From surgery to endoscopy: the evolution of the bariatric discipline

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Abstract

Obesity, with its increasing morbidity and prevalence, is now a worldwide public health problem. Obesity and its related comorbidities impose a heavy burden on societal health and the economy. The practice of bariatric surgery has evolved from its early surgical procedures, many of which are no longer routine operations. With clinical practice, research, and experience, bariatric surgery has gradually become an important last resort for the control of weight and obesity-related metabolic diseases in moderately and severely obese patients. However, there is still room for further improvements in bariatric surgical procedures, especially with regard to long-term issues and complications. Endoscopic weight loss technology has developed rapidly in recent years. The advantages of this technology include minimal invasiveness, an obvious weight loss effect, and few complications, thus filling the gap between medications and lifestyle adjustments and surgical treatment of obesity. Endoscopic weight loss technology may even replace surgical bariatric procedures. This review summarized the current status of bariatric metabolic surgery and newly developed bariatric endoscopic procedures.

Keywords: Bariatric surgery; Endoscopic bariatric techniques; Endoscopic weight loss technology; Intragastric balloons; Obesity; Sleeve gastrectomy

Introduction

Obesity is a high-risk factor for multisystem diseases such as diabetes, metabolic syndrome, cardiovascular and cerebrovascular diseases, cancer, and psychological diseases. These diseases seriously affect the quality of life of obese patients. Changes in society, the economy, and the environment have led to tremendous shifts in lifestyle factors such as dietary habits and physical activity, and obesity has gradually become a global public health issue that threatens the physical and mental health of the world's population.[1] According to criteria for the Chinese population, the latest national survey found that more than half of Chinese adults are overweight or obese.[2] In recent years, an increasing evidence has confirmed that weight loss can effectively improve insulin resistance, abnormal blood lipid metabolism, and physical function; protect vascular endothelial function; provide multisystem benefits; improve quality of life; and reduce the incidence of related complications.[3]

Current clinical guidelines recommend multidisciplinary obesity treatment, including patient selection, intervention, and long-term follow-up to maintain the effect of weight loss. However, for many moderately and severely obese patients, it is difficult to achieve effective weight control through only diet modification, exercise, and pharmacological therapy due to low long-term adherence to the treatment regimen. In addition, lost weight is frequently regained easily. For obese patients who cannot lose weight satisfactorily through lifestyle adjustment and pharmacological therapy, bariatric surgery has become the most effective therapeutic option to achieve excellent and long-lasting weight loss effects and reduce obesity-related comorbidities.[3,4]

As an extension of bariatric metabolic surgery, minimally invasive treatment is a major trend in bariatric treatment for obese patients. In recent years, minimally invasive endoscopic bariatric strategies, such as intragastric balloons (IGBs), endoscopic sleeve gastroplasty (ESG), and endoscopic duodenal-jejunal bypass liners (EDJBLs), have provided a new direction for bariatric discipline development, with the advantages of less trauma, fast recovery, high cost effectiveness, and fewer complications. Preliminary clinical studies have confirmed the encouraging weight loss effect of endoscopic treatment, which may be comparable to that of bariatric surgery, especially when endoscopic treatment is combined with minimally invasive bariatric procedures.[5-7] This review summarized the current research status of bariatric surgery and endoscopic bariatric treatment.

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Bariatric Surgery

In the 1950s, Henriksen in Gothenburg first attempted surgical treatment of obesity after noticing the significant weight loss of patients with extensive small bowel resection.[4] In the following decades, dozens of surgical bariatric procedures were created to treat obesity, but various short-term and long-term complications of these procedures were observed. Therefore, bariatric surgery has been continuously explored and developed.[3,4] The trend toward minimally invasive bariatric surgery shows the evolution and refinement of the discipline. In the early stages of bariatric surgery development, open surgery was performed. In the 1990s, the rapid development and application of laparoscopic technology greatly reduced the trauma and postoperative complications caused by open surgery, strongly promoting the development of bariatric metabolic treatment. In addition, robotic surgical systems have been rapidly popularized in recent years, providing advantages such as flexibility and accessibility of the operating arm, clearer and more realistic surgical field images, and ergonomic design, all of which extend the careers of surgeons and improve the accuracy of surgery. Robotic surgical systems are especially beneficial for complicated cases, such as revision surgery and bariatric surgery for superobese patients.[8]

The global number of bariatric metabolic surgeries is increasing annually. In 1997, only 40,000 bariatric metabolic surgeries were performed worldwide. In 2018, the number of bariatric metabolic surgeries worldwide exceeded 696,191, which was an increase of more than 17-fold, and almost all of these operations (99.3%) were performed under laparoscopy.[9,10] With the development of surgical experience and evidence-based medicine, Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), biliopancreatic diversion and duodenal switch (BPD/DS), and one anastomosis gastric bypass (OAGB) have become the most popular and standard bariatric surgeries in the world.

There is still room for improvement in these existing standard bariatric surgeries, especially in the face of some long-term events. As a new medical discipline, bariatric and metabolic surgery is progressing, with continuous experience and improvement.

Roux-en-Y gastric bypass

The Roux-en-Y structure used for gastric bypass surgery was first reported by Griffen *et al.*[11] The RYGB procedure is based on gastrojejunostomy, in which a jejunum-jejunal anastomosis is created, which can significantly reduce bile reflux-related problems and the tension of the gastrojejunal anastomosis. In 1994, Wittgrove *et al*[12] first reported laparoscopic RYGB surgery, which has gradually become one of the gold-standard bariatric surgical procedures, with remarkable weight loss effects and few complications. The pathophysiological mechanism underlying RYGB is the reduction of the volume of stomach, which reduces nutrient absorption and regulates the endocrine metabolism of the small intestine through the construction of the alimentary and biliopancreatic limb. Studies have shown that RYGB results beyond 25–35% lasting total body weight loss (TBWL) (or 50–80% excess weight loss [EWL]) in the short and long terms and is also very effective in treating type 2 diabetes.[13,14]

However, RYGB has more surgical steps than other types of bariatric surgeries, leading to a higher incidence of surgery-related complications. Moreover, the bypassed portion of stomach cannot be viewed by conventional gastroscopy; therefore, if cancer occurs after surgery, early diagnosis is almost impossible. The design of operation may also lead to marginal ulcers of the gastrojejunal anastomosis, internal hernia, dumping syndrome, and postoperative deficiency of trace elements and vitamins.[15] Nonetheless, the major weight loss and related multisystem benefits that RYGB provides to obese patients have led to the widespread use of RYGB for >40 years. For a long time, RYGB ranked first globally in the number of bariatric surgeries performed each year. This status remained unchanged until the more convenient SG unexpectedly showed a weight loss effect that was comparable to that of RYGB and a lower risk of complications. Currently, RYGB ranks second in the number of global bariatric surgeries each year, only after SG. RYGB remains an important alternative for revision surgery following SG, when weight regain with associated reflux or an enlarged fundus occurs or other bariatric surgery results are unsatisfactory.[16]

Although the basic structure and form of RYGB have been standardized for decades, improvements in details, such as adjustments to the volume and shape of the gastric pouch and changes in Roux limb length, continue to be made and are expected to improve weight loss and reduce adverse events.[13,17]

Biliopancreatic diversion and duodenal switch

Based on the experience on jejunum-ileum bypass, Scopinaro *et al*[18] proposed BPD in 1979. BPD includes distal gastrectomy and closure of the duodenal stump, gastroileal anastomosis, and ileoileal anastomosis to create a 50-cm common channel and a 250-cm alimentary channel. The weight loss effect of this procedure is excellent, with an average permanent reduction of 75% EWL, but there is also a greater probability of complications such as diarrhea, abdominal distension, anemia, ulcers, protein malabsorption, dumping syndrome, peripheral neuropathy, and Wernicke's encephalopathy.[19] In 1988, Hess *et al*[20] developed BPD/DS as a hybrid procedure between Scopinaro's BPD and the Roux-en-Y duodenojejunostomy procedure developed by DeMeester. BPD/DS includes SG, transection of the duodenum distal to the pylorus, and creation of an alimentary limb 200–250 cm long, thereby reducing the problems of anastomotic ulcers and dumping syndrome while retaining excellent weight loss effects.[21] However, technical complexity and the risk of short-term and long-term complications limit the application of BPD/DS, especially in the era of laparoscopy. In addition, this surgery requires an adequate follow-up plan because the risk of malnutrition is significantly increased compared with other bariatric surgeries.[22]

In 2010, single-anastomosis duodenal-ileal bypass with sleeve gastrectomy (SADI-S) was reported as a simplified version of BPD/DS.[23] Short-term research results suggest that there are no significant differences between SADI-S and BPD/DS in terms of the %EWL ($81.20 \pm 3.71\%$ for BPD/DS; $74.82 \pm 3.45\%$ for SADI-S) and improvement of obesity-related diseases, malnutrition, and postoperative complications.

Statistics in recent years have shown that the proportion of BPD/DS procedures among all bariatric and metabolic surgeries is gradually decreasing. At present, BPD/DS and related procedures are more often used in superobese ($BMI \geq 50$ kg/m^2) patients or in those with inadequate weight loss after SG in the absence of reflux symptoms, with maximal %EWL ranging from 70% to 80% at two years.[24]

Sleeve gastrectomy

SG was originally conceived as a restrictive component of BPD/DS in high-risk obese patients with a BMI above 50 kg/m^2. However, after undergoing the first stage of SG as the initial surgery before switching to BPD/DS or RYGB in the second stage, the %EWL of these patients reached at least 35%, which gave researchers great encouragement.[25] With the advancement of minimally invasive technologies and the accumulation of surgical experience, SG eventually became the first choice for the treatment of morbid obesity in the laparoscopic era. Laparoscopic sleeve gastrectomy (LSG) creates a sleeve-shaped stomach along the lesser curvature of the stomach, which leads to weight loss through both restrictive and endocrine mechanisms. A large number of prospective and retrospective studies have shown that the long-lasting weight loss and efficiency of obesity comorbidity improvement with LSG are comparable to those of RYGB.[26-28] Due to its effectiveness, relatively simple technical procedure, short duration, and low complication rates, including approximately 1.0% for margin bleeding, 1.06% for leakage, and 0.35% for postoperative stenosis, LSG rapidly became the most popular surgical bariatric operation after it was listed as an indication for bariatric surgery in 2008.[29,30]

However, the incidences of gastroesophageal reflux and dysphagia are higher after SG than those after other procedures, which limits the long-term effects of surgery and may be severe enough to require revision to gastric bypass for resolution. Due to the lack of a bypass, SG is also not perfect in improving obesity comorbidities for patients with superobesity, and there is a risk of obesity recurrence and poor postoperative diabetes treatment.[31,32] Studies have evaluated the addition of a bypass based on SG, such as SADI-S, duodenal-jejunal bypass with sleeve gastrectomy (DJB-SG), and single-anastomosis duodenal-jejunal bypass with sleeve gastrectomy, to enhance the regulatory effect on obesity metabolism.[33]

One anastomosis gastric bypass

OAGB consists of a single gastrojejunal anastomosis between a long gastric pouch and a jejunal omega loop derived from the loop gastric bypass procedure initially described by Mason and Ito[34] in 1967. Later, Rutledge[35] and Carbajo *et al*[36] successively modified this procedure to reduce the occurrence of bile reflux and anastomotic tension. In the current OAGB procedure, the gastric pouch is narrow and long; the position of the anastomosis is low; the tension of the anastomosis is low; the left gastric vascular arch of the gastric pouch is fully preserved; and the blood supply of the anastomosis is rich. Therefore, theoretically, the incidence of anastomosis-related complications in the OAGB perioperative period should be lower than that of RYGB. In terms of the operation itself, OAGB can be regarded as a simplified version of RYGB, with significantly lowered operation difficulty and a significantly shorter learning curve and operation time.[37,38]

There is a long-standing controversy about the weight loss benefits of OAGB and possible complications such as bile reflux and marginal ulcers. It is speculated that the different conclusions are related to differences in the length of the biliopancreatic limb, multidisciplinary participation in weight loss management, and insufficient sample size. Based on years of clinical practice experience, in March 2018, the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) officially recommended OAGB as a standard weight loss metabolic surgery.[39]

A recent study included 1075 patients who regained weight after initial bariatric surgery, such as LAGB, SG, and gastric plication, underwent OAGB as a revision surgery. The %EWL was 65.2%, 68.5%, and 71.6% at 1 year, 2 years, and 5 years after revision surgery, respectively. In addition to greatly improving type 2 diabetes and hypertension, the number of complications that occurred following OAGB as revision surgery was very low. The mean leak rate was 1.54%, the marginal ulcer rate was 2.44%; the anemia rate was 1.9%; and mortality was 0.3%.[40] In addition to being an effective option for primary bariatric surgery, OAGB achieves good effects as a revision option following other surgical procedures. Nevertheless, because of the higher rate of long-term complications compared with RYGB and SG, OAGB is currently not a routine first choice for many surgeons. However, the choice of bariatric procedure may be related to the medical background and clinical experience of the doctor. A recent survey showed that OAGB is the second most popular weight loss surgery after SG in India.[33]

Endoscopic Bariatric Techniques

Inspired by the clinical weight loss results caused by the reduced gastric volume in patients with gastroliths, Nieben and Harboe[41] first reported the results of an endoscopic IGB procedure in 1982, which opened the door to endoscopic bariatric treatment strategies. The pathophysiological mechanisms underlying endoscopic bariatric techniques are mostly similar to those of surgical bariatric procedures and mainly include limiting gastric capacity, reducing nutrient absorption, and promoting the non-absorbed discharge of gastric contents. Compared with bariatric surgery, endoscopic bariatric surgery is a more recently developed treatment option. Except for IGBs, most of the clinical practice experience with endoscopic bariatric strategies is far inferior to that of surgical operations in terms of time and scale, and the long-term effects of these techniques on metabolic changes remain to be studied.

At present, the most widely practiced endoscopic bariatric strategies are IGBs, ESG, and EDJBLs [Figure 1]. These methodologies provide a useful treatment alternative for obese patients in whom medications or lifestyle changes have proved unable to achieve long-lasting weight loss, especially when these patients are unwilling to undergo bariatric surgery or fail to meet the criteria for bariatric surgery. The preliminary clinical research results on endoscopic bariatric procedures are encouraging, with little trauma, reversibility, fast recovery, cost-effectiveness, and effective weight loss. Endoscopic bariatric procedures are expected to fill the gap between conservative treatment and surgical bariatric procedures.[42] Recent studies suggest that when combined with drug treatment, endoscopic bariatric procedures can achieve effects similar to those of surgical procedures.[5]

Intragastric balloons

The design of an IGB allows the balloon to be sent into the stomach via gastroscopy or swallowed by the patient. IGBs can be filled with liquid or gas to reduce the effective volume of the stomach, thereby lowering the threshold for inducing a feeling of fullness after eating, stimulating gastric chemical and motor receptors, regulating levels of ghrelin and other related hormones, reducing food intake, and delaying stomach emptying to achieve the goal of weight loss. Early IGBs were small and had poor elasticity, resulting in less than ideal weight loss effects, a large number of complications, and their removal from the market.[43]

Continuous improvement and innovation of the technology and materials have facilitated the IGB procedure and made it safer for practical clinical applications. A meta-analysis of 5668 obese patients treated with IGBs showed that the IGB procedure can effectively improve diabetes indicators and abnormal blood lipid metabolism.[44] Three types of IGBs are approved by the USA Food and Drug Administration (FDA) and European Certification Group for the treatment of obesity: the Orbera balloon (Apollo Endosurgery, Inc., Austin, TX, USA), the ReShape Duo balloon (ReShape Medical, Inc., San Clemente, CA, USA), and the Obalon capsule balloon (Obalon Therapeutics, Inc., Carlsbad, CA, USA).[45]

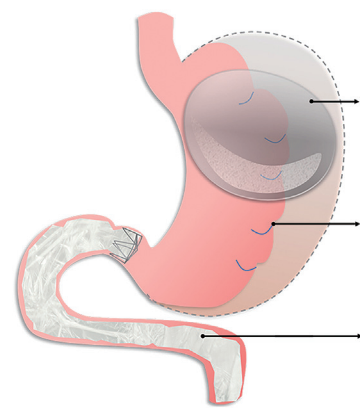

Figure 1: The three most widely practiced endoscopic bariatric strategies in the world.

Orbera balloon

The Orbera balloon is the most widely and longest used IGB. The Orbera balloon is made of silicone material and is delivered to and removed from the gastric cavity using a gastroscope. The inside of the balloon is connected to the catheter through a one-way valve, and approximately 400–750 mL of methylene blue and physiological saline mixture is injected to expand the balloon into a spherical shape so that it occupies the stomach space. If the balloon leaks or ruptures, methylene blue is excreted from the body through the urinary system, turning the urine blue and revealing the problem in a timely manner. Considering the texture and safety of the material, the placement time of the IGB is generally not >6 months.

A meta-analysis of 1683 patients who underwent an Orbera balloon implantation procedure to lose weight showed that the %TBWL at 3 months, 6 months, and 12 months after IGB implantation was 12.3%, 13.16%, and 11.27%, respectively, showing a significant weight loss effect.[46] The most common adverse reactions after IGB placement were pain (33.7%), nausea (29.0%), gastroesophageal reflux disease (18.3%), and gastric mucosal erosion (12.0%). In most patients, proton pump inhibitors and symptomatic treatment improved these adverse reactions and allowed the patient to gradually tolerate the IGB. However, approximately 7.5% of patients still needed to undergo premature balloon removal because they could not tolerate the balloon. Severe complications, including gastric ulcers (2.0%), balloon displacement (1.4%), small bowel obstruction (0.3%), perforation (0.1%), and death (0.08%), were rare, and among these complications, perforations only occurred in patients with a history of gastric surgery. All deaths (four patients) were secondary to perforation or aspiration. Therefore, for patients who are planning to undergo gastroscopic bariatric treatment, individualized and detailed risk assessments are necessary.[7]

Reshape duo balloon

The ReShape Duo balloon is a two-balloon device that is placed and retrieved through a gastroscope; the two balloons are connected by a soft silicone rod in the middle. Each balloon is filled with 450 mL of a methylene blue and physiological saline mixture, and after 6 months in the stomach, the device is removed with a gastroscope. If one of the balloons leaks or ruptures, the methylene blue will change the color of urine, and the leaking balloon can be removed while the other balloon can be retained to prevent device displacement. The two-balloon design prevents premature failure of the device, better conforms to the curvature of the human stomach, and improves patient tolerance.[47]

The ReShape Duo two-balloon device significantly reduces the incidence of serious adverse events such as displacement, obstruction, and perforation compared with the Orbera balloon device, but the incidence of common postoperative adverse reactions such as abdominal pain, nausea, vomiting, gastroesophageal reflux disease, gastric ulcer, and mucosal erosion is still relatively high.[7]

Obalon balloon

The Obalon balloon device consists of a capsule and a catheter. The capsule contains folded and compressed balloons, each with a capacity of approximately 250 mL, and is swallowed directly into the stomach. Gas is then injected into the balloons under X-ray observation. According to the patient's tolerance, three balloons are swallowed at once or individually and removed by gastroscopy within 6 months. Obalon balloons are small in size, independent of each other, and contain gas, which, compared with liquid-filled balloons, reduces irritation to the patient, improves safety, and is more advantageous for adolescent obese patients.[45,48] Common adverse reactions are similar to those of other balloon devices, mainly nausea and mild abdominal pain, and serious adverse events are rare. However, leaking occurs more easily with gas-filled balloons than with liquid-filled balloons, and leaking balloons must be removed by gastroscopy, which is a disadvantage of the Obalon balloon.

In addition to the previous three classic IGB devices, many balloon devices are in development with the aim of reducing complications while improving the efficiency of weight loss. These devices have not been certified by the US FDA or European Certification Group, and their clinical applications are still limited.[45,49] IGB procedures are minimally invasive and simple to perform, but similar to surgical bariatric surgery, there is no perfect procedure; therefore, research is ongoing.

For many obese patients, IGB procedures are a low-cost opportunity to cultivate good diet and exercise habits during the period of IGB placement, thus providing a basis for other weight loss strategies to be successful. However, the time of IGB placement to assist patients with weight loss is generally <6 months. After the balloon is removed, a considerable number of patients regain weight. Of course, due to the minimally invasive nature of the IGB procedure itself, IGB insertion can be repeated if the patient is willing to pay for the procedure.

Endoscopic sleeve gastroplasty

ESG is a minimally invasive and incisionless procedure for bariatric treatment. Since the use of ESG was first reported in 2013,[50] an increasing number of clinical results have confirmed its effectiveness and durability for weight loss in obese patients.[51] In ESG, the Overstitch system (Apollo Endosurgery, Inc.) is typically used to make a series of intermittent or continuous full-thickness sutures in the stomach from the antrum to the cardia to reduce the gastric cavity by creating more gastric folds. The procedure is named after the postoperative shape of the stomach, which resembles that with surgical SG. To further improve or maintain the effect of weight loss, ESG can be repeated if necessary or performed as an effective revision for surgical weight loss surgery.[52,53] Other than the control of caloric intake, the pathophysiological mechanisms of ESG still need to be further explored.[54] A meta-analysis of 1859 obese patients who underwent ESG showed that at 6 months, 12 months, and 24 months after surgery, the average %TWL was 14.86%, 16.43%, and 20.01%, respectively, and the average %EWL was 55.75%, 61.84%, and 60.40%, respectively.[55] The incidence of pooled serious adverse events was 2.26%, mainly gastrointestinal bleeding and perigastric effusion, which accounted for 1%, and no procedure-related mortality was reported.

In the <10 years since the use of ESG was first reported, the effectiveness, safety, and durability of ESG for weight loss have attracted the attention of researchers. Recent research shows that, compared with dietary exercise adjustment and IGB procedures, the weight loss effect of ESG is more obvious and longer lasting.[56,57] Compared with surgical bariatric procedures such as LSG, ESG has a slightly lower weight loss effect but is safer and more cost-effective.[58,59] Moreover, compared with LAGB, the %TWL of ESG is higher and longer lasting, with fewer complications.[6]

Recently, the results of a prospective study cohort with a 5-year follow-up after ESG (currently the longest follow-up after ESG) were reported.[60] This study included 216 obese patients. The average %TWL was 15.6%, 14.9%, and 15.9% at 1 year, 3 years, and 5 years after surgery, respectively. In addition, 90% and 61% of obese patients maintained >5% and 10% TWL, respectively, at 5 years after the procedure. However, due to the complicated control of ESG equipment and higher skill requirements for endoscopy, many endoscopists worry that the learning curve is too long and are hesitant to perform ESG, which may affect the further promotion of ESG.

To further improve the effectiveness and safety of ESG, researchers are continuing to explore different aspects of the procedure, such as simplifying surgical methods, improving the strength of sutures, and combining other treatments.[61-63] A study published in 2020 demonstrated that treatment with ESG combined with liraglutide greatly improved the effect of weight loss under the premise of ensuring safety.[5] Although the research and development history of ESG are still short, a number of studies have shown the great potential of this procedure for weight reduction.

Endoscopic duodenal-jejunal bypass liners (EndoBarrier)

The EndoBarrier (GI Dynamics, Inc., Lexington, MA, USA) is a duodenojejunal bypass liner that extends a 60 cm tubular mantle from the bulb of the duodenum to the upper end of the jejunum. In addition to preventing chyme from contacting the small intestine and reducing digestion and absorption, this liner speeds up the passage of food through the proximal small intestine and inhibits the secretion of hormones related to insulin resistance, thus leading to a weight loss effect.

A multicenter randomized controlled trial involving 77 patients indicated that the %EWL of the experimental group and the diet control group were 32.0% and 16.4%, respectively, and the blood glucose control effect was satisfactory at 6 months after surgery.[64] This procedure improves type 2 diabetes and dyslipidemia more effectively than reducing weight, suggesting that it may be a better choice for patients with type 2 diabetes with mild to moderate obesity. However, this device has the risk of displacement and intestinal obstruction after placement. In addition, possible complications include hepatic abscess, upper gastrointestinal bleeding, cholangitis, and pancreatitis, and a small number of patients even have intolerable pain and need to have the device removed. A recent multicenter double-blind clinical trial (ENDOMETAB) was terminated early due to a higher-than-expected incidence of hepatic abscess-related adverse events, and related clinical studies were also halted.[65]

This procedure is still in the preliminary development and practice stage in China and abroad, and further optimization of the device to reduce adverse reactions (such as hepatic abscesses, device displacement, and abdominal pain) may be the greatest obstacle that needs to be overcome.

Other endoscopic techniques in research

Other gastroplasty methods include transoral gastroplasty, the transoral endoscopic restrictive implant system, ACE stapler, and primary obesity surgery endoluminal (POSE). However, these methods are limited by poor operability, unsatisfactory results, and a high risk of complications, and have gradually been replaced by ESG in recent years.

Endoscopic intragastric botulinum toxin-A and gastric electrical stimulation (GES) are currently under preliminary exploration as new endoscopic bariatric strategies designed to affect gastric emptying. Preliminary results suggest that these strategies are conducive to weight control, but their detailed parameters, effectiveness, and complications need to be evaluated and confirmed in further studies.[66,67]

Duodenal mucosal resurfacing (Fractyl Laboratories, Inc., Lexington, MA, USA) is a recent innovative technique based on the EDJBL technique for the treatment of type 2 diabetes under endoscopy. The principle of duodenal mucosal resurfacing is to insert a miniature balloon catheter into the duodenum with an endoscope and then inject hot water into the catheter to ablate the duodenal surface mucosa.[68] Although recent research on this technology shows that its safety is acceptable, the duration of its effect on type 2 diabetes and weight improvement needs to be verified by long-term clinical studies.[7]

The Endoluminal Bypass (ValenTx, Inc., Carpinteria, CA, USA) technique is similar to that of the EndoBarrier. The Endoluminal Bypass device has a 120 cm liner that mimics the pathophysiological effect of RYGB. This device is still in the small-scale preliminary exploration stage, and its clinical effect is not clear.[7]

Transoral outlet reduction has been applied to some patients who experienced weight regain after a surgical procedure, and compensatory dilation of the gastric cavity was observed under endoscopy. Studies of the use of the Overstitch system to shrink and suture the outflow tract to safely and effectively reduce weight gain are ongoing.[7,69] Some researchers have also attempted endoscopic sclerotherapy and radiofrequency treatment on the expanded outflow tract to reduce anastomosis and improve compliance to achieve weight control.[70,71]

For Adolescents

In the past few decades, the prevalence of childhood obesity, which is also often difficult to control solely by diet and exercise, has risen sharply. For obese children, there are hidden risks for rapid weight gain as adults. For obese people who have been obese since childhood, obesity-related comorbidities such as cardiovascular and cerebrovascular diseases and diabetes have more extensive and severe effects. An increasing number of studies continue to support the benefits of early intervention for severely obese adolescents.[72,73] Compared with adults, the weight loss effects of adolescents undergoing bariatric surgery are similar, with fewer complications and greater safety. However, long-term deficiencies in nutrients such as iron, vitamin B12, vitamin D, and vitamin B1 are potential problems that may affect the growth and development of adolescents.[73]

Due to the special growth and development status of adolescents, consensus has not been reached on bariatric surgery, and there are relatively few high-quality research studies.[74] Currently, the most widely used surgical bariatric procedures for children, adolescents, and adults are SG and RYGB. Compared with RYGB, SG is simpler, and the risk of nutrient deficiency is lower, and so the advantages are more obvious.[75] Due to the higher incidence of complications, BPD-DS and AGB have gradually been withdrawn from mainstream use in recent years and are currently not recommended for weight loss in young people.[72] For adolescents, a minimally invasive and reversible endoscopic bariatric strategy may be a more worthwhile option than RYGB or SG. Preliminary research suggests that IGBs and ESG have not only good effects in obese adolescents but also lower incidences of adverse reactions and smaller impacts on future growth and development.[76,77]

Conclusion

The treatment of obesity through bariatric surgical procedures has gradually progressed from open surgery to minimally invasive and refined procedures. Although there is still no perfect bariatric metabolic surgical procedure, these procedures, including endoscopic procedures, are continuously progressing and improving. Further advances will improve opportunities for obese patients to lose weight and to prevent and treat obesity multisystem comorbidities, which will also greatly reduce the pressure on national health and economic systems caused by obesity and obesity-related comorbidities.

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Conflicts of interest

None.

References

1. Jaacks LM, Vandevijvere S, Pan A, McGowan CJ, Wallace C, Imamura F, *et al*. The obesity transition: stages of the global epidemic. Lancet Diabetes Endocrinol 2019;7:231–240. doi: 10.1016/S2213-8587(19)30026-9.
2. Pan XF, Wang L, Pan A. Epidemiology and determinants of obesity in China. Lancet Diabetes Endocrinol 2021;9:373–392. doi: 10.1016/S2213-8587(21)00045-0.
3. Wharton S, Lau D, Vallis M, Sharma AM, Biertho L, Campbell-Scherer D, *et al*. Obesity in adults: a clinical practice guideline. CMAJ 2020;192:E875–E1875. doi: 10.1503/cmaj.191707.
4. Wiggins T, Majid MS, Agrawal S. From the knife to the endoscope – A history of bariatric surgery. Curr Obes Rep 2020;9:315–325. doi: 10.1007/s13679-020-00386-x.
5. Badurdeen D, Hoff AC, Hedjoudje A, Adam A, Itani MI, Farha J, *et al*. Endoscopic sleeve gastroplasty plus liraglutide versus endoscopic sleeve gastroplasty alone for weight loss. Gastrointest Endosc 2021;93:1316. e1-1324.e1. doi: 10.1016/j.gie.2020.10.016.
6. Novikov AA, Afaneh C, Saumoy M, Parra V, Shukla A, Dakin GF, *et al*. Endoscopic sleeve gastroplasty, laparoscopic sleeve gastrectomy, and laparoscopic band for weight loss: how do they compare. J Gastrointest Surg 2018;22:267–273. doi: 10.1007/s11605-017-3615-7.
7. Egan AM, Vella A. Endoscopic treatments for obesity: the good, the bad, and the ugly. Endocrinol Metab Clin North Am 2020;49:315–328. doi: 10.1016/j.ecl.2020.02.001.
8. Kersebaum JN, Möller T, von Schönfels W, Taivankhuu T, Becker T, Egberts JH, *et al*. Robotic Roux-en-Y gastric bypass procedure guide. JSLS 2020;24:e2020. 00062. doi: 10.4293/JSLS.2020.00062.
9. Welbourn R, Hollyman M, Kinsman R, Dixon J, Liem R, Ottosson J, *et al*. Bariatric surgery worldwide: baseline demographic description and one-year outcomes from the fourth IFSO global registry report 2018. Obes Surg 2019;29:782–795. doi: 10.1007/s11695-018-3593-1.
10. Angrisani L, Santonicola A, Iovino P, Ramos A, Shikora S, Kow L. Bariatric surgery survey 2018: similarities and disparities among the 5 IFSO chapters. Obes Surg 2021;31:1937–1948. doi: 10.1007/s11695-020-05207-7.
11. Griffen WO Jr, Young VL, Stevenson CC. A prospective comparison of gastric and jejunoileal bypass procedures for morbid obesity. Ann Surg 1977;186:500–509. doi: 10.1097/00000658-197710000-00012.
12. Wittgrove AC, Clark GW, Tremblay LJ. Laparoscopic gastric bypass, Roux-en-Y: preliminary report of five cases. Obes Surg 1994;4:353–357. doi: 10.1381/096089294765558331.
13. Boerboom A, Cooiman M, Aarts E, Aufenacker T, Hazebroek E, Berends F. An extended pouch in a Roux-En-Y gastric bypass reduces weight regain: 3-year results of a randomized controlled trial. Obes Surg 2020;30:3–10. doi: 10.1007/s11695-019-04156-0.
14. van Rijswijk AS, van Olst N, Schats W, van der Peet DL, van de Laar AW. What is weight loss after bariatric surgery expressed in percentage total weight loss (%TWL)? A systematic review. Obes Surg 2021;31:3833–3847. doi: 10.1007/s11695-021-05394-x.
15. Tornese S, Aiolfi A, Bonitta G, Rausa E, Guerrazzi G, Bruni PG, *et al*. Remnant gastric cancer after Roux-en-Y gastric bypass: narrative review of the literature. Obes Surg 2019;29:2609–2613. doi: 10.1007/s11695-019-03892-7.
16. Kichler K, Rosenthal RJ, DeMaria E, Higa K. Reoperative surgery for nonresponders and complicated sleeve gastrectomy operations in patients with severe obesity. An international expert panel consensus statement to define best practice guidelines. Surg Obes Relat Dis 2019;15:173–186. doi: 10.1016/j.soard.2018.11.006.
17. Zorrilla-Nunez LF, Campbell A, Giambartolomei G, Lo Menzo E, Szomstein S, Rosenthal RJ. The importance of the biliopancreatic limb length in gastric bypass: a systematic review. Surg Obes Relat Dis 2019;15:43–49. doi: 10.1016/j.soard.2018.10.013.
18. Scopinaro N, Gianetta E, Civalleri D, Bonalumi U, Bachi V. Bilio-pancreatic bypass for obesity: II. Initial experience in man. Br J Surg 1979;66:618–620. doi: 10.1002/bjs.1800660906.
19. Scopinaro N, Adami GF, Marinari GM, Gianetta E, Traverso E, Friedman D, *et al*. Biliopancreatic diversion. World J Surg 1998;22:936–946. doi: 10.1007/s002689900497.
20. Hess DS, Hess DW. Biliopancreatic diversion with a duodenal switch. Obes Surg 1998;8:267–282. doi: 10.1381/096089298765554476.
21. DeMeester TR, Fuchs KH, Ball CS, Albertucci M, Smyrk TC, Marcus JN. Experimental and clinical results with proximal end-to-end duodenojejunostomy for pathologic duodenogastric reflux. Ann Surg 1987;206:414–426. doi: 10.1097/00000658-198710000-00003.
22. Gagner M. For whom the bell tolls? It is time to retire the classic BPD (bilio-pancreatic diversion) operation. Surg Obes Relat Dis 2019;15:1029–1031. doi: 10.1016/j.soard.2019.03.029.
23. Sánchez-Pernaute A, Herrera MA, Pérez-Aguirre ME, Talavera P, Cabrerizo L, Matía P, *et al*. Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S). One to three-year follow-up. Obes Surg 2010;20:1720–1726. doi: 10.1007/s11695-010-0247-3.
24. Merz AE, Blackstone RB, Gagner M, Torres AJ, Himpens J, Higa KD, *et al*. Duodenal switch in revisional bariatric surgery: conclusions from an expert consensus panel. Surg Obes Relat Dis 2019;15:894–899. doi: 10.1016/j.soard.2019.03.009.
25. Milone L, Strong V, Gagner M. Laparoscopic sleeve gastrectomy is superior to endoscopic intragastric balloon as a first stage procedure for super-obese patients (BMI >or =50). Obes Surg 2005;15:612–617. doi: 10.1381/0960892053923833.
26. Golomb I, Ben David M, Glass A, Kolitz T, Keidar A. Long-term metabolic effects of laparoscopic sleeve gastrectomy. JAMA Surg 2015;150:1051–1057. doi: 10.1001/jamasurg.2015.2202.
27. Eid GM, Brethauer S, Mattar SG, Titchner RL, Gourash W, Schauer PR. Laparoscopic sleeve gastrectomy for super obese patients: forty-eight percent excess weight loss after 6 to 8 years with 93% follow-up. Ann Surg 2012;256:262–265. doi: 10.1097/SLA.0b013e31825fe905.
28. Gagner M, Hutchinson C, Rosenthal R. Fifth international consensus conference: current status of sleeve gastrectomy. Surg Obes Relat Dis 2016;12:750–756. doi: 10.1016/j.soard.2016.01.022.
29. Brethauer SA, Hammel JP, Schauer PR. Systematic review of sleeve gastrectomy as staging and primary bariatric procedure. Surg Obes Relat Dis 2009;5:469–475. doi: 10.1016/j.soard.2009.05.011.
30. Rosenthal RJ, Diaz AA, Arvidsson D, Baker RS, Basso N, Bellanger D, *et al*. International sleeve gastrectomy expert panel consensus statement: best practice guidelines based on experience of (12,000 cases. Surg Obes Relat Dis 2012;8:8–19. doi: 10.1016/j.soard.2011.10.019.
31. Roth AE, Thornley CJ, Blackstone RP. Outcomes in bariatric and metabolic surgery: an updated 5-year review. Curr Obes Rep 2020;9:380–389. doi: 10.1007/s13679-020-00389-8.
32. Arterburn DE, Telem DA, Kushner RF, Courcoulas AP. Benefits and risks of bariatric surgery in adults: a review. JAMA 2020;324:879–887. doi: 10.1001/jama.2020.12567.
33. Bhasker AG, Prasad A, Raj PP, Wadhawan R, Khaitan M, Agarwal AJ, *et al*. OSSI (Obesity and Metabolic Surgery Society of India) guidelines for patient and procedure selection for bariatric and metabolic surgery. Obes Surg 2020;30:2362–2368. doi: 10.1007/s11695-020-04497-1.
34. Mason EE, Ito C. Gastric bypass in obesity. Surg Clin North Am 1967;47:1345–1351. doi: 10.1016/s0039-6109(16)38384-0.
35. Rutledge R. The mini-gastric bypass: experience with the first 1,274 cases. Obes Surg 2001;11:276–280. doi: 10.1381/096089201321336584.
36. Carbajo M, García-Caballero M, Toledano M, Osorio D, García-Lanza C, Carmona JA. One-anastomosis gastric bypass by laparoscopy: results of the first 209 patients. Obes Surg 2005;15:398–404. doi: 10.1381/0960892053576677.

37. Lee WJ, Yu PJ, Wang W, Chen TC, Wei PL, Huang MT. Laparoscopic Roux-en-Y versus mini-gastric bypass for the treatment of morbid obesity: a prospective randomized controlled clinical trial. Ann Surg 2005;242:20–28. doi: 10.1097/01.sla.0000167762.46568.98.
38. Robert M, Espalieu P, Pelascini E, Caiazzo R, Sterkers A, Khamphommala L, *et al*. Efficacy and safety of one anastomosis gastric bypass versus Roux-en-Y gastric bypass for obesity (YOMEGA): a multicentre, randomised, open-label, non-inferiority trial. Lancet 2019;393:1299–1309. doi: 10.1016/S0140-6736(19)30475-1.
39. De Luca M, Tie T, Ooi G, Higa K, Himpens J, Carbajo MA, *et al*. Mini gastric bypass-one anastomosis gastric bypass (MGB-OAGB)-IFSO position statement. Obes Surg 2018;28:1188–1206. doi: 10.1007/s11695-018-3182-3.
40. Parmar CD, Gan J, Stier C, Dong Z, Chiappetta S, El-Kadre L, *et al*. One anastomosis/mini gastric bypass (OAGB-MGB) as revisional bariatric surgery after failed primary adjustable gastric band (LAGB) and sleeve gastrectomy (SG): a systematic review of 1075 patients. Int J Surg 2020;81:32–38. doi: 10.1016/j.ijsu.2020.07.007.
41. Nieben OG, Harboe H. Intragastric balloon as an artificial bezoar for treatment of obesity. Lancet 1982;1:198–199. doi: 10.1016/s0140-6736(82)90762-0.
42. Ball W, Raza SS, Loy J, Riera M, Pattar J, Adjepong S, *et al*. Effectiveness of intra-gastric balloon as a bridge to definitive surgery in the super obese. Obes Surg 2019;29:1932–1936. doi: 10.1007/s11695-019-03794-8.
43. Hogan RB, Johnston JH, Long BW, Sones JQ, Hinton LA, Bunge J, *et al*. A double-blind, randomized, sham-controlled trial of the gastric bubble for obesity. Gastrointest Endosc 1989;35:381–385. doi: 10.1016/s0016-5107(89)72839-x.
44. Popov VB, Ou A, Schulman AR, Thompson CC. The impact of intragastric balloons on obesity-related co-morbidities: a systematic review and meta-analysis. Am J Gastroenterol 2017;112:429–439. doi: 10.1038/ajg.2016.530.
45. Bazerbachi F, Vargas EJ, Abu Dayyeh BK. Endoscopic bariatric therapy: a guide to the intragastric balloon. Am J Gastroenterol 2019;114:1421–1431. doi: 10.14309/ajg.0000000000000239.
46. Bariatric Endoscopy Task Force ASGE, Technology Committee ASGE, Abu Dayyeh BK, Kumar N, Edmundowicz SA, Jonnalagadda S, Larsen M, *et al*. ASGE bariatric endoscopy task force systematic review and meta-analysis assessing the ASGE PIVI thresholds for adopting endoscopic bariatric therapies. Gastrointest Endosc 2015;82:425. e5-438.e5. doi: 10.1016/j.gie.2015.03.1964.
47. Ponce J, Woodman G, Swain J, Wilson E, English W, Ikramuddin S, *et al*. The REDUCE pivotal trial: a prospective, randomized controlled pivotal trial of a dual intragastric balloon for the treatment of obesity. Surg Obes Relat Dis 2015;11:874–881. doi: 10.1016/j.soard.2014.12.006.
48. Vyas D, Deshpande K, Pandya Y. Advances in endoscopic balloon therapy for weight loss and its limitations. World J Gastroenterol 2017;23:7813–7817. doi: 10.3748/wjg.v23.i44.7813.
49. McCarty TR, Thompson CC. The current state of bariatric endoscopy. Dig Endosc 2021;33:321–334. doi: 10.1111/den.13698.
50. Abu Dayyeh BK, Rajan E, Gostout CJ. Endoscopic sleeve gastroplasty: a potential endoscopic alternative to surgical sleeve gastrectomy for treatment of obesity. Gastrointest Endosc 2013;78:530–535. doi: 10.1016/j.gie.2013.04.197.
51. de Miranda Neto AA, de Moura D, Ribeiro IB, Khan A, Singh S, da Ponte Neto AM, *et al*. Efficacy and safety of endoscopic sleeve gastroplasty at Mid term in the management of overweight and obese patients: a systematic review and meta-analysis. Obes Surg 2020;30:1971–1987. doi: 10.1007/s11695-020-04449-9.
52. de Moura D, Barrichello S Jr, de Moura E, de Souza TF, Dos Passos Galvão Neto M, Grecco E, *et al*. Endoscopic sleeve gastroplasty in the management of weight regain after sleeve gastrectomy. Endoscopy 2020;52:202–210. doi: 10.1055/a-1086-0627.
53. Lopez-Nava G, Asokkumar R, Negi A, Normand E, Bautista I. Re-suturing after primary endoscopic sleeve gastroplasty (ESG) for obesity. Surg Endosc 2021;35:2523–2530. doi: 10.1007/s00464-020-07666-6.
54. Lopez-Nava G, Negi A, Bautista-Castaño I, Rubio MA, Asokkumar R. Gut and metabolic hormones changes after endoscopic sleeve gastroplasty (ESG) *vs*. laparoscopic sleeve gastrectomy (LSG). Obes Surg 2020;30:2642–2651. doi: 10.1007/s11695-020-04541-0.
55. Singh S, Hourneaux de Moura DT, Khan A, Bilal M, Ryan MB, Thompson CC. Safety and efficacy of endoscopic sleeve gastroplasty worldwide for treatment of obesity: a systematic review and meta-analysis. Surg Obes Relat Dis 2020;16:340–351. doi: 10.1016/j.soard.2019.11.012.
56. Cheskin LJ, Hill C, Adam A, Fayad L, Dunlap M, Badurdeen D, *et al*. Endoscopic sleeve gastroplasty versus high-intensity diet and lifestyle therapy: a case-matched study. Gastrointest Endosc 2020;91:342. e1-349.e1. doi: 10.1016/j.gie.2019.09.029.
57. Singh S, de Moura D, Khan A, Bilal M, Chowdhry M, Ryan MB, *et al*. Intragastric balloon versus endoscopic sleeve gastroplasty for the treatment of obesity: a systematic review and meta-analysis. Obes Surg 2020;30:3010–3029. doi: 10.1007/s11695-020-04644-8.
58. Lopez-Nava G, Asokkumar R, Bautista-Castaño I, Laster J, Negi A, Fook-Chong S, *et al*. Endoscopic sleeve gastroplasty, laparoscopic sleeve gastrectomy, and laparoscopic greater curve plication: do they differ at 2 years. Endoscopy 2021;53:235–243. doi: 10.1055/a-1224-7231.
59. Jalal MA, Cheng Q, Edye MB. Systematic review and meta-analysis of endoscopic sleeve gastroplasty with comparison to laparoscopic sleeve gastrectomy. Obes Surg 2020;30:2754–2762. doi: 10.1007/s11695-020-04591-4.
60. Sharaiha RZ, Hajifathalian K, Kumar R, Saunders K, Mehta A, Ang B, *et al*. Five-year outcomes of endoscopic sleeve gastroplasty for the treatment of obesity. Clin Gastroenterol Hepatol 2021;19:1051–1057.e2. doi: 10.1016/j.cgh.2020.09.055.
61. Neto MG, Silva LB, de Quadros LG, Grecco E, Filho AC, de Amorim A, *et al*. Brazilian consensus on endoscopic sleeve gastroplasty. Obes Surg 2021;31:70–78. doi: 10.1007/s11695-020-04915-4.
62. Glaysher MA, Moekotte AL, Kelly J. Endoscopic sleeve gastroplasty: a modified technique with greater curvature compression sutures. Endosc Int Open 2019;7:E1303–E11303. doi: 10.1055/a-0996-8089.
63. Farha J, McGowan C, Hedjoudje A, Itani MI, Abbarh S, Simsek C, *et al*. Endoscopic sleeve gastroplasty: suturing the gastric fundus does not confer benefit. Endoscopy 2021;53:727–731. doi: 10.1055/a-1236-9347.
64. Koehestanie P, de Jonge C, Berends FJ, Janssen IM, Bouvy ND, Greve JWM. The effect of the endoscopic duodenal-jejunal bypass liner on obesity and type 2 diabetes mellitus, a multicenter randomized controlled trial. Ann Surg 2014;260:984–992. doi: 10.1097/SLA.0000000000000794.
65. Caiazzo R, Branche J, Raverdy V, Czernichow S, Carette C, Robert M, *et al*. Efficacy and safety of the duodeno-jejunal bypass liner in patients with metabolic syndrome: a multicenter randomized controlled trial (ENDOMETAB). Ann Surg 2020;272:696–702. doi: 10.1097/SLA.0000000000004339.
66. de Moura E, Ribeiro IB, Frazão M, Mestieri L, de Moura D, Dal Bó C, *et al*. EUS-guided intragastric injection of botulinum toxin A in the preoperative treatment of super-obese patients: a randomized clinical trial. Obes Surg 2019;29:32–39. doi: 10.1007/s11695-018-3470-y.
67. Paulus GF, van Avesaat M, van Rijn S, Alleleyn A, Swain JM, Abell TL, *et al*. Multicenter, phase 1, open prospective trial of gastric electrical stimulation for the treatment of obesity: first-in-human results with a novel implantable system. Obes Surg 2020;30:1952–1960. doi: 10.1007/s11695-020-04422-6.
68. van Baar A, Holleman F, Crenier L, Haidry R, Magee C, Hopkins D, *et al*. Endoscopic duodenal mucosal resurfacing for the treatment of type 2 diabetes mellitus: one year results from the first international, open-label, prospective, multicentre study. Gut 2020;69:295–303. doi: 10.1136/gutjnl-2019-318349.
69. Jaruvongvanich V, Vantanasiri K, Laoveeravat P, Matar RH, Vargas EJ, Maselli DB, *et al*. Endoscopic full-thickness suturing plus argon plasma mucosal coagulation versus argon plasma mucosal coagulation alone for weight regain after gastric bypass: a systematic review and meta-analysis. Gastrointest Endosc 2020;92:1164. e6-1175.e6. doi: 10.1016/j.gie.2020.07.013.
70. Abu Dayyeh BK, Jirapinyo P, Weitzner Z, Barker C, Flicker MS, Lautz DB, *et al*. Endoscopic sclerotherapy for the treatment of weight regain after Roux-en-Y gastric bypass: outcomes, compli-

cations, and predictors of response in 575 procedures. Gastrointest Endosc 2012;76:275–282. doi: 10.1016/j.gie.2012.03.1407.
71. Abrams JA, Komanduri S, Shaheen NJ, Wang Z, Rothstein RI. Radiofrequency ablation for the treatment of weight regain after Roux-en-Y gastric bypass surgery. Gastrointest Endosc 2018;87:275. e2-279.e2. doi: 10.1016/j.gie.2017.06.030.
72. Bolling CF, Armstrong SC, Reichard KW, Michalsky MP. Metabolic and bariatric surgery for pediatric patients with severe obesity. Pediatrics 2019;144:e20193224. doi: 10.1542/peds.2019-3224.
73. Pratt J, Browne A, Browne NT, Bruzoni M, Cohen M, Desai A, *et al*. ASMBS pediatric metabolic and bariatric surgery guidelines, 2018. Surg Obes Relat Dis 2018;14:882–901. doi: 10.1016/j.soard.2018.03.019.
74. Roebroek YGM, Pruijssers SR, Bouvy ND, van Heurn ELWV. Current opinions and practices of bariatric surgery in adolescents: a survey among pediatric surgeons. Eur J Pediatr Surg 2020;30:117–121. doi: 10.1055/s-0040-1701469.
75. Gonzalez DO, Michalsky MP. Update on pediatric metabolic and bariatric surgery. Pediatr Obes 2021;16:e12794. doi: 10.1111/ijpo.12794.
76. Cardel MI, Atkinson MA, Taveras EM, Holm JC, Kelly AS. Obesity treatment among adolescents: a review of current evidence and future directions. JAMA Pediatr 2020;174:609–617. doi: 10.1001/jamapediatrics.2020.0085.
77. Alqahtani A, Elahmedi M, Alqahtani YA, Al-Darwish A. Endoscopic sleeve gastroplasty in 109 consecutive children and adolescents with obesity: two-year outcomes of a new modality. Am J Gastroenterol 2019;114:1857–1862. doi: 10.14309/ajg.0000000000000440.

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