



Retrospective Cohort Study

## Dysphagia after vertical sleeve gastrectomy: Evaluation of risk factors and assessment of endoscopic intervention

Anand Nath, Sayali Yewale, Tung Tran, John S Brebbia, Timothy R Shope, Timothy R Koch

Anand Nath, Department of Medicine, MedStar-Washington Hospital Center and Georgetown University School of Medicine, Washington, DC 20010, United States

Sayali Yewale, Unterberg Children's Hospital at Monmouth Medical Center, Long Branch, NJ 07740, United States

Tung Tran, John S Brebbia, Timothy R Shope, Timothy R Koch, Center for Advanced Laparoscopic General and Bariatric Surgery, MedStar-Washington Hospital Center and Georgetown University School of Medicine, Washington, DC 20010, United States

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Correspondence to: Timothy R Koch, MD, Professor of Medicine (Gastroenterology), Center for Advanced Laparoscopic General and Bariatric Surgery, POB South Tower, Suite 301, 106 Irving Street, NW, Washington, DC 20010, United States. [timothy.r.koch@medstar.net](mailto:timothy.r.koch@medstar.net)  
Telephone: +1-202-8777788  
Fax: +1-877-6808198

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### Abstract

#### AIM

To evaluate the risks of medical conditions, evaluate gastric sleeve narrowing, and assess hydrostatic balloon dilatation to treat dysphagia after vertical sleeve gastrectomy (VSG).

#### METHODS

VSG is being performed more frequently worldwide as a treatment for medically-complicated obesity, and dysphagia is common post-operatively. We hypothesize that post-operative dysphagia is related to underlying medical conditions or narrowing of the gastric sleeve. This is a retrospective, single institution study of consecutive patients who underwent sleeve gastrectomy from 2013 to 2015. Patients with previous bariatric procedures were excluded. Narrowing of a gastric sleeve includes: inability to pass a 9.6 mm gastroscope due to stenosis or sharp angulation or spiral hindering its passage.

## RESULTS

Of 400 consecutive patients, 352 are included; the prevalence of dysphagia is 22.7%; 33 patients (9.3%) have narrowing of the sleeve with 25 (7.1%) having sharp angulation or a spiral while 8 (2.3%) have a stenosis. All 33 patients underwent balloon dilatation of the gastric sleeve and dysphagia resolved in 13 patients (39%); 10 patients (30%) noted resolution of dysphagia after two additional dilatations. In a multivariate model, medical conditions associated with post-operative dysphagia include diabetes mellitus, symptoms of esophageal reflux, a low whole blood thiamine level, hypothyroidism, use of non-steroidal anti-inflammatory drugs, and use of opioids.

## CONCLUSION

Narrowing of the gastric sleeve and gastric sleeve stenosis are common after VSG. Endoscopic balloon dilatations of the gastric sleeve resolves dysphagia in 69% of patients.

**Key words:** Obesity; Bariatric surgery; Vertical sleeve gastrectomy; Dysphagia; Stomach dilatation

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**Core tip:** Vertical sleeve gastrectomy (VSG) is rapidly becoming the most commonly performed bariatric surgical procedure. Post-operative dysphagia is present in 22.7% of patients after VSG. Medical conditions significantly associated with post-operative dysphagia include diabetes mellitus, symptoms of esophageal reflux, low whole blood thiamine level, hypothyroidism, use of non-steroidal anti-inflammatory drugs, and use of opioids. After VSG, 9.3% of patients develop narrowing of the gastric sleeve. In patients with dysphagia after sleeve gastrectomy and evidence for narrowing of the gastric sleeve, hydrostatic balloon dilatations of the gastric sleeve leads to resolution of dysphagia in 69% of patients.

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## INTRODUCTION

Obesity is a leading predisposing factor internationally for multiple chronic diseases<sup>[1]</sup> including hypercholesterolemia, type 2 diabetes mellitus, hypertension, osteoarthritis, asthma, and decreased health status. The rapid rise in the prevalence of overweight [Body mass index (BMI)  $\geq$  25] and obese (BMI  $\geq$  30) individuals is concerning and has been described

as a global pandemic<sup>[1]</sup>. In the years between 1980 and 2013, the worldwide combined prevalence of overweight and obesity individuals increased by 47.1% for children and 27.5% for adults<sup>[2]</sup>.

Dietary and activity program or the addition of weight loss medications generally do not induce sufficient weight loss or provide long term maintenance of weight loss<sup>[3,4]</sup>, especially for individuals with medically-complicated obesity. Surgical interventions have been shown to result in more effective and sustained weight loss as compared to non-surgical interventions in multiple randomized controlled and cohort studies<sup>[5,6]</sup>.

Vertical sleeve gastrectomy (VSG) is a newer and effective surgical option for the management of medically-complicated obesity<sup>[7]</sup>. VSG was initially introduced as a modification of the biliopancreatic diversion, but was then combined with the duodenal switch<sup>[7]</sup> as a staged procedure (to try to reduce the complication rate). In the early report by Hess *et al*<sup>[7]</sup>, gastrectomy was performed by stapling alongside a 40 French dilator passed along the lesser curvature of the stomach. VSG became more commonly performed for treatment of medically-complicated obesity after it was reported to be effective in producing weight loss as the first stage of this modified procedure<sup>[8]</sup>. VSG is now the most commonly performed bariatric surgery in the United States and of 196000 bariatric surgeries performed in 2015, 53.8% were VSG<sup>[9]</sup>. VSG is also the second most common bariatric surgery worldwide. According to a worldwide survey from 2013, 37% of 468609 bariatric surgeries were a VSG<sup>[10]</sup>.

VSG is mainly a restrictive procedure in which the gastric fundus and body are surgically excised, leaving a narrow, lesser-curvature based stomach<sup>[11]</sup>. Despite proven benefits in the management of medically-complicated obesity, VSG can produce complications including a leak or perforation along the staple line, bleeding, significant gastroesophageal reflux, gastric fistula, dilation of the gastric sleeve, inadequate weight loss, and stenosis of the gastric sleeve<sup>[12-14]</sup>.

Dysphagia and postoperative emesis are commonly encountered after sleeve gastrectomy<sup>[13,14]</sup>, but few studies have simultaneously addressed the causes of and the treatment of this complication. Given the rapid rise in the number of VSGs performed, gastroenterologists will be frequently consulted for dysphagia in patients with history of VSG. The suggested treatment strategies to manage narrowing of the gastric sleeve include conservative medical therapy, endoscopic hydrostatic balloon dilation, pneumatic achalasia balloon dilation, or surgical intervention<sup>[13-15]</sup>. Due to a lack of evidence, currently there are no guidelines for a standardized management plan for symptomatic narrowing of the gastric sleeve after VSG<sup>[15]</sup>.

Our hypothesis is that post-operative dysphagia is related to underlying medical conditions or narrowing of the gastric sleeve. The primary aims of this study

of individuals who have undergone VSG include: evaluation of the risks of medical conditions that may be associated with post-operative dysphagia, evaluation of the prevalence of narrowing of the gastric sleeve in patients presenting for post-operative dysphagia, and assessment of hydrostatic balloon dilatation of the gastric sleeve as a symptomatic treatment of VSG patients with post-operative dysphagia.

## MATERIALS AND METHODS

Approval for human studies was obtained from the Human Studies Subcommittee of MedStar Research Institute (Hyattsville, MD, United States) on December 17, 2015. This is a retrospective, single institution study performed in a large, urban community hospital. Clinical and endoscopic electronic medical records of 400 consecutive patients who underwent VSG in our Center for Bariatric Surgery from 2013 to 2015 have been reviewed.

This study includes individuals of age 18 years old or above who have a BMI > 34.9 kg/m<sup>2</sup> and who underwent VSG. Exclusion criteria includes a history of a prior bariatric procedure, less than 6 mo of follow up after surgery, onset of dysphagia less than 2 wk after VSG, and identification of pregnancy during post-operative visits (for a total of 48 individuals).

Briefly, all VSG procedures were performed laparoscopically and included staple line reinforcement. After initial mobilization of the greater curvature of the stomach by division of the gastrocolic and gastrosplenic ligaments, a 36 French Maloney dilator was then passed along the lesser curvature of the stomach to the pylorus. An Ethicon Echelon Stapler with a 60 mm length cartridge was used to perform the gastrectomy. The gastrectomy specimen was then removed from the abdomen through an epigastric port site.

The standard protocol for our bariatric program includes our suggesting that all patients begin one daily multivitamin with minerals prior to VSG and then increase to using two daily multivitamins with minerals after VSG for the first one year. Routine follow up for patients who underwent VSG were scheduled at 2 wk, 6 wk, and 6 mo post-operatively, and then every 6 mo thereafter. Non-steroidal anti-inflammatory drug use and opioid use are recorded at each visit. For patients with dysphagia, use of non-steroidal anti-inflammatory drug use and use of opioid is recorded at the onset of dysphagia. Since the mean time period to the onset of dysphagia is 13 wk, use of non-steroidal anti-inflammatory drugs and use of opioids in patients with dysphagia at 6 wk follow up is compared to documentation of non-steroidal anti-inflammatory drug use and opioid use at 6 wk follow up in patients without dysphagia.

A survey of national bariatric programs by the Ad Hoc Nutrition Committee of the American Society for Metabolic and Bariatric Surgery reported that initiating a mechanically altered soft diet is recommended  $\geq$  2

wk post-operatively<sup>[16]</sup>. We therefore include dysphagia that began  $\geq$  2 wk after VSG in our final analysis. Each patient's age, sex, race, weight, height, body mass index, history of diabetes mellitus, medication history, serum vitamin B12 level, folic acid level, whole blood thiamine level, thyroid function tests, magnesium levels, presence of nausea with emesis, abdominal pain, constipation, symptoms of gastroesophageal reflux, dysphagia, and the post-operative time of onset of dysphagia are recorded.

All patients with symptomatic dysphagia had been offered upper endoscopy to look for the presence of mucosal changes such as esophagitis, gastric sleeve stenosis, or ulceration. Narrowing of the gastric sleeve is defined by either an inability to pass a 9.6 mm Olympus video gastroscope due to stenosis of the gastric sleeve or sharp angulation or a spiral of the gastric sleeve hindering passage of a 9.6 mm Olympus gastroscope. Endoscopic reports are reviewed to record presence of narrowing of the gastric sleeve. All of the patients with narrowing of the gastric sleeve had been offered endoscopic hydrostatic balloon dilation using a Boston Scientific through-the-scope controlled radial expansion (CRE) single use esophageal balloon dilator with balloon inflations of 10 mm to 18 mm for 1 min periods. Patients with recurrent or persistent symptoms and narrowing of the gastric sleeve were offered repeat dilatations of their gastric sleeve in order to achieve resolution of symptoms. The clinical outcomes of these interventions are recorded.

Statistical analysis has been performed by a biomedical statistician. In our statistical analysis of the continuous variables, differences in the averages between two groups are tested by two sample *t*-test when normality assumption is satisfied. The non-parametric Wilcoxon rank sum test is used when normality assumption is not satisfied.  $\chi^2$  and Fisher exact (when cells have counts less than 5) tests as appropriate are used to investigate differences for categorical variables between groups. A *P*-value  $\leq$  0.05 is accepted as a statistically significant difference. For multiple categorical variables associated with dichotomous outcome, stepwise multiple logistic regressions is performed to develop a multivariate model. The confounding factor is corrected for the variables in logistic regression. The results are reported as OR and 95%CI.

## RESULTS

Of 400 consecutive patients who underwent VSG with our three bariatric surgeons in our Center for Bariatric Surgery from 2013 to 2015, 352 study subjects are included in the final analysis and 48 subjects were not included due to our exclusion criteria. As shown in Table 1, the mean age of the study population is 47.0 years old ( $\pm$  10.8) with a range of 19 to 75 years. The pre-operative mean body mass index is 47.5 kg/m<sup>2</sup> with a range of 35 to 82 kg/m<sup>2</sup>. This is a female-

**Table 1 Summary of the pre-operative demographics of 352 study subjects who underwent vertical sleeve gastrectomy**

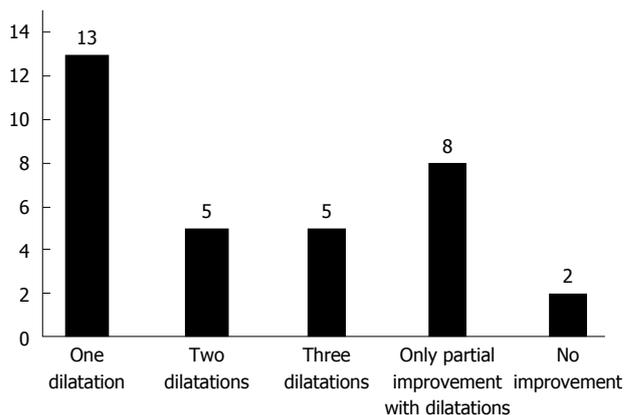
| Characteristics                      | Value       |
|--------------------------------------|-------------|
| Total patients (n)                   | 352         |
| Age (yr)                             |             |
| mean ± SD                            | 47.0 ± 10.8 |
| Range                                | 19-75       |
| Gender                               |             |
| Women                                | 296 (84.1%) |
| Men                                  | 56 (15.9%)  |
| Body mass index (kg/m <sup>2</sup> ) |             |
| Mean                                 | 47.5 ± 8.2  |
| Range                                | 35-82       |
| Race                                 |             |
| African-American                     | 277 (78.7%) |
| Caucasian                            | 61 (17.3%)  |
| Other                                | 14 (4.0%)   |

predominant study and 84% of the study subjects are women. The majority (79%) of this study population is African-American, which is representative of the predominant population served by our hospital center.

Out of the 352 study subjects, 80 individuals (22.7%) report an onset of dysphagia at up to 2 years during their follow up after VSG. The mean time to the onset of symptoms is 13.1 wk (range: 2-60 wk) in these 80 patients.

As shown in Table 2, there is increased prevalence of diabetes mellitus in those individuals who develop postoperative dysphagia compared to individuals with no dysphagia ( $P < 0.01$ ). Patients with symptoms of gastroesophageal reflux ( $P < 0.0001$ ) show an increased risk toward the development of postoperative dysphagia. There is also a statistically significant relationship between postoperative dysphagia and low whole blood thiamine levels ( $P = 0.008$ ), low thyroid blood test ( $P = 0.003$ ), non-steroidal anti-inflammatory drug use at 6 wk post-operatively ( $P = 0.018$ ), and opioid narcotic use at 6 wk post-operatively ( $P = 0.05$ ) as determined through stepwise logistic regression (summarized in Tables 2 and 3). No statistical correlation between age, gender, body mass index, abnormal vitamin B12 level, abnormal folic acid level, or abnormal magnesium level and post-operative dysphagia is seen (see Table 2).

Out of 80 patients with dysphagia, 55 patients agreed to undergo upper endoscopy. Thirty-three of these patients (9.3% of the total study population) have narrowing of their gastric sleeve. Among these 33 individuals, 25 (7.1% of the total study population) have sharp angulation or spiral of the gastric sleeve while 8 (2.3% of the total study population) have evidence for stenosis of the gastric sleeve. All of these 33 individuals with narrowing of their gastric sleeve underwent endoscopic hydrostatic balloon dilation as an initial intervention. As shown in Figure 1, among these 33 study subjects, 13 individuals (39.4%) note resolution of their symptoms after a single dilation, 5 individuals (15.2%) required two sessions of dilation



**Figure 1 Response of study subjects with narrowing of the gastric sleeve after vertical sleeve gastrectomy.** This figure shows the number of individuals (on the Y axis) who underwent one, two or three or more dilatations (on the X axis) of their gastric sleeve and then obtained full, partial, or no resolution of their symptom of dysphagia.

for symptomatic relief, 5 individuals (15.2%) required three sessions of balloon dilation for symptomatic relief, while 8 individuals (24.2%) obtained only partial symptomatic resolution after multiple hydrostatic balloon dilations of their gastric sleeve. Two (6%) individuals describe no clinical improvement despite multiple balloon dilations of their gastric sleeve.

## DISCUSSION

Dysphagia is a commonly encountered symptom after VSG<sup>[13-15]</sup>. A novel feature of this present study is the use of a multivariate analysis to examine potential medical risk factors in individuals with post-operative dysphagia after VSG; individuals with endoscopic evidence for narrowing of their gastric sleeve are simultaneously treated by hydrostatic balloon dilatation of the sleeve to try to obtain relief from dysphagia. Individuals with immediate (up to 2 wk post-operative) dysphagia were excluded from our study population. Any individual with immediate post-operative dysphagia is excluded because most patients will experience mild symptoms of swallowing difficulty immediately after VSG. An immediate post-operative symptom of dysphagia may be due to edema of the gastric staple line, inflammation of the gastric mucosa after the procedure, or the use of opioids for post-operative pain<sup>[13,14]</sup>. Subacute to chronic dysphagia persisting after two weeks requires careful follow-up evaluation since it may evolve into a chronic and disabling disorder inducing malnutrition, which is an indication for consideration of revisional surgery with conversion to Roux-en-Y gastric bypass<sup>[12]</sup>.

There is presently a paucity of data with regards to the prevalence of dysphagia as a postoperative complication after VSG. We evaluated the prevalence of dysphagia after VSG and its time of onset after this surgical procedure. In our present study, the prevalence of postoperative dysphagia was 22.7%

**Table 2 Summary of the statistical analyses of clinical characteristics of 352 study subjects after vertical sleeve gastrectomy *n* (%)**

| Characteristics                      | Dysphagia ( <i>n</i> = 80) | No dysphagia ( <i>n</i> = 272) | <i>P</i> value |
|--------------------------------------|----------------------------|--------------------------------|----------------|
| Age                                  | 48.0 ± 11.0                | 46.7 ± 10.7                    | 0.32           |
| Body mass index (kg/m <sup>2</sup> ) | 47.8 ± 8.4                 | 47.4 ± 8.3                     | 0.72           |
| Gender                               | <i>n</i> = 80              | <i>n</i> = 272                 | 0.19           |
| Female                               | 71 (88.8)                  | 225 (82.7)                     |                |
| Male                                 | 9 (11.3)                   | 47 (17.3)                      |                |
| Race                                 | <i>n</i> = 80              | <i>n</i> = 272                 | 0.038          |
| African-American                     | 66 (82.5)                  | 211 (77.6)                     |                |
| Caucasian                            | 9 (11.3)                   | 52 (19.1)                      |                |
| Asian                                | 0 (0.0)                    | 3 (1.1)                        |                |
| Hispanic                             | 0 (0.0)                    | 3 (1.1)                        |                |
| Others                               | 5 (6.3)                    | 3 (1.1)                        |                |
| Diabetes mellitus                    | <i>n</i> = 80              | <i>n</i> = 272                 | 0.006          |
| Yes                                  | 36 (45.0)                  | 78 (28.7)                      |                |
| No                                   | 44 (55.0)                  | 194 (71.3)                     |                |
| Symptom of esophageal reflux         | <i>n</i> = 80              | <i>n</i> = 272                 | < 0.0001       |
| Yes                                  | 55 (68.8)                  | 44 (16.2)                      |                |
| No                                   | 25 (31.3)                  | 228 (83.8)                     |                |
| Normal blood thiamine level          | <i>n</i> = 42              | <i>n</i> = 106                 | 0.008          |
| Yes                                  | 31 (73.8)                  | 96 (90.6)                      |                |
| No                                   | 11 (26.2)                  | 10 (9.4)                       |                |
| Normal vitamin B12 level             | <i>n</i> = 45              | <i>n</i> = 117                 | 0.49           |
| Yes                                  | 42 (93.3)                  | 117 (95.9)                     |                |
| No                                   | 3 (6.7)                    | 5 (4.1)                        |                |
| Normal serum folic acid level        | <i>n</i> = 43              | <i>n</i> = 119                 | 0.46           |
| Yes                                  | 42 (97.7)                  | 118 (99.2)                     |                |
| No                                   | 1 (2.3)                    | 1 (0.8)                        |                |
| Normal thyroid function test         | <i>n</i> = 36              | <i>n</i> = 83                  | 0.003          |
| Yes                                  | 28 (77.8)                  | 80 (96.4)                      |                |
| No                                   | 8 (22.2)                   | 3 (3.6)                        |                |
| Normal serum magnesium level         | <i>n</i> = 20              | <i>n</i> = 27                  | 0.57           |
| Yes                                  | 18 (90.0)                  | 26 (96.3)                      |                |
| No                                   | 2 (10.0)                   | 1 (3.7%)                       |                |
| NSAID use (6 wk follow up)           | <i>n</i> = 80              | <i>n</i> = 272                 | 0.017          |
| Yes                                  | 25 (31.3)                  | 51 (18.8)                      |                |
| No                                   | 55 (68.8)                  | 221 (81.3)                     |                |
| Opioid use (6 wk follow up)          | <i>n</i> = 80              | <i>n</i> = 272                 | 0.05           |
| Yes                                  | 15 (18.8)                  | 29 (10.7)                      |                |
| No                                   | 65 (81.3)                  | 243 (89.3)                     |                |

NSAID: Non-steroidal anti-inflammatory drug.

**Table 3 Summary of odds ratio estimates using logistic regression analysis in individuals with and without dysphagia after vertical sleeve gastrectomy**

| Effect                       | Point estimate | 95% Wald confidence limits |        |
|------------------------------|----------------|----------------------------|--------|
| History of diabetes mellitus | 2.035          | 1.218                      | 3.399  |
| Esophageal reflux symptoms   | 11.397         | 6.430                      | 20.201 |
| Low blood thiamine level     | 3.406          | 1.321                      | 8.784  |
| Low thyroid blood testing    | 7.619          | 1.888                      | 30.740 |
| NSAID use at 6 wk            | 1.970          | 1.122                      | 3.456  |
| Opioid use at 6 wk           | 2.183          | 1.093                      | 4.361  |

NSAID: Non-steroidal anti-inflammatory drug.

(excluding dysphagia symptoms during the first two weeks after the procedure) and the mean time of onset was 13.1 wk (range: 2–60 wk) among the 352 patients who underwent VSG at our Center for Bariatric Surgery. In support of our first hypothesis, statistical analysis does identify multiple medical conditions associated with dysphagia after VSG.

In our patient population, the odds of developing

dysphagia is 2.035 (95%CI: 1.22–3.40) in patients with a history of diabetes mellitus prior to VSG (*P* = 0.006). Abnormal gastrointestinal motility is a recognized complication of longstanding diabetes mellitus and has been attributed to gut autonomic neuropathy leading to reduced contractility<sup>[17]</sup>. In a large population based survey by Bytzer and associates of 8657 individuals, diabetes mellitus was associated

with an increased prevalence of upper gastrointestinal symptoms as compared with controls<sup>[18]</sup>. In a case-control study of 40 patients by Horowitz *et al*<sup>[19]</sup>, delayed upper gastrointestinal emptying was related to plasma glucose concentrations and occurred more frequently in patients with Type 2 diabetes mellitus. In addition to hyperglycemia, pre-existing gut autonomic neuropathy in diabetic patients could further exacerbate dysphagia.

In our patient population, the odds of developing dysphagia is 7.62 (95%CI: 1.89-30.74) in patients with low blood thyroid level ( $P = 0.003$ ). Gastrointestinal motility and thyroid hormone levels are closely related. Studies have shown that hypothyroidism prominently decreased gastroesophageal motility *via* reduced velocity and amplitude of esophageal peristalsis with a decrease in lower esophageal sphincter pressure<sup>[20,21]</sup>. In our study, a significantly higher proportion of patients with dysphagia have low thyroid hormone levels compared to those without dysphagia, supporting evaluation of thyroid function testing in patients with dysphagia after VSG.

Out of the 352 patients in this study, whole blood thiamine levels are available in 148 individuals. Low whole blood thiamine levels are present in 26.2% of patients with dysphagia compared to 9.4% of patients with no dysphagia ( $P = 0.008$ ). In our patient population, the odds of developing dysphagia is 3.406 (95%CI: 1.32-8.78) in patients with a low whole blood thiamine level. Stores of thiamine can become depleted as quickly as within 2 to 3 wk, and thiamine deficiency commonly involve multiple organ systems<sup>[22,23]</sup>. Symptoms of nausea, vomiting and dysphagia have been observed in a significant proportion of individuals with thiamine deficiency<sup>[22,23]</sup>. Thiamine deficiency is a known complication of bariatric surgery, and in a previous prospective study we found an 18% prevalence of thiamine deficiency in patients after gastric bypass surgery<sup>[24]</sup>. In parallel work, Van Rutte *et al*<sup>[25]</sup> reported a 5.5% prevalence of thiamine deficiency one year after VSG, while Saif *et al*<sup>[26]</sup> reported thiamine deficiency in 14.3% and 30.8% of patients 3 years and then 5 years after VSG.

In our patient population, the odds of developing dysphagia is 11.397 (95%CI: 6.43-20.20) in patients with symptoms of gastroesophageal reflux ( $P = 0.001$ ). Documented symptoms of gastroesophageal reflux or evidence for reflux esophagitis at upper endoscopy is seen in 68.8% of our patients with dysphagia compared to 16.2% of patients without dysphagia. In previous work, authors had reported improvement in the preexisting symptoms of gastroesophageal reflux after VSG<sup>[12,27]</sup>. However, a complex interplay of anatomical and physiologic factors after VSG could contribute to worsening of reflux. Braghetto *et al*<sup>[28]</sup> examined the effects of VSG on the lower esophageal sphincter. A hypotensive lower esophageal sphincter was observed in 85% of their patients at 6 mo after VSG. Baumann *et al*<sup>[29]</sup> evaluated post-operative changes after VSG

with multislice computed tomography. Out of the 27 patients, 10 had proximal migration of the staple line, with 4 of these patients complaining of persistent regurgitation despite continuous acid suppressive therapy. Using high-resolution impedance manometry with 24-h pH and intraluminal impedance, Del Genio *et al*<sup>[30]</sup> demonstrated an increase in ineffective esophageal peristalsis, incomplete bolus transit, and retrograde flow within the esophagus. Similar to a hiatal hernia, dilated fundus may function as a reservoir predisposing to reflux<sup>[31]</sup>. Yehoshua *et al*<sup>[32]</sup> demonstrated low distensibility of the sleeve by peri-operatively insufflating the abdomen with carbon dioxide; therefore removal of the majority of fundus may result in reduced accommodation.

In our present study, the odds of developing dysphagia is 1.97 (95%CI: 1.12-3.46) in patients receiving a non-steroidal anti-inflammatory drug for 6 wk after VSG ( $P = 0.016$ ). Non-steroidal anti-inflammatory drug use can commonly cause esophageal mucosal injury in the form of non-reflux esophagitis. Zayachkivska *et al*<sup>[33]</sup> reported that naproxen increased the corneal and epithelial cell layer thickness of the esophagus and produced disorganization of the muscle plate and irregular submucosal edema. The authors documented that naproxen suppressed endogenous hydrogen sulfide synthesis, a critical factor for submucosal protection and repair<sup>[33]</sup>.

Our present study shows that the odds of developing dysphagia is 2.183 (95%CI: 1.09-4.36) in patients taking opioids for 6 wk after VSG ( $P = 0.05$ ). The effects of opioids on esophageal function and motility may benefit from further study. Studies using healthy volunteers showed that morphine decreased lower esophageal sphincter relaxation<sup>[34]</sup>. Case series documented dysphagia in patients receiving intrathecal fentanyl, possibly secondary to a central effect<sup>[35,36]</sup>. A retrospective study examined patients who received opioids and developed dysphagia<sup>[37]</sup>; the authors documented manometric abnormalities including abnormal lower esophageal sphincter relaxation during swallows, hypertensive lower esophageal sphincter, spastic achalasia-like esophageal dysmotility, and abnormal esophageal body contractions<sup>[37]</sup>.

In our present study, the prevalence of gastric sleeve stenosis in patients who underwent VSG is 2.3%, in agreement with previously reported prevalence of 0.1% to 3.9%<sup>[38-43]</sup>. At upper endoscopy we also identify 25 patients (or 7.1% of our study population) who have sharp angulation or a spiral of the gastric sleeve. Hydrostatic balloon dilatation of the gastric sleeve leads to resolution of dysphagia in 39% of patients, while two additional sessions of dilatation of the gastric sleeve leads to resolution of dysphagia in 30% of patients with persistent dysphagia. In support of our second hypothesis, narrowing of the gastric sleeve is associated with dysphagia after VSG.

Narrowing or stenosis of the gastric sleeve is known to cause dysphagia after VSG<sup>[44]</sup>. We define stenosis in

our study as obstruction of passage through the gastric sleeve. Mechanical gastric sleeve stenosis has been proposed to be caused by retraction of scar, oversewing of the staple line at VSG, overtraction of the greater curvature during stapling, or small hematomas or leaks which heal as scar tissue<sup>[44,45]</sup>. Sharp angulation or a spiral of the gastric sleeve could result from an incomplete gastric sleeve stenosis or other mechanisms such as asymmetrical lateral traction while stapling leading to twisting of the gastric tube in a volvulus-like mechanism<sup>[46]</sup>. There could be indentation of the incisura angularis within the gastric lumen creating a flap-valve<sup>[47]</sup> or a small Bougie dilator could create too tight of a sleeve in an area where gastric contents cannot readily pass<sup>[38,48,49]</sup>.

For acute dysphagia, rehydration involves intravenous fluids or frequent sips of small volumes of fluids. Suggested management of subacute or chronic gastric sleeve stenosis has included therapeutic endoscopic intervention and surgical procedures<sup>[13,14,38,40,50]</sup>. Therapeutic endoscopic interventions include hydrostatic balloon dilatation with a repeat session as needed at 4 to 6 wk<sup>[49,51,52]</sup> or use of a pneumatic achalasia balloon dilator. Parikh *et al.*<sup>[53]</sup> identified "short-segment" gastric sleeve stenosis in 8 patients out of 230 patients who underwent VSG, and endoscopic balloon dilatation successfully resolved symptoms in all 8 patients with a mean of 1.6 dilatations. Proposed surgical interventions include revision of the sleeve gastrectomy, seromyotomy, or Roux-en-Y gastric bypass. Due to the paucity of data, there are presently no guidelines for the management of symptomatic gastric sleeve stenosis after VSG<sup>[15]</sup>.

### Limits of the study

Since this is a retrospective study, it shares limitations with other retrospective studies which include difficulty controlling for all variables, difficulty minimizing the compliance of study subjects with regards to our recommendations, difficulty with determination of sample size (a power analysis could not be performed because we were uncertain what the effect size would be), and there is difficulty assessing the temporal relationships. In addition, our study contains a large proportion of African-American females from the Northeast United States and so we are uncertain whether our study results can be extrapolated to other patient populations.

In conclusion, post-operative dysphagia is reported by 22.7% of patients in up to 2 years of follow up after VSG. Medical conditions that are significantly associated with post-operative dysphagia include diabetes mellitus, symptoms of esophageal reflux, a low whole blood thiamine level, hypothyroidism, the use of non-steroidal anti-inflammatory drugs, and the use of opioids. After VSG, 9.3% of patients develop stenosis or sharp angulation of the gastric sleeve. Hydrostatic balloon dilatation of the gastric sleeve

leads to resolution of dysphagia in 39% of patients, while two additional sessions of dilatation of the gastric sleeve leads to resolution of dysphagia in 30% of patients with persistent dysphagia.

## COMMENTS

### Background

The prevalence of overweight and obese individuals has continued to rise worldwide. Surgical interventions have been shown to result in more effective and sustained weight loss as compared to non-surgical interventions. Vertical sleeve gastrectomy (VSG) is a newer bariatric surgical procedure for treatment of individuals with medically-complicated obesity and is mainly a restrictive procedure in which the gastric fundus and body are surgically excised, leaving a narrow, lesser-curvature based stomach. VSG is now the second most common bariatric surgical procedure being performed worldwide. Important complications after VSG include gastric perforation and dysphagia.

### Research frontiers

Narrowing or stenosis of the gastric sleeve is known to cause dysphagia after VSG. It has been suggested that gastric sleeve stenosis can be caused by retraction of scar, oversewing of the staple line at VSG, overtraction of the greater curvature during stapling, or small hematomas or leaks which heal as scar tissue. Therapeutic endoscopic interventions proposed to treat narrowing or stenosis of the gastric sleeve include hydrostatic balloon dilatation or use of a pneumatic achalasia balloon dilator. The effectiveness of dilation for treatment of dysphagia after VSG is not well understood. The contributions of potential medical conditions to the development of dysphagia after VSG are unclear.

### Innovations and breakthroughs

In a previous study of patients who underwent VSG, short-segment gastric sleeve stenosis was identified in 8 patients out of 230 total patients. Endoscopic balloon dilatation successfully resolved symptoms in these 8 patients with a mean of 1.6 dilatations of the gastric sleeve. In the present study, the authors aimed to investigate the effectiveness of dilation of the gastric sleeve by endoscopic hydrostatic balloon dilatation for treatment of postoperative dysphagia. In the present study, the authors aimed to investigate the contributions of potential medical conditions to the development of dysphagia after VSG by using stepwise multiple logistic regressions.

### Applications

Identification of medical conditions that may contribute to the development of dysphagia in postoperative patients after VSG may permit the incorporation of additional preventative care in the postoperative program of patients. Preventative care may reduce the prevalence of postoperative dysphagia in individuals who undergo VSG.

### Terminology

Narrowing of the gastric sleeve is defined by either an inability to pass a 9.6 mm Olympus video gastroscope due to stenosis of the gastric sleeve, or sharp angulation of or a spiral of the gastric sleeve hindering passage of a 9.6 mm Olympus gastroscope.

### Peer-review

This article is interesting and provides some important information about the incidence, risk factors for developing dysphagia following laparoscopic sleeve gastrectomy and some useful information about the endoscopic treatment for this complication.

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