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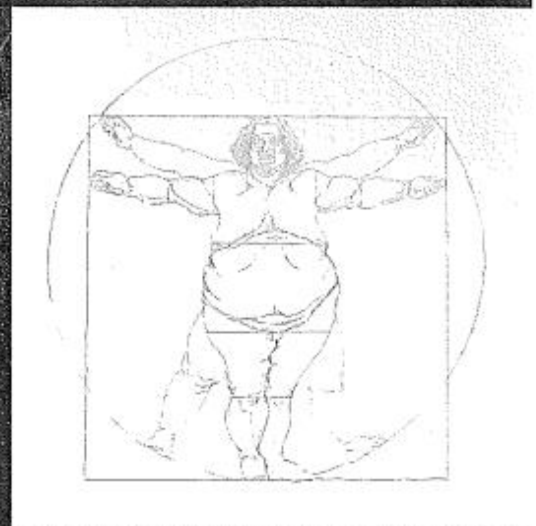

Principles of Metabolic Surgery

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16

Pathophysiology of Restrictive Procedures

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There are three different types of restrictive surgical procedures for morbid obesity: vertical banded gastroplasty (VBG), adjustable gastric banding (AGB), and sleeve gastrectomy (SG). These procedures are currently realized via laparoscopy. The mechanism of VBG is related to the size of the gastric pouch and to the calibrated outlet. After a solid meal, patients describe a sensation of fullness and satiety or even epigastric or low-retrosternal discomfort, indicating pouch fullness; at this point the patient must stop eating. If eating continues, discomfort increases until voluntary or spontaneous regurgitation of the excess food occurs. Satiety is dependent on the thickness and consistency of the food eaten; hence patients who consume mainly liquids usually have less weight loss. Gastric motility may play a part in the rate of drainage of the gastric pouch, and excessive motility may be responsible for poor weight loss in some cases. The variability in weight loss after gastroplasty and other restrictive procedures highlights the fact that the final amount of weight loss depends on patient-controlled factors as well as on the surgical procedure. Following placement of laparoscopic AGB (LAGB), as soon as the patient ingests two spoonfuls the small gastric compartment above the band is filled and he or she experiences a feeling of fullness. Since it takes a long time for this compartment to empty because of the narrowed stoma, more food can be ingested only after substantial time has elapsed. The patient must therefore eat at a much slower pace, and this slower pace allows the satiety center to be stimulated. As the hunger sensation is no longer present, overall food intake is reduced. The major advantage of LAGB is the possibility to adjust the size of the outlet. Another hypothesis not confirmed as the mode of action of gastric banding was gut hormone modulation. The mechanism of action of laparoscopic SG (LSG) is not only the restriction obtained by resecting part of the body and the entire fundus of the stomach, leaving a small gastric tube of 100–150 ml. Hormonal changes following this procedure must also be considered. Ghrelin is a 28-amino-acid orexigenic peptide, secreted essentially by the fundus of the stomach, which stimulates feeding behavior and hunger. In LSG, the gastric fundus is resected and plasma ghrelin levels are expected to decrease following surgery. Another mechanism explaining weight loss after LSG could be the relationship between appetite and gastric emptying, as the gastric clearance seems to be improved.

16.1 Basics

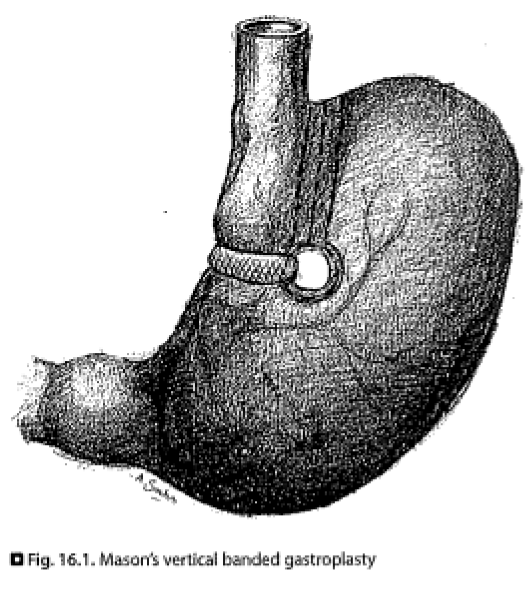
A traditional classification of the different procedures for the treatment of morbid obesity is based on their mode of action. Three groups can be identified: restrictive, mixed, and malabsorptive procedures. Restrictive procedures for morbid obesity are represented by three different types:

- Vertical banded gastroplasty (VBG)
- Adjustable gastric banding (AGB)
- Sleeve gastrectomy (SG)

The most common restrictive and malabsorptive procedure is Roux-en-Y gastric bypass (RYGBP).

16.1.1 Vertical Banded Gastroplasty

In 1966 Mason and Ito performed the first gastric bypass for morbid obesity [1]. In 1971, Mason reasoned that if the mechanism of weight loss in this procedure was food intake reduction, a small gastric pouch emptying directly into the distal stomach should be equally effective in promoting weight loss. Hence some complications of the gastric bypass, such as micronutrient deficiency, could be avoided, making surgery easier and safer. The first gastroplasty performed by Mason divided the stomach into a smaller upper section and a larger distal part connected by a channel on the greater curve. This procedure was unsuccessful in maintaining weight loss [2, 3]. Mason and Gomez performed various modifications of the gastroplasty procedure. The last variation was realized in 1980, the so-called vertical banded gastroplasty (VBG) (◘ Fig. 16.1) [4]. This procedure employed a lesser-curve stoma supported by a Marlex band (1.5 cm wide and 5.5 cm long) passed through a window created by a circular

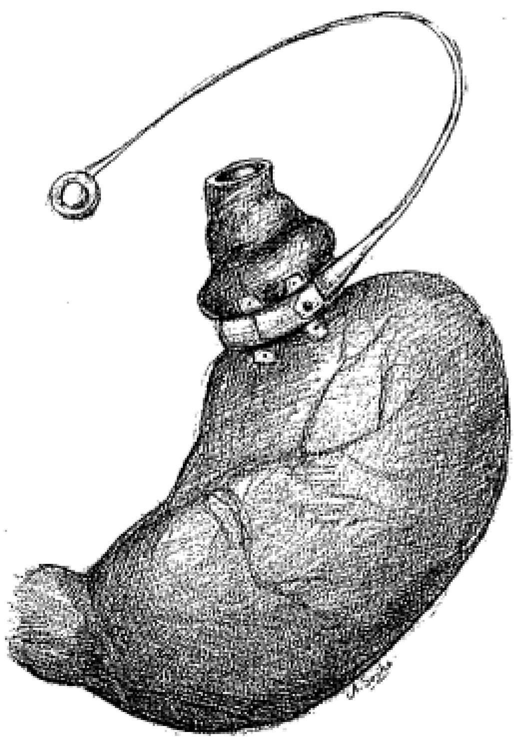


◘ Fig. 16.1. Mason's vertical banded gastroplasty stapler [5]. One year later, Laws and Piatadosi replaced the Marlex band with a silastic ring as a permanent non-expandable support for the VBG [6]. The procedure was called silastic ring vertical banded gastroplasty (SRVBG). At the time, VBG became the most popular procedure for the treatment of morbid obesity. Technical principles of the mechanism of this procedure are related to the size of the gastric pouch, which measures 50 ml or less, and to the calibrated outlet, which measures between 10 and 12 mm in diameter. In the era of minimally invasive surgery, VBG was first performed via laparoscopy in 1993 by Chua and Mendiola [7]. This new approach boosted its popularity [8, 9]. Gastroplasty and its many variants rely on the physical restriction of food intake in order to achieve weight loss by radical reduction of energy intake over the first year. After the first year a moderate restriction remains, which allows weight stabilization and prevents future weight regain. The advantage of this restrictive approach is that micronutrient deficiencies (iron, calcium, vitamin B12) are less likely to occur. It has been demonstrated that a pouch volume of about 20 ml or less is important for good weight loss. Liquids pass easily and rapidly through the empty pouch according to their viscosity and the rate at which they enter the pouch. Solids pass through much more slowly, depending on the particle size of the swallowed food and on its consistency and the degree of resistance at the stoma. After a solid meal, patients describe a sensation of fullness and satiety or even epigastric or low-retrosternal discomfort, indicating pouch fullness. At this point the patient must stop eating. If eating continues, discomfort increases until voluntary or spontaneous regurgitation of the excess food occurs. There is no nausea, despite a definite feeling of relief after regurgitation. Patients should be advised not to eat until the next meal. The feeling of satiety induced by filling the gastric pouch is a very important factor in weight loss. Satiety is dependent on the thickness and consistency of the food eaten; hence patients who ingest mainly liquids usually have poor weight loss, whereas those who can cope with solid food do much better. If the gastric stoma is made too large, weight loss is poor. Similarly, if there is breakdown of the partition of the stoma, patients report an increase in hunger and an earlier loss of postprandial satiety as well as an increased volume of intake accompanying their weight regain. Patients must be advised to avoid eating and drinking at the same time. If a small amount of solid food is followed by a mouthful of liquid, the food will be washed through into the distal stomach. Satiety will not be achieved, and the sequence can be repeated over and over, resulting in excessive intake of food. Some patients use this strategy to appear to be eating more normally when coping with socially difficult situations, but if it is used at all meals, weight loss will be inadequate. Gastric motility may play a part in the rate of drainage of the gastric pouch, and excessive motility may be responsible for poor weight loss in some cases. The variability in weight loss after gastroplasty and other restrictive procedures highlights the fact that the final amount of weight loss depends on patient-controlled factors as well. Lack of dietary counseling may result in poor weight loss, since surgery cannot control the following four aspects:

- The type or caloric content of food: fats, oils, sweet foods are easy to chew
- The frequency of eating: small amounts taken frequently add up to a large amount
- The amount or quality of liquids: liquids can be drunk almost without limit
- The consumption of food and drink beyond what is needed for adequate nutrition

16.1.2 Adjustable Gastric Banding

Wilkinson and Peloso in 1981 [10], Kolle in 1982 [11], and Molina and Oria in 1983 [12] have been credited with initiating the nonadjustable gastric banding approach to restrictive bariatric surgery [13]. An adjustable technique, based on a liquid-filled silastic cuff, was introduced because of a high number of reoperations [14]. After the first adjustable gastric banding (AGB) was realized by Kuzmak [15] in 1986, further successful developments in human subjects were the adjustable silicone gastric band (ASGB) and the Swedish adjustable gastric band (Swedish band) [16], both initially placed by open surgery. The laparoscopic technique was introduced in 1992 by Cadiere et al. [17]. Thanks to laparoscopy, LAGB gained in popularity, owing to less invasiveness and to the option of adjustment of the stoma offered to the patient. The adjustable gastric band is implanted to reduce the stomach's volume by dividing it into two compartments through an adjustable restricted opening (stoma): a small gastric pouch of 25 cc and the rest of the stomach (◘ Fig. 16.2). As soon as two spoonfuls are ingested, the first compartment is filled and one experiences a feeling of fullness. Since it takes a long time for the first compartment to empty because of the narrowed stoma, more food can be ingested only after substantial time has elapsed. One must therefore eat at a much slower pace, and this allows the satiety center to be stimulated. As the hunger sensation is no longer present, overall food intake is reduced [18]. Finally, weight loss achieved with this procedure is determined mainly by changes in eating behavior [19]. The major advantage of LAGB is the possibility to adjust the



■ Fig. 16.2. Adjustable gastric banding

size of the outlet (stoma) without anesthesia by injecting or withdrawing saline via the percutaneous access port, thereby inflating or deflating the inflatable portion of the silicone band. The adjustments should be based on objective criteria, including documented dietary inquiry, postoperative weight loss curves, and radiological studies. Another hypothesis regarding the mode of action of AGB is gut hormone modulation. Numerous studies on the relationship between the ghrelin hormone and appetite suppression with LAGB have been reported [19–22]. Ghrelin, a 28-amino-acid orexigenic peptide, is secreted essentially by the fundus of the stomach [23] and acts on the hypothalamic arcuate nucleus, which stimulates feeding behavior and hunger. Serum ghrelin levels increase during fasting and decrease after a meal. Uzzan et al. [20] found a significant increase of ghrelin expression 1 year after gastric banding, which seems to exclude the role of ghrelin in weight loss following laparoscopic AGB. Decrease of hunger with increasing fasting plasma ghrelin following gastric banding was demonstrated by Schindler et al. [19]. Together with other reports, these data seem to confirm the absence of a relationship between ghrelin fluctuations and appetite modifications in patients subjected to LAGB [21, 22]. The role played by other hormones such as glucagon-like-peptide-1 (GLP-1) and peptide-YY (PYY) in weight loss after LAGB was also studied [24], but no known hormonal changes can demonstrate a relation with weight loss after the procedure of gastric banding. There may be still another mechanism, in addition to mechanical restriction, which explains satiety: the presence of a foreign body in contact with the gastric wall, which contains afferent as well as efferent vagus nerve fibers. This assumption needs to be confirmed by research on the electrophysiology of the banded stomach. The possible link between pressure, volume, the physical behavior of implanted bands, and the physiology of the banded patient constitutes the "pressure-volume theory". Hopefully, the ongoing laboratory and clinical investigation of the pressure-volume theory will come up with data to provide clear guidelines for further band engineering and band adjustment policies [25].

16.1.3 Sleeve Gastrectomy

Sleeve gastrectomy (SG) is an essentially restrictive procedure for morbid obesity (■ Fig. 16.3). It was first described in 1988 as part of the procedure of biliopancreatic diversion with duodenal switch by Hess and Hess [26], and Marceau et al. [27]. In 1993 the SG was reported in isolated form by Johnston et al. [28]. This procedure targets the same patient group as LAGB. It is more invasive, however, and not reversible, and it carries a longer learning curve. In the literature it has been reported mostly as the first step in another bariatric procedure, such as biliopancreatic diversion with duodenal switch [29–33] or gastric bypass [34–37]. SG is justified as a first step, owing to decreased postoperative morbidity in super-obese (BMI >50 kg/m^2) or super super-obese patients (BMI >60 kg/m^2). This first step allows the surgeon to perform the second bariatric procedure under better and safer conditions. The mechanism of action of this procedure is not only the restriction obtained by resecting part of the body and the entire fundus of the stomach, leaving a small gastric tube of 100–150 ml. The Banded Sleeve Gastrectomy (LBGS) is developing even more restriction (■ Fig. 16.4). Many surgeons are convinced that 90% reduction of the gastric volume and thus decreasing caloric intake early postoperatively may explain the resolution of diabetes after the operation [38]. However, the hormonal changes following this procedure have to be considered as well. The gastric fundus, known as the main source of ghrelin-producing cells, is resected by SG, and plasma ghrelin levels are expected to decrease following surgery. Fruhbeck et al. [39] described reduction of the circulating

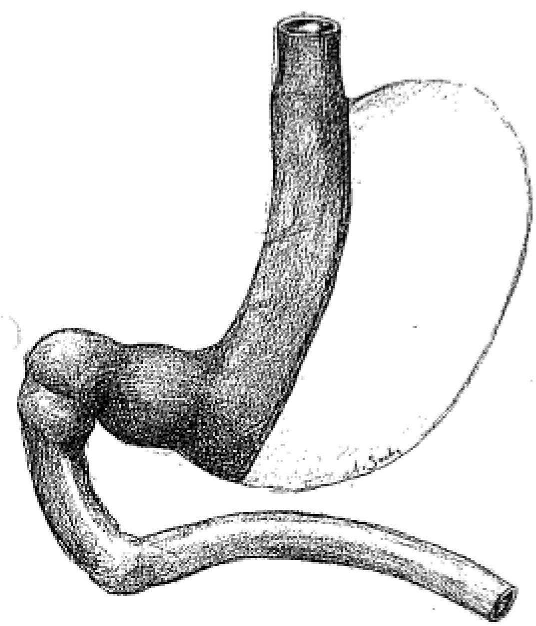


Fig. 16.3. Sleeve gastrectomy

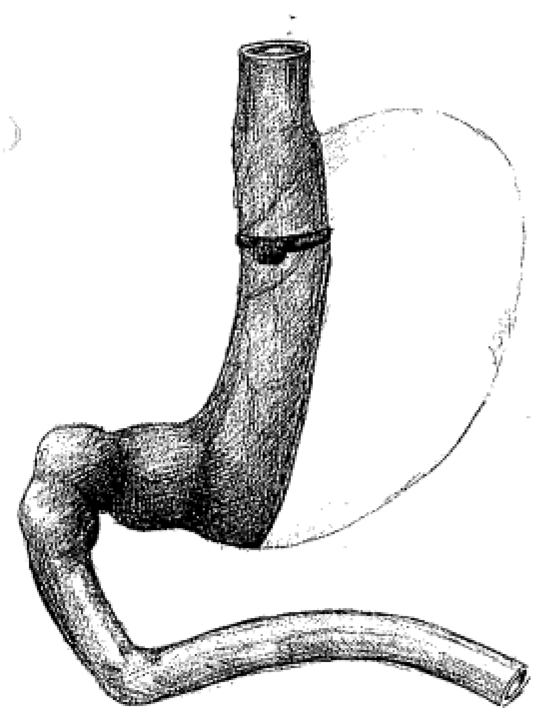


Fig. 16.4. Banded Sleeve Gastrectomy

ghrelin concentrations after bariatric operations depending on the degree of fundus exclusion and subsequent isolation of ghrelin-producing cells from direct contact with ingested nutrients. In a study comparing the effects on plasma ghrelin levels after laparoscopic SG and LAGB, Langer et al. [40] showed a significant decrease of plasma ghrelin levels at day 1 after laparoscopic SG compared with the preoperative levels. Moreover, plasma ghrelin remained stable at 1 month and 6 months postoperatively. In contrast, patients who underwent LAGB showed no change of plasma ghrelin levels at day 1, while a significant increase was found at 1 month and 6 months of follow-up. Thus, the reduction of ghrelin production after SG, unlike after LAGB [21], could explain the superior weight loss achieved after laparoscopic SG [41]. Another study [42] compared the modifications of ghrelin levels in super super-obese patients submitted to laparoscopic SG. The authors confirmed the reduction of ghrelin levels after laparoscopic SG but found a significant increase of this hormone after LAGB. An interesting study by Karamanakos et al. [43], comparing the weight loss and the fasting ghrelin levels between laparoscopic SG and laparoscopic RYGBP at 6 and 12 months, showed a significant difference in favor of laparoscopic SG. After laparoscopic RYGBP, fasting ghrelin levels did not change significantly compared with baseline and did not decrease significantly following meals, unlike laparoscopic SG, where a marked reduction in fasting ghrelin levels and significant suppression after meals was observed. Another mechanism to explain weight loss after SG could be the relationship between appetite and gastric emptying. A randomized and double-blind trial reported by Bergmann et al. [44] showed an association between gastric emptying as evaluated by echography and appetite. The more the antrum is expanded, the less the feeling of hunger seems to be. This mechanism can be linked to the new anatomy of the stomach after SG. The gastric emptying mechanisms were studied and compared in three different groups: control patients, obese patients, and patients submitted to a procedure similar to SG called the Magenstrasse and Mill technique [45]. This study showed no statistically significant differences in the emptying times between the three groups and concluded that a procedure similar to SG achieved acceptable weight loss while preserving gastric emptying mechanisms and minimizing possible side effects such as vomiting. Melissas et al. [46] confirmed improved gastric clearance after laparoscopic SG, which also explains less vomiting than after VBG. Almost all patients have the feeling of satiety after LSG. Strong restriction alone could partly explain the situation; on the other hand, the early vagal stimulation due to postprandial increased tensile pressure on the gastric wall could be responsible for increased intestinal motility via acetylcholine release. This may explain an early stimulation of the ileum, which could elevate GLP-1 and PYY3-33, and which, together with ghrelin, influences peptide Y in the CNS and decreases appetite [47].

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