SURGERY FOR OBESITY AND RELATED DISEASES

Surgery for Obesity and Related Diseases ▮ (2013) 00–00

Original article

# The effect of laparoscopic sleeve gastrectomy with or without hiatal hernia repair on gastroesophageal reflux disease in obese patients

Antonella Santonicola, M.D.[a], Luigi Angrisani, M.D.[b], Pierpaolo Cutolo, M.D.[b], Giampaolo Formisano, M.D.[b], Paola Iovino, M.D.[c,*]

[a]Clinical and Experimental Medicine Department, Federico II University of Naples, Naples, Italy
[b]General and Endoscopic Surgery Unit, San Giovanni Bosco Hospital, Naples, Italy
[c]Medicine and Surgery Department, University of Salerno, Salerno, Italy

Received March 13, 2013; accepted September 14, 2013

**Abstract**

**Background:** Obesity is an independent risk factor for gastroesophageal reflux disease (GERD), which is often associated with the presence of a hiatal hernia (HH). Despite increasing popularity of laparoscopic sleeve gastrectomy (LSG) in bariatric surgery, its effect on GERD is still unclear. The objective of this study was to evaluate the effect of LSG with or without hiatal hernia repair (HHR) on GERD in obese patients.

**Methods:** Seventy-eight patients with HH underwent LSG with concomitant HHR (LSG+HHR group). Their data were compared with that of 102 patients without HH, who underwent only LSG (LSG-group). All patients underwent a standardized questionnaire, a double-contrast barium swallow, and an upper-gastrointestinal endoscopy before the surgical procedure and at least 6 months later.

**Results:** At baseline, the prevalence of GERD symptoms and their frequency-intensity scores did not differ between groups. At follow up, there was a significant decrease in the prevalence of typical GERD symptoms only in the LSG-group ($P = .003$). LSG+HHR patients showed a significantly higher heartburn frequency-intensity score compared with LSG patients ($P = .009$).

**Conclusion:** This finding confirms that LSG has a beneficial effect on relieving GERD symptoms, although the underlying mechanisms are still unclear; conversely, the procedure of HHR did not produce any improvement in GERD symptoms. (Surg Obes Relat Dis 2013;▮:00-00.) © 2013 American Society for Metabolic and Bariatric Surgery. All rights reserved.

*Keywords:* Obesity; Gastroesophageal reflux disease; Laparoscopic sleeve gastrectomy; Hiatal hernia repair

Gastroesophageal reflux disease (GERD) is defined as reflux of stomach content causing troublesome symptoms and/or complications [1]. According to the Montreal Consensus Conference, patients may be diagnosed based on typical symptoms alone [1]. The presence of hiatal hernia (HH) is closely associated with GERD and its complications [2–4]. The HH diagnosis is based on indirect techniques: double-contrast barium swallow (dc-BS), upper-gastrointestinal endoscopy (UGIE), or manometry [5]. These techniques do not allow the direct assessment of the gastroesophageal junction, which is easily disclosed intraoperatively during upper abdominal surgery procedures. The presence of HH is frequent in obese patients [6,7], and obesity is considered an independent risk factor for GERD. It has been suggested that a higher BMI causes an increased prevalence of GERD by increasing the risk of developing HH [8]. Among all surgical techniques performed in obese patients, laparoscopic Roux-en-Y gastric bypass seems to be the most promising in achieving weight reduction and in improving GERD [7]. Furthermore, in obese patients submitted to laparoscopic gastric banding

*Correspondence: Paola Iovino, M.D., Department of Medicine and Surgery, University of Salerno, Via Allende, Baronissi, 84081 Salerno, Italy.
E-mail: piovino@unisa.it

1550-7289/13/$ – see front matter 
http://dx.doi.org/10.1016/j.soard.2013.09.006

(LGB) or laparoscopic Roux-en-Y gastric bypass, a concomitant HH repair (HHR) has been performed with good results on GERD symptoms regardless of HH size [9,10]. In the past years, laparoscopic sleeve gastrectomy (LSG) has gained increasing popularity in the surgical treatment of obese patients, but current data of its effect on GERD are still controversial [11]. In addition, there are only a few studies investigating the effect of the concomitant repair of HH during LSG on GERD [12,13], which despite some methodological limitations, suggest an improvement of symptoms. The aim of the present study was to research the effect of LSG alone or combined with HHR on GERD symptoms in obese patients.

## Methods

From January 2007 to April 2011, 180 obese patients eligible for bariatric surgery [14] underwent LSG. Seventy-eight consecutive patients, in whom sliding HH was intraoperatively disclosed, underwent LSG with concomitant HHR (LSG+HHR group), and 102 obese patients, similar for age and gender distribution in whom no HH was intraoperatively disclosed, underwent only LSG (LSG-group). The study was approved by the institutional review board of the university hospital. Adherence to the ethical conduct standards of the Declaration of Helsinki ensured patients' welfare [15]. Informed consent was obtained from all patients.

### *Protocol*

The preoperative evaluation included a careful medical history, evaluation of co-morbidities (i.e., hypertension, dyslipidemia, diabetes [16]), a dc-BS, an UGIE, and an assessment of GERD symptoms. The postoperative evaluation was performed at least 6 months after the bariatric surgery and included a reassessment of GERD symptoms. If a patient was positive for GERD, he underwent a second dc-BS.

### *Surgical technique*

The surgical technique has been previously described [17]. Briefly, the presence of HH was identified according to the following protocol: upon incision of the lesser omentum but before incision of the peritoneum over the pillars, the hiatus was examined for a HH with para-esophageal involvement to exclude these patients from the study. After incision of the peritoneum, gastroesophageal junction and its relationship to the hiatus were carefully identified to disclose the presence of sliding HH [18]. Whenever intraoperative HH was found it was always posteriorly repaired on the basis of the following technique: the esophagus was encircled, and the diaphragmatic crura were completely dissected to the mediastinal space. The gastric herniation was reduced into the abdomen. Reconstruction was performed using nonabsorbable (0 Ethibond) interrupted sutures reinforced with a 1×1 pledget of Marlex (Bard ®, Murray Hill, NJ), Vascu-Guard ® and Veritas ® (Collagen Matrix, Synovis Surgical Innovations, St Paul, MN), calibrated on a 40-French orogastric bougie. The gastric greater curvature was freed up to the cardioesophageal junction close to the stomach with the use of a vessel-sealing device (Ultracision Harmonic Scalpel, EES, Cincinnati, OH; LigaSure, Covidien, Mansfield, MA) sparing the gastroepiploic vessels. The final surgical preparation was a mobilized stomach tethered at the celiac axis. The stomach was resected with the linear stapler parallel to a 40-French orogastric tube along the lesser curve. The calibrating bougie was replaced by a nasogastric tube positioned in the distal stomach to perform the methylene blue dye test for determination of staple-line integrity then, the resected stomach was removed. Concomitant cholecystectomy was performed in all patients with preoperative ultrasound evidence of lithiasis.

### *GERD symptoms assessment*

Participants underwent an assessment of GERD symptoms using a standardized questionnaire evaluating the prevalence of typical GERD symptoms (heartburn and/or regurgitation). The frequency of heartburn and regurgitation was scored from 0 to 3 (0 = absent; 1 = 2 day/week; 2 = 3–5 d/wk; and 3 = 6 or 7 d/wk). The intensity of heartburn and regurgitation was scored from 0 to 3 (0 = absent; 1 = not very bothersome, not interfering with daily activities; 2 = bothersome, but not interfering with daily activities; and 3 = interfering with daily activities). A score out of a maximum of 6 was obtained for each symptom, which was defined as a mild (1–2), moderate (3–4), and severe (5–6) symptom frequency-intensity score [19,20].

### *Statistical analysis*

Data are expressed as mean ± standard error (M ± SE) unless otherwise indicated. $\chi^2$ and Mann-Whitney (M-W) U tests were used to compare nonparametric data and ANOVA for parametric data. The McNemar ($\chi^2$ test for within-patients) and Wilcoxon tests were used to compare the prevalence of a binary variable in the same patients (i.e., the prevalence of GERD symptoms prebariatric surgery versus postbariatric surgery in the LSG+HHR and LSG groups) and the frequency-intensity score within patients, respectively. A multiple linear regression analysis was constructed as appropriate. The significance level was set below .05. The statistical program used was the Statistical Package for Social Sciences (SPSS) for Windows, version 12.0.

## Results

### *Preoperative evaluation*

Demographic characteristics of participants are shown in Table 1.

Table 1
Demographic characteristics and prevalence of co-morbidities in LSG+HHR group and LSG group before surgery and at follow-up

| Characteristics | LSG+HHR group (n = 78) | LSG group (n = 102) | *P* |
|---|---|---|---|
| *Baseline* | | | |
| Gender (M/F) | 10/68 | 23/79 | .09 |
| Age (years) | 39.3 ± 1.4 | 36.5 ± 1.2 | .12 |
| BMI (kg/m$^2$) | 44.6 ± .7 | 46.4 ± .7 | .08 |
| Cholecystectomy, n (%) | 4 (5.1%) | 4 (4.3%) | .70 |
| Hypertension | 18 (23.1%) | 22 (21.6%) | .81 |
| Patients on antihypertensive medication | 100% | 100% | |
| Type 2 diabetes mellitus | 8 (10.3%) | 9 (8.8%) | .74 |
| Patients on antidiabetic medication | 87.5% | 77.8% | .60 |
| *Follow-up* | | | |
| BMI (kg/m$^2$) | 31.7 ± .8 | 30.8 ± .7 | .41 |
| Excess weight loss (%) | 62.8 ± 3.53 | 67.8 ± 2.65 | .25 |
| Patients on antihypertensive medication | 11 (61.1%) | 10 (45.5%) | .32 |
| Patients on antidiabetic medication | 3 (37.5%) | 4 (44.4%) | .77 |

Data are expressed as % or mean ± SE.
LSG+HHR = laparoscopic sleeve gastrectomy with concomitant hiatal hernia repair; LSG = laparoscopic sleeve gastrectomy; M = male; F = female; BMI = body mass index.

### *GERD symptoms assessment and HH detection*

The prevalence of typical GERD symptoms did not differ between LSG+HHR and LSG patients (*P* = .9) (Fig. 1). Heartburn and regurgitation frequency-intensity scores were similar between the LSG+HHR and LSG groups (*P* = .5 and *P* = .5, respectively) (Fig. 2). The dc-BS showed a significantly higher presence of HH in LSG+HHR patients compared with LSG patients (28.9% versus6.4%) (*P* = .004). Using UGIE, no differences in the presence of HH (29.5% LSG+HHR versus 25.0% LSG groups, *P* = .7) and esophagitis (18% LSG+HHR versus 7.1% LSG groups, *P* = .2 were disclosed between groups. Heartburn and regurgitation frequency-intensity scores did not differ between patients with or without HH, as shown by double-contrast barium swallow and/or upper GI endoscopy (heartburn 1.5 ± 2.0 versus1.3 ± 1.9, *P* = .8; regurgitation 1.4 ± 1.9 versus1.3 ± 1.8, *P* = .5, respectively).

### *Postoperative evaluation*

All patients underwent a reassessment of anthropometric characteristics and co-morbidities (Table 1). No differences in the interval after bariatric surgery were shown between the LSG+HHR and LSG group (14.6 ± 1.1 months versus 17.1 ± 1.0 months, *P* = .09).

### *GERD symptoms assessment*

All patients underwent the reassessment of GERD symptoms. The prevalence of typical GERD symptoms in LSG+HHR group did not show any significant change compared with that evaluated before surgery (within group-comparison presurgery versus postsurgery 30/78 (38.4%) versus 24/78 (30.8%), *P* = .3). A significant decrease in the prevalence of typical GERD symptoms was found in LSG group compared with before surgery (within-group comparison presurgery versus postsurgery 40/102 (39.2%) versus 20/102 (19.6%), *P* = .003). Fig. 1 illustrates a schematic flow diagram of patients with or without GERD symptoms before LSG and LSG+HHR and during the follow-up process; it shows, after surgery in the 2 groups (LSG and LSG+HHR), the frequency of patients who still complained of GERD symptoms and of those who referred a new onset of GERD symptoms. In addition, heartburn and regurgitation intensity-frequency scores significantly decreased within LSG group, and no improvement was shown within LSG+HHR group (Fig. 2).

In the comparisons between groups, LSG+HHR patients showed significantly higher heartburn frequency-intensity scores, and the regurgitation frequency-intensity score just failed to reach a statistical significance compared with LSG patients (*P* = .02 and *P* = .08, respectively) (Fig. 2). Multiple linear regression analysis was performed with heartburn and regurgitation frequency-intensity scores as

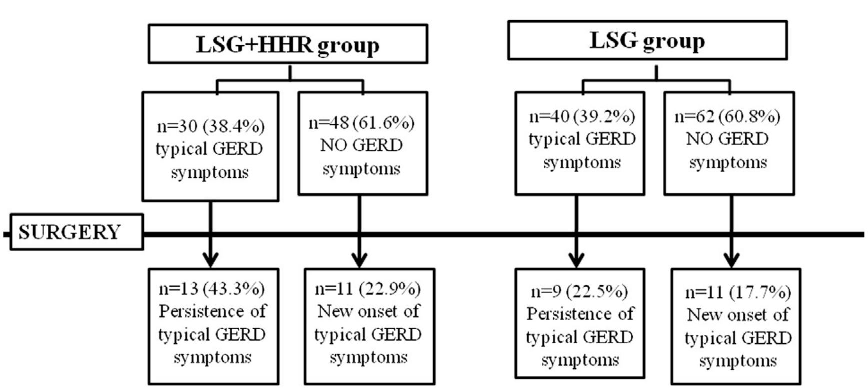


Fig. 1. Prevalence of typical Gastroesophageal reflux disease (GERD) symptoms before and after surgery in laparoscopic sleeve gastrectomy with concomitant hiatal hernia repair group (LSG+HHR group) and laparoscopic sleeve gastrectomy (LSG group).

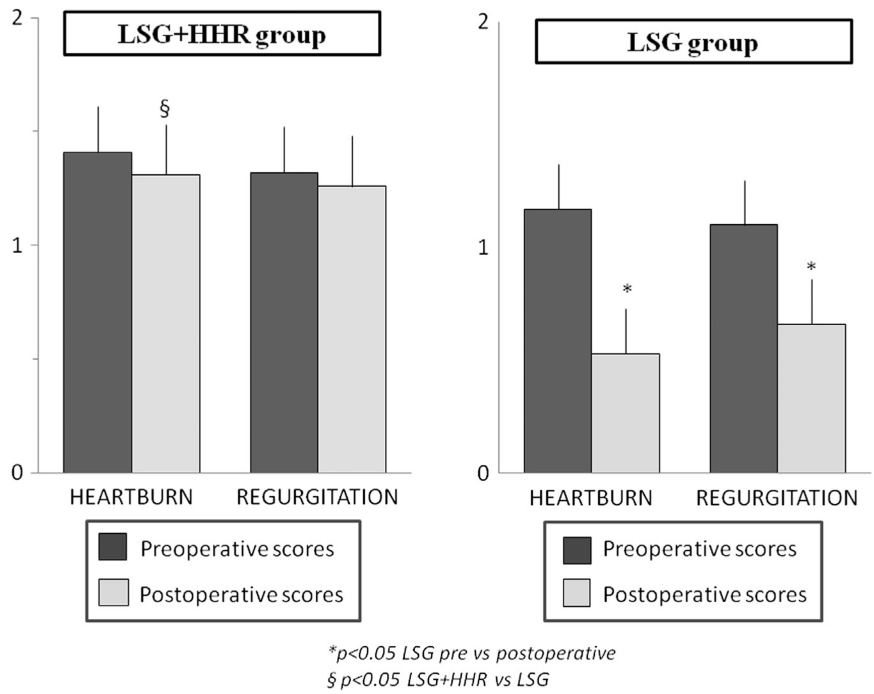


Fig. 2. Heartburn and regurgitation frequency-intensity scores before and after surgery in laparoscopic sleeve gastrectomy with concomitant hiatal hernia repair group (LSG+HHR group) and laparoscopic sleeve gastrectomy (LSG group).

dependent variables and with the presence of GERD before surgery and surgical techniques as covariates. Higher heartburn intensity-frequency score postoperatively was significantly associated with LSG+HHR (regression coefficient, B = –.77, SE .34, $P$ = .024). All patients who referred GERD typical symptoms were scheduled for a second dc-BS, but 3 patients (12.5%) in the LSG+HHR group and 9 patients (45%) in the LSG group refused.

Heartburn and regurgitation frequency-intensity scores were significantly higher in patients with HH recurrence compared with those without HH recurrence (heartburn 4.3 ± .5 versus 2.4 ± .4, $P$ = .004; regurgitation 4.1 ± .5 versus 2.5 ± .3, $P$ = .009, respectively).

## Discussion

Our results show that obese patients, who underwent LSG, achieved a significant postoperative decrease in the prevalence and intensity-frequency scores of typical GERD symptoms compared with patients who underwent LSG combined with HH repair. Moreover, after bariatric surgery the LSG patients with concomitant HHR had a significantly higher heartburn intensity-frequency score than patients who underwent LSG alone. To our knowledge, this is the first study to compare LSG to LSG combined with HHR in the management of obese patients evaluated for GERD symptoms by a standardized frequency-intensity symptoms score questionnaire before surgery and in a medium follow-up. According to the Montreal Consensus Conference, the diagnosis of GERD should be based on the presence of typical symptoms such as heartburn and regurgitation [1], and no further diagnostic tests for GERD are necessary especially after exclusion of misdiagnoses and GERD complications by UGIE [21]. In our study, we confirmed the efficacy of the 2 surgical techniques in reducing excess of weight and co-morbidities, although LSG alone showed a further beneficial effect on decreasing GERD symptoms. Data about the effect of LSG on GERD are still controversial [11], showing either an improvement or a worsening [22–24]. Another study that reported long term results at least 6 years after LSG, revealed a biphasic pattern in GERD symptoms: the first peak developed during the first follow-up year, related to the lack of gastric compliance and the blunting of the angle of His; the second peak showing up later and linked with the appearance of a neo-fundus, caused by the dilation of the stomach, with a relative mid-stomach stenosis [25]. The authors hypothesized that the consequent stasis of food and a growing surface of acid production might promote the GERD onset [25]. Recently, Petersen et al. [26] suggested that LSG might be a beneficial procedure to reduce GERD in obese patients, reporting an increase in the lower esophageal sphincter pressure after LSG, but the weakness of this study was the lack of a standardized GERD symptoms evaluation after surgery [27]. It should be taken into account that the surgical procedure of LSG modifies the upper GI anatomy, which could affect its function [23]. The effect on GERD symptoms of LSG combined with HHR has not been extensively studied. Some authors reported an improvement of GERD symptoms [12,13] after LSG with concomitant

HHR. However, the results of these studies are limited because of the absence of standardized questionnaires for GERD symptoms' assessment. The obese patients enrolled in the present study were preoperatively evaluated by a standardized GERD questionnaire, showing no differences either in the prevalence of typical GERD symptoms or in the intensity-frequency score of heartburn and regurgitation. As previously suggested [17,18], we considered HH intraoperative findings the reference standard for its diagnosis and classification. In fact, whereas a large HH can be detected and diagnosed using dc-BS, UGIE, and traditional esophageal manometry, the diagnosis of a small HH could be challenging with each modality having its limitation [5]. Despite the recognized superiority of UGIE compared with dc-BS or to traditional esophageal manometry, it still has a low sensitivity [28]. All these methodologies, in fact, did not involve the direct observation of gastroesophageal anatomy that could be achieved only during the surgery. Further studies are needed to confirm the accuracy of the intraoperative observation in the diagnosis of HH [29]. In our patients, whenever a HH was intraoperatively diagnosed, it was repaired. In fact, it has become increasingly clear that outcomes are improved with HH repair regardless of size. Small HH that are not repaired at the time of bariatric surgery may get larger with weight loss and loss of fat at the gastroesophageal junction [30]. Moreover, most retrospective studies have not shown increased morbidity, length of stay, or complication rate with concurrent HH repair [12,13,17,31,32]. The association between the prevalence of intraoperative HH and dc-BS HH diagnosis was statistically significant, but no association was found between the prevalence of intraoperative HH and UGIE diagnosis. However, HH was not scored on the basis of its diameter, so small HH could be detected only at UGIE, which could explain the lack of significant differences between groups. The novel result of the present study was that patients who underwent LSG+HHR did not show any improvement in the prevalence and intensity-frequency scores of typical GERD symptoms and had significantly higher heartburn frequency-intensity scores than patients who underwent LSG alone. Moreover, preoperatively the obese patients in both group showed no differences in heartburn and regurgitation frequency-intensity scores irrespective of the presence or absence of HH intraoperatively found. This finding confirms that LSG has a beneficial effect on relieving GERD symptoms, as previously suggested [11], although the underlying mechanisms are still unclear; conversely, the procedure of HH repair did not produce any improvement in GERD symptoms. We might suppose that HH repair, modifying the antireflux mechanism, which is a very complex multianatomic arrangement of muscular fibers from the stomach and esophagus, including the high-pressure zone of the lower esophageal sphincter, the diaphragmatic crura, and ligamentous structures, such as the phrenoesophageal and cardiophrenic ligaments, might perpetuate reflux or cause reflux. This is a very interesting as well as controversial area in bariatric surgery, and the result of this study is a warning against a very aggressive attitude toward HH management.

This study has several limitations. Firstly, we did not perform any reflux testing to quantify the effect of this bariatric procedure on GERD, although there is no gold standard for the diagnosis of GERD; in fact, UGIE, ambulatory pH, and impedance/pH monitoring have problems with a high false negative rate. In addition, at the reassessment after bariatric surgery, the dc-BS was performed only in patients who referred typical GERD symptoms, and a number of patients refused. Moreover, intraoperative diagnosis of HH should be further standardized and the size of HH should be quantified. Hopefully, the advent of high resolution manometry (HRM) will modify the approach to diagnosis and size score of HH preoperatively.

## Conclusion

LSG has a beneficial effect on relieving GERD symptoms, although the underlying mechanisms are still unclear; conversely, the procedure of HHR did not produce any improvement in GERD symptoms. Further studies, with a complete assessment of GERD (i.e., using a standardized questionnaire, esophageal HRM, 24-hour pH-metry before and after surgery at scheduled long-term follow-up combined with an intraoperative assessment of the size of HH, are warranted to tailor the HH management and avoiding aggressive treatment.

## References

[1] Vakil N, van Zanten SV, Kahrilas P, Dent J, Jones R, Global Consensus Group. The Montreal definition and classification of gastroesophageal reflux disease: a global evidence-based consensus. Am J Gastroenterol 2006;101:1900–20.

[2] Boeckxstaens GE. Review article: the pathophysiology of gastro-oesophageal reflux disease. Aliment Pharmacol Ther 2007;15(26):149–60.

[3] Zagari RM, Fuccio L, Wallander MA, et al. Gastro-oesophageal reflux symptoms, oesophagitis and Barrett's oesophagus in the general population: the Loiano-Monghidoro study. Gut 2008;57:1354–9.

[4] Cameron AJ. Barrett's esophagus: prevalence and size of hiatal hernia. Am J Gastroenterol 1999;94:2054–9.

[5] Hyun JJ, Bak YT. Clinical significance of hiatal hernia. Gut Liver 2011;5:267–77.

[6] Hampel H, Abraham NS, El-Serag HB. Meta-analysis: obesity and the risk for gastroesophageal reflux disease and its complications. Ann Intern Med 2005;143:199–221.

[7] De Groot NL, Burgerhart JS, Van De Meeberg PC, de Vries DR, Smout AJ, Siersema PD. Systematic review: the effects of conservative and surgical treatment for obesity on gastro-oesophageal reflux disease. Aliment Pharmacol Ther 2009;30:1091–102.

[8] deVries DR, van Herwaarden MA, Smout AJ, Samsom M. Gastroesophageal pressure gradients in gastroesophageal reflux disease:

relations with hiatal hernia, body mass index, and esophageal acid exposure. Am J Gastroenterol 2008;103:1349–54.

[9] Dolan K, Finch R, Fielding G. Laparoscopic gastric banding and crural repair in the obese patient with a hiatal hernia. Obes Surg 2003;13:772–5.

[10] Perry Y, Courcoulas AP, Fernando HC, Buenaventura PO, McCaughan JS, Luketich JD. Laparoscopic Roux-en-Y gastric bypass for recalcitrant gastroesophageal reflux disease in morbidly obese patients. JSLS 2004;8:19–23.

[11] Chiu S, Birch DW, Shi X, Sharma AM, Karmali S. Effect of sleeve gastrectomy on gastroesophageal reflux disease: a systematic review. Surg Obes Relat Dis 2011;7:510–5.

[12] Soricelli E, Iossa A, Casella G, Abbatini F, Calì B, Basso N. Sleeve gastrectomy and crural repair in obese patients with gastroesophageal reflux disease and/or hiatal hernia. Surg Obes Relat Dis 2013;9: 356–61.

[13] Korwar V, Peters M, Adjepong S, Sigurdsson A. Laparoscopic hiatus hernia repair and simultaneous sleeve gastrectomy: a novel approach in the treatment of gastroesophageal reflux disease associated with morbid obesity. J Laparoendosc Adv Surg Tech A 2009;19:761–3.

[14] National Institutes of Health. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults—the evidence report. Obes Res 1998;6(Suppl 2):51S–209S.

[15] World Medical Association (WMA) Declaration of Helsinki—ethical principles for medical research involving human subjects. Adopted by the 18th WMA General Assembly, Helsinki, Finland, June 1964, amended by the 59th WMA General Assembly, Seoul, October 2008. World Med J 2008;54:122–5.

[16] American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care 2010;33(Suppl 1):S62.

[17] Angrisani L, Cutolo PP, Buchwald JN, et al. Laparoscopic reinforced sleeve gastrectomy: early results and complications. Obes Surg 2011; 21:783–93.

[18] Linke GR, Borovicka J, Schneider P, et al. Is a barium swallow complementary to endoscopy essential in the preoperative assessment of laparoscopic antireflux and hiatal hernia surgery? Surg Endosc 2008;22:96–100.

[19] Iovino P, Angrisani L, Galloro G, et al. Proximal stomach function in obesity with normal or abnormal oesophageal acid exposure. Neurogastroenterol Motil 2006;18:425–32.

[20] Amato G, Limongelli P, Pascariello A, Rossetti G, Del Genio G, Del Genio A, Iovino P. Association between persistent symptoms and long-term quality of life after laparoscopic total fundoplication. Am J Surg 2008;196:582–6.

[21] Kahrilas PJ, Shaheen NJ, Vaezi MF, et al. American Gastroenterological Association medical position statement on the management of gastroesophageal reflux disease. Gastroenterology 2008;135:1383–91.

[22] Himpens J, Dapri G, Cadiere GB. A prospective randomized study between laparoscopic gastric banding and laparoscopic isolated sleeve gastrectomy: results after 1 and 3 years. Obes Surg 2006;16:1450–6.

[23] Weiner RA, Weiner S, Pomhoff I, Jacobi C, Makarewicz W, Weigand G. Laparoscopic sleeve gastrectomy—influence of sleeve size and resected gastric volume. Obes Surg 2007;17:1297–305.

[24] Braghetto I, Lanzarini E, Korn O, Valladares H, Molina JC, Henriquez A. Manometric changes of the lower esophageal sphincter after sleeve gastrectomy in obese patients. Obes Surg 2010;20: 357–62.

[25] Himpens J, Dobbeleir J, Peeters G. Long-term results of laparoscopic sleeve gastrectomy for obesity. Ann Surg 2010;252:319–24.

[26] Petersen WV, Meile T, Küper MA, Zdichavsky M, Königsrainer A, Schneider JH. Functional importance of laparoscopic sleeve gastrectomy for the lower esophageal sphincter in patients with morbid obesity. Obes Surg 2012;22:360–6.

[27] Musella M, Milone M, Leongito M, Jovino P. Letter to "Functional importance of laparoscopic sleeve gastrectomy for the lower esophageal sphincter in patients with morbid obesity". Obes Surg 2012;22: 1517–8.

[28] Khajanchee YS, Cassera MA, Swanström LL, Dunst CM. Diagnosis of type-I hiatal hernia: a comparison of high-resolution manometry and endoscopy. Dis Esophagus 2013;26:1–6.

[29] Koch OO, Kaindlstorfer A, Antoniou SA, Asche KU, Granderath FA, Pointner R. Influence of the esophageal hiatus size on the lower esophageal sphincter, on reflux activity and on symptomatology. Dis Esophagus 2012;25:201–8.

[30] Gulkarov I, Wetterau M, Ren CJ, et al. Hiatal hernia repair at the initial laparoscopic adjustable gastric band operation reduces the need for reoperation. Surg Endosc 2008;22:1035–41.

[31] Soricelli E, Casella G, Rizzello M, et al. Initial experience with laparoscopic crural closure in the management of hiatal hernia in obese patients undergoing sleeve gastrectomy. Obes Surg 2010;20: 1149–53.

[32] Deitel M, Gagner M, Erickson A, et al. Third international summit: current status of sleeve gastrectomy. Surg Obes Relat Dis 2011;7: 749–59.