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REVIEWS

Clinical application of laparoscopic bariatric surgery: an evidence-based review

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Abstract
Background Approximately one-third of U.S. adults are obese. Current evidence suggests that surgical therapies offer the morbidly obese the best hope for substantial and sustainable weight loss, with a resultant reduction in morbidity and mortality. Minimally invasive methods have altered the demand for bariatric procedures. However, no evidence-based clinical reviews yet exist to guide patients and surgeons in selecting the bariatric operation most applicable to a given situation.
Methods This evidenced-based review is presented in conjunction with a clinical practice guideline developed by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). References were reviewed by the authors and graded as to the level of evidence. Recommendations were developed and qualified by the level of supporting evidence available at the time of the associated SAGES guideline publication. The guideline also was reviewed and co-endorsed by the American Society for Metabolic and Bariatric Surgery.
Results Bariatric surgery is the most effective treatment for severe obesity, producing durable weight loss, improvement of comorbid conditions, and longer life. Patient selection algorithms should favor individual risk–benefit considerations over traditional anthropometric and demographic limits. Bariatric care should be delivered within credentialed multidisciplinary systems. Roux-en-Y gastric bypass (RGB), adjustable gastric banding (AGB), and biliopancreatic diversion with duodenal switch (BPD + DS) are validated procedures that may be performed laparoscopically. Laparoscopic sleeve gastrectomy (LSG) also is a promising procedure. Comparative data find that procedures with more dramatic clinical benefits carry greater risks, and those offering greater safety and flexibility are associated with less reliable efficacy.
Conclusions Laparoscopic RGB, AGB, BPD + DS, and primary LSG have been proved effective. Currently, the choice of operation should be driven by patient and surgeon preferences, as well as by considerations regarding the relative importance placed on discrete outcomes.

Keywords Bariatric surgery · Biliopancreatic diversion · Gastric bypass · Gastroplasty · Laparoscopy · Morbid obesity

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In the United States, 5% of adults have a body mass index (BMI) exceeding 40 kg/m^2 [1]. The health consequences of severe obesity have been well described [2]. Current evidence has validated surgical therapy as the best hope of the morbidly obese for substantial and sustainable weight loss [3], with resultant mortality reduction [4]. These data, together with improvements in laparoscopic techniques, have driven a fourfold increase in the population-based rate of bariatric surgery performed in recent years [5].

This review is intended to guide surgeons applying laparoscopic techniques to the practice of bariatric surgery. It does not address the credentialing of surgeons or centers, which is the focus of the Guidelines for Institutions Granting Bariatric Privileges Utilizing Laparoscopic Techniques published by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). The recommendations are the result of a systematic review of the literature, graded according to an accepted literature evaluation scale (see Appendix 1).

Evidence-based clinical practice guidelines and related review articles are intended to present the best practices available for the treatment of medical conditions. Recommendations are not intended to be exclusive given the complexity of the health care environment. The recommendations in this review are meant to provide a frame of reference for patient care but should be viewed as flexible enough to be varied when necessary. They should be applied with consideration given to the unique needs of individual patients and the evolving medical literature.

Materials and methods

Data sources

A broad search of the English language literature was performed in late 2007 using both electronic and physical means. The electronic search used the PubMed and Cochrane Library databases. The main objectives of this study were to analyze the impact of laparoscopic bariatric surgery on mortality, weight loss, and comorbidities; to review the indications for bariatric surgery; to review the ancillary services required for a bariatric practice; to compare gastric bypass, biliopancreatic diversion, and laparoscopic adjustable gastric banding; and to review the various reoperative options available. The search terms used were therefore combinations of "obesity surgery," "bariatric surgery," "gastric bypass," "gastroplasty," "gastric band," "biliopancreatic diversion," "duodenal switch," "sleeve gastrectomy," "reoperation," "revision," "laparoscopic," "diabetes," "hypertension," "hyperlipidemia," "sleep apnea," "nutrition," and "complications." Manual reference checks of published review articles were performed to supplement the aforementioned electronic searches.

Literature review and classification

Abstracts were excluded if no subsequent manuscript was available, or if the paper could be classified as an isolated case report, letter, or comment. Full articles were obtained and further screened for inclusion if they had at least one of the following categories of information: surgical outcomes (including efficacy and safety), guidelines, health care economics, or disease impact (use of resources, readmissions, quality of life).

The articles were reviewed by the authors according to the protocol developed by the SAGES Guidelines Committee for internal use and graded as to level of evidence (Appendix 1). These levels of evidence and subsequent recommendations were incorporated into an evidence-based clinical practice guideline entitled the SAGES Guideline for the Clinical Application of Laparoscopic Bariatric Surgery, approved by a majority of the members of the SAGES Guidelines Committee and the SAGES Bariatric Liaison Group, as well as the SAGES Board of Governors, and subsequently co-endorsed by the American Society for Metabolic and Bariatric Surgery. This review article expounds upon the recommendations published in the SAGES guideline.

Results

Introduction and rationale for surgery

The United States has experienced a steady rise in obesity prevalence over the past 20 years and currently ranks second in the world [6]. At the turn of the millennium, nearly two-thirds of Americans were overweight or obese, and almost 5% were morbidly obese [7]. This trend is ominous because morbid obesity predisposes patients to comorbid diseases, which affect nearly every organ system. These diseases include type 2 diabetes, cardiovascular disease, hypertension, hyperlipidemia, hypoventilation syndrome, asthma, sleep apnea, stroke, pseudotumor cerebri, arthritis, several types of cancer, urinary incontinence, gallbladder disease, and depression [8–10]. Obesity shortens life expectancy [11], with increasing BMI resulting in a proportionally shorter life span [12]. Morbid obesity, associated with more than 300,000 deaths in the United States each year, is projected to overtake smoking as the leading cause of death in the near future [13].

Currently, more than 9 million morbidly obese Americans need treatment. However, nonoperative management using diet, exercise, behavior modification, and medications rarely achieves adequate durable weight loss [14]. Four long-term studies investigating the nonoperative management of obesity showed an average weight loss of only 4% [15–18]. In the recent Swedish Obese Subjects prospective controlled study, medical management over 10 years was associated with a 1.6% increase in body weight compared with a 13.2% weight loss after gastric banding and a 25% weight loss after gastric bypass [19].

The advent of minimally invasive therapies caused a dramatic increase in gastrointestinal procedures that produce significant sustainable weight loss with low complication rates [19–22]. Surgically induced weight loss is associated with resolution or improvement of comorbid diseases for 75–100% of patients [22], and with less mortality than among medically treated patients [23–25]. Public awareness and demand, together with improved systems for surgeon training and delivery of care, have combined to fuel a national explosion in bariatric procedures. In 2003, 102,798 operations were reportedly performed in the United States compared with only 13,365 in 1998 [26].

Justification for the surgical treatment of obesity

- Weight loss surgery is the most effective treatment for morbid obesity, producing durable weight loss, improvement of comorbid conditions, and longer life (level 1)

Evolution of contemporary surgical options

Operations to alter the gastrointestinal tract and produce weight loss have been applied for half a century. Weight loss operations may cause malabsorption, restriction of food intake, or a combination of the two. The original operation for morbid obesity, the jejunoileal bypass, was first performed in 1954. However, this purely malabsorptive operation led to unacceptable morbidity and mortality related to bacterial overgrowth and liver damage [27]. The focus shifted away from purely malabsorptive procedures until the 1970s, when biliopancreatic diversion (BPD) was first described [28], with eventual description of duodenal switch (DS) in 1993 [29]. This operation has been applied laparoscopically with effective weight loss [30].

Gastric bypass was introduced by Mason in 1966 as a combined restrictive-malabsorptive procedure [31]. Several variations and modifications of the original procedure have evolved over time, such as complete gastric transection, reduction in gastric pouch size, and application of a Roux-en-Y [32]. As of 2003, Roux-en-Y gastric bypass (RGB) accounted for more than 80% of all bariatric procedures performed in the United States [26]. Laparoscopic RGB was popularized and validated in the early 1990s by Wittgrove and Clark [33], and several corroborating series have followed [34–37]. Differences exist in the technique for laparoscopic gastrojejunostomy as part of the procedure, including transoral circular stapling [33], transgastric circular stapling [35], linear stapling [36], and handsewing [37] approaches, but all are supported in the literature as producing similar safety and weight loss results.

In the early 1970s, Printen and Mason [38] developed a purely restrictive operation, the gastroplasty. This operation later developed into vertical banded gastroplasty (VBG) [39] and ultimately laparoscopic VBG by the 1990s [40]. Despite efforts to simplify the procedure [41], gastroplasty operations decreased and accounted for only 7% of U.S. bariatric procedures in 2002 [26]. Stomach banding for weight loss, originally introduced in the 1980s with nonadjustable devices, became popular in the early 1990s [42]. In 1993, Belachew and Legrand placed the first laparoscopic adjustable gastric band (AGB) using the LAP-BAND® system (Allergan Inc., Irvine, CA, USA) [43]. Although multiple versions of AGB are available for laparoscopic use, most published results are derived from the LAP-BAND® system.

Laparoscopic adjustable bands quickly became popular worldwide due to their relative ease of placement and safety. The LAP-BAND® system was not approved for use in the United States until 2001, and its use has increased steadily. A recent worldwide survey showed that the laparoscopic AGB accounted for 24% of obesity operations, whereas 26% of the operations were laparoscopic RGB and 23% were open gastric bypass [44].

Another contemporary restrictive procedure that derives from the concept of vertical gastroplasty is the laparoscopic sleeve gastrectomy (LSG). The LSG technique developed as a first-stage procedure before DS or gastric bypass for high-risk patients [45, 46]. Studies have shown that LSG used in this manner reduces weight, comorbidities, and operative risk [American Society of Anesthesiology (ASA) score] at the time of a second bariatric procedure [47–49]. There is increasing application of LSG as a primary weight loss operation [45, 46, 50, 51]. Evolving data demonstrate that LSG provides substantial weight loss and resolution of comorbidities over 3- to 5-year follow-up periods [45, 47, 52–54]. Early comparative data demonstrate that the percentage of excess body weight loss (EBWL) with LSG at 1 year is superior to that with AGB and approaches that with RGB and BPD [55].

Other minimally invasive weight loss procedures are in developmental stages. Gastric pacing, under development in Europe for more than 10 years, has shown acceptable safety and early efficacy (<15 months), although its use is appropriately limited to clinical trials until more mature data become available [56].

Guidelines for selecting validated bariatric procedures

- Laparoscopic RGB, gastric banding by VBG or AGB, and BPD ± DS are established and validated bariatric procedures that may be performed laparoscopically (level 2)
- LSG is validated as providing effective weight loss and resolution of comorbidities as long as 3–5 years (level 2)

Patient selection considerations

According to the 1991 National Institutes of Health (NIH) consensus conference on gastrointestinal surgery for severe obesity, patients are candidates for surgery if they are morbidly obese (BMI >40 kg/m^2 or >35 kg/m^2 with comorbidities), have failed attempts at diet and exercise, are motivated and well informed, and are free of significant psychological disease [57]. In addition, the expected benefits of the operation must outweigh the risks.

Surgery for morbid obesity has a low failure rate and a mean EBWL of 61.2% [22]. Adverse events vary among procedures, but may reach 20% for high-risk patients. Mortality rates approximate 0.1% for gastric banding, 0.5% for RGB, and 1.1% for BPD [22]. There are no absolute contraindications to bariatric surgery. Relative contraindications to surgery may include severe heart failure, unstable coronary artery disease, end-stage lung disease, active cancer diagnosis or treatment, cirrhosis with portal hypertension, uncontrolled drug or alcohol dependency, and severely impaired intellectual capacity. Crohn's disease, a possible relative contraindication to RGB [58] and BPD [59], is listed by the manufacturer as a contraindication to the LAP-BAND® system.

Laparoscopic surgery may be difficult or impossible for patients with giant ventral hernias, severe intraabdominal adhesions, a large liver, high BMI with central obesity, or physiologic intolerance of pneumoperitoneum. Surgeons performing laparoscopic bariatric surgery should possess the necessary skills to perform open bariatric surgery in the event that conversion to an open procedure becomes necessary [32].

Weight loss surgery for individuals with a BMI of 30–35 kg/m^2 and comorbidities merits consideration given the poor results of nonoperative weight loss regimens [60]. One controlled trial of laparoscopic AGB with this group found superior weight loss, resolution of metabolic syndrome, and improvement in quality of life compared with medical management during a 2-year follow-up period [61]. Another report of 37 patients undergoing RGB showed excellent weight loss and near complete resolution of comorbidities [62]. Further data are necessary before surgery for patients with a BMI exceeding 35 kg/m^2 becomes standard practice.

Early in the laparoscopic bariatric era, many traditional programs declined superobese (BMI > 50 kg/m^2) or super-super-obese patients (BMI > 60 kg/m^2) because of perceived high risk and technical challenge. However, as endosurgical techniques and equipment have improved, laparoscopic RGB and AGB have been more liberally applied at extreme BMIs, with consequent health and quality-of-life benefits, acceptable rates of morbidity and mortality, but lower EBWL [63–71]. Laparoscopic BPD + DS also may be appropriate for superobese patients given the superior weight loss compared with laparoscopic RGB [72].

Age restrictions are less rigidly used in the current era of refined anesthesiology, effective critical care, and high-quality surgical outcomes. Laparoscopic bariatric surgery has been performed for patients older than 55–60 years [73–75], but with comparatively less weight loss, longer length of stay, higher morbidity and mortality, and less complete resolution of comorbidities than with younger patients. Still, the reduction in comorbidities supports the use of laparoscopic RGB or laparoscopic AGB for well-selected older patients [76–83].

At the time of the NIH consensus conference in 1991, bariatric surgery for morbidly obese children and adolescents was not advised because of insufficient data. However, with pediatric obesity increasing in prevalence and severity, interest in adolescent bariatric surgery is growing [84]. The RGB procedure is well tolerated and produces excellent weight-loss outcomes for patients younger than 18 years through a 10-year follow-up period [85–91]. Advocates believe weight reduction at an early age prevents or minimizes emotional and physical consequences of obesity [92]. Well-designed prospective studies are just emerging to define better the place for adolescent bariatric surgery [93].

Guidelines for patient selection

- The 1991 NIH consensus guidelines provide valid but incomplete patient selection criteria for contemporary bariatric procedures including laparoscopic BPD ± DS, RGB, VBG, and AGB (level 2)
- Other well-selected patients may benefit from laparoscopic bariatric surgery by experienced surgeons:
  - BMI exceeding 60 kg/m^2 (level 2)
  - Patients older than 60 years (level 2)
- Adolescent bariatric surgery (age <18 years) has been proved effective but should be performed in a specialty center (level 2). Patient selection criteria should be the same as the criteria used for adult bariatric surgery (level 2)
- Individuals with a BMI of 30–35 kg/m^2 may benefit from laparoscopic bariatric surgery (level 1)

Bariatric program and facility

The etiology of morbid obesity seems to involve genetic, environmental, metabolic, and psychosocial factors [94]. Therefore, treatment of the bariatric patient lends itself to a team approach for systematic evaluation and management [95]. Although a multidisciplinary team is seen as an important component of a bariatric surgery practice [32, 56, 96, 97], no comparative clinical trials have proved this. The team leader is the surgeon, complemented by nurses, physician extenders, and clerical staff for scheduling, insurance precertification, and coordination of patient flow.

The surgeon must have acquired the proper education and hands-on training as per the SAGES Guidelines for Institutions Granting Bariatric Privileges Utilizing Laparoscopic Techniques. Other important team members include nutritionists, psychologists with specific training and experience, and medical subspecialists (e.g., endocrinologists, anesthesiologists, radiologists, pulmonologists, gastroenterologists) to help evaluate and optimize patients preoperatively and to provide postoperative care if necessary [32, 96, 97].

The institutional needs of a bariatric program extend across outpatient and inpatient environments. It is important to have office and hospital furniture, equipment, clothing, fixtures, beds, and wheelchairs appropriate and comfortable for patients with morbid and supermorbid obesity. In the operating room, specially rated tables and attachments, extra-long instruments, and appropriate staplers and retractors are necessary [97]. Health care providers and staff must be experienced with the special needs of bariatric patients and sensitive to these needs. They also need to be protected against ergonomic and lifting injuries.

Postoperative support groups, also an important aspect of a bariatric program, may improve postoperative results and limit relapse [32, 97–99]. Two nonrandomized studies have shown that patients attending support groups achieve greater weight loss than those who do not [100, 101].

A hospital annual case volume exceeding 100 may be associated with reduced morbidity and mortality and improved costs [102]. Higher surgeon volume has been associated with reduced mortality [103]. Center of excellence designation programs have gained traction [95] and are maintained by the American College of Surgeons [104] and the American Society for Metabolic and Bariatric Surgery [105].

Guidelines for bariatric programs

- Bariatric surgery programs should include multidisciplinary providers with appropriate training and experience (level 3)
- Institutions must accommodate the special needs of bariatric patients and their providers (level 3)
- Participation in support groups may improve outcomes after bariatric surgery (level 2)

Preoperative workup

The preoperative evaluation is similar for all bariatric procedures. The components include determining a patient's indications for surgery, identifying issues that may interfere with the success of the surgery, and assessing and treating comorbid diseases. The typical assessment includes psychological testing, nutrition evaluation, and medical assessment [97, 106].

Psychological evaluation

Patients referred for bariatric surgery are more likely than the overall population to have psychopathology such as somatization, social phobia, obsessive–compulsive disorder, substance abuse/dependency, binge-eating disorder, posttraumatic stress disorder, generalized anxiety disorder, and depression [107]. Patients with psychiatric disorders may have a suboptimal outcome after bariatric surgery [107]. However, no consensus recommendations exist regarding preoperative psychological evaluation [106, 108]. A recent survey reported that 88% of U.S. bariatric programs use some psychological evaluation, with half requiring a formal standardized assessment [106]. Many insurance companies require such psychological evaluation before granting precertification for a bariatric procedure. Nevertheless, the bulk of evidence shows no relationship between preexisting axis 1 psychiatric diagnosis or axis 2 personality disorder and total weight loss [106, 109, 110]. It is not certain which psychosocial factors predict success after bariatric surgery [108], yet many programs exclude patients who are illicit drug abusers and those with active uncontrolled schizophrenia or psychosis, severe mental retardation, heavy alcohol use, or lack of knowledge about the surgery [106].

Nutrition consult

The nutrition professional is an integral part of multidisciplinary bariatric care [111, 112]. He or she is charged with nutritional assessment, diet education regarding postoperative eating behaviors, and preoperative weight loss efforts [113]. A preoperative very-low-calorie diet for 6 weeks has been shown to reduce liver volume by 20% and improve access to the upper stomach during laparoscopic surgery [114, 115], with 80% of the volume change occurring in the first 2 weeks [114]. Furthermore, patients who can achieve 10% EBWL preoperatively have a shorter hospital stay and more rapid weight loss [116].

Despite the wide use of preoperative nutritional efforts and the requirement by many insurance companies for dietary counseling, data still are needed to prove an association with postoperative weight loss or dietary compliance [117, 118]. No evidence-based, standardized dietary guidelines exist for either pre- or postoperative nutritional management of the bariatric patient, and no convincing data support the need for routine use of nutrition specialists after surgery. Outcome studies and clinical trials are necessary to help define the role of the nutrition professional on the bariatric team.

Preoperative medical evaluation

Medical assessment before bariatric surgery is similar to that before abdominal operations of the same magnitude. A thorough history and a physical examination with systematic review are used to identify comorbidities that may complicate the surgery. Consultation with a medical subspecialist often is necessary to optimize medical conditions for reduction of perioperative risk.

Routine laboratory evaluation typically includes complete blood count, metabolic profile, coagulation profile, lipid profile, thyroid function tests, and ferritin tests. Vitamin B12, thiamine, and fat-soluble vitamin levels may be evaluated if a malabsorptive procedure is considered. Cardiovascular evaluation includes an electrocardiogram and a possible stress test to identify occult coronary artery disease. Respiratory evaluation may include chest X-ray, arterial blood gas, and pulmonary function tests. Sleep apnea may be diagnosed by a sleep study, and the patient may be started on continuous positive airway pressure before surgery.

An upper endoscopy may be used to exclude gastric pathology. If *Helicobacter pylori* infection is present, preoperative therapy is advised [119]. The liver may be assessed by hepatic profile and ultrasound. In cases of suspected cirrhosis, biopsy may be indicated. Ultrasound may be used to detect gallstones, allowing the surgeon to decide on concomitant cholecystectomy [98, 120].

Guidelines for preoperative preparation

- A psychological evaluation is commonly part of the preoperative workup for bariatric patients (level 3)
- Treated psychopathology does not preclude the benefits of bariatric surgery (level 2)
- Preoperative weight loss may be useful to reduce liver volume and improve access for laparoscopic bariatric procedures (level 2, grade B), but mandated preoperative weight loss does not affect postoperative weight loss or comorbidity improvements (level 1)

Surgical techniques and outcomes

Laparoscopic biliopancreatic diversion with duodenal switch

After jejunoileal bypass was abandoned [121], most of the bariatric community focused on restrictive operations [122]. However, Scopinaro revisited the value of malabsorption in his description of BPD in the late 1970s [28]. Since then, modifications have included the DS [123], the sleeve gastrectomy [29], and the laparoscopic approach [124]. The DS diminishes the most severe complications of BPD, including dumping syndrome and peptic ulceration of the anastomosis [125]. Sleeve gastrectomy spares the lesser curvature, vagus nerves, and pylorus, in contrast to the original distal gastrectomy, although theoretical beneficial effects on eating behavior, weight loss, and side effects are not universally reported [125, 126]. The laparoscopic approach decreases wound complications, pain, and hospital length of stay [127].

Technical considerations

The standard BPD + DS technique involves dividing the small bowel 250 cm above the ileocecal valve with a stapler, and then forming a biliopancreatic limb by connecting the bowel proximal to the transection to a point 100 cm above the ileocecal valve. The bowel distal to the transection is elevated as an alimentary limb to the upper abdomen. Sleeve resection creates a tubularized stomach of approximately 100 cm^3. The duodenum is divided 3 cm distal to the pylorus, and duodenoileostomy establishes continuity of the alimentary limb. Limb lengths determine weight loss and complications. A common limb that is too long provides inadequate weight loss, whereas one that is too short causes debilitating diarrhea and nutritional deficiencies. The gastric remnant size should provide some restriction but not prevent initiation of protein digestion.

Whether BPD should be tailored to patient characteristics such as age, size, or BMI is uncertain [128]. Scopinaro, in his original animal study [129, p. 616], found that "insertion of the bypass into the ileum at a distance from the ileocecal valve equivalent to one-sixth of the intestinal length allows adequate weight loss with minimal complications." However, by the time of his human studies [28, p. 620], he noted that "the exact length of the common ileal segment and the length of the jejunum in the biliopancreatic tract required to achieve maximum weight reduction with minimum complications have yet to be determined." Hess [130] reported excellent results by measuring small bowel length and then distributing 10% to the common channel and 40% to the alimentary limb. A large Spanish series reports excellent outcomes with a common channel of 60 cm and an alimentary limb of 200–360 cm [131, 132]. A U.S. study suggests that common channels longer than 100 cm result in inferior results [132]. In a comparative study of outcomes and complications, a 100-cm common channel was superior to a 50-cm channel, and sleeve gastrectomy was superior to distal gastrectomy [125].

Although data for comparing open and laparoscopic BPD are scarce, a few comments can be made on the utility of the minimally invasive procedure. First, because the details of the resection and reconstruction are the same, long-term outcomes are likely to be similar. Indeed, at follow-up periods of 1 and 3 years, weight loss is similar to that achieved by open surgery [133, 134]. Laparoscopic BPD has reduced hospital stay and complications, mainly due to a lower rate of wound infections and dehiscence [127]. Laparoscopic BPD is an advanced, complex, and feasible technique in bariatric surgery, and one that has a steep learning curve [135].

Outcomes

The BPD ± DS technique initiates dramatic weight loss during the first 12 postoperative months, which then continues at a slower rate over the next 6 months. Weight loss is durable up to at least 5 years postoperatively. Ninety-five percent of patients with a BMI less than 50 kg/m^2, and 70% of those with a BMI exceeding 50 kg/m^2 achieve more than 50% EBWL [29, 136, 137]. Weight may be regained over time [138], highlighting the importance of long-term follow-up assessment.

The BPD procedure has a dramatic impact on comorbidities. At least 90% of patients with type 2 diabetes cease diabetic medications by 12–36 months [127, 128, 139]. Between 50% and 80% of hypertensive patients are cured, with another 10% experiencing improvement [140–142]. Up to 98% of patients with obstructive sleep apnea experience resolution [143, 144].

Although BPD, RGB, and AGB all are superior to nonsurgical therapy, the relative effectiveness of these procedures has not been fully compared. Available data are rarely randomized or controlled and often compare non-equivalent cohorts. Nonetheless, available data suggest that the weight loss effect of BPD is greater and more durable than that of laparoscopic AGB [143, 145]. Likewise, BPD may be superior to RGB for patients with a BMI of 50 kg/m^2 or greater [71] (Table 1).

A metaanalysis examining studies published between 1990 and 2003 found that BPD resulted in more weight loss and improvement of diabetes, hyperlipidemia, hypercholesterolemia, hypertriglyceridemia, and obstructive sleep apnea than any other type of bariatric procedure [22]. Despite the favorable reports of BPD for the treatment of morbid obesity, it has been slow to gain widespread acceptance [29].

Postoperative assessment

An upper gastrointestinal series typically is performed in the early postoperative period to exclude contrast extravasation. If the results are normal, a clear liquid diet is started, with gradual introduction of solids. Discharge usually is within 4–5 days.

Close follow-up evaluation in the postoperative period is recommended. For example, visits at 2 and 6 weeks, then quarterly for the first year, biannually for the second year, and annually thereafter would be one acceptable strategy [126, 131]. Assessments are made by both the surgeon and the nutritionist, and biochemical surveillance by complete blood count, chemical metabolic profile, and parathormone level is performed at intervals. An exercise program is helpful, as are multivitamin, iron, vitamin D, and calcium supplements.

Complications

The 30-day mortality of early laparoscopic BPD series ranges from 2.6% to 7.6% [134, 147]. Major complications, which occur in up to 25% of cases, may include early occurrence of anastomotic leak, duodenal stump leak, intraabdominal infection, hemorrhage, and venous thromboembolism [29, 147–150], or later bowel obstruction, incarceration, or stricture [151].

The performance of a sleeve gastrectomy as part of the BPD + DS allows patients two-thirds of their preoperative

Table 1 Percentage of excess body weight loss (EBWL) after bariatric surgical procedures [145]

Operation		Mean follow-up period (years)							
		1	2	3	4	5	7	8	10
BPD ± DS	%EBWL	71.8	75.1	76.3	75.5	73.3	69	75.8	77.0
	Aggregate *n*	896	1,623	410	1,278	174	89	405	122
	No. of studies	4	3	4	3	3	1	2	1
RGB (proximal)	%EBWL	67.3	67.5	62.5	58.0	58.2	55.0		52.5
	Aggregate *n*	1627	385	285	509	176	2		194
	No. of studies	7	5	4	4	3	1		2
AGB	%EBWL	42	57.2	54.8	54.5	55.2	51.0	59.3[a]	
	Aggregate *n*	4456	3383	3104	1435	640	29	100	
	No. of studies	11	11	12	9	5	2	1	

BPD ± DS biliopancreatic diversion with or without duodenal switch, *RGB* Roux-en-Y gastric bypass, *AGB* adjustable gastric banding

[a] 42 patients with 8-year follow-up and band not removed [146]

dietary volume without specific food intolerances. Between 70% and 98% of the patients maintain normal serum albumin 3 years after surgery [29, 126]. Diarrhea is a frequent chronic complication of BPD. A common channel length of 50 cm is associated with reports of diarrhea in most patients [126], whereas a length of 100 cm is not [29]. Iron deficiency is common, with 6% of patients experiencing serious iron deficiency anemia (hemoglobin <10 mg/dl) [152]. Surveillance of biochemical and hematologic markers of iron deficiency should drive replacement. Calcium and vitamin D malabsorption also are common, manifesting as secondary hyperparathyroidism [153]. Supplements do not prevent the development of secondary hyperparathyroidism.

An increase in bone resorption is known to occur irrespective of parathormone levels, suggesting a phenomenon of bone reshaping parallel to the loss of weight [154]. Because of fat malabsorption resulting from BPD, supplementation of fat-soluble vitamins is recommended. Deficiency of these vitamins is more likely with a shorter common channel.

Cholelithiasis postoperatively occurs in 6% of patients [155] to 25% [28]. Some surgeons advocate routine cholecystectomy given the alteration in endoscopic accessibility to the biliary tract, whereas others argue for delayed cholecystectomy only if symptoms develop because cholecystitis occurs uncommonly after BPD [156].

Guidelines for laparoscopic BPD ± DS

- In BPD, the common channel should be 60–100 cm and the alimentary limb 200–360 cm (level 2)
- DS diminishes the most severe complications of BPD, including dumping syndrome and peptic ulceration of the anastomosis (level 2)
- BPD is effective in all BMI >35 kg/m^2 subgroups, with durable weight loss and control of comorbidities beyond 5 years (level 2)
- Laparoscopic BPD provides equivalent weight loss, shorter hospital stay, and fewer complications compared with open BPD (level 3)
- BPD may result in greater weight loss (level 2) and resolution of comorbidities (level 2) than other bariatric surgeries, but with the highest mortality rate (level 2)
- After BPD ± DS, close nutritional surveillance and supplementation are needed (level 3)

Laparoscopic Roux-en-Y gastric bypass

Gastric bypass was first developed in the 1960s as a means for combining restrictive, malabsorptive, and behavioral components to achieve weight loss. Physiologic changes in the gastrointestinal tract after gastric bypass (e.g., dumping, neuroendocrine responses) also appear to influence weight loss and comorbidity improvements, which may precede weight loss. Since then, modifications have included the use of a small lesser curvature-based gastric pouch, gastric transection, Roux-en-Y reconstruction, and variations in length of the alimentary limb [157, 158]. Feasibility of the laparoscopic approach to RGB was first shown in the early 1990s [33].

Technical considerations

The stomach is divided to form a small proximal gastric pouch, and the small intestine is reconstructed using a Roux-en-Y to form an alimentary limb. Although accurate measurement of pouch volume is difficult and prospective data are lacking, a retrospective study has suggested that smaller pouches may be associated with greater weight loss [159]. Most surgeons choose the transection point by measuring from the esophagogastric junction or by counting vascular arcades.

In creating the Roux en-Y bypass, the jejunum typically is divided below the ligament of Treitz, with the distal segment then elevated and surgically connected to the gastric pouch to create the alimentary (Roux) limb, using variations of the path and method for anastomosis. The proximal bowel segment, also called the biliopancreatic limb, usually is connected to the alimentary limb 75–150 cm distal to the gastrojejunostomy. This reconstruction serves to bypass the distal stomach, duodenum, and a portion of jejunum to create malabsorption [157].

Several authors have addressed the issue of limb length during RGB. For patients with a BMI of 50 kg/m^2 or less, both retrospective [160] and prospective [161, 162] data fail to show a benefit for alimentary limbs longer than 150 cm. However, patients with a BMI greater than 50 kg/m^2 who were randomized to a 250-cm rather than a 150-cm alimentary limb did show improved weight loss at 18 months, although the study was not powered to confirm this benefit for a longer follow-up period [162]. Other studies examining the use of alimentary limbs longer than 300 cm for patients with a BMI greater than 50 kg/m^2 have found improved weight loss over that of standard RGB, but with increased nutritional deficiencies and need for reoperation [163, 164].

Laparoscopic RGB is a technically demanding procedure. The available literature suggests that experience with 50–150 cases is required for surgeons to become safe and proficient in its performance [34, 36, 165–168].

Outcomes

The literature comparing laparoscopic RGB with open RGB and with contemporary medical and surgical treatments for obesity includes several prospective randomized controlled trials [161, 169–175], a large prospective case–controlled cohort study [19], numerous case series, and four metaanalyses [2, 21, 22, 176].

Surgical therapy clearly is more effective than medical therapy in terms of weight loss and resolution of comorbidities. Morbidly obese patients using behavioral and medical therapies alone actually gain weight in the long term [2, 19]. Surgical patients have a lower 5-year mortality rate than nonsurgical patients (0.68% vs. 6.17%) despite a 0.4% perioperative mortality rate [177].

Patients who undergo laparoscopic RGB typically experience an EBWL of 60–70%, with 75% control of comorbidities [2, 19, 21, 22]. In general, these outcomes are better than those for banding procedures, which have an EBWL of 45–50% and less predictable improvement of comorbidities, but poorer than the outcomes for BPD ± DS, which has an EBWL of 70–80% with excellent control of comorbidities [22] (Table 2).

Open and laparoscopic RGB have similar efficacy. In prospective randomized trials [169–171, 174], they show no significant differences in weight loss in up to 3 years of follow-up evaluation. Similar results have been reported in case series [176].

Postoperative assessment

Close, long-term follow-up evaluation is recommended for patients after bariatric surgery [57]. A typical example for recommendations of follow-up assessment after laparoscopic RGB would be evaluation at 1–3 weeks, followed by quarterly visits during the first year and annually thereafter to assess weight loss, resolution of comorbidities, long-term complications, and need for continuing education and support. Patients are counseled to eat small, frequent meals of high-protein and low-carbohydrate content. They should take long-term vitamin supplements (multivitamins, vitamin B12, and calcium, with some patients requiring iron supplementation) and undergo periodic blood testing to identify and treat deficiencies early. Patients should be encouraged to develop regular exercise practices. Two retrospective studies have investigated the impact of follow-up evaluation on outcomes after laparoscopic RGB. The one study suggests that patient follow-up evaluation does not play an important role, whereas the other study reports improved weight loss for patients compliant with follow-up assessment at 1 year [178, 179].

Complications

The mortality rate after RGB ranges from 0.3% in case series to 1% in controlled trials, and the rate of preventable and nonpreventable adverse surgical events is 18.7% [21]. The mortality rate in a review of selected laparoscopic RGB series ranged from 0.5% to 1.1% [180]. The safety of laparoscopic RGB has been compared with that of open RGB. The findings show that laparoscopic patients have a reduced incidence of iatrogenic splenectomy, wound infection, incisional hernia, and perioperative mortality, but higher rates of bowel obstruction, intestinal hemorrhage, and stomal stenoses [181].

The most frequently reported perioperative complications associated with laparoscopic RGB are wound infection (2.98%), anastomotic leak (2.05%), gastrointestinal tract hemorrhage (1.93%), bowel obstruction (1.73%), and pulmonary embolus (0.41%), whereas the most frequently reported late complications are stomal stenosis (4.73%), bowel obstruction (3.15%), and incisional hernia (0.47%) [181].

Guidelines for laparoscopic RGB

- In laparoscopic RGB, a small lesser-curvature-based pouch that excludes the gastric fundus and a 75- to 150-cm alimentary (Roux) limb are effective for most patients (level 2)
- Alimentary limbs longer than 150 cm may improve intermediate-term weight loss but also may increase nutritional complications (level 3)
- Laparoscopic RGB is similar in efficacy to open RGB (level 1), with reduced early complications and risk of hernia (level 2)
- Long-term follow-up evaluation is recommended and may improve weight loss outcomes after bariatric surgery (level 3)

Laparoscopic adjustable gastric banding

In the 1980s, gastroplasty was the most common restrictive bariatric procedure, with vertical banded gastroplasty the most commonly performed iteration. However, due to poor long-term weight loss [182, 183] and a high rate of late complications, alternatives to this operation were sought [184].

Table 2 Improvement of comorbidities after surgical bariatric procedures [22]

Operation	Diabetes resolved (%)	Hypercholesterolemia improved (%)	Hypertension resolved (%)	Sleep apnea resolved (%)
Banding	47.8	71.1	38.4	94.6
RGB	83.8	93.6	75.4	86.6
BPD ± DS	97.9	99.5	81.3	95.2

RGB Roux-en-Y gastric bypass, *BPD ± DS* biliopancreatic diversion with or without duodenal switch

Open gastric banding procedures inspired laparoscopic AGB, first described in 1993 [43], which involves the placement of a restrictive inflatable balloon device around the gastric cardia approximately 1 cm below the gastroesophageal junction. This balloon is connected by tubing to a subcutaneous port, which is attached to the rectus sheath. Saline injected into the port will cause balloon inflation, which results in narrowing of the stomach at the level of the balloon.

Various brands of laparoscopic AGB exist, although only the LAP-BAND® system and the REALIZE™ adjustable gastric band (Ethicon Endosurgery, Cincinnati, OH, USA) currently have Food and Drug Administration (FDA) approval for use in the United States. The equivalence between the two FDA-approved devices in the United States has been demonstrated [185], but to date, comparative trials with other devices do not exist.

Technical considerations

The laparoscopic AGB is best placed via a pars flaccida approach, that is, via a retrogastric tunnel between the pars flaccida medially and the angle of His laterally. This has efficacy equivalent to the initially described perigastric approach but a significantly decreased rate of band slippage (i.e., gastric prolapse) [186–188]. The pars flaccida approach results in the incorporation of more extraneous tissue, particularly the lesser curvature fat pad, into the band. Compensation by placement of a band with a greater diameter may be required to limit stomal obstruction.

At the time of placement, a per-oral calibration balloon may be placed into the stomach and filled with 15–25 ml of saline, allowing the band to be fastened below this level. A 15- to 25-ml pouch is thereby created.

Avoiding the risks of gastrointestinal stapling and anastomosis, AGB allows complete reversibility. Most authors agree that laparoscopic AGB is less technically demanding and less morbid than laparoscopic RGB [71, 189]. However, potential disadvantages of laparoscopic AGB compared with laparoscopic RGB include the ongoing need for band adjustments, delayed or unsatisfactory weight loss [190], and unique indications for reoperation such as pouch dilation, esophageal dilation, band slippage, band erosion, port-site complications, and leaks from the device [185].

Outcomes

Laparoscopic AGB has been compared with intensive pharmacotherapy, behavioral modification, diet modification, and exercise among patients with a BMI of 30–35 kg/m^2. In this population, laparoscopic AGB is seen to be more effective in reducing weight, resolving metabolic derangements, and improving quality of life [61].

Laparoscopic AGB is very effective at producing weight loss, with patients losing approximately 50% of their excess body weight [22, 191]. This weight loss occurs in a gradual manner, with approximately 35% EBWL by 6 months, 40% by 12 months, and 50% by 24 months. This percentage appears to remain stable after 3–8 years based on the few studies providing a follow-up period of this length [145, 192–194]. However, as many as 25% of laparoscopic AGB patients fail to lose 50% of their excess body weight by 5 years [22, 190].

Laparoscopic AGB has positive effects on the comorbidities of obesity. Type 2 diabetes is improved for about 90% of patients due to increased insulin sensitivity and increased pancreatic beta-cell function [195], and diabetic medications are eliminated for 64% [196, 197]. After AGB, resolution of type 2 diabetes mirrors weight loss and therefore is slower to occur than after RGB or BPD, in which the diabetes may resolve almost immediately [196, 198]. Symptoms of gastroesophageal reflux disease may be eliminated for at least 89% of patients at 12 months, even for those with large hiatal hernias [199, 200], but with the side effect of impaired lower esophageal sphincter relaxation and possible altered esophageal motility [201]. The rate of obstructive sleep apnea drops from 33% to 2% for laparoscopic AGB patients [202]. Major quality-of-life improvements are seen after AGB placement, with all subscales of the Medical Outcomes Study Short Form 36 (SF-36) general quality-of-life questionnaire significantly improved, particularly in areas of bodily pain, general health perception, and mental health perception [203–205].

The short-term (<12 months) weight loss with laparoscopic AGB is inferior to that with RGB [206]. This discrepancy is seen to continue, with a randomized controlled trial illustrating that EBWL at 5 years was 47.5% with AGB versus 66.6% with RGB [207]. Still, life-threatening complications are less frequent with laparoscopic AGB than with laparoscopic RGB.

Postoperative assessment

Successful weight loss after laparoscopic AGB requires close follow-up evaluation for band adjustments, education, and support. In the absence comparative data, guidelines for follow-up care and adjustment are based on manufacturer recommendations and expert opinion.

Physicians with extensive experience placing and managing the AGB adhere to a number of basic tenets necessary for successful weight loss. Immediately after the operation, oral intake is restricted to liquids and soft foods to prevent vomiting and dislodgment of the band. After a recovery period, the diet is transitioned to solid foods that induce satiety and no-calorie liquids between meals.

Eventually, a wide range of foods is tolerated, although whole meats and heavy breads may always cause dysphagia or regurgitation. To avoid protein–calorie malnutrition and loss of lean body mass, diets should focus on protein and complex carbohydrate intake, with a limited quantity of simple sugars and fats. Physical activity is recommended to maintain lean body mass and to improve cardiovascular fitness and total weight loss.

In the initial postoperative period, most clinicians advocate leaving the band unfilled. The first adjustment usually occurs about 6 weeks after placement, with initial and subsequent fill volumes determined by band type and patient factors. Fluid should be added if weight loss falls below expectations or if meal volumes increase with loss of satiety. Adjustment is not needed if there is adequate weight loss, satiety, and tolerance. Fluid should be removed for vomiting, coughing, choking, or significant solid food intolerance. Bands may be adjusted with or without radiographic guidance with acceptable results [208].

Complications

Case series and systematic reviews put early mortality rates after laparoscopic AGB at 0.05–0.4% [21, 209], compared with 0.5–1.1% for laparoscopic RGB [180], 0.5–1.0% for open RGB [21, 22], 1.1% [21] for open BPD, and 2.5–7.6% for laparoscopic BPD [134, 147, 148]. Regarding relative morbidity rates, comparative data are few. Overall complications and major complications are less common with laparoscopic AGB than with laparoscopic RGB or laparoscopic BPD in a single-center experience [151] (Table 3).

A recent review analyzing a multicenter, prospective U.S. trial of laparoscopic AGB placement by the perigastric approach [205] found uncommon occurrence of gastrointestinal perforation (1%) or other visceral injury (1%). Band-related complications such as slippage/pouch dilation (24%), esophageal dilation (8%), and stomal obstruction (14%) accumulated over a 5-year follow-up period. Port-site complications including pain, port displacement, and leak arose in about 7% of patients. The mean explantation or major revision rate by 9 years was 33%.

In contrast, parallel review of a subsequent trial that implemented the pars flaccida technique [205] found reduced slippage/pouch dilation (7%), esophageal dilation (1%), and stomal obstruction (2%) at 1 year. Non-U.S. surgeons also have championed the pars flaccida method [186–188, 210, 211] for reduction of band-specific complications. One pure pars flaccida series with a 7-year follow-up period reported 12% slippage/pouch dilation. However, the cumulative reoperation rate was 32% [211].

Guidelines for laparoscopic AGB

- The pars flaccida approach for laparoscopic AGB placement should be used instead of the perigastric approach to decrease the incidence of gastric prolapse (level 2)
- Laparoscopic AGB is effective in all BMI subgroups, with durable weight loss and control of comorbidities past 5 years (level 1)
- Intermediate-term weight loss after laparoscopic AGB may be less than after laparoscopic RGB (level 1)
- Frequent outpatient visits are suggested in the early postoperative period. Band filling should be guided by weight loss, satiety, and patient symptoms (level 3)

Revisional surgery

Patients may require revision of prior bariatric procedures because of anatomic failure, with persistent or recurrent obesity, development of secondary complications, or need for reversal.

Anatomic failure

In planning revisional bariatric operations, surgeons must have an understanding of the prior procedures, the typical anatomic complications, and the current state of the relevant anatomy. In past decades, several procedures have been used that have since fallen out of favor [212]. A number of pure restrictive procedures that involved gastric partitioning with staples have been limited by stomal dilation or recanalization of nondivided staple lines [213, 214]. Even procedures acceptable by current standards, such as VBG [215], RGB [216], and AGB, are at risk for

Table 3 Mortality and morbidity after laparoscopic bariatric surgical procedures

Operation	30-day mortality [21, 95, 134, 147, 148, 180, 208] (%)	Overall complications [151] (%)	Major complications [151] (%)
Lap AGB	0.05–0.4	9	0.2
Lap RGB	0.5–1.1	23	2
Lap BPD	2.5–7.6	25	5

Lap laparoscopic, *AGB* adjustable gastric banding, *RGB* Roux-en-Y gastric bypass, *BPD* biliopancreatic diversion anatomic derangement that may be amenable to surgical revision [217–219]. In recent years, the explosion of bariatric surgery also has resulted in application of interventions that may create unfamiliar anatomy and complications for surgeons performing revisional procedures [220]. For all these reasons, it is vital that the surgeon make every effort, using medical record review as well as preoperative radiographic and endoscopic assessment, to define the prior procedure or procedures performed [221, 222].

Upper gastrointestinal contrast studies may define the location and integrity of gastric staple lines as well as the nature and patency of outflow from the proximal stomach [223]. Endoscopy assesses for ulcers and internalized foreign bodies and may allow for therapeutic dilation in some cases. Indirect evidence of gastric or intestinal motor dysfunction also may be appreciated. Finally, in some cases, imaging by CT scan will allow for visualization of pathology in excluded portions of the anatomy or suggest internal hernias.

Patients who never lose weight may have had a technical complication such as incomplete stapling [224, 225] or an inappropriate operation. Those who regain weight after years may have experienced staple line recanalization or behavioral failure [226]. Reoperation on a previous gastroplasty usually involves creating a Roux-en-Y, if not already present, to a newly stapled proximal stomach pouch above all prior gastric interventions [227–230]. However, BPD, AGB, and other operations also have been used in this setting [231–233]. Likewise, most authors advocate RGB for revision of AGB because of complications or insufficient weight loss [217–219], although other operations have been applied [234, 235]. Finally, in cases of failed BPD + DS, some have advocated the use of a pouch reduction procedure [236], and in cases of failed RGB, either AGB to improve the restrictive component [237] or lengthening to improve the malabsorptive component [238] have been used. Comparative data are lacking.

Secondary complications

In some cases, bariatric procedures require revision when unexpected complications emerge over time. For example, the jejunoileal bypass resulted in dramatic weight loss, but became marred by the occurrence of unforseen malabsorptive complications including renal and hepatic failure [122, 239]. The importance of long-term follow-up evaluation is a lesson that must not be forgotten as new procedures are introduced.

Contemporary bariatric patients may seek revision due to evolution of other conditions or complications, such as gastroesophageal reflux, bile reflux, complicated ulcers, or obstruction [240]. Severe gastroesophageal reflux may occur after gastroplasty or VBG in the absence of outflow obstruction [229], whereas bile reflux may occur with procedures that use Bilroth II gastrojejunostomy [220]. In either case, conversion to RGB is therapeutic [241]. Easily treated marginal ulcers are common in the healing phase [242], but later should raise concern for salicylate or nonsteroidal antiinflammatory drug (NSAID) abuse [243] or gastrogastric fistula [224]. Late gastrogastric fistula closure may be a difficult procedure requiring laparotomy, sometimes with resection [225], whereas marginal ulcer perforation is more easily managed with a laparoscopic approach [244]. Obstruction due to internal herniation may require major resection and intestinal reconstruction [245].

Excessive weight loss, steatorrhea, or evolution of severe nutritional complications, particularly protein–calorie malnutrition, may indicate an excessively long malabsorptive component. Proximal relocation of the pancreaticobiliary secretions by intestinal reconstruction should be considered [163]. One option is to relocate the junction of the biliary and alimentary limbs more proximally, with a 50-cm distance suggested by Hamoui et al. [246].

An alternative and technically easier operation is to leave the original anastomosis intact and to create another enteroenterostomy 100 cm proximally. This allows for more proximal partial mixing of biliary and pancreatic secretions with the alimentary limb contents. It is effective in resolving malnutrition and diarrhea while causing minimal weight gain [246]. However, complication rates are high even with this simple procedure, presumably due to the poor physiologic state of the malnourished patient.

Desire for reversal

Ease of reoperation after laparoscopic AGB is one of its putative benefits, and up to 33% of patients may come to reversal or major revision [210, 211]. Laparoscopic RGB and BPD cause more dramatic anatomic changes that trade ease and possibility of reversal for better weight loss outcomes and independence from an implantable device [246, 247].

Role of laparoscopy in revisional procedures

Revisional bariatric operations may be performed laparoscopically [248–250] or via open technique [251, 252]. Complications are more common after reoperations than after primary bariatric procedures [253]. Surgeons may prefer an open approach to address severe adhesions or to permit tactile localization of prior partitions in the stomach to avoid creation of undrained or ischemic segments during restapling [230]. Foreign body removal and partial gastric resection also may be required [216]. Drain placement

Table 4 Relative risks and benefits of bariatric surgical procedures

	AGB	RGB	BPD	Comparative trials and metaanalyses	Noncomparative trials
Objective					
Least perioperative risk	+++	++	+	[22, 208]	[21, 36, 134, 147, 165, 166, 210]
Most effective durable weight loss	+	++	+++	[72, 143, 145, 206, 207]	[2, 19, 21, 29, 136, 137, 145, 193–195]
Best comorbidity resolution	+	++	+++	[22, 208]	[126, 128, 139–141, 195, 199, 200]
Most reversible	+++	+	+		[210, 211, 246, 247]
Best procedure for avoiding reoperation due to					
Technical complications—early	+++	++	+		[21, 181, 205]
Technical complications—late	+	++	+++		[181, 210, 211]
Metabolic complications—late	+++	++	+		[29, 126, 152–154]
Least chance of inadequate weight loss	+	++	+++	[22, 207]	[190]
Subjective					
Fewest outpatient visits needed	+	+++	++		[57, 138, 178, 179]
Fewest unintended metabolic consequences of poor follow-up	+++	++	+		
Durable weight loss despite poor patient compliance	+	++	+++		[138]

Relative scale: +++ > ++ > +

AGB adjustable gastric banding, *RGB* Roux-en-Y gastric bypass, *BPD* biliopancreatic diversion

often is performed in response to a recognized increased possibility of leak [254].

Guidelines for revisional bariatric surgery

- Before elective procedures, the anatomy should be defined by review of available records plus radiographic and/or endoscopic assessment (level 2)
- Laparoscopic revisional procedures may be performed safely, but with more complications than primary bariatric procedures. Therefore, the relative risks and benefits of laparoscopy should be considered on a case-by-case basis (level 3)

Summary

Bariatric surgery is medically indicated for morbidly obese patients who fail to respond to dietary, behavioral, nutritional, and medical therapies, with clear evidence of efficacy and safety. Age- and BMI-based candidacy guidelines should not limit access for patients experiencing progressive or poorly controlled obesity-related comorbidities if the risk-versus-benefit analysis favors surgery. Laparoscopic RGB, AGB, and BPD all have been proved effective.

Given the marked paucity of prospectively collected comparative data among the different bariatric operations, it remains impossible to make definitive recommendations for one procedure over another. Currently, decisions are driven by patient and surgeon preferences as well as by considerations regarding the degree and timing of necessary outcomes versus tolerance of risk and lifestyle change.

Until the emergence of additional randomized, controlled comparative studies, decisions between procedures will depend on the current evidence and the relative importance placed by patients and surgeons on purported discriminating factors (Table 4).

Appendix 1: Levels of evidence

Level 1	Evidence from properly conducted randomized, controlled trials
Level 2	Evidence from controlled trials without randomization
	or
	Cohort or case-control studies
	or
	Multiple time series, dramatic uncontrolled experiments
Level 3	Descriptive case series, opinions of expert panels

Appendix 2: Summary of guidelines

Justification for surgical treatment of obesity

- Weight loss surgery is the most effective treatment for morbid obesity, producing durable weight loss, improvement or remissions of comorbid conditions, and longer life (level 1)

Guidelines for selecting validated bariatric procedures

- Laparoscopic RGB, gastric banding by VBG or AGB, and BPD ± DS are established and validated bariatric procedures that provide effective long-term weight loss and resolution of comorbid conditions (level 2)
- LSG is validated as providing effective weight loss and resolution of comorbidities for as long as 3–5 years (level 2)

Guidelines for patient selection

- The 1991 NIH consensus guidelines provide valid but incomplete patient selection criteria for contemporary bariatric procedures including laparoscopic BPD ± DS, RGB, VBG, and AGB (level 2)
- Other well-selected patients may benefit from laparoscopic bariatric surgery by experienced surgeons:
  - Patients with a BMI exceeding 60 kg/m^2 (level 2)
  - Patients older than 60 years (level 2)
- Adolescent (age <18 years) bariatric surgery has been proved effective but should be performed in an experienced center (level 2). Patient selection criteria should be the same as the criteria used for adult bariatric surgery (level 2)
- Individuals with a BMI of 30–35 kg/m^2 may benefit from laparoscopic bariatric surgery (level 1)

Guidelines for bariatric programs

- Bariatric surgery programs should include multidisciplinary providers with appropriate training and experience (level 3)
- Institutions must accommodate the special needs of bariatric patients and their providers (level 3)
- Participation in support groups may improve outcomes after bariatric surgery (level 2)

Guidelines for preoperative preparation

- A psychological evaluation is commonly part of the preoperative workup for bariatric patients (level 3)
- Treated psychopathology does not preclude the benefits of bariatric surgery (level 2)
- Preoperative weight loss may be useful to reduce liver volume and improve access for laparoscopic bariatric procedures (level 2), but mandated preoperative weight loss does not affect postoperative weight loss or comorbidity improvements (level 1)

Appendix 2 continued

Guidelines for laparoscopic BPD ± DS

- In BPD, the common channel should be 60–100 cm, and the alimentary limb should be 200–360 cm (level 2)
- DS diminishes the most severe complications of BPD, including dumping syndrome and peptic ulceration of the anastomosis (level 2)
- BPD is effective in all BMI >35 kg/m^2 subgroups, with durable weight loss and control of comorbidities beyond 5 years (level 2)
- Laparoscopic BPD provides equivalent weight loss, shorter hospital stay, and fewer complications compared with open BPD (level 3)
- BPD may result in greater weight loss (level 2, grade A) and resolution of comorbidities (level 2) compared with other bariatric surgeries, but with the highest mortality rate (level 2)
- After BPD ± DS, close nutritional surveillance, and supplementation are needed (level 3)

Guidelines for laparoscopic RGB

- In laparoscopic RGB, a small lesser-curvature-based pouch that excludes the gastric fundus and a 75- to 150-cm alimentary (Roux) limb are effective for most patients (level 2)
- Alimentary limbs (150 cm) may improve intermediate-term weight loss but also may increase nutritional complications (level 3)
- Laparoscopic RGB is similar in efficacy to open RGB (level 1), with reduced early complications and risk of hernia (level 2)
- Long-term follow-up evaluation is recommended and may improve weight loss outcomes after bariatric surgery (level 3)

Guidelines for laparoscopic AGB

- The pars flaccida approach for laparoscopic AGB placement should be used instead of the perigastric approach to decrease the incidence of gastric prolapse (level 2)
- Laparoscopic AGB is effective in all BMI subgroups, with durable weight loss and control of comorbidities past 5 years (level 1)
- Intermediate-term weight loss after laparoscopic AGB may be less than after laparoscopic RGB (level 1)
- Frequent outpatient visits are suggested in the early postoperative period. Band filling should be guided by weight loss, satiety, and patient symptoms (level 3)

Guidelines for revisional bariatric surgery

- Before elective procedures, the anatomy should be defined by review of available records plus radiographic and/or endoscopic assessment (level 2)
- Laparoscopic revisional procedures may be performed safely, but with more complications than with primary bariatric procedures. Therefore, the relative risks and benefits of laparoscopy should be considered on a case-by-case basis (level 3)

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