

Update on Treatment of Morbid Obesity with Adjustable Gastric Banding



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KEYWORDS

- Morbid obesity • Laparoscopic adjustable gastric banding • Complications • Reoperations

KEY POINTS

- Laparoscopic adjustable gastric banding (LAGB) underwent several changes over the years in both design and technique of insertion. These modifications contributed to the significant decrease of complications.
- LAGB has the lowest perioperative complications and hospital stays of the bariatric surgery options.
- Overall, the weight loss achieved with the band is lower than with other bariatric operations, such as gastric bypass and sleeve gastrectomy.
- The long-term complications and the need for reintervention have contributed to a significant decrease in the use of LAGB as a bariatric surgery option.

INTRODUCTION

The pandemic proportion of obesity disease is well known, with more than 300 million people affected worldwide. According to the most recent National Health and Nutrition Examination Survey, 140.2 million (64.5%) of United States adults are candidates for weight loss treatment.¹ This is a significant increase from 1998, when the estimated number was 116 million, or 20.9% of the population. Although up to 53.4% of these candidates are considered for pharmacologic treatment, 14.7% could be candidates for bariatric surgery. The increase in potential candidates for bariatric surgery translated

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to an increase of the number of bariatric operations performed annually, although on a much smaller scale. Of the potential 20 million bariatric surgery candidates, only 193,000 patients underwent bariatric operations in the United States in 2014 (Table 1). Also, the mix of cases has changed over the years. Noticeably, the popularity trajectories of 2 procedures are moving in opposite directions, as the rise of laparoscopic sleeve gastrectomy (LSG) numbers is closely paralleled with the fall of LAGB numbers. The factors that contributed to the steep rise in popularity of the LAGB and the reasons for its even quicker fall are analyzed.

HISTORY

After the disappointing experience with the first highly malabsorptive operations, such as the jejunioileal bypass, in the 1950s, the concept of only restricting the food reservoir began to take a stand in the bariatric arena.² One of the early adopters of the band, Steffen, has extensively highlighted the historic milestones of the evolution of the band.³

Nonadjustable Bands

The first experiments on purely restrictive operation were conducted in dogs by Wilkinson and Peloso in the 1970s.⁴ These investigators then published their results of placing a nonadjustable polypropylene (Marlex) band around the top part of the esophagus (Fig. 1).⁴ At approximately the same time, other investigators in different parts of the world performed similar procedures. One of the most well known was the gastric partition described by Molina and colleagues.⁵ Although the results of both the Wilkinson and Peloso and Molina and colleagues procedures were similar, the main differences were the material of the band (polyester Dacron instead of Marlex) and the size of the resulting pouch (smaller in the Molina). It was soon obvious, however, that both materials create a significant inflammatory reaction and even ingrowth within the stomach. This is the primary reason similar gastric partitions started to be performed with more inert materials, such as silicone.⁶

Not unexpectedly, every fixed type of gastric band resulted in either short-term or long-term failures, regardless of the material of the band, size of the resulting pouch, or other technical variations. The idea of putting a fixed band on a distensible

Table 1 Estimated bariatric operations between 2011 and 2014				
	2011	2012	2013	2014
Total	158,000	173,000	179,000	193,000
LRYGB	36.7%	37.5%	34.2%	26.8%
Band	35.4%	20.2%	14%	9.5%
Sleeve	17.8%	33%	42.1%	51.7%
Biliopancreatic diversion with duodenal switch	0.9%	1%	1%	0.4%
Revisions	6%	6%	6%	11.5%
Other	3.2%	2.3%	2.7%	0.1%

American Society for Bariatric and Metabolic Surgery total bariatric procedures numbers from 2011, 2012, 2013, and 2014 are based on the best estimation from available data (Bariatric Outcomes Longitudinal Database, American College of Surgeons/Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program, National Inpatient Sample data, and outpatient estimations).

Data from American Society for Bariatric and Metabolic Surgery (ASMBS). Available at: <https://asmbs.org/>.

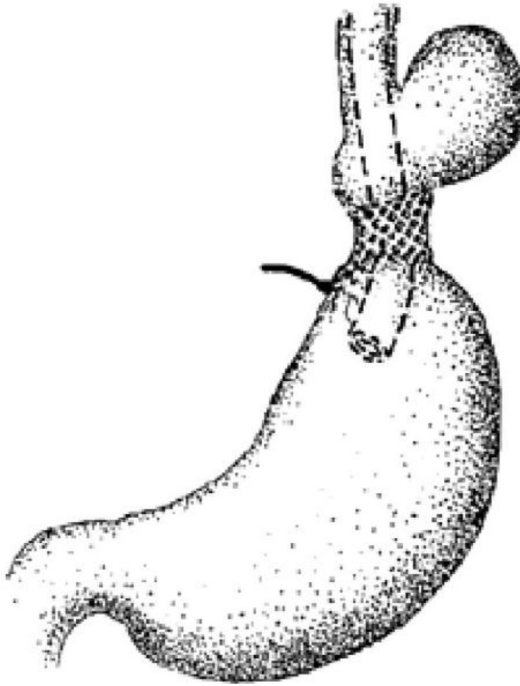


Fig. 1. Nonadjustable Marlex band at the proximal part of the stomach. (From Deitel M, Cowan GSM, editors. *Update: Surgery for the Morbidly Obese Patient*. Toronto, Ontario: FD-Communications Inc.; 2000; with permission.)

structure, such as the gastric fundus, would determine prolapse of the fundus itself and, over time, stretching of the reservoir. Both complications can lead to poor weight loss or weight regain but most importantly chronic reflux with esophageal dilatation.

Adjustable Bands

To decrease the likelihood of slippage, erosion, and chronic reflux, the idea of being able to adjust the diameter of the perigastric band started to develop. After an initial prototype was developed in the laboratory and tested on animal models by Szinicz and colleagues,⁷ the first clinical application of the modern adjustable gastric band took place in Sweden by Forsell and colleagues.⁸ This was the first version of the so-called Swedish band in 1985. Applying an identical concept, Kuzmak and colleagues in 1986⁹ described a different design of the adjustable gastric band in the United States, initially known as the American band. Both the Swedish and American bands had an identical conceptual design of the modern bands, in which the Silastic outer ring of the band is complemented by an inner inflatable balloon. The balloon is connected to a subcutaneous port via a tube. Once accessed with a noncoring needle, the subcutaneous port allows for adjustment in the diameter of the band. Undoubtedly the ability to adjust the diameter of the band and individualize it for different patients significantly decreased the morbidity associated with the previous nonadjustable bands.⁹

Laparoscopy for Adjustable Gastric Bands

Although bands were considered safer than other more complex bariatric alternatives, the simple fact that a laparotomy was needed to implant them resulted in significant

source of morbidity. It was only in 1995 that Belachew and colleagues¹⁰ reported the first successful laparoscopic placement of an adjustable gastric band. As seen in other procedures that implemented laparoscopic techniques, the popularity of the LAGB began to rise exponentially. This surge first started in Europe and expanded to other countries of the world, except the United States. It was only in 2001 that the Food and Drug Administration (FDA) approved the first band for use in the United States. This was the band derived from Kuzmak's prototype and commercialized as the Lap-Band (Allergan, Irvine, California; now Apollo Endosurgery, Austin, Texas) (Figs. 2 and 3). On the other end, the Swedish band, available in Europe since 1987, was finally marketed in the United States as the Realize band (Ethicon Endo-Surgery Cincinnati, Ohio) only 2 decades later (Fig. 4). Partially responsible for this late adoption of the new technology that was quickly spreading throughout the world were the disappointing results of one of the initial FDA trials in the United States.¹¹ These results were in definite contrast with the much more positive ones reported in both Europe and Australia.^{12,13} Despite initial disappointing results, the technical simplicity and overall safety of the device contributed to the continuous expansion of the LAGB within the bariatric arena.

EVOLUTION AND TECHNICAL ADVANCEMENT OF THE LAPAROSCOPIC ADJUSTABLE GASTRIC BAND

In addition to the technical simplicity and the perioperative safety (discussed previously), several milestones contributed to the exponential rise in popularity of the LAGB.

Adoption of Laparoscopy

As previously discussed, the first major technical milestone in the history of LAGB was the adoption of the laparoscopic technique of insertion. Because, at this stage of the evolution of the band technique, the advancements were based on the previous open nonadjustable band, many of the original technical flaws were repeated in the adjustable band technique. The first laparoscopic placement was of a nonadjustable type of band done almost simultaneously by 2 investigators in different countries.^{14,15} It is not surprising, then, how the early laparoscopic technique resembled the open one and consisted of placement of the band around the upper body of the stomach, also known as the perigastric technique. This resulted in 2 major consequences: the



Fig. 2. First version of the Lap-Band. Note the narrow foot print, not circumferential, and the smaller volume balloon. (Courtesy of Apollo Endosurgery, Austin, TX; with permission.)



Fig. 3. Lap-Band AP. Wider footprint, larger circumferential balloon with lower volume. (Courtesy of Apollo Endosurgery, Austin, TX; with permission.)

inclusion of a variable portion of the distensible fundus in the pouch above the band and the violation of the lesser sac. These 2 technical points were later deemed responsible for a majority of the most common complications initially encountered with the band: prolapse and concentric pouch enlargement.¹⁶

The Pars Flaccida Technique

According to Belachew and colleagues¹⁰ original description, the band was placed around the superior portion of the stomach by creating a retrogastric tunnel from the lesser to the greater curvature across the lesser sac (perigastric technique).¹⁰ This resulted in a generous gastric pouch of 25 cc to 30 cc, which included the gastric body and portion of the more distensible fundus. After the fundus was plicated over the band, the band was immediately filled with few milliliters of saline based on the measurements of a gastrostomometer. The high incidence of prolapse (up to 30%)



Fig. 4. Realize band equivalent to the Swedish band. (Courtesy of Ethicon Endo-Surgery, Cincinnati, OH; with permission.)

and of erosion (3%) was soon linked to the specific technical detail of surgical implantation. It was the recognition of those major pitfalls in the laparoscopic placement of the band that led to the second milestone in the technical evolution of the band: the adoption of the pars flaccida technique. This was the technique Forsell and colleagues⁸ originally described for the placement of the Swedish band. This consists in the placement of the band higher in the stomach, preserving the lesser sac and the posterior gastric attachments. The tunnel to place the band originates from the gastrohepatic ligament above the bursa omentalis. The higher placement of the band results in the creation of a 1-cm virtual gastric pouch without any significant portion of distensible stomach. The preservation of the lesser sac attachments has been linked to the elimination of the posterior type of gastric prolapse and the significant reduction of the anterior type from 17% to 4%.^{17,18} Also, the smaller gastric pouch above the band with virtually no fundus has contributed to the decrease of the concentric enlargement of the pouch, which was responsible not only for failure of weight loss and weight regain but also for chronic reflux.¹⁶ Finally the diameter of the tunnel is kept very narrow, avoiding the disruption of the natural posterior attachments of the stomach to the diaphragmatic crura. The gastrogastic plication is made loose enough to accommodate future volume expansions of the band, and fluid is not added to the band intraoperatively but 4 weeks to 6 weeks postoperatively.

Design Changes of the Laparoscopic Adjustable Gastric Band

Additional technical advancements were made specifically to the design of the bands. The Lap-Band was originally designed with a low-volume, high-pressure inflatable balloon, not fully encircling the cardia and attached to a relatively narrow height band (footprint) (see Fig. 2). The superior compression on the gastric tissue was linked to higher incidence of erosion and anterior slippage.¹⁹ Subsequent designs of the band modified the footprint of the band itself and included a 360° balloon able to accommodate higher volumes of fills and maintaining lower pressure (see Fig. 3). The adoption of wider bands also contributed to the decrease incidence of erosion.¹⁹

Increased Popularity of Laparoscopic Adjustable Gastric Band

The popularity of LAGB continued to increase exponentially. Between 2004 and 2007, the reported number of cases tripled from 7% to 23%, and between 2008 and 2010 it was the most commonly performed bariatric procedure worldwide.^{20,21} The main features that determined the rapid increase of LAGB adoption were the technical simplicity; the early recovery with minimal, if any, in hospital stay; the gradual patient adjustment to the dietary modifications; the belief of total reversibility of the procedure; and the relative lower cost. These characteristics were consolidated by multiple reports of low morbidity and mortality of LAGB (11% and 0.05%, respectively) compared with the rates of the procedure more popular at the time, laparoscopic Roux-en-Y gastric bypass (LRYGB) (23.6% and 0.5%, respectively).²⁰ When longer-term data began to surface, the complications rate of LAGB increased to 31% to 60%, and the reoperation rates went up to 60%.^{20,22} Even the concept of total reversibility began to be challenged and after removal some of the anatomic alteration of the gastroesophageal anatomy were more permanent than previously believed. A new concept of removability, instead of reversibility, started to gain ground.²⁰ Also the idea of lower costs started to be re-evaluated. Although true that the initial cost of the device and the quick operation with no in-hospital stay was lower, when the more intense follow-up and costs of complications and reoperations was factored in, the gap between LAGB and other operations was noticeably smaller than initially reported.²³ The continuing popularity of the band, along with the promising short-

term and midterm results, resulted in a push for the application of the band in lower body mass index (BMI) ranges. This movement culminated in 2011 with the FDA approval in the United States of the LAGB for BMI between 30 kg/m² and 35 kg/m² with associated comorbid conditions.

COMPLICATIONS

To understand the reasons for the decline of the band, an in-depth analysis of its potential complications and their relative probability has to be done. Although the initial studies reported low rates of early complications, and certainly lower mortality rates of other bariatric operations,^{24,25} several complications remain a substantial problems related to the LAGB.

The complications of LAGB can be divided as band related and port related (**Box 1**).

If the port-related complications are generally minor and require only minor surgery, often done under local anesthesia, the band-related complications can be the source of severe morbidity and potentially mortality.²⁶

Acute Slippage

Slippage, also known as prolapse or eccentric pouch dilatation, is a herniation of portion of the stomach in a cephalad direction through the band. Based on the portion of herniated stomach, the slippage is divided in anterior or posterior. The herniation of the stomach changes the orientation of the axis of the band in a characteristic and diagnostic way. The posterior prolapse determines a counterclockwise rotation of the band with the axis of the band becoming almost parallel to the vertebral column (**Fig. 5**). On the other hand, in the anterior prolapse, the gastric tissue displaces the band clockwise, resulting in a horizontal appearance of the band (**Fig. 6**). Similarly

Box 1

Potential complications of laparoscopic adjustable gastric banding

Band related

- Slippage
- Erosion
- Pouch dilatation
- Esophageal dilatation
- System leak
- Infection
- Dysphagia
- GERD

Port tubing related

- Port displacement
- Tube disconnection
- System leak
- Infection

From Lo Menzo E, Szomstein S, Rosenthal R. Reoperative bariatric surgery. In: Nguyen N, Balckstone R, Morton J, et al, editors. The ASMBS textbook of bariatric surgery. New York: Springer; 2015. p. 276; with permission.

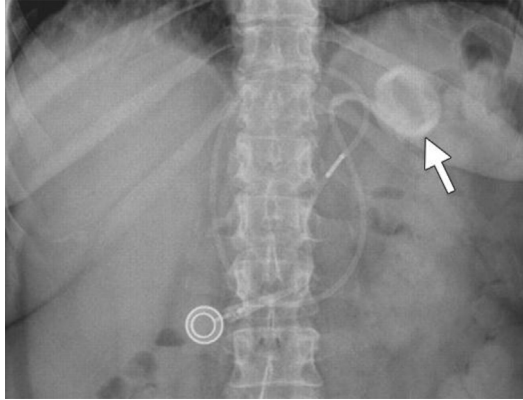


Fig. 5. Plain x-ray study showing a posterior prolapse. The band is oriented vertically almost parallel to the spine. The arrow denotes the typical O sign of the prolapsed band. (From Sonavane SK, Menias CO, Kantawala KP, et al. Laparoscopic adjustable gastric banding: what radiologists need to know. *Radiographics* 2012;32(4):1171; with permission.)

to other types of herniations, the prolapsed gastric tissue is at risk for ischemia and perforation. As discussed previously, the adoption of the pars flaccida technique and the band design modifications to lower pressure and higher volume balloons has eliminated the posterior prolapse.

Chronic Pouch Dilatation

Chronic pouch dilatation is one of the most common chronic findings of LAGB. Although the creation of a virtual pouch of the pars flaccida technique has decreased the incidence of pouch dilatation, this remains a significant cause of morbidity and

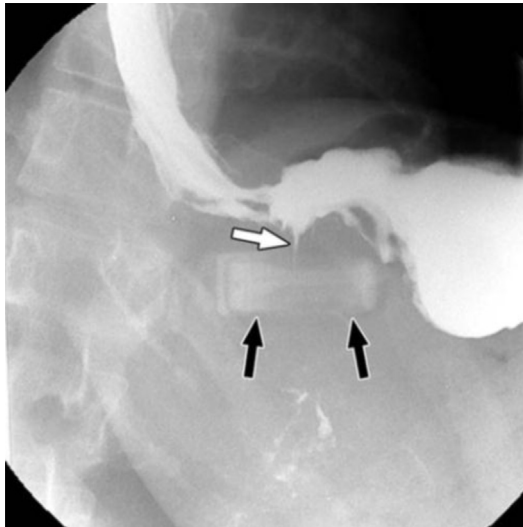


Fig. 6. Upper gastrointestinal study showing an anterior prolapse. The white arrow indicates severely narrowed outlet of the stomach. Black arrows show the horizontal position of the band.

indication for band revision, conversion, or removal. The functional stenosis at the level of the band determines a progressive dilatation of the gastric pouch. Because there is no prolapse of gastric tissue across the band, there is no risk of ischemia. The radiographic appearance is different from the prolapse (**Fig. 7**). The main contributing factor for the stenosis is an over-adjustment of the band. Dietary habits, however, are believed to play a role as well.²⁷ Because the loss of restriction is often interpreted as a loose band, the subsequent adjustments done without the aid of fluoroscopy create perpetuation of the outlet obstruction and worsening of the concentric dilatation.

Esophageal Dilatation

The persistent gastroesophageal obstruction with or without gastric concentric dilatation can determine insufficiency of the lower esophageal sphincter and stasis of food in the lower esophagus. Similar to primary achalasia, over time the esophageal muscle weakens and the esophageal lumen begins to dilate. If unrecognized, this process can cause permanent esophageal damage even after band removal (**Fig. 8**).

Band Erosion

Also known as band migration, the band erosion complication consists of the partial or complete penetration of the band in the gastric lumen (**Fig. 9**). The most helpful diagnostic tool is the esophagogastroduodenoscopy. Upper gastrointestinal contrast



Fig. 7. Upper gastrointestinal study showing a concentric pouch dilatation. B indicates the band. (From Behr S, Campos G, Westphalen A. Applied radiology imaging and bariatric surgery. *Appl Radiol* 2012;41(6):18; with permission.)

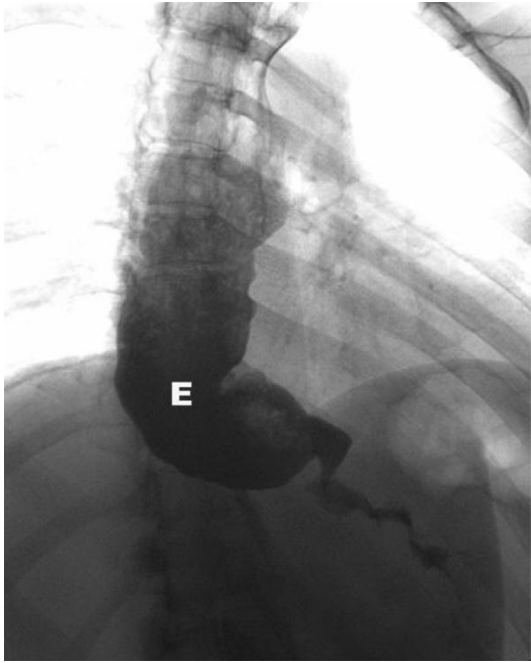


Fig. 8. Megaesophagus from chronic gastric outlet obstruction at the level of the band. E, esophagus.

study or CT scan can identify the presence of contrast media between the outside of the band and the inside of the gastric wall ([Fig. 10](#)). Early erosion is usually secondary to a technical error during the band placement, that is, gastric perforation. Another less common possibility is an early infection of the implant. Erosions presenting in more chronic form are mostly due to band overfilling, tight gastric plication, and,



Fig. 9. Esophagogastroscopy study showing intraluminal migration of the band.



Fig. 10. Upper gastrointestinal study showing an intragastric band migration.

possibly, maladaptive eating behaviors. The development of a subcutaneous port site infection could be the first manifesting sign of band erosion.

Port-related Complications

Port-related complications account for approximately 12% of LAGB revisions.²⁰ The suspicion of a port tube complication should be raised when the port cannot be accessed, the band does not hold the fluid injected, or for abdominal pain of unclear origin. A fluoroscopic study with injection of contrast is the test of choice to identify the complication.

Although most of the port-related complications can be approached with minor surgery under local anesthesia, occasionally a diagnostic laparoscopy might be necessary to address problems, such as bowel obstructions and intra-abdominal dislodgement of the end of the tube.

Gastroesophageal Reflux Disease

The placement of an artificial prosthesis around the esophagogastric junction for the purpose of recreating the lower esophageal sphincter was in clinical use at the time of the description of the fixed band for weight loss. The first results of the so-called Angelchik prosthesis were reported in 1979.²⁸ Although initially effective, the long-term results of the device did not live up to its expectations because of the long-term outcomes and complications, in particular dysphagia, migration, and erosion.²⁹ According to the 2-year results on 122 patients of the APEX study, gastroesophageal reflux disease (GERD) symptoms resolved completely in 98 patients (80%), improved in 13 (11%), were unchanged in 9 (7%), and worsened in 2 (2%), leading to an overall

improvement or resolution rate of 91%.³⁰ These impressive rates did not seem dependent on the extent of weight loss. Even objective data based on pH studies before and after the LAGB revealed short-term improvements after of LAGB.^{31,32} Long-term significant worsening of both the symptoms and the pH positive reflux, however, has been demonstrated by the same investigators.³²

Gastric Perforation

Gastric perforation is a rare complication, reported in 0.1% to 0.4% of the band placements.³³ In acute settings, this is considered a technical error at the time of band insertion. Aggressive retrogastric tunnel creation can cause perforations at or near the posterior esophagogastric junction. Some of the smaller perforations can remain silent and manifest in a delayed fashion with subcutaneous port infection. The perforations that occur more chronically are due to band erosions, as previously described.

Failure of Weight Loss

Although several definitions are available, failure of weight loss is usually defined as less than 50% excess body weight loss.³⁴ According to these parameters, 10.5% of the patients who underwent LAGB present with inadequate weight loss at 5 years and 14% at 10 years.³⁵ Failure of weight loss remains the most prevalent reason for conversion surgery after LAGB (up to 62%).³⁶

RESULTS

LAGB is still regarded as a technically simple and relatively inexpensive bariatric surgical option. Also, its safety is known in short-term and medium-term follow-ups. According to early studies, LAGB offered significantly lower morbidities and mortalities compared with the standard of care laparoscopic gastric bypass (mortality 0.05% vs 0.5%).³⁷ Even the weight loss outcomes of the LAGB were more than satisfactory compared with the potentially more morbid LRYGB. If the initial weight loss was lower compared with the LRYGB, multiple studies reported up to 65% EWL after 2 or 3 years.^{37,38} The reports showed, however, a great degree of variability. Some of the variability was likely due to the lack of standardization of the postoperative band adjustments. Also it was evident how more-intense follow-ups and adjustments resulted in better weight loss outcomes, as shown by Shen and Ren.³⁹ Several long-term studies on LAGB are available. O'Brien and colleagues¹⁹ reported the 15-year follow-up data on more than 3000 patients. They reported no mortality for either the primary LAGB procedure or for any subsequent revisional procedures. The EWL was 47% at 10 years and 15 years, although only 22% and 1.6% of the patients respectively were available for follow-up. They also reported a significant decrease in the need of reoperations and revisional surgeries after the introduction of the pars flaccida techniques as well as the new band design.¹⁹ They identified 3 separate periods in the evolution of the band and technique: the first period of the perigastric technique, the second of the pars flaccida, and the third of the newer and current designs of the band (Lap-Band AP, Apollo Endosurgery, Austin, Texas). Besides the prolapse (discussed previously), even the incidence of erosions significantly decreased with the in technique and band design. According to the investigators, the erosion rates went from 8.5%, to 2.25, and to 0.8% in the 3 evolution periods (groups 1, 2, and 3, respectively). Most of the revisions occurred for proximal pouch enlargement (26%) in the first 10 years of the investigators' experience. Port and tubing complications accounted for 21% of the revisions. Band removal occurred in 5.6% of the

patients, mostly because of patients' request for reflux type symptoms. In the pooled analysis of studies reporting the results of LAGB and LRYGB with more than 10-year follow-up, they concluded that LAGB offers similar long-term weight loss, lower peri-operative mortality, and similar need for revisional surgery (median of 22% for LRYGB and 26% for the LAGB).¹⁹

Along with the weight loss, comorbidity resolution was evident in many studies. Most of the typical manifestations of the metabolic syndrome were deeply improved by the band-related weight loss. Hypertension, for instance, has been reported improving in up to 92% of the patients.³⁷ Even the randomization of diabetic patient between LAGB and conventional medical treatment favor the former.⁴⁰ Also the initial concerns of creating a surgical achalasia were proved inaccurate by multiple reports showing improvement of the GERD after LAGB. Dixon and O'Brien⁴¹ reported an 89% resolution of GERD after LAGB, 5% improvement, and only 2.5% worsening of the symptoms.

Longevity of Laparoscopic Adjustable Gastric Band

Despite a multitude of positive reports on the short-term and midterm results of LAGB, subsequent studies began to question the efficacy and durability of the LAGB long term. These results and the availability of more effective and equally safe options, such as the LSG, contributed to the significant decline in popularity of the LAGB.

One of the main concerns about the longevity of results after LAGB is attributed to the need for long-term follow-up, more so than in other bariatric operations. It is often the misconception of the need for such intense follow-up that has given the band the reputation of an easy and quick fix and is the reason it has been offered to a large nonselected cohort of patients.

Large-scale studies on LAGB have been reported; however, they tend to be single-institution and nonrandomized. Among these, Favretti and colleagues⁴² reported on more than 1700 patients with an excellent 91% follow-up at 12 years. The mean weight loss was 40% at 1 year, 37% at 6 years, and 49% at 12 years. They also reported a 5.9% incidence of complication related to reoperation and 2.3% conversion for failure of weight loss or weight regain. Similar good weight loss results and resolution of comorbidities were reported in Australia by O'Brien and colleagues³⁸ on 709 patients. They reported an excessive weight loss (EWL) of 57% at 72 months. They also noted, however, a higher incidence of slippage (12.5%), band erosion of 2.8%, and port-related complications (3.6%). Other positive reports included the one from Switzerland of Steffen,³ in which 824 patients were followed for 7 years. A respectable 61% EWL was reported, with, however, a 5.6% annual reoperation rate.

Concerning Results

If many positive studies on LAGB exist in the literature, more negative ones are reported, especially when longer follow-up data are available. Suter and colleagues³⁵ reported on 317 patients at 8 years. The overall complication rate they reported was 33%, mostly due to erosion (9.5%), port-related complications (7.6%), and slippage or pouch dilatation (6.3%). Also, the same investigators describe a worrisome 21.7% rate of major reoperations. Patel and colleagues reported a reoperation rate of 17.5% in band placed over an 8 year period.²⁰ In the author experience the majority of the reoperations were due to band removals alone (44%), conversion to Roux-en-Y gastric bypass (14.8%), conversion to sleeve gastrectomy (13.6%), band repositioning (10.2%), and band replacements (2.3%). Himpens and colleagues²² also reported high rates of removal (60%). More interestingly is the failure of weight loss (EWL <25%) or need for reoperation rates, reaching 36.9% at 7 years. Similar high long-term complication

rates requiring reoperations for explantation and conversions were reported by other investigators.⁴³ These investigators reported a 17.6% incidence of reoperation in their 448 patients followed for an average of 3.2 ± 2.2 years. Only 36% of the reoperations were considered minor. The main reasons for reoperation were again pouch dilatation (37%), erosion (20%), and insufficient weight loss (20%). They estimated the need for major reoperation after LAGB to be 4.1 interventions per 100 person-years. It is noticeable how only 19% of the patients were available for greater than 5-year follow-up.

Morino and colleagues⁴⁴ in their prospective randomized trial comparing LAGB to laparoscopic vertical banded gastroplasty found that early morbidities were similar between the 2 procedures, but the late complications were more common after LAGB (32.7% vs 14%, $P < .05$). LAGB was also more likely to require additional operations compared with laparoscopic vertical banded gastroplasty (24.5% vs 0, $P < .001$). Some of the complications of the LAGB were related to the technique (perigastric placement) used and the experience of the surgeon. Weiner and colleagues¹⁷ reported that the rate of slippage decreased from 17% during the first 100 operations to 0 in the last 300 cases. Additional reports continued to appear on the high rate on complications (19% to 44%), reinterventions (25% or higher), and conversion for failure of weight loss.^{45,46} Finally the most recent of the reports analyzed more than 19,000 LAGB patients in the state of New York over a 6-year period.⁴⁷ According to these investigators, the rate of revision after LAGB is more than 22%, 20% of which required multiple operations. Furthermore, the complication rates at the time of revisions were significantly higher (30%). The higher complication rates after revisional surgery have been well described by other investigators.⁴⁸

Laparoscopic Adjustable Gastric Banding in Adolescents

LAGB has been selectively used in the treatment of morbid obesity in adolescents. After the first report in this patient population in 2003, multiple other studies have shown the medium-term safety and efficacy of the LAGB in the adolescent population.^{49,50} Even in a randomized trial between intense medical management and LAGB in adolescents, the latter group compared favorably for weight loss and comorbidity resolution. Similarly to the adult studies, however, the overall weight loss seems inferior to the LRYGB.⁵¹ Although solid long-term results are still lacking, there is more evidence that LAGB in adolescents presents similar long-term complication as in the adults.⁵¹

Laparoscopic Adjustable Gastric Banding for Lower Body Mass Indices

The other category of patients worth mentioning is those with lower BMIs (30 kg/m²–35 kg/m²). In a review of 6 studies encompassing 515 patients, the mean EWL% ranged from 52.5 to 78.6 at 1 year and from 57.6 to 87.2 at 2 years. The weight loss is maintained over time, as shown by the 3-year EWL of 68%. The complication rates were overall low (6.6%).⁵² Again, the long-term data are missing, so only partial conclusions can be drawn from this study.

FUTURE OF LAPAROSCOPIC ADJUSTABLE GASTRIC BANDING

The rapid decline of the utilization of LAGB and the proportional steep increase in LSG popularity have put the future of LAGB in question. Even the companies producing the different bands have significantly scaled down their marketing strategies, once targeting patients directly. So the question is, Would the LAGB disappear from the bariatric arena just like the vertical banded gastroplasty did, or there are still some potential indications for it?

To attempt an answer to this question, the results of LAGB are compared with the other bariatric options.

When the authors analyze randomized trials comparing LAGB to other bariatric procedures, the conclusions are overall consistent. The LAGB is not the most effective bariatric procedure in terms of weight loss, but it is associated with lower early complications and shorter operative time and length of stay.⁵³ LAGB is also effective in reducing obesity-related comorbidities, but its efficacy varies depending on the degree of success in weight loss.⁵³ LAGB presents, however, a higher potential for long-term of complications and reoperations.

It is well known how quality of life and self-image improve with increasing weight loss.⁵⁴ But postoperative complications, lengthy hospital admissions, and postoperative complications may reduce the general well-being of patients. In this setting, LAGB with minimal early complications and in-hospital stay might have a potential advantage over other, more complex bariatric operations. The only prospective randomized trial comparing quality of life after LRYGB and LAGB showed no significant difference between the 2 arms at 12 months.²³ Other more recent studies have confirmed the improvement of quality of life after LAGB, both short term and up to 3 years.⁵⁵ According to the same randomized study, the mean operative time and blood loss were higher, but as expected, the length of stay was also longer in the LRYGB gastric bypass group. The 30-day complication rate was higher after gastric bypass (21.6% vs 7.0% for gastric band), although the only statistically significant difference was in the minor complications. The late complications were once again higher in the LRYGB group (29% vs 10%, $P = .01$), with the most common ones anastomotic stricture (15%) and band slippage and erosion (5.8%), respectively. Treatment failure (EWL <20%), however, was only observed in the LAGB group (16.7%).

Despite the reported variability of weight loss results, it seems a consistent finding that the ability to reach adequate weight loss is greater with the LRYGB, followed by the LSG, and finally by the LAGB. The incidence of patients reaching EWL% less than 50% has been reported higher after LAGB (50%) than after LSG and LRYGB (33% and 23%, respectively).⁵⁶

If the other potential field of application of LAGB is analyzed, the adolescent population, the results remain consistent. Even the most recent of the reviews for bariatric surgery and adolescents focuses on EWL results.⁵⁷ In this review, the investigators, reporting on the results of 37 studies, found a maximum weight loss of the LRYGB (BMI loss of 16.6 kg/m²), followed by the LSG (BMI loss of 14 kg/m²), and lastly the LAGB (BMI loss of 11.6 kg/m²). Complications of the LAGB were reported in 10.5%, and reoperation was necessary in 14% of the cases (including replacement or repositioning, removal, and port revision).

Finally, as previously reported by other investigators, the revision rate after LAGB in large studies could be as high as 34.17%.⁴⁷ Although a majority of these patients (80%) require only 1 procedure, up to 20% of them require multiple revisional and conversional operations. According to Altieri and colleagues,⁴⁷ patients particularly at risk for needing reinterventions were younger patients, female patients, and those with chronic pulmonary disease, hypothyroidism, psychoses, or rheumatoid arthritis. Despite the authors' best efforts, more than 3500 patients could not be followed up, so it is reasonable to believe that the percentages of complications could be even higher.

SUMMARY

LAGB presents fewer short-term complications and shorter hospital stays than other bariatric operations. Although its efficacy in terms of comorbidity resolution seems

adequate in many studies, the variability of results is such that without robust level 1 data, final conclusions are difficult to draw. The main concern regarding LAGB remains with the long-term complications and durability of the procedure. Overall it is fair to conclude that the role of the band seems limited at the moment. The availability of more effective procedures with acceptable short-term and long-term complication rates, such as LSG, has eclipsed the role of the formally popular LAGB.

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