium studies who underwent endoscopic dilation procedures vs those with sleeve stenosis who underwent

conservative management ($p = 1.0$), though these findings could be related to the small sample size. Treatment and outcomes for the 17 patients with obstructive symptoms and 2 with non-obstructive symptoms who underwent barium studies and endoscopy are summarized in Table 2.

DISCUSSION

LSG is rapidly becoming the most popular form of bariatric surgery because of excellent weight loss results and fewer complications than laparoscopic Roux-en-Y gastric bypass.⁴⁻⁷ It, therefore, is important for radiologists to be familiar with the normal findings (Figure 1) and complications of this procedure on fluoroscopic barium studies. One serious complication after LSG is stenosis of the sleeve, which occurs in 0.6 to 4% of LSGs,¹⁵⁻¹⁸ leading to persistent nausea, vomiting, and food intolerance in these patients.¹²

In our study, stenosis of the gastric sleeve was a frequent finding in patients who underwent barium studies for upper GI symptoms after LSG, occurring in 26 (60%) of 43 patients during the late post-operative period (*i.e.* more than 4 weeks after surgery). The unusually high frequency of stenosis of the sleeve in our study reflects an inherent selection bias, as barium studies were performed predominantly on patients with obstructive symptoms after LSG. Nevertheless, the number of patients with stenosis of the sleeve enabled us to make observations about the radiographic features of this complication. It should also be recognized that we only included patients who underwent barium studies more than 1 month after surgery in order to exclude acute post-operative changes as the cause of sleeve narrowing. Given that the mean interval from the date of surgery to the date of the barium study was more than 1 year, it is unlikely that the stenoses in these patients were caused by residual post-surgical oedema, inflammation, or spasm of the sleeve.

In our study, stenosis of the gastric sleeve was characterized by a short segment of smooth narrowing with tapered margins and frequent upstream dilation of the sleeve, indicating an obstructive component (Figures 2-5). Most of the stenoses were located in the proximal or distal thirds of the sleeve, with fewer than 10% in the middle third. Conversely, other studies have found the majority of stenoses to be located in the middle third of the sleeve.^{15,18-20} It has been suggested that these stenoses could be secondary to suboptimal operative technique, with excessive lateral traction on the greater curvature during stapling leading to a narrowed sleeve when the bougie is removed and the sleeve recoils.¹⁵ As more surgeons become aware of this pitfall, the number of stenoses developing in the mid portion of the sleeve could decrease. In contrast, it has been postulated that stenoses at the proximal or distal ends of the sleeve (as in our study) result from small, self-limited leaks causing focal scarring of the sleeve as they heal.²¹

Stenosis of the gastric sleeve in our patients was characterized on barium studies by a short segment of narrowing that had a mean width of 7.5 mm and a mean length of only 8 mm. In the study by Rebibo et al, the stenotic segment of the sleeve had a mean length of about 2.5 cm,²⁰ greater than three times the mean length of

Table 2. Radiographic and endoscopic findings, treatment, and outcomes (*i.e.* improvement/resolution vs no improvement of obstructive symptoms) in 19 patients who underwent barium studies and endoscopy after laparoscopic sleeve gastrectomy

Patient no.	Stenosis on barium study	Stenosis on endoscopy	Treatment	Symptom improvement/resolution
1	Yes	Yes	Dilation x 1	Yes
2	Yes	Yes	Dilation x 1	Yes
3	Yes	Yes	Dilation x 1	Yes
4	Yes	Yes	Dilation x 2	Yes
5	Yes	Yes	Dilation x 1	Yes
6	Yes	Yes	Dilation x 2	Yes
7	Yes	Yes	None	No
8	Yes	Yes	Dilation x 1 followed by surgical revision of sleeve and gastropexy	No
9	Yes	No	Dilation x 1	Yes
10	Yes	No	None	No
11	Yes	No	None	No
12	Yes	No	None	Yes
13	No	No	None	Yes
14	No	No	None	Yes
15	No	No	None	No
16	No	No	None	No
17	No	Yes	Dilation x 1	Yes
18	No	No	None	N/A
19	No	No	None	N/A

N/A, not applicable; No., number.

Note. Patients 1 through 17 had obstructive symptoms, whereas patients 18 and 19 had non-obstructive symptoms, so improvement/resolution of obstructive symptoms was not applicable.

the stenotic segment in our patients. While the cause of this discrepancy is uncertain, obstructive symptoms were present in 23 (88%) of our 26 patients with stenosis of the gastric sleeve. Our findings, therefore, suggest that these strictures are likely to cause obstructive symptoms, regardless of their length.

When evaluating for possible sleeve stenosis after LSG, it is important to obtain views in multiple projections while the sleeve is maximally distended in order to detect areas of narrowing that could be obscured by overlapping portions of the sleeve. If barium empties so quickly from the sleeve that it cannot be adequately distended, rapid sequence images should be obtained while the patient continuously swallows barium in a recumbent position to increase sleeve distention and detect areas of stenosis that might otherwise be missed. Conversely, we have found that focal spasm of the sleeve in the upright position sometimes can lead to false-positive diagnoses of strictures. However, areas of spasm that are seen when the patient is upright usually resolve when the patient is placed in a recumbent position. Radiologists, therefore, should routinely evaluate the gastric sleeve in both upright and recumbent positions to avoid this diagnostic pitfall.

In our study, 23 (88%) of 26 patients with stenosis of the gastric sleeve had obstructive symptoms, and these patients were

significantly (2.3 times) more likely to have stenosis of the sleeve than those with non-obstructive symptoms ($p = 0.03$). Nevertheless, obstructive symptoms also were present in 10 (59%) of 17 patients without stenosis of the gastric sleeve. Obstructive symptoms, therefore, constitute a relatively sensitive but nonspecific clinical presentation for patients with sleeve stenosis, underscoring the value of barium studies for differentiating stenosis of the gastric sleeve from other causes of obstructive symptoms after LSG.

Overall, 23 (70%) of 33 patients with obstructive symptoms had stenosis of the gastric sleeve, so the barium study has a high diagnostic yield for sleeve stenosis in patients with nausea, vomiting, regurgitation, or early satiety more than 4 weeks after LSG. Nevertheless, 3 (30%) of 10 patients with non-obstructive symptoms such as heartburn and abdominal pain had stenosis of the gastric sleeve, so sleeve stenosis can also be detected in patients with an atypical clinical presentation. The barium study, therefore, is a useful diagnostic test for stenosis of the gastric sleeve in patients with obstructive or nonobstructive symptoms after LSG.

In our study, endoscopy revealed stenosis of the gastric sleeve in 8 (67%) of 12 patients with sleeve stenosis on barium studies vs only one (20%) of five without stenosis on barium studies. It

previously has been shown that barium studies can reveal strictures at the gastrojejunal anastomosis after Roux-en-Y gastric bypass that are not detected on upper endoscopy.²² Similarly, our four patients with stenosis of the gastric sleeve seen only on barium studies could have had false-negative endoscopic examinations. It should be recognized that endoscopy enables assessment only of the lumen of the gastric sleeve, whereas barium studies permit direct visualization of the length and width of the sleeve, facilitating detection of strictures. Insufflation of air into the gastric sleeve at endoscopy could also lead to distention of the sleeve with artificially high pressures, obscuring areas of narrowing, whereas barium studies produce more physiologic distention of the sleeve similar to that when patients swallow other liquids. Whatever the explanation, endoscopists should consider dilating the gastric sleeve in symptomatic patients with stenosis of the sleeve on barium studies even when no definite stenosis is found at endoscopy. In such cases, the endoscopist could empirically dilate the portion of the sleeve that is narrowed on the barium study.

Our investigation is limited by the retrospective nature of the study design, resulting in selection and interpretation bias. It was particularly difficult to evaluate the efficacy of endoscopic dilation procedures because of the small number of patients who underwent this form of treatment and uncertainty from the medical records why some patients underwent dilation procedures and others did not. Our small sample sizes when symptomatic patients with sleeve stenosis were stratified by endoscopic dilation vs conservative management could also account for our inability to show a clinical difference in treatment response between these groups. Because of the small number of patients who underwent endoscopy or were treated

by endoscopic dilation procedures, a larger series of treated patients with stenosis of the gastric sleeve could be performed to further elucidate whether particular features of the stenosis, such as length and width, affect the response to treatment.

CONCLUSION

Stenosis of the gastric sleeve after LSG was manifested on barium studies by a short segment of narrowing with smooth contours and tapered margins, typically in the proximal or distal third of the sleeve, often associated with upstream dilation. Approximately, 70% of patients with obstructive symptoms after LSG had sleeve stenosis on barium studies, but sleeve stenosis was also present in 30% of patients with non-obstructive symptoms. Finally, one-third of radiographically diagnosed sleeve stenoses were not seen at endoscopy. The barium study, therefore, is a useful diagnostic test for stenosis of the gastric sleeve in patients with obstructive or nonobstructive symptoms after LSG.

ACKNOWLEDGEMENT

Dr Levine and Dr Rubesin are consultants for Bracco, Diagnostics.

INFORMED CONSENT

Our research study was approved by our institutional review board, which waived the need for informed consent. Our study also was compliant with the Health Insurance Portability and Accountability Act.

ETHICAL

All of the authors of this study have fully adhered to the standards set out in the Code of Ethics of the World Medical Association for research involving humans.

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