Hematological, Biochemical, and Immunological Laboratory and Histomorphological Effects of Sleeve Gastrectomy on Female Rats

Ali Aktekin · Kazım Kazan · Pembegül Gunes ·
Murat Yekrek · Tolga Muftuoglu · Abdullah Saglam

Received: 29 January 2013 / Accepted: 22 April 2013 / Published online: 5 May 2013
© Association of Surgeons of India 2013

Abstract Restriction of food intake leads to immunologic and histomorphological changes in rats demonstrated by Moriyama. This study is planned to show how sleeve gastrectomy restricts food intake and its effects on biochemical liver function, immunologic and hematologic laboratory parameters, and histomorphological changes in rats. We used sleeve gastrectomy model on seven young adult female rats and compared study group with sham and control groups. Food consumption of rats was measured. All rats were sacrificed on the 50th day, and blood and tissue samples were collected. There was a significant low food intake in sleeve gastrectomy group ($p=0.013$). No differences were observed on hematologic, biochemical, and immunologic laboratory parameters between groups. Toxicity parameters in liver samples such as cytoplasmic atrophy, single-cell

hepatocellular necrosis, and necrotic eosinophilic cells were significantly high in sleeve gastrectomy group ($p=0.005$). Histomorphological examination of the spleen and kidneys revealed significant changes in sleeve gastrectomy and sham groups compared with controls ($p=0.004$ and $p=0.018$, respectively). Although sleeve gastrectomy does not lead to alteration in hematologic, biochemical, and immunologic laboratory parameters, it causes decreased food consumption, which results in toxicological histomorphological changes in rat liver as well as some changes in kidney and spleen samples.

Keywords Bariatric surgery · Obesity · Gastrectomy · Rat

Abbreviations

SG	Sleeve gastrectomy
WBC	Total leukocyte
AST	Aspartate aminotransferase
ALT	Alanine aminotransferase
OGTT	Oral glucose tolerance test
ITT	Insulin tolerance test

Introduction

Severe obesity is a worldwide public health problem. It has morbidity–mortality and high costs for the public health care systems, but weight loss leads to the improvement or disappearance of its comorbidities [1]. In fact, surgery is the only method capable of maintaining proper and long-lasting weight loss [2, 3]. Surgical techniques are based on food intake restriction, malabsorption, or both. On the other hand, all of the operations have some complications and the search for less aggressive treatments led to the development of sleeve gastrectomy (SG) [4]. SG decreases the gastric capacity without altering the continuity of the upper

A. Aktekin (✉) · K. Kazan · T. Muftuoglu · A. Saglam
4th General Surgery Clinic, Haydarpasa Numune Training
and Research Hospital, 17 Selimiye Uskudar,
34668, Istanbul, Turkey
e-mail: draliaktekin@yahoo.com

K. Kazan
e-mail: kazimkazan@yahoo.com

T. Muftuoglu
e-mail: tmuftuoglu@ttmail.com

A. Saglam
e-mail: abdullahsaglam@hotmail.com

P. Gunes
Pathology Section, Haydarpasa Numune Training and Research
Hospital, 17 Selimiye Uskudar,
34668, Istanbul, Turkey
e-mail: pembegulgunes@gmail.com

M. Yekrek
Biochemistry Section, Haydarpasa Numune Training and Research
Hospital, 17 Selimiye Uskudar,
34668, Istanbul, Turkey
e-mail: myekrek@yahoo.com

digestive tube, maintains access for endoscopic examination, and allows an additional operation in case of weight loss failure or weight regain [5].

The prevalence of extreme obesity is greater in women than men (7 versus 3 %), so women are more likely to undergo bariatric surgery [6]. Although most patients undergoing bariatric surgery are women, a few female gender-specific animal studies have been developed. Although women disproportionately undergo bariatric surgery, the rodent models investigating the mechanisms of bariatric surgery have been limited to males. Female rodent models can also potentially allow us to understand the effects of surgical intervention on future generations of offspring. SG is an attractive weight loss procedure for reproductive age female patients because it avoids the malabsorption associated with intestinal bypass.

SG leads to less amount of food consumption. On the other hand, during the course of toxicity studies for new drug candidates, treatment-related decreases in body weight related to decreased food consumption are often observed concomitantly with changes in clinical pathology and histopathology. Moriyama et al. evaluated the effects of decreased food intake on a wide range of toxicological parameters including general condition, body weight, ophthalmology, clinical pathology, and anatomic pathology in a dietary-optimized rat model. They reported histomorphological remarkable changes including erythrophagocytosis in the spleen/liver and renal tubular necrosis with hyaline cast/droplets in 25 % of the group, in addition to bone marrow depletion, lymphoid depletion in the thymus/spleen/lymph node, and/or decreased secretion in prostate/seminal vesicle in all restriction groups [7]. There are few references in the literature, which have indicated the decreased amount of food intake in rats by SG as well as its effects on hematological, biochemical, and immunological laboratory results and in histomorphological changes in rats. We presented how SG can decrease the food intake and its effects on some toxicity study parameters in a female rodent model.

Material and Method

This trial was approved by the Marmara University Animal Ethics Committee (17.12.2009-89.2009.mar). Seventeen 6-month-old female Wistar-Albino rats were kept in individual cages at room temperature, respecting light/dark cycles, and they received standard solid food to get accustomed to the environment in order to decrease stress. Seven rats had SG and five had laparotomy and stomach manipulation, the latter being the sham group. No medication and surgical procedure was performed on five animals in the control group.

Animals in SG and sham groups received a special liquid diet composed of 5 % glucose + 0.9 % saline solution on the day prior to surgery, to have the least possible volume of food

remnant in the gut. Only sterile surgical materials were used. Antibiotic prophylaxis was applied with 50 mg/kg intramuscular ceftriaxone 30 min prior to the procedure, and 75 mg/kg ketamine and 10 mg/kg xylazine were used for analgesia and anesthesia. Upper median laparotomy was conducted, stomach was exposed, and its contents were emptied into the small bowel. In the SG group, adhesions were released, and vessels of gastric greater curvature were cauterized with a thermal cautery, from the cardia to pylorus. A SG was performed; about 70 % of gastric tissue is resected, including most of the fundal portion [8]. The remaining stomach was closed by 5/0 polypropylene. In both groups, laparotomy was closed in a continuous single plane with polypropylene. To avoid dehydration, 10 ml of saline solution was injected in subcutaneous tissue. All animals were kept in separate boxes. Upon resuming oral nutrition, all animals were given a liquid diet composed of 5 % glucose + 0.9 % saline solution for 3 days, after which standard solid feed was allowed. Daily amount of consumed solid food were measured individually. On day 50, all the rats were anesthetized and sacrificed after blood samples were taken for liver and immunologic tests, as described by Castelan. The liver, kidney, and spleen were excised and fixed in 10 % formaldehyde and paraffin-embedded sections were stained with hematoxylin and eosin for histomorphological examination under light microscopy. A single pathologist performed pathological review of all specimens.

We investigated cytoplasmic atrophy, single cell hepatocellular necrosis, and necrotic eosinophilic cells in the liver; hyaline drops, cortical hyaline accumulation, and tubular necrosis in the kidney; and lymphoid depletion and erythrophagocytosis in the spleen. According to Moriyama, the observed histomorphological changes were scored from mildly (+), moderately (++), to severely (+++) positive [7]. The liver, kidney, and spleen and also total histomorphological scores for each group were calculated.

Statistical Analysis

The results were analyzed with computer program Number Cruncher Statistical System 2007 and PASS 2008 Statistical Software (Utah, USA). Parameters were compared by analyzing with Kruskal–Wallis and Mann–Whitney *U* tests. Level of significance was accepted as $p < 0.05$ and $p < 0.01$, respectively.

Results

One of the rats in the SG group died on the second postoperative day due to intra-abdominal sepsis. There was a significant difference between daily food consumption of the groups: SG group had the lowest amount of daily consumption compared

Table 1 Evaluations of daily food consumption in rats

	Daily food intake Mean±SD (g/day)	<i>p</i> value
SG	16.83±2.31	0.013*
Sham group	18.84±1.99	
Control group	21.52±1.50	

SG sleeve gastrectomy group

**p*<0.05 (significant; Kruskal–Wallis test)

to the other groups (*p*=0.013) (Table 1). There was no significant difference in WBC, aspartate aminotransferase (AST), alanine aminotransferase (ALT), total protein, albumin, IgA, IgG, and IgM blood levels between the groups (*p*=0.214, *p*=0.463, *p*=0.211, *p*=0.206, *p*=0.058, *p*=0.435, and *p*=0.974, respectively) (Table 2).

All rats showed mild positivity in SG group, whereas only two rats showed mild (+) cytoplasmic atrophy in the sham group, and none in the control group. Single-cell hepatocellular necrosis was observed only in one rat of the SG group but none among the other rats. All rats in the SG group had mild (+) tubular necrosis, but none had in the sham or control groups. Only two rats in the SG group showed mild (+) hyaline droplets and three rats showed moderate positivity in sham groups, whereas none in the control group. None of the rats had hyaline accumulation in the renal cortex. In the SG group, four rats showed mildly decreased positivity and two rats showed moderately decreased positivity in the lymphoid tissue. In sham group, two rats showed mildly decreased positivity and one rat showed moderately decreased positivity in the lymphoid tissue. Mild (+) erythrophagocytosis was observed in one rat in the SG group and one in the sham group. No histomorphological change was observed in the spleen of the control group.

There was statistically significant changes in liver scores (*p*=0.005). The score of the SG group was significantly higher than the other two groups (SG versus sham groups, *p*=0.032, and SG versus control groups, *p*=0.002). There

was no statistically significant difference between the sham and control groups (*p*=0.134). There was a statistically significant change in the scores of histomorphological change in the kidneys (*p*=0.023). The scores of the SG and sham groups were significantly higher than those in the control groups (*p*=0.003; *p*=0.05), but no statistically significant change was observed in the SG and sham groups (*p*=1). There was significant differences in the scores of histomorphological changes in the spleen (*p*=0.017). The score of the SG group were significantly higher than those in the control groups (*p*=0.003), but no significant change was observed in SG and sham groups (*p*=0.438). The score of the sham group was not statistically more significant than that of the control group (*p*=0.05). The scores of total histomorphological changes showed statistically significant differences in all groups (*p*=0.006). The scores of total histomorphological changes were significantly high in the SG and sham groups (*p*=0.004 and *p*=0.018, respectively), but no statistically significant change was observed between SG and sham groups (*p*=0.150) (Table 3).

Discussion

SG is a bariatric surgery used worldwide with fundus resection and decreases the level of ghrelin without malabsorption component. In addition, it is also the preferred method in patients with comorbid diseases because it is rapidly performed, simple, and with a low morbidity rate [9]. SG strongly decreases the level of fundus secretion of appetizing ghrelin and improves and even leads to remission of type II diabetes mellitus [10]. SG becomes popular and also is one of the most frequently encountered surgical approaches, but its side effects and long time results are not well known.

The present study was one of unique studies in that it focused on female rodents, which demographically represent the gender most likely to undergo bariatric surgery in humans [6]. Nearly 80 % of patients undergoing bariatric

Table 2 Effects of low food consumption on liver and immunological laboratory parameters

	SG Mean±SD	Sham Mean±SD	Control Mean±SD	<i>p</i> value
WBC (10 ³ /mm ³)	5.97±2.68	3.38±2.68	5.32±1.76	0.214
ALT (IU/l)	91.00±27.86	113.80±35.48	91.40±16.13	0.463
AST (IU/l)	200.33±166.44	204.20±56.40	145.80±25.52	0.211
Total Protein (g/dl)	6.53±0.15	7.32±1.08	6.44±0.75	0.206
Albumin (g/dl)	3.20±0.32	4.00±0.47	3.14±0.85	0.058
IgA (mg/dl)	1.83±0.41	2.00±0.00	2.00±0.00	0.435
IgG (mg/dl)	335.00±13.07	319.60±62.44	261.60±146.02	0.797
IgM (mg/dl)	24.33±17.59	27.60±23.09	22.20±22.00	0.974

Kruskal–Wallis test; level of significance is at *p*<0.05

SG sleeve gastrectomy group, WBC white blood cells, AST aspartate aminotransferase, ALT alanine aminotransferase

Table 3 The evaluation of histomorphological change scores of the liver, kidney, and spleen for each group

	SG	Sham	Control		SG versus sham; SG versus control; sham versus control
	Mean±SD	Mean±SD	Mean±SD	<i>p</i> value ^a	<i>p</i> value ^b
Liver	1.17±0.41	0.40±0.55	0+0	0.005*	0.032**; 0.002*; 0.134
Kidney	1.00±0.52	1.20±1.09	0+0	0.023**	1.00; 0.003*; 0.050**
Spleen	1.50±0.84	1.00±1.00	0+0	0.017**	0.438; 0.003*; 0.05**
SG sleeve gastrectomy group					
Total score	4.00±1.26	2.60±1.82	0+0	0.006*	0.150; 0.004*; 0.018**

p*<0.01; *p*<0.05^aKruskal–Wallis test^bMann–Whitney *U* test

surgery are women, and 35 % are of reproductive age. It is important to evaluate both the potentially beneficial and the potentially deleterious effects of bariatric surgery on reproductive age women. Reproductive age women are also of particular interest because of the link among maternal obesity, gestational diabetes, adverse perinatal outcomes, and transgenerational transmission of a metabolic phenotype to the offspring. Despite previous concerns about the potentially deleterious effect of bariatric surgery on maternal nutrition, bariatric surgery has been demonstrated to improve maternal outcomes and likely improves neonatal outcomes [11, 12]. Although women disproportionately undergo bariatric surgery, the rodent models investigating the mechanisms of bariatric surgery have been limited to males. Female rodent models can also potentially allow us to understand the effects of surgical intervention on future generations of offspring. SG is an attractive weight loss procedure for reproductive age female patients because it avoids the malabsorption associated with intestinal bypass.

SG also leads to low food consumption in animal models. Moriyama studied the effects of low food consumption in rats and its relationship with toxicological parameters in 2008 [7]. Toxicological parameters are often affected by decreased amounts of food consumptions. They evaluated the effects of food amount reduction on a wide range of toxicological parameters including general condition, body weight, ophthalmology, clinical pathology, and anatomic pathology in a dietary-optimized rat models. Moriyama classified rats into groups and supplied them with different amounts of food; for example, some groups even ate 4–6 g in a day. After 2 weeks, mortality, hemolysis, hemoglobinuria, hemoconcentration, increased blood AST and ALT levels, decreased glucose, and protein levels were more observed at the lowest amounts of food consumed by the

groups. Even more histomorphological changes, such as renal tubular necrosis and hyaline accumulation, decrease in lymphoid tissue observed in least food consumption group [7]. In our study, the effects of SG model, which was defined by Castellán, were investigated on rats [8]. The food intake of groups was 16 g/day in SG, 18 g/day in sham group, and 21 g/day in control group. The reduced food intake in the SG group compared to the control was nearly 22 %. Moriyama noted an increase in erythroid parameters; decreases in leukocyte, thrombocyte and reticulocyte counts decrease in glucose, total protein, and albumin, whereas increases in AST, ALT, and blood urea nitrogen electrolyte imbalance lymphoid depletion and erythrophagocytosis in lymphoid tissue cytoplasmic atrophy and hepatocellular single cell necrosis in liver and tubular necrosis and hyaline droplet in the kidneys in the group with 25 % food reduction [7]. In our study, we have not detected such remarkable changes, but we have noted that the SG procedure has caused significant histomorphological changes in the liver compared with the sham and control groups. On the other hand, the SG and sham groups had more histomorphological changes in the kidney and spleen than the control group. These findings have indicated that there were also some histomorphological effects, which were attributable to other factors than SG. On the other hand, some of these effects may be different in humans after a laparoscopic approach. The laparoscopic approach is less harmful and most commonly used in surgical practice.

In the literature, some studies have presented the metabolic effects of SG in rats, especially on ghrelin and lipid profiles. The most important production site of ghrelin is the fundus of the stomach. It is resected during SG and leads to very serious decrease in ghrelin levels [13]. Low level of ghrelin has been considered as

advantageous because of its effects on energy balance and lipid and glucose metabolism. Brinckerhoff et al. evaluated the effect of SG on young female rats with diet-induced obesity. SG was associated with significant weight loss (5 ± 6 % versus -4 ± 6 %; $p < 0.001$), lower leptin levels (1.3 ± 1.2 versus 3.5 ± 2.3 ng/ml; $p < 0.01$), and higher adiponectin levels (0.43 ± 0.19 versus 17 ± 0.14 ng/ml; $p < 0.004$) compared with the sham-operated rats and no significant differences were found in the fasting ghrelin levels. Furthermore, they did not observe evidence of insulin resistance or steatohepatitis after 11 weeks of high-fat diet. They conclude that SG appears to result in weight loss and improvements in adiponectin and leptin by way of mechanisms independent of ghrelin levels in a female model of diet-induced obesity [14]. Masuda et al. evaluated the efficacy of SG in comparison with gastric banding in an obese diabetic rat model. The gastric banding and SG groups showed significant decreases in weight, cumulative intake, and metabolic parameters and significant improvement of oral glucose tolerance test (OGTT) and insulin tolerance test (ITT). There were no significant differences in weight and cumulative food intake between the groups. However, the SG group showed significantly higher gastric emptying rate and plasma level of adiponectin and lower plasma levels of free fatty acid, total cholesterol, and ghrelin compared with the gastric banding group. Furthermore, the SG group showed improvement of OGTT and ITT results in comparison with the gastric banding group. They concluded that in obese diabetic rats, SG may improve glucose and lipid metabolism compared with gastric banding, although there was no significant difference in the effect on body weight loss between the two procedures. The hormonal and digestive changes induced by SG may have relevance to the effects on metabolism [15]. Wang and Liu reported from their study that body weight control provided by SG could relieve high-fat diet-induced steatohepatitis in rats [16]. Stefater et al. reported that rats receiving vertical SG and high-fat diets reduced postprandial levels of plasma lipid, resulted from reduced intestinal secretion of triglycerides following ingestion of a lipid-rich meal, and indicated that vertical SG had important effects on metabolism [17]. Chambers et al. had adapted two bariatric surgical procedures commonly employed in humans to a rat model to begin to understand the mechanisms underlying the improvements in energy homeostasis. Young adult male rats received either Roux-en-Y gastric bypass or vertical sleeve gastrectomy and both had comparable beneficial effects relative to controls. They ate less food and lost more weight, and they both had improved glucose parameters. The two surgical procedures had such similar effects in spite of having

quite different rearrangements of the gastrointestinal system [18].

One of the limitations of the present study was the short follow-up of 50 days. However, this period is equivalent to 3 human years [19]. Although we could not exclude the potential for weight regain after SG, other investigators have demonstrated that weight loss is maintained at 15 weeks after SG in rodents [20, 21]. In human beings, the failure of weight lost after SG has been explained by the dilatation of the stomach. Langer has observed gastric dilatation with contrast-enhanced upper GIS series in one patient, and weight gain after weight lost in 3 out of 23 patients in 12 months [22]. In rats, postmortem examinations revealed that the dilation of resected gastric tissue reached nearly normal size, and dilatation of remnant gastric tissue in SG has been also observed in our study (Fig. 1). On day 50, dilatation of gastric tissue could be explained by the feeding habit of rats. In the SG group, dilatation of remnant gastric tissue may be explained by continued food consumption in small amounts, with hard pellet, without long interruption during the whole day. Another limitation of the present study was the relatively high complication rate in these relatively young female rats. These results were obtained after several pilot studies, technique refinements, and the development of a rigorous perioperative care protocol. Despite these efforts, we observed that the aglandular forestomach in rodents remains susceptible to the development of a leak or abscess.

In conclusion, increasing indications of SG has led to investigate and understand long-term side effects of SG. In our study, SG has decreased the food intake in rats but has not changed biochemical, hematological, and immunological laboratory parameters, along with renal and splenic histomorphology. It has led to some significant toxicological histomorphological changes on the liver of rats in a short duration. Its long time effects should be investigated with prospective clinical studies.

Fig. 1 Gastric dilatation of remaining stomach at 50th day of operation. Notice the fully filled stomach

References

1. Thompson D, Wolf AM (2001) The medical-care cost burden of obesity. *Obes Rev* 2:189–197
2. NHLBI Obesity Education Initiative Task Force Members (1998) Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. The evidence report. National Institute of Health, Bethesda. No. 98-4083. Available from: http://www.nhlbi.nih.gov/guidelines/obesity/ob_gdlns.pdf. Accessed 10 Oct 2008
3. Deitel M (2003) Overweight and obesity worldwide now estimated to involve 1.7 billion people. *Obes Surg* 13:329–330
4. Buchwald H, Buchwald JN (2002) Evolution of operative procedures for the management of morbid obesity 1950–2000. *Obes Surg* 12:705–717
5. Regan JP, Inabnet B, Gagner M, Pomp A (2003) Early experience with two-stage laparoscopic Roux-en-Y gastric bypass as an alternative in the super-super obese patient. *Obes Surg* 13:861–864
6. Martin M, Beekley A, Kjorstad R, Sebesta J (2010) Socioeconomic disparities in eligibility and access to bariatric surgery: a national population-based analysis. *Surg Obes Relat Dis* 6:8–15
7. Moriyama T, Tsujioka S, Ohira T, Nonaka S, Ikeda H, Sugiura H et al (2008) Effects of reduced food intake on toxicity study parameters in rats. *J Toxicol Sci* 33:537–547
8. de Bona CJ, Bettiol J, d'Acampora AJ, Castelan JV, de Souza JC, Bressiani V et al (2007) Sleeve gastrectomy model in Wistar rats. *Obes Surg* 17:957–961
9. Magee CJ, Barry J, Arumugasamy M, Javed S, Macadam R, Kerrigan DD (2011) Laparoscopic sleeve gastrectomy for high-risk patients: weight loss and comorbidity improvement-short-term results. *Obes Surg* 21:547–550
10. Wood PD, Stefanick ML, Dreon DM, Frey-Hewitt B, Garay SC, Williams PT et al (1988) Changes in plasma lipids and lipoproteins in overweight men during weight loss through dieting as compared with exercise. *N Engl J Med* 319:1173–1179
11. Maggard MA, Yermilov I, Li Z, Maglione M, Newberry S, Suttorp M et al (2008) Pregnancy and fertility following bariatric surgery: a systematic review. *JAMA* 00:2286–2296
12. Smith J, Cianflone K, Biron S, Hould FS, Lebel S, Marceau S et al (2009) Effects of maternal surgical weight loss in mothers on intergenerational transmission of obesity. *J Clin Endocrinol Metab* 94:4275–4283
13. Langer FB, Reza Hoda MA, Bohdjalian A, Felberbauer FX, Zacherl J, Wenzl E et al (2005) Sleeve gastrectomy and gastric banding: effects on plasma ghrelin levels. *Obes Surg* 15:1024–1029
14. Brinckerhoff TZ, Bondada S, Lewis CE, French SW, Deugarte DA (2011) Metabolic effects of sleeve gastrectomy in female rat model of diet-induced obesity. *Surg Obes Relat Dis* 9(1):108–112
15. Masuda T, Ohta M, Hirashita T, Kawano Y, Eguchi H, Yada K et al (2011) A comparative study of gastric banding and sleeve gastrectomy in an obese diabetic rat model. *Obes Surg* 21:1774–1780
16. Wang Y, Liu J (2009) Sleeve gastrectomy relieves steatohepatitis in high-fat-diet-induced obese rats. *Obes Surg* 19:921–925
17. Stefater MA, Sandoval DA, Chambers AP, Wilson-Pérez HE, Hofmann SM, Jandacek R et al (2011) Sleeve gastrectomy in rats improves postprandial lipid clearance by reducing intestinal triglyceride secretion. *Gastroenterology* 141:939–949
18. Chambers AP, Stefater MA, Wilson-Perez HE, Jessen L, Sisley S, Ryan KK et al (2011) Similar effects of Roux-en-Y gastric bypass and vertical sleeve gastrectomy on glucose regulation in rats. *Physiol Behav* 105:120–123
19. Christou NV, Look D, Maclean LD (2006) Weight gain after short- and long-limb gastric bypass in patients followed for longer than 10 years. *Ann Surg* 244:734–740
20. Kotidis EV, Koliakos GG, Baltzopoulos VG, Ioannidis KN, Yovos JG, Papavramidis ST (2006) Serum ghrelin, leptin and adiponectin levels before and after weight loss: comparison of three methods of treatment—a prospective study. *Obes Surg* 16:1425–1432
21. Patrikakos P, Toutouzias KG, Perrea D, Menenakos E, Pantopoulou A, Thomopoulos T et al (2009) A surgical rat model of sleeve gastrectomy with staple technique: long-term weight loss results. *Obes Surg* 19:1586–1590
22. Langer FB, Bohdjalian A, Felberbauer FX, Fleischmann E, Reza Hoda MA, Ludvik B et al (2006) Does gastric dilatation limit the success of sleeve gastrectomy as a sole operation for morbid obesity? *Obes Surg* 16:166–171