Scintigraphic Evaluation of Gastric Emptying in Obese Patients Submitted to Sleeve Gastrectomy Compared to Normal Subjects

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Abstract

Background Sleeve gastrectomy (SG) has been accepted as an option for surgical treatment for obesity. This operation could be associated with motor gastric dysfunction and abnormal gastric emptying. The purpose of this prospective study is to present the results of gastric emptying to liquids and solids using scintigraphy in patients who underwent SG compared to normal subjects.

Methods Twenty obese patients were submitted to laparoscopic SG and were compared to 18 normal subjects. Gastric emptying of liquids and solids was measured by scintigraphic technique. Results were expressed as half time of gastric emptying and the percentage of retention at 20, 30, and 60 min for liquids and at 60, 90, and 120 min for solids.

Results In the group of operated patients, 70% of them (n=14) presented accelerated emptying for liquids and 75% (n=15) for solids compared to 22.2% and 27.7%, respectively, in the control group. The half time of gastric emptying ($T_{1/2}$) in patients submitted to SG both for liquids and solids were significantly more accelerated compared to the control group (34.9±24.6 vs 13.6±11.9 min for liquids and 78±15.01 vs 38.3±18.77 min for solids; $p<0.01$). The gastric emptying for liquids expressed as the percentage of retention at 20, 30, and 60 min was 30.0±0.25%, 15.4±0.18%, and 5.7±0.10%, respectively, in operated patients, significantly less than the control subjects ($p<0.001$). For solids, the percentage of retention at 60, 90, and 120 min was 56±28%, 34±22%, and 12±8%, respectively, for controls, while it was 25.3±0.20%, 9±0.12%, and 3±0.05%, respectively, in operated patients ($p<001$).

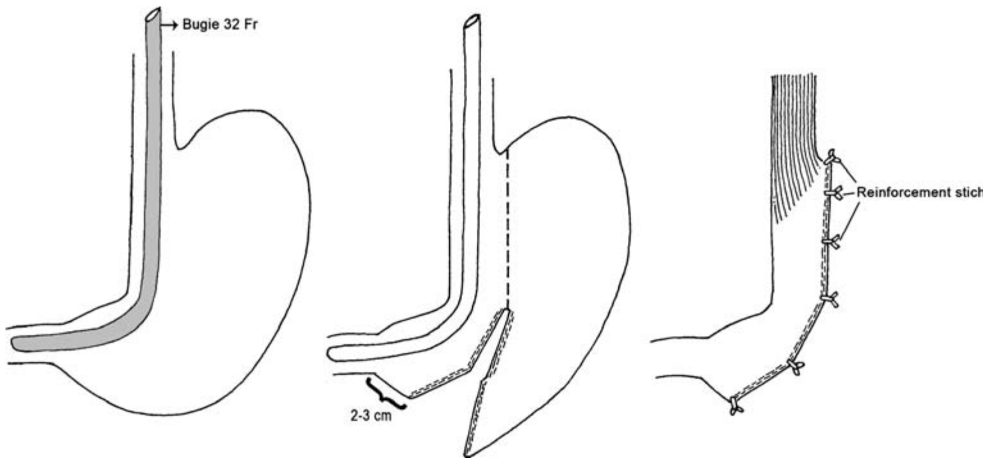
Conclusions Gastric emptying after SG is accelerated either for liquids as well as for solids in the majority of patients. These results could be taken in consideration for the dietary indications after surgery and could play a significant role in the definitive results during the late follow-up.

Keywords Obesity · Sleeve gastrectomy · Gastric emptying

Introduction

The main motor function of the stomach is to serve as an active reservoir which stores and mixes ingested food as a wheel while modulates its emptying to the duodenum. The functional anatomy and motility behavior are well known in normal subjects [1]. Altered gastrointestinal motor function has been observed in obese patients but its significance is incompletely understood because there are controversial data concerning gastric emptying in obese patients. Some reports have shown rapid emptying after surgery, but also normal or even delayed emptying in these patients has been published [2]. After gastrectomy with Roux-en-Y gastrojejunostomy, delayed gastric emptying was reported [3]. However, after the modified technique with near total gastric resection, rapid gastric emptying has been documented in some reports [4, 5]. Other authors reported rapid emptying for

Fig. 1 Gastric tubulization over a 32-French bougie starting 2–3 cm from the pylorus until 1 cm from the His's angle



liquids and slower emptying for solids after gastric bypass [6]. Few data are available in the literature concerning this topic in patients submitted to other bariatric operations. In patients submitted to gastroplasty, the emptying of solids was initially faster followed by a prolonged slow rate of emptying indicating retention of solid foods in the proximal partitioned pouch [7], but this technique has been abandoned. No definitive results have been reported in gastric emptying after adjustable gastric banding [8, 9]. Recently, sleeve gastrectomy (SG) has been proposed as an option for surgical treatment of obesity. This operation involves a major gastric resection which could be associated with motor gastric dysfunction due to the resection of gastric pacemaker [10, 11]. Therefore, gastric emptying could be affected, having an important role in the definitive results after this procedure. The purpose of this prospective study was to evaluate the results of gastric emptying of liquids and solids using scintigraphic assessment in 18 patients who underwent SG.

Patients and Methods

Patients

In this prospective study, we have evaluated 20 patients, 14 women (mean age of 43 years) and six men (mean age of 45.2 years) submitted to SG. They were evaluated 3 months after surgery with scintigraphic assessment for liquids and solids gastric emptying. The mean body mass index (BMI) of this group was 38.3 kg/m^2 (range 34.5–48.3 kg/m^2). Eighteen normal subjects (BMI 19.8–23.5 kg/m^2) were studied with the same assessment and served as control group.

Surgery

Laparoscopic SG performing a narrow tubular subtotal gastrectomy using a 32-French bougie as guide for tubulization, starting 2 cm from the pylorus up to 1 cm lateral to the His's angle, was created according to the technique previously described [12]. In Fig. 1, we represent the type of gastric transection and Fig. 2 shows the radiological images with barium sulfate swallow of the tubulized gastric remnant after surgery.

Radionuclide Study for Gastric Emptying

All patients have signed the informed consent according to the ethics committee of the university hospital. They were submitted to the examination 2–3 months after the operation. Patients were in fasting condition for 8 h and an oral ingestion of the radiotracer sulfur colloid labeled with ^{99m}Tc in liquid and solid phase was used [13]. For the study of emptying of liquids, 200 ml of water with ^{99m}Tc

Fig. 2 Postoperative radiological image obtained with barium sulfate swallow demonstrating a narrow tube of stomach with antrum resection

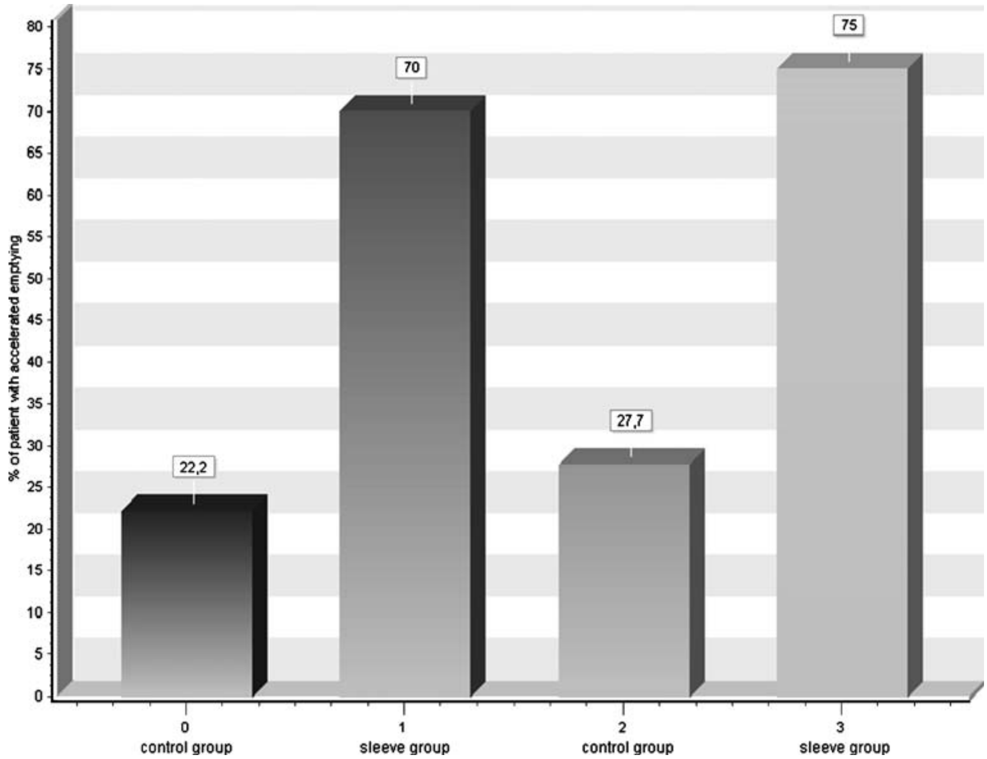


Fig. 3 Gastric emptying for liquids and solids comparing the control group vs the SG group

was employed. For the solids study, administration of an egg sandwich (bread approximately 200 g) was used. The equipment used is a gamma camera Camstar General Electric with multipurpose low-energy collimator. The acquisition data were obtained with the patient seated in left lateral projection for both procedures with the gamma camera detector in upright position. In the liquids study, a dynamic acquisition for 60 min (one frame per minute) is started as soon as patient drinks the radiotracer (^{99m}Tc-sulphur colloid) with water. With respect to the solids study, a sequential static acquisition is started after the patient eats the sandwich, obtaining 1 min frame at 0, 15, 30 up to 120 min. Processing includes visual and quantification assessment with region of interest around the stomach and generating a time activity curve on which half time ($T_{1/2}$) of emptying and percentage of retention were calculated [13].

Statistical Analysis

For statistical significance analysis of half time of gastric emptying, Student's t test was used.

Results

Fig. 3 shows the results of gastric emptying for liquids and solids comparing the control group vs the SG group. For gastric emptying of liquids, 22.2% of control subjects had accelerated emptying. Six out of 20 patients (30%) presented a normal trend of emptying; on the contrary, 70% (14 out of 20) of the operated patients presented accelerated emptying. For solids, five out of 20 (25%) had a normal range of emptying, but 75% (15 out of 20) of the operated patients presented accelerated gastric emptying compared to 27.7% of the control group ($p<0.001$).

Table 1 shows the half time ($T_{1/2}$) gastric emptying for liquids and solids comparing the control group vs patients submitted to SG. The $T_{1/2}$ gastric emptying both for liquids and solids were significantly more accelerated in patients with SG compared to the control group ($p<0.01$).

Gastric emptying expressed as percentage of retention for liquids is shown in Table 2. Similar findings were observed for the percentage of retention for solids (Table 3). SG patients demonstrated a significantly less

Table 1 Half time ($T_{1/2}$) gastric emptying in the control group and patients submitted to SG

	Half time gastric emptying		p value
	Control group (n=18)	SG (n=20)	
Liquids, mean (range)	34.9±24.6 (5–34)	13.6±11.9 (0.12–43)	<0.01
Solids, mean (range)	78±15.01 (66–84)	38.3±18.77 (2–74)	<0.01

Table 2 Percentage of retention at 20, 30, and 60 min in the control group compared to patients submitted to SG

	Percentage of retention for liquids		
	20 min	30 min	60 min
Controls (n=18)	61.6±13	45.3±18	29.3±21
Patients (n=20)	37.0±0.25	15.4±0.18	5.8±0.10
p value	<0.01	<0.01	<0.01

percentage of retention at each period of time compared to the control group (p<0.01). Fig. 4 shows the gastric emptying trend for liquids in patients submitted to SG expressed as the percentage of retention at 20, 30, and 60 min and Fig. 5 shows an example of accelerated gastric emptying for liquids.

Gastric emptying for solids expressed as the percentage of retention at 60, 90, and 120 min in patients submitted to SG compared to the control group is shown in Fig. 6. Fifteen patients submitted to SG showed an accelerated gastric emptying while only five had a normal range of emptying very similar to normal subjects.

Fig. 7 shows an example of accelerated gastric emptying for solids after the operation.

Discussion

Anatomically, the stomach is divided into three main chambers: fundus, corpus, and antrum, but with regard to the functional anatomy, there are two parts: the proximal stomach (fundus and corpus) for accommodation of foods and the distal stomach (antrum) for trituration and emptying.

For the motor function, the intrinsic nervous system is more important than extrinsic innervation and motility is regulated by the Cajal's interstitial cells located within the myenteric plexus of the upper part of the greater curvature, which are thought to be the pacemaker of the gut motor function [1, 10, 11]. Distension of the antrum causes relaxation of the pylorus, facilitating the transport of gastric contents into the duodenum [11, 14].

Table 3 Percentage of retention at 60, 90, and 120 min in the control group compared to patients submitted to SG

	Percentage of retention for solids		
	60 min	90 min	120 min
Controls (n=18)	56±28	34±22	12±8
Patients (n=20)	24.1.3±0.20	8.5±0.12	1.7±0.05
p value	<0.01	<0.01	<0.01

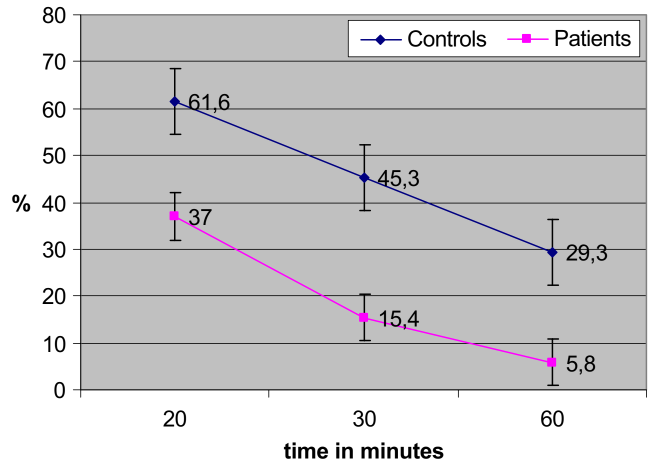


Fig. 4 Gastric emptying for liquids in control subjects compared to patients submitted to SG

Accommodation, trituration, mixing, and grinding food in the distal stomach, once properly mixed and nearly liquefied, are emptied into the duodenum by gastric peristaltic well-regulated contractions [1, 10, 11, 15]. After SG, gastric reservoir function is reduced substantially because the gastric receptive relaxation or accommodation is eliminated due to gastric resection and, as a consequence, secondary rapid emptying to the antrum and duodenum can be observed [16]. This well-controlled process of gastric emptying may play an important role in the regulation of satiety and may be related to the pathogenesis of obesity [11]. Abnormal gastric emptying in the obese has been previously suggested and the rate of solid gastric emptying in the obese subjects is abnormally rapid in whom gastric motility is up to now incompletely understood and no clear-cut explanation for this finding yet exists because there are also papers reporting normal or even delayed gastric emptying [2, 16–20]. Whereas gastric emptying of liquids is mainly driven by gastric fundus tone under the control of both vagal and hormonal influences, the propulsive contractions of the antral pump are the most important mechanism controlling gastric emptying of solids [21, 22]. These functions are almost abolished after different surgical procedures and, therefore, after SG.

In spite of the fact that vagal innervation through the Latarjet's nerve of the lesser curvature and antrum remains intact, resection of the greater curvature (including gastric pacemaker) and an important segment of the antrum could affect the normal motility and antropyloric or antroduodenal reflexes. Normal gastric emptying requires an intact antropyloric coordination, which could be modified according to the technique employed, resecting or not resecting a large segment of the antrum [23].

The technique employed by us for performing SG involves a major resection of the fundus, corpus, and

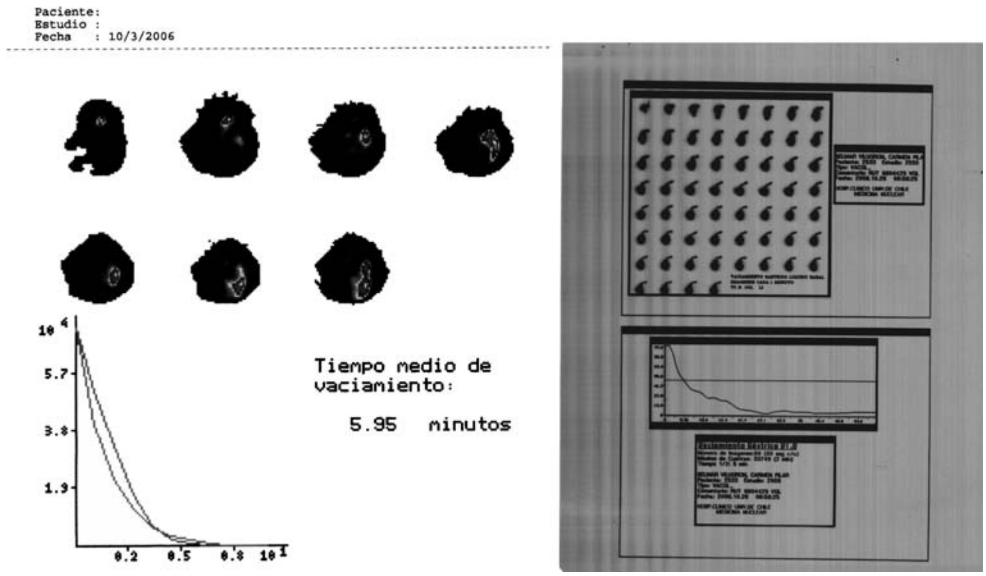


Fig. 5 Accelerated gastric emptying for liquids assessed by radionuclide technique

partially the antrum. Therefore, changes in the normal gastric motor function must occur. The functions of accommodation, trituration, and emptying are altered. The pacemaker region activity is deeply modified because a wide resection of this neuromuscular area is done, resulting in a significant alteration of all the functional motility resulting in rapid passing to the duodenum [1]. However, the propulsion function of the antrum remains almost intact because antral innervation remains intact.

In the present paper, we have found a fast gastric emptying measured for liquids and solids evaluated separately and these results agree with the Melissas's publication in patients submitted to SG [24, 25] in which an accelerated gastric emptying for solid meals was found. Others [26] have evaluated gastric emptying with scintigraphic assessment for a semisolid meal, demonstrating that gastric emptying is not affected after SG with antrum preservation. The surgical technique employed in those patients differs from our technique because we partially resect the antrum starting 2–3 cm from the pylorus. On the contrary, the other surgeons do not perform resection of the antrum. Probably, these differences could explain the different results. Another important mechanism involved in the fast gastric emptying after SG is the ratio volume/pressure suggested by Yehoshua et al. [27, 28]. The intragastric pressure is significantly increased in patients submitted to this operation, reaching up to 40 mmHg (32–58 mmHg) compared with 19 mmHg (11–26 mmHg) in the intact stomach. This higher pressure reflects its lesser distensibility and is a factor promoting fast gastric emptying when antrum resection is performed. Therefore, if we perform a very narrow gastric tube, the increased intragastric pressure also promotes fast gastric emptying considering that the antral pump function do not change because vagal innervation through the Latarjet's nerve remain intact. Even dumping syndrome due to accelerated gastric emptying was communicated in the last International Consensus Summit on Sleeve Gastrectomy (ICSSG, Miami, March 2009) [29].

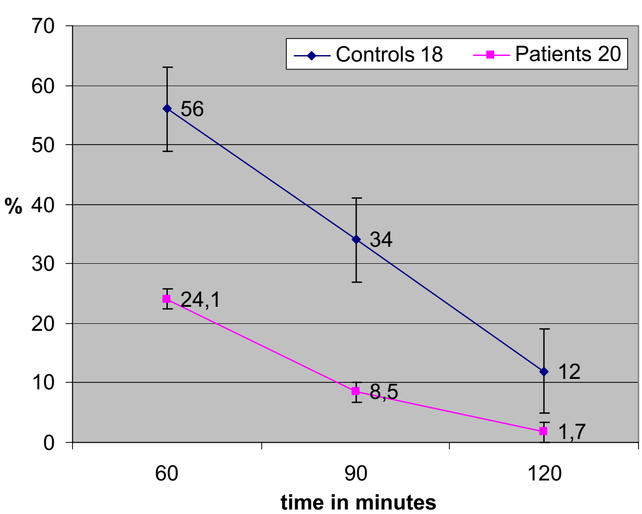


Fig. 6 Gastric emptying for solids in control subjects compared to patients submitted to SG

Other surgical techniques also modified gastric emptying. Highly selective vagotomy significantly delayed gastric emptying; however, after 6 months, gastric emptying time has practically normalized. It appears that this is the result of the preservation of the antropyloric vagal nerve supply and it does not impair gastric motility. In other studies, after highly selective vagotomy, the gastric emptying time for liquids was statistically shorter compared with preoperative values [30, 31]. Billroth I or II operations were associated with fast gastric emptying for liquids and unchanged for solids, but in these techniques, not only resecting the antrum and pylorus was performed, but truncal vagotomy was also performed in order to avoid anastomotic ulcers and, therefore, fast gastric emptying and dumping syn-

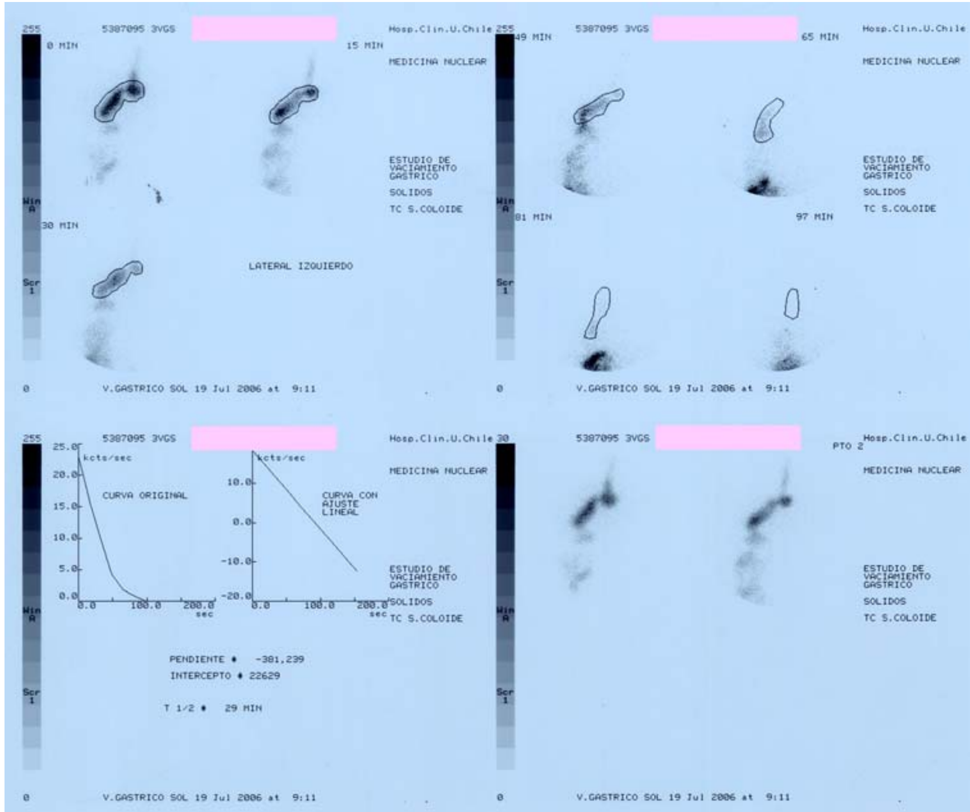


Fig. 7 Accelerated gastric emptying for solids assessed by radionuclide technique

drome was frequently observed [32, 33]. The physiology after SG is not comparable to highly selective vagotomy or distal gastric resection with gastroenterostomies.

We postulate that some implications of the accelerated gastric emptying could participate in the mechanism of increased secretion of GLP1 after SG. Some papers in experimental models of obesity suggest metabolic changes and hormonal release after SG in which GLP1 in enhanced [34]. Santoro et al. [35] have performed SG with omentectomy and ileal transposition demonstrating enterohormonal changes. The question is: which is the influence of SG in these changes? Therefore, more information is needed in this topic. In addition, improvement in the management of type II diabetes could be observed after this surgery, absolutely comparable with the results obtained after Roux-en-Y gastric Bypass [36].

SG may induce weight loss by reducing food intake, but in accelerated gastric emptying, delivery of nutrients to the small intestine early in the eating cycle could activate small intestine satiety-inducing chemoreceptors that could modify food ingestion periodicity with the subsequent consequences of weight regain. It has been shown that obese patients presents more rapid gastric emptying compared to non-obese subjects and, therefore, they eat more frequently and the same phenomenon may occur in patients with SG. A negative impact regarding the risk of weight regain can occur later after SG because rapid emptying could reduce the negative feedback satiety signals produced by the nutrients inside the stomach and thus precipitating a feeling of hunger and, therefore, shorten the interval between consecutive meals. Similar findings were observed in obese patients. This topic is controversial in the available literature because altered gastrointestinal motility in obese patients is incompletely understood. However, these alterations can be considered as potential contributing factors in the development and maintenance of obesity and changed eating behavior [2, 34–39]. However, in patients submitted to SG, a decreased release of ghrelin has been reported and, therefore, patients feel less appetite with the consequent modification in the food intake behavior [40–42].

In summary, we have observed accelerated gastric emptying for liquids and solids after SG and the mechanisms could be:

a) modification in the functional anatomy;
b) reduction in gastric reservoir function;
c) alteration of gastric pacemaker and interdigestive motility;
d) alteration of antrum–duodenal motor complex;
e) gastrointestinal hormonal modifications.

These findings must be known and considered by the nutritionist in order to indicate the more adequate diet after surgery, and these results could play a role in the long-term results.

References

1. Verdich C, Madsen JL, Toubro S, et al. Effect of obesity and major weight reduction on gastric emptying. Int J Obes. 2000;24:899–905.
2. Gallagher TK, Geoghegan JG, Baird AW, Winter DC. Implications of altered gastrointestinal motility in obesity. Obes Surg. 2007;17:1399–407.
3. Csendes A, Burdiles P, Braghetto I, et al. Early and late results of the acid suppression and duodenal diversion operation in patient with Barrett's esophagus: analysis of 210 cases. World J Surg. 2002;26:566–76.
4. Hinder RA, Esser J, DeMeester TR. Management of gastric emptying disorders following the Roux-en-Y procedure. Surgery. 1988;104:765–72.
5. Miedema BW, Kelly KA. The Roux operation for postgastrectomy syndromes. Am J Surg. 1991;161:256–61.
6. Horowitz M, Cook DJ, Collins PE, et al. Measurement of gastric emptying after gastric bypass surgery using radionuclides. Br J Surg. 1982;69:655–7.
7. Horowitz M, Collins PJ, Chatterton BE, et al. Gastric emptying after gastroplasty for morbid obesity. Br J Surg. 1984;71:435–7.
8. Bennett J, Rhodes M, Malcom P, et al. Assessment of the relationship between postmeal satiety, gastric volume and gastric emptying after Swedish adjustable gastric banding. A pilot study using magnetic resonance imaging to assess postsurgery gastric function. Obes Surg. 2008;19:757–63.
9. de Jong JR, van Ramshorst B, Gooszen HG, et al. Weight loss after laparoscopic adjustable gastric banding is not caused by altered gastric emptying. Obes Surg. 2008;19:287–92.
10. Lacy BE, Weiser K. Gastric motility, gastroparesis and gastric stimulation. Surg Clin N Am. 2005;85:967–87.
11. Sanjeevi A. Gastric motility. Curr Opin Gastroenterol. 2007;23:625–30.
12. Braghetto I, Korn O, Valladares H, et al. Laparoscopic sleeve gastrectomy: surgical technique, indications and clinical results. Obes Surg. 2007;17:1442–50.
13. Lillo R, Jouanne E, Gonzalez P, et al. Vaciamiento gástrico: Comparacion de valores normales para diferentes proyecciones par alimentos sólidos y líquidos. Rev Esp Med Nucl. 1995;12:263 (A).
14. Tack J. Gastric motor disorders. Best Pract Res Clin Gastroenterol. 2007;21:633–44.
15. Cardoso-Junior A, Vaz Coelho LG, Savassi-Rocha PR, et al. Gastric emptying of solis and semisolids in morbid obese and non obese subjects: an assessment using the 13 C-octanoic acid and 13C-acetic acid breath test. Obes Surg. 2007;17:236–41.
16. Gryback P, Naslund E, Helstrom PM, et al. Gastric emptying of solids in humans, improved evaluation by Kaplan–Meier plots, with special reference to obesity and gender. Eur J Nucl Med Mol Imaging. 1996;23:1562–7.
17. Horowicz M, Collins PJ, Cook DJ, et al. Abnormalities of gastric emptying in obese patients. Int J Obes. 1983;7:415–21.
18. Jackson SJ, Leathy FE, McGowan AA, et al. Delayed gastric emptying in the obese: an assessment using non invasive (13)C-octanoic acid breath test. Diabetes Obes Metab. 2004;6:264–70.
19. Maddox A, Horowicz M, Wishart J, et al. Gastric and esophageal emptying in obesity. Scand J Gastroenterol. 1989;24:593–8.
20. Wright RA, Krinsky S, Fleeman C, et al. Gastric emptying and obesity. Gastroenterology. 1983;84:747–51.
21. Xing J, Chen JDZ. Alterations of gastrointestinal motility in obesity. Obes Res. 2004;12:1723–32.
22. Tosetti C, Corinaldesi R, Stanghellini V, et al. Gastric emptying of solids in morbid obesity. Int J Obes Relat Metab Disord. 1996;20:200–5.
23. Hinder RA, Kelly K. Human gastric pacesetter potential. Site of origin, spread and response to gastric transection or proximal vagotomy. Am J Surg. 1977;133:29–33.
24. Melissas J, Daskalakis M, Koukouraki S, et al. Sleeve gastrectomy—a food “limiting” operation. Obes Surg. 2008;18:1251–6.
25. Melissas J, Koukouraki S, Askoxylakis J, et al. Sleeve gastrectomy—a restrictive procedure? Obes Surg. 2007;17:57–62.
26. Bernstine H, Tzioni_Yehoshua R, Groshar D, et al. Gastric emptying is nor affected by sleeve gastrectomy—scintigraphic evaluation of gastric emptying after Sleeve gastrectomy without removal of the gastric Antrum. Obes Surg. 2009;19:293–8.
27. Yehoshua RT, Eidelman LA, Stein M, et al. Laparoscopic sleeve gastrectomy—volume and pressure assessment. Obes Surg. 2008;18:1083–8.
28. Rubin M, Yehoshua RT. The role of the various factros contributing to the redfuction of food intake following sleeve gastrectomy. Proceedings of the 2nd Annual International Consensus Summit for Sleeve Gastrectomy ICSSG-2 Miami, March 2009
29. Altuve J, Gonzales R, Aceituno L. Does sleeve gastrectomy really avoid dumping syndrome? Proceedings of the 2nd Annual International Consensus Summit for Sleeve gastrectomy ICSSG-2 Miami, March 2009
30. Van Hee R, Mistiaen W, Block P. Gastric emptying of liquids after highly selective vagotomy for duodenal ulcer. Hepatogastroenterology. 1989;36:92–6.
31. Mistiaen W, Van Hee R, Blockx P, et al. Gastric emptying for solids in patients with duodenal ulcer before and after highly selective vagotomy. Am Surg. 1985;51:690–2.
32. Morioka J. Gastric emptying for liquids and solids after distal gastrectomy with Billroth I reconstruction. Hepatogastroenterolgy. 2008;55:1136–9.
33. Woodward ER, Hocking MP. Postgastrectomy syndromes. Surg Clin N Am. 1987;67:509–20.
34. Pereferrer FS, Gonzalez MH, Rovira AV, et al. Influence of sleeve gastrectomy in several experimental model of obesity: metabolic and hormonal implications. Obes Surg. 2008;18:97–108.
35. Santoro S, Milleo FO, Malzoni CE, et al. Enterohormonal changes after digestive adaptation. Five years results of surgical proposal to treat obesity and associated diseases. Obes Surg. 2008;18:17–26.
36. Vidal J, Ibarzabal A, Romero F, et al. Type 2 diabetes mellitus and metabolic syndrome following sleeve gastrectomy in severely obese subjects. Obes Surg. 2008;18:1077–82.
37. Cardoso-Junior A, Savassi-Rocha PR, Coelho LGV, et al. Botulinum A toxin injected into gastric wall for treatment of morbid obesity: a pilot study. Obes Surg. 2006;16:335–43.
38. Moon-In P, Camilleri M. Gastric motor and sensory function in obesity. Obes Res. 2005;13:481–500.
39. Mason EE. Editorial. Gastric emptying controls type 2 diabetes mellitus. Obes Surg. 2007;17:853–5.
40. Reza LFB, Hoda MA, Bohdjalian A, et al. Sleeve gastrectomy and gastric banding: effects on plasma ghrelin levels. Obes Surg. 2005;15:1024.
41. Cohen R, Uzzan B, Biham H, et al. Ghrelin level and sleeve gastrectomy in superobesity. Obes Surg. 2005;15:1501–2.
42. Deitel M, Crosby RD, Gagner M. The First International Consensus Summit for Sleeve Gastrectomy (SG), New York City, October 25–27, 2007. Obes Surg. 2008;18:487–96.