

Procedures and devices for bariatric and metabolic endoscopy

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Abstract: Obesity is a leading cause of preventable death in developed countries, with a rising incidence over time. Lifestyle modification, pharmacotherapy, and bariatric surgery are the mainstays of bariatric therapy, even though burdened by several limitations in terms of efficacy or safety. Bariatric endoscopy has been developed in the last decades as a minimally invasive alternative, aimed to bridge the gap between conservative and interventional conventional therapies. This review aims to provide an updated overview of the bariatric and metabolic available endoscopic procedures and to drive the choice of the right procedure for the right patient.

Keywords: bariatric endoscopy, minimal invasive, multidisciplinary approach, obesity

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Introduction

Obesity is a chronic, relapsing, multifactorial disease defined as abnormal or excessive adipose tissue accumulation that may impair health and significantly increase disease risk.^{1–3} In the clinical setting, obesity is defined as body mass index (BMI) of 30 kg/m² or above.² Obesity is a major risk factor for several chronic diseases, including diabetes, cardiovascular diseases, sleep apnea, gastrointestinal and endocrine disorders, bone and joint diseases, and malignancies.² Notably, the prevalence of obesity is rising over time; in the United States in 2016, 39.8% of adults and 18.5% of young aged 2–19 years were obese.⁴ Treatment for obesity include dietary and lifestyle interventions, pharmacology, endoscopy, and surgery. A multidisciplinary team should be involved in order to maximize the efficacy of each intervention through a personalized approach.^{2,5,6} While dietary monitoring, lifestyle interventions and medications are still considered as the cornerstone of bariatric treatments, nevertheless, their efficacy alone is often temporary and/or inadequate.^{7–11} Bariatric surgery has been shown to be the most effective treatment for obesity.⁸ However, inclusion criteria for surgery are BMI over 40.0 kg/m² or of 35–39.9 kg/m² with comorbidities,⁹ and less than 2% of surgical candidates finally undergo intervention, due to contraindications, patient preference or inaccessibility.^{7,12,13}

Therefore, in the last decades, there has been a trend in developing minimally invasive and potentially long-lasting approaches for the treatment of obese patients for whom conservative strategies fail (Figure 1).²

Choosing the right procedure among this wide variety of endoscopic techniques for the right patient may be challenging, also considering that specific guidelines that may drive the choice are still lacking. The aim of this review is then to provide an updated overview of the current bariatric endoscopic interventions and to help drive the choice among the available strategies.

Review of the literature

A comprehensive review of the English-language literature on bariatric and metabolic endoscopic interventions was performed using the MEDLINE (Via PubMed) database up to September 2019 by two authors (B.O. and I.B.), using the keywords “Bariatric endoscopy,” “Metabolic endoscopy,” and “Obesity AND endoscopy.” Hand-search of bibliographies of included studies and previous reviews was also performed to search for additional relevant studies. The following data were recorded: number of patients, follow-up duration, total body weight loss (TBWL), excess weight loss (EWL), metabolic outcomes such as

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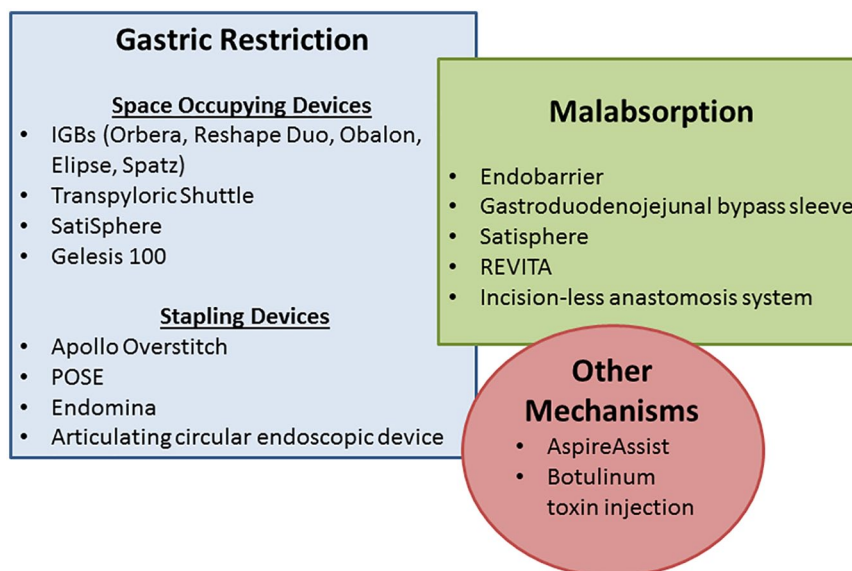


Figure 1. Bariatric noninvasive endoscopic techniques.

fasting plasma glucose (FPG), glycated hemoglobin A1c (Hb1Ac), rate and type of severe adverse events (SAEs).

Restrictive procedures

Space-occupying devices

Restrictive procedure by space-occupying devices is one of the mainstays of endoscopic bariatric treatments. There is a large body of evidence suggesting the efficacy and safety of space-occupying devices so far.

Intragastric balloons. **Intragastric balloons (IGBs)** are minimally invasive and temporary weight loss systems associated with a reduction of the gastric volume and with alteration of gastric motility.¹⁴ Alteration in gut hormones and peptides levels such as leptin, ghrelin, cholecystokinin, and pancreatic polypeptide, seems to be implicated in the weight loss process as well.^{15,16} IGBs have shown to improve most metabolic outcomes, including FPG, Hb1Ac, triglycerides, cholesterol, thyroid-stimulating hormone, waist circumference or blood pressure.^{17–22} All the IGBs have to be removed after 6–12 months to reduce the risk of spontaneous deflation.¹² Considering that obesity is a chronic disease, this short-time application may be a downside; however, this procedure is repeatable over time.²³ Scientific evidence deriving from main pivotal clinical trials regarding follow-up outcomes (%EWL and %TBWL mainly)

for each type of IGB is reported in Table 1.^{20,24–26} Several systematic reviews and meta-analysis have evaluated the efficacy and safety of IGBs: Tate and Geliebter²⁷ reported a main %TBWL of 9.7% and a rate of SAEs of 10.5%, including acute pancreatitis at 6-month follow-up. In 2018, the US Food and Drug Administration (FDA) issued an alert concerning the Orbera and ReShape Duo IGBs being implicated in 33 deaths, 27 of which being specifically associated with Orbera.²⁷ Among such fatalities, at least six occurred within 1 month after IGB placement, four were linked to esophagogastric perforation, one to massive aspiration, whereas the others were due to unspecified causes.^{28–31} Recommendations on adequate endoscopic training and strict supervision after IGB placement have been stated thereafter,^{31–33} whereas Apollo Endosurgery has stopped selling and distributing ReShape Balloon since January 2019.

The latest balloon available in the market is the Eclipse balloon (Allurion Technologies, Wellesley, MA). This is a swallowable device that can be externally filled up with saline solution and that has the peculiarity of self-emptying after a period of 4 months, allowing spontaneous excretion through the GI tract. The device received European marketing approval (EMA) and is waiting for FDA approval. The evidence available on Eclipse device are still scanty; however, in the last 2 years, one prospective series on 135 patients and one on 112 patients were published.^{35,36} The first study reported a mean %TBWL of 15.1% at

Table 1. Space Occupying Devices—Intragastric balloons.

IGB device	FDA approval	Duration of treatment	TBWL (%)	TBWL (kg)	EWL (%)	Premature balloon removal (%)	SAEs (%)	SAEs description
Orbera ²⁴	Approved in 2015: BMI 30–40 kg/m ²	6 months	10.2 at 6 mo.; 9.1 at 9 mo.; 7.6 at 12 mo.	9.9 at 6 mo.; 8.8 at 9 mo.; 7.4 at 12 mo.	26.5 at 9 mo.; 22.1 at 12 mo.	18.8	10	Device intolerance, dehydration, gastric outlet obstruction, gastric perforation, pneumonia, abdominal cramping, laryngospasm, esophageal injury
ReShape duo ²⁵	2015: BMI 30–40 kg/m ² and at least one obesity-related comorbidity ^a	6 months	7.6 ± 5.5 at 6 mo.	7.2 ± 5.4 at 6 mo.	27.9 ± 21.3 at 6 mo.	9.1	n.r.	Accommodative symptoms, esophageal tear, gastroesophageal junction ulcer, esophageal perforation, pneumonitis, gastric ulceration
Obalon ²⁰	Approved in 2016: BMI 30–40 kg/m ²	6 months	6.6 ± 5.1 at 6 mo.	6.6 ± 5.3 at 6 mo.	23.9 ± 19.2 at 6 mo.	3.3	0.5	Bleeding ulcer and balloon deflation
Spatz ³⁴	Not approved (CE approved)	12 months	14.9 ± 7.2 at 8 mo.	n.r.	n.r.	2.7	5.3	Accommodative symptoms and gastric ulcer
Ellipse ²¹	Not approved (EMA approved)	4 months	10.0 ± 6.6 at 4 mo.	n.r.	n.r.	0	0	

BMI, body mass index; EMA, European marketing approval; EWL, excess weight loss; IGB, intragastric balloon; TBWL, total body weight loss.

^aIn January 2019, Apollo Endosurgery stopped selling and distributing the ReShape Balloon.

4-month follow-up, while in the latter found a mean %TBWL of 10.9% at 6 months.^{35,36}

Non-balloon space-occupying device. *TransPyloric Shuttle (TPS)* Device (BARONova, San Carlos, CA) is a silicone spherical device connected to a smaller cylindrical bulb by a flexible catheter. The shape of this device is designed to take place across the pylorus, inducing a delayed gastric emptying. TPS has been approved by the FDA in 2019 for patients with a BMI of 35–40 kg/m² or 30–34.9 kg/m² with at least one obesity-related comorbidity.³⁷ Early results on TPS were retrieved from a pilot study on 20 patients, who achieved mean %EWL of 41.0% and mean %TBWL of 14.5% at 6 months.³⁸ More recently, a randomized clinical trial showed a mean difference of 6.7% in %TBWL between the TPS group and the controls at 12-month follow-up (%TBWL of

9.5% and %EWL of 30.9% at 12 months in the TPS group). SAEs were rare (2.8%) and included: esophageal rupture, device impaction, upper abdominal pain, gastric ulcer, vomiting, pneumothorax. Premature balloon removal occurred in 22.7% (46/203) of the cases.³⁸

SatiSphere (Endosphere, Columbus, OH) is a 20–25 cm long device composed of mesh spheres mounted on a nitinol wire with pigtail ends, which self-anchors in the distal part of the stomach or in the proximal duodenum and which is designed to delay the duodenal transit. SatiSphere received CE Mark regulatory approval but did not achieve FDA approval. Despite the mild effect on %TBWL, positive metabolic outcomes such as delay of glucose absorption and insulin secretion, or increasing in alterations of glucagon-like peptide 1 (GLP-1) kinetics were reported in a

small cohort of patients. The trial was prematurely interrupted due to a high percentage of device migration (48%).³⁹

Plenity (Gelesis, Boston, MA) is an orally administered capsulated device containing hydrogel particles that expand inside the stomach after water absorption, with consequent early satiety, delayed gastric emptying, and delayed glucose absorption. Plenity has recently obtained FDA approval for patients with a BMI of 25–40 kg/m² in association with dietary interventions.⁴⁰ The pilot study on 128 non-diabetic overweight patients showed that Plenity 2.25 g twice daily was associated with significant weight loss compared to the placebo group.⁴¹ These results were confirmed in the Gelesis Loss Of Weight (GLOW) study, which showed a significant reduction of Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) and greater weight loss in patients treated with Plenity over placebo, with a mean %TBWL of 6.4% versus 4.4% at 6 months.⁴² Better results were achieved in patients with untreated type-2 diabetes or elevated FPG.⁴¹ No SAEs were reported.⁴² More recently, the compatibility of Plenity with metformin was demonstrated in a 24-patient cohort.⁴³

Suturing/stapling devices

Suturing or stapling techniques aim to reduce the gastric capacity by changing the anatomy of the stomach.²³

Endoscopic Sleeve Gastroplasty (ESG) with Apollo OverStitch Suturing System is a technique aimed to restrict the gastric cavity into a sleeve-like configuration using the FDA-approved full-thickness suturing device (OverStitch; Apollo Endosurgery, Austin, TX) aided by a helix grasp through a double-channel therapeutic gastroscope (Figure 2).^{44,45} ESG procedure is potentially reversible and repeatable to achieve extra weight loss.⁴⁶ Its mechanism of action induces alteration in gastric capacity and motility, increases satiety and seems to induce ghrelin reduction.⁴⁶ In 2014, Sharaiha and colleagues⁴⁷ published the first results of ESG on 10 patients, showing a mean %EWL of 30% at a 6-month follow-up. More recently, the same authors reported a %TBWL of 14.4% at 6 months on 73 patients treated with ESG. A significant reduction in values of systolic blood pressure, HbA1C, triglycerides, and alanine aminotransferase were reported in patients treated with ESG at a 12-month follow-up.⁴⁸ Consistent

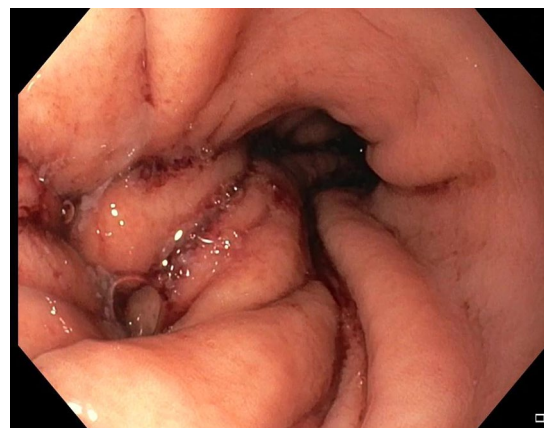


Figure 2. Endoscopic sleeve gastroplasty with the Apollo OverStitch endoscopic suturing system. Endoscopic appearance immediately after the procedure.

results in terms of %TBWL at 6 months were reported in recent retrospective or prospective series.^{45,49–51} In the largest cohort published so far, Alqahtani and colleagues⁴⁵ reported a %EWL of 64.3% at 6 months ($n = 369$) and of 67.5% at 12 months ($n = 216$). A higher rate of %EWL was reported by Graus Morales and colleagues,⁵² namely $75.4 \pm 85\%$ at 12 months, while Sartoretto and colleagues⁵⁰ and Barrichello and colleagues⁵¹ described a %EWL of 50.3% and 56.1% at 6-month follow-up, respectively. Long-term data were available in the series by Lopez-Nava and colleagues,⁵³ who reported a mean %EWL of 60.4% at 24 months. A recent meta-analysis concluded that ESG is associated to a mean %EWL of 57.7% (95% CI, 52.0–63.4) and a mean %TBWL of 15.1% (95% CI, 14.3–16.0) at 6-month follow-up.⁵⁴ ESG procedure has shown to be relatively safe, with a pooled rate of SAEs of 2.2% (95% CI, 1.6–3.1%), including perigastric fluid collection or leak, bleeding, and abdominal pain.⁵⁴ Incidence of less-severe adverse events (AEs) such as abdominal pain and nausea was variable, ranging from 20 to 90% across different series.^{45,48,51} When compared to surgery, two studies pointed out similar results in terms of efficacy and safety. Fayad and colleagues⁵⁵ and Novikov and colleagues,⁵⁶ in fact, reported a significantly higher %TBWL in patients treated with laparoscopic sleeve gastrectomy compared to ESG but a lower rate of SAEs in the ESG cohort. Table 2 summarizes ESG outcomes considering the most impactful studies.

Primary Surgery Endoluminal (POSE) consists of full-thickness tissue plications performed

Table 2. Outcomes of endoscopic sleeve gastroplasty.

Study	Number of patients	Age (mean)	Mean BMI	6 months %TWL	12 months %TWL	24 months %TWL
Lopez-Nava and colleagues ⁵³	154	NA	38.3 ± 5.5	15.8 ± 7.1	20.2 ± 12.2	21.3 ± 13.4
Alqahtani and colleagues ⁴⁵	1000	34.4 ± 9.5	33.3 ± 4.5	13.7 ± 6.8	15.0 ± 7.7	14.8 ± 8.5 ^a
Fayad and colleagues ⁵⁵	54	48	43.1	17.2	NA	NA
Sartoretto and colleagues ⁵⁰	112	45.1 ± 11.7	37.9 ± 6.7	14.9 ± 6.1	NA	NA
Sharaiha and colleagues ⁴⁸	91	43.86 ± 11.26	40.7 ± 7	14.4	17.6	20.9
Lopez-Nava and colleagues ⁴⁹	248	44.5 ± 10	37.8 ± 5.6	15.2	NA	18.6
Abu Dayyeh and colleagues ⁴⁶	25	47.6 ± 10	35.5 ± 2.6	53 ± 17	54 ± 40 ^b	45 ± 41 ^{b,c}

BMI, body mass index; NA: not available; %TWL: total body weight loss.
^a18-month follow-up.
^b%EWL.
^c20-month follow-up.

in the fundus and in the distal gastric body using an incisionless operating platform (IOP; USGI Medical, San Clemente, California, USA) (FDA approved for tissue apposition, received CE mark). The POSE procedure was shown to increase the sense of satiety by temporarily retarding the gastric emptying and to improve leptin levels and glucose homeostasis at the 15-month follow-up.⁵⁷ The efficacy of POSE was evaluated in a randomized multicenter trial, in which mean %TBWL in the POSE cohort ($n = 221$) was 4.9% compared with 1.4% in the lifestyle intervention group ($n = 111$). The co-primary endpoint of the study, namely the achievement of a %TBWL greater than 5% in more than 50% of patients, was not reached, but improvement of glycemic control, hypertension, and cholesterol levels were reported in the POSE group.⁵⁸ Better results were achieved in a European multicenter study, which reported a %TBWL of 13% and a %EWL of 45% in the active group versus 5.3% and 18.1% in the lifestyle group, respectively.⁵⁹ Consistent results with this trial were previously published by two observational Spanish cohorts.^{60,61} No SAEs were reported, except in the first trial, where one case of extra-gastric bleeding requiring surgical intervention and one case of hepatic abscess requiring interventional drainage were reported (overall SAEs rate of 4.7%).⁵⁸ A recent systematic review and meta-analysis by Gys and colleagues analyzed the efficacy and safety of ESG and POSE procedure. The authors concluded that pooled %EWL at

12 months was 68.3% for ESG and 44.9% for POSE procedure.⁶² The superiority of ESG over POSE procedure was confirmed in the recently published meta-analysis by Khan and colleagues.⁶³ In terms of safety, bleeding was described for both techniques, but ESG was associated to a higher number of perigastric collection, pulmonary complications, and leakage.⁶² Of note, Cohen and colleagues⁶⁴ recently questioned the scientific quality of studies evaluating the gastroplasty procedure, suggesting the need for more robust evidence. Recently, a POSE II procedure has been developed, and this consists of placing stitches at the level of the greater gastric curvature, and not at the fundus.

ESG with Endomina suturing system (Endo Tools Therapeutics, SA-ETT, Gosselies, Belgium) (not FDA approved, received CE mark) is a single-use over-the-scope device that allows creating a double plicature of the greater curvature through the use of interrupted sutures, transmural anterior-to-posterior endoscopic suture (Figure 3). The safety and feasibility of Endomina were evaluated in two studies by Huberty and colleagues,^{65,66} reporting %EWL of 31% at 6 months and 29% at 12 months. No SAEs occurred.

The articulating circular endoscopic device (ACE) (Boston Scientific Corporation, Natick, MA) (not FDA approved) consists of an endoscopic rotatable and retroflexable stapler creating full-thickness gastric volume reduction. Early

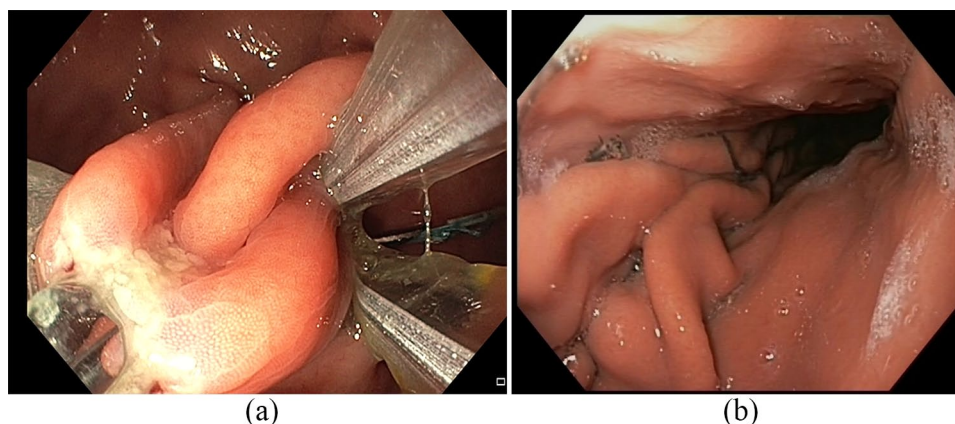


Figure 3. (a) Endoscopic sleeve gastropasty with the endomina suturing system. (b) Endoscopic sleeve gastropasty with the endomina suturing system: endoscopic appearance one.

results have shown technical feasibility and safety of this device on 17 patients, in which the main %EWL was 34.9% at 12 months.⁶⁷ Accordingly, in a multicenter study on 69 patients, similar results were achieved at a 12-month follow-up, while %EWL at 24 months was 21.0%.⁶⁸ No SAEs were reported in both series.^{67,68}

Malabsorptive techniques

Malabsorptive endoscopic techniques aim to physically prevent the contact between nutrients and the upper intestinal mucosa, emulating anatomical alterations of Roux-en-Y gastric bypass.

Duodenal-jejunal Bypass liner Endobarrier (DJBL) (GI Dynamics, Lexington, Massachusetts, USA) (not FDA approved, withdrawal of CE mark) is a 60-cm-long fluoropolymer sleeve anchored in the duodenal bulb and extending into the proximal jejunum. This system is contained within a capsule and is deployed under endoscopic and fluoroscopic control. Endoscopic removal is performed after 3–12 months, thanks to a specially designed hook that grasps the device inside a protective hood. Since its introduction in 2010, a wide number of studies have shown conflicting results in terms of efficacy and safety for this device. Five pivotal trials have compared DJBL with control or placebo group.^{69–73} The systematic review and meta-analysis conducted by the ASGE Bariatric Endoscopy Task Force concluded that DJBL induced a mean %EWL of 35.3% (95% CI, 24.6–46.1%) at 12 months.⁷⁴ Mean additional %EWL over the control group, however, was shown to be 9–12%, therefore unable to meet the expected 15% difference.^{74,75} In parallel, several reports have shown that DJBL system was associated with

significant improvement in glycemic parameters in patients with type-2 diabetes,^{74–79} but one meta-analysis failed to demonstrate statistically significant differences in terms of HbA1c in comparison with the control group.⁸⁰ The mechanisms associated with a positive metabolic effect are yet to be elucidated, but they may be similar to those already investigated in the Roux-en-Y gastric bypass.⁷⁸ Concerning the safety of this system, abdominal pain and nausea have been the most common mild AEs reported.⁷⁸ The most recent systematic review calculated a 3.7% rate of more severe SAEs, mainly including GI bleeding, hepatic abscess, and esophageal perforation.⁸¹ The rate of SAEs has been proved to significantly increase after 1 year of treatment.⁸² Early removal of the device was necessary in 24.1% of patients treated with DJBL.⁸¹ Of note, one multicenter, randomized, sham-controlled pivotal trial named ENDOtrial was prematurely abandoned after enrolment of 325/500 patients due to a relatively high incidence of hepatic abscess formation (3.5%).⁸³ For safety reasons, the device did not receive FDA approval, whereas CE mark was achieved in 2009, then withdrawn in 2017.⁸⁴

Gastroduodenojejunal bypass sleeve (GJBS) (ValenTx Inc, Carpinteria, CA) (not FDA approved) is a malabsorptive device 60 cm longer than EndoBarrier anchored at the gastroesophageal junction. In a small cohort of 22 patients, Sandler and colleagues found that 17/22 patients had the device correctly positioned at the 12-week follow-up. In this cluster of patients, GJBS induced a %EWL of 39.7%.⁸⁵ The same authors published the results of GJBS at 12 months on 13 patients. Among the six patients having fully attached functional devices, GJBS achieved a mean %EWL of 54% without experiencing any

SAE.⁸⁶ Significant improvement of comorbidities was reported in both series;^{85,86} however, more robust data are needed to confirm these results.

Revita duodenal mucosal resurfacing procedure (DMR) (Fractyl Laboratories, Cambridge, MA) (not FDA approved, received CE mark) consists of thermal ablation of duodenal mucosa through a balloon filled with heated water. This approach has shown to achieve only mild effects as a bariatric treatment but positive outcomes in terms of glycemic control in patients with type-2 diabetes. In the pilot study by Rajagopalan and colleagues, 39 patients with type-2 diabetes underwent DMR procedure, with consequent improvement of 1.2% in mean HbA1c at 6-month follow-up, without statistically significant difference depending on the length of the ablation at 6 months. Three cases of duodenal stenosis were reported, all managed with endoscopic dilation.⁸⁷ We might presume that adequate submucosal lift and avoidance of overlapping ablations might reduce the risk of this complication, but further data are needed. More recently, a prospective study on 46 patients was published by van Baar and colleagues. After the exclusion of 20% of patients due to technical failure, the procedure was associated with significant improvement of HbA1c, FPG, and HOMA-IR at 12 months. Mild to moderate AEs were reported in 52% of patients, while any patient experienced procedure-related SAEs.⁸⁸ Ongoing clinical trials are aimed to clarify the effects of DMR in patients with type-2 diabetes and other chronic diseases such as polycystic ovary syndrome.⁸⁹

Incisionless Anastomosis System (IMAS) (GI Windows, W. Bridgewater, Massachusetts, USA) (not FDA approved) consists of self-assembling magnets delivered through the endoscope into the terminal ileum and proximal jejunum to create an enteral diversion. The magnets are self-eliminated through the stools. A pilot study on 10 patients showed significant improvements of HbA1c and blood glucose levels in diabetic and pre-diabetic patients, as well as promising results in terms of weight loss: %TBWL and %EWL at 12 months of 14.6% and 40.2%, respectively. No device-related SAEs were reported.⁹⁰ More reliable studies are needed.

Other techniques

The AspireAssist Aspiration therapy (AA) (Aspire Bariatrics, King of Prussia, PA, USA) consists of a percutaneous gastrostomy A-tube

coupled with a SkinPort and an aspiration tube, aimed to partially drain the ingested food. This system was approved by FDA in 2016 for long-term use in patients aged over 22 years with BMI of 35–55 kg/m², after the failure of nonsurgical strategies, in association with lifestyle counseling and cognitive behavior therapy.^{91,92} Positive association between AspireAssist (AA) device and cardio-metabolic improvement (including HbA1c, triglycerides, high-density lipoprotein cholesterol, and blood pressure values) was reported.^{93,94} Several pivotal studies have investigated the AA system as a weight-loss strategy.⁹⁴ Of these, the pivotal aspiration therapy with adjusted lifestyle therapy (PATHWAY) study showed higher weight loss in the AA group ($n = 111$) compared with the lifestyle counseling group ($n = 60$): %TBWL 12.1% versus 3.5% and %EWL 31.5% versus 9.8% at 52 weeks.⁹³ Recently, the 4-year long-term maintenance study was published on 58 participants who completed 1 year of treatment. Of these, 43 patients withdrew the study before the fourth year, due to adequate weight loss (58%), lack of efficacy, or local irritation (42%). Patients achieved a mean %EWL of 50.82% and mean %TBWL of 18.7% at 4-year follow-up.⁹⁵ In the meta-analysis by Khan and colleagues, AA system was associated with a mean %EWL of 50.85% (range 46–55.7%) and to a mean %TBWL of 15.4% (range 9–21.7%) at 12 months. No statistically significant difference was found in terms of %EWL and %TBWL between patients treated with AA, ESG, and POSE.⁶³ Concerning safety, SAEs were shown to be infrequent, including severe abdominal pain, pre-pyloric ulceration, peritonitis, secondary fistula, and A-tube replacement.^{93,95} No significant eating disorders or malnutrition were reported after AA treatment in the available series.^{93–95}

Botulinum toxin A (BTA) (not FDA approved) injection has been used in BE because of its effect on blocking the acetylcholine release that induces a transitory delay of the gastric emptying and reduction in maximal gastric capacity.^{96,97} A systematic review by Bustamante and colleagues⁹⁸ stated against the use of BTA as not effective in achieving a significant TBWL greater than placebo. These results were confirmed in a very recent randomized clinical trial.⁹⁹

Absorbable biocompatible material injection has been recently introduced as a complementary treatment together with IGB placement. The procedure involves the injection of hyaluronic acid

(HA) at the level of the esophagogastric junction. In a prospective multicenter randomized trial, 101 patients were treated either (A) with IGB alone, (B) with IGB followed by HA at IGB removal, or (C) with HA and IGB at 6 months. The study showed a significantly lower weight loss in the HA group (%TBWL 5.8%) compared with the IGB cohorts at 6 months (%TBWL 8% and 10.8%). Combined treatment with HA was significantly superior at 18 months only compared with IGB alone. One hepatic abscess was recorded in the IGB followed by the HA injection group.¹⁰⁰

Choosing the right procedure in bariatric endoscopy

Obesity is a chronic systemic disease that requires a multidisciplinary approach in prevention, treatment, and follow-up.^{2,5,101} Before recommending a bariatric procedure, we suggest to evaluate the patient in a multidisciplinary team composed by the endoscopist, the gastroenterologist, the surgeon, the anesthesiologist, the psychiatrist, the nutritionist, and the endocrinologist. All patients addressed to our center are usually evaluated by the endocrinologist first, for setting the diagnostic work-up that is tailored according to each patient's characteristics. As for any other major abdominal surgical procedures, preoperative assessment includes medical history and physical examination, laboratory tests including fasting blood glucose, serum lipid profile, thyroid hormones, and liver function tests, chest X-ray, electrocardiography.^{5,102,103} Moreover, all patients undergo a glucose-tolerance test and insulin test, abdominopelvic ultrasound, barium swallow radiographic study, upper GI endoscopy with *Helicobacter pylori* research.^{5,102,103} Of note, these examinations allow a baseline reference to make the comparison in the posttherapeutic period and to highlight the benefits obtained from the treatment. To exclude clinical contraindications to bariatric treatments, nutritional and psychological/psychiatric counseling are always performed as first-level investigations, whereas a cardiologist and/or pneumologist evaluation is offered to selected patients.^{5,102} Of note, polysomnography should be routinely done in patients with a high-risk of sleep apnea.¹⁰² As psychological disorders may negatively affect postoperative bariatric outcomes,^{104,105} a careful selection of patients should be performed to exclude patients with poorly controlled or major psychiatric disorders (i.e. drug or alcohol abuse, nonstabilized psychotic disorders, severe depression, personality, and eating disorders, unless specifically advised by a psychiatrist experienced in obesity).¹⁰⁶⁻¹⁰⁹

Nowadays, in fact, psychiatric conditions should be diagnosed and treated before addressing the patient to any bariatric surgical treatment.^{5,106,110}

If guidelines counseling the right procedure for bariatric surgical treatments are widely available,¹⁰⁷ endoscopic procedure still miss of uniform recommendations. During the multidisciplinary reunions, once selected, the patient who might benefit from interventional bariatric treatment, we carefully assess all procedure-related contraindications, which are usually shared by the main endoscopic procedures (i.e. previous GI surgery, GI structural, or functional abnormality, coagulation disorders, GI tract obstruction or bleeding, pregnancy, breastfeeding, severe liver disease, and any contraindication to endoscopy).^{27,37,46,51,57,82,86,88,91,111} The type of surgical or endoscopic procedure best fitting the patient is chosen according to personal history, dietary habits, lifestyle, and the clinical evaluation performed. As it concerns BMI, almost every procedure has different indications related to it (*see in each device section*). Among the most widespread endoscopic procedures available in our Department, we mainly suggest IGBs as a bridge to surgery in selected cases^{112,113} whereas we would suggest ESG for patients with BMI between 30 and 40, and as a bridge to surgery in super obese patients, or patients unfit surgery. For the treatment of metabolic conditions such as type-2 diabetes, more robust evidence is needed to compare endoscopic and surgical bariatric procedures. We believe that there is still a certain discrepancy in terms of treatment choice for obesity among reference centers and the scientific community is experiencing the absolute need of universal criteria to choose the right bariatric treatment for each patient.

Conclusion

Obesity is a major cause of death, with a rising incidence over time. It is not only linked to overeating, but it can be considered as a complex disease where genetic and environmental factors are tied together. Endoscopic bariatric therapies include a complex network of procedures that may bridge the gap of efficacy and safety in the management of obesity, but further evidence is required. Among the available endoscopic techniques, the procedure best fitting each patient should be tailored following a multidisciplinary approach. Despite promising attempts, specific and proper guidelines are still a key unmet need: it is, therefore, fundamental to establish universal

criteria, easy to apply and of undoubted scientific value in order to orientate the choice of the specific bariatric treatment best fitting each patient.


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Conflict of interest statement

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