Review Article

LAPAROSCOPIC SURGERY FOR MORBID OBESITY

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Obesity is a chronic, debilitating, life long disease giving rise to many other diseases. Severe obesity is associated with co-morbidities including type 2 DM, hypertension, dyslipidemia, obstructive sleep apnoea, obesity hypoventilation syndrome, polycystic ovarian syndrome, stateohepatosis, asthma, back and lower limb degenerative problem, cancer and premature death. Morbid obesity has acquired epidemic proportions in the west. Traditional approaches to weight loss including diet, exercise and medication achieve no more than 5-10 % reduction in body weight with high relapse rates. So far, there was no effective remedy for morbid obesity. Bariatric surgery is the only effective means of achieving long term weight loss in the severely obese. The international guideline for bariatric surgery are BMI > 40 kg/m^2 BMI > 35 kg/m^2 together with obesity related disease. Bariatric surgery can achieve sustained weight loss durable to at least 15 years and causes marked improvement in co-morbidities.

Key words: Bariatric surgery, Weight loss surgery, Lap band, Lap gastric bypass Roux-en-y, Lap sleeve gastrectomy.

Obesity was identified as a disease thirty years ago when, the WHO listed obesity as a disease condition in its International Classification of Diseases in 1979. The prevalence of obesity, and especially of morbid obesity, is increasing worldwide and it is today becoming a significant health hazard. Indeed, obesity rates have now reached epidemic proportions in the western hemisphere, with over 25 % of the population being obese in US and 15 % in Europe [1]. A similar pattern of increasing degrees of obesity has been demonstrated in the pediatric population. Overweight children and adolescents have a higher risk of becoming obese adults.

Prevalence of obesity in India is up to 50% in women and 32.2% in men in the upper strata of the society [2]. In Delhi alone the prevalence of obesity stands at 33.4% in women and 21.3% in men [3].

CALCULATING THE RISK OF OBESITY

(*i*) Waist/hip ratio

Normal ≤ 1.0 in males, ≤ 0.8 in females

(*ii*) Waist circumference

	Increased risk to life	Substantial risk to life
Male	>94 cms (34 inches)	>102 cms (37 inches)
Female	>80 cms (32 inches)	>88 cms (35 inches)
Male Indian	> 90 cms	
Female Indian	> 80 cms	

(*iii*) Body mass index

Obesity generally is determined by calculating body mass index (BMI), which measures weight for height and is stated in numbers. BMI is calculated by the weight in kilograms divided by height in meter square

$$\text{BMI in Kgs/m}^2 = \frac{\text{Weight (in Kgs)}}{\text{Height (in meters)} \times \text{Height (in meters)}}$$

Body Mass Index (BMI) in Kg / m^2

Obesity Grade		Asians
• Normal	18 to 25	16 to 23
• Over Weight	25 to 30	>23 to 28
• Obese	30 to 35	>28 to 33
• Severe obesity	35 to 40	>33 to 38
• Morbid obesity	40 & above	>38
• Super morbid obesity	50 & above	

NIH Classification

Obesity is further classified in the 1998 NIH Clinical Guidelines on the identification, evaluation, and treatment of overweight and obesity in Adults [4] into

Class I BMI 30.0 kg/m^2 to 34.9 kg/m^2

Class II BMI 35.0 kg/m^2 to 39.9 kg/ m^2

Class III BMI $\geq$ 40 kg/ m^2

HEALTH HAZARDS OF MORBID OBESITY

Clinically severe obesity and/or morbid obesity are recognized as major public health risks throughout the world. Much of the associated morbidity and mortality is related to co-morbid conditions. Morbid obesity is the harbinger of many other diseases that affect essentially every organ system:

- Decreased life span and premature death. The impact of obesity on longevity has been well documented. There is a direct relationship between increasing BMI and relative risk of dying prematurely. The Framingham data [1] revealed that for each pound gained between ages 30 to 42 years, there was a 1% increased mortality within 26 years, and for each pound gained thereafter, there was a 2% increased mortality. In the morbidly obese population, average life expectancy is reduced by 9 years in women and 12 years in men. The death is early because of heart disease, sleep apnoea and cancer. If they lose weight by surgery, their life span becomes normal.
- Diabetes mellitus Type 2 [5] is 40 times more common in morbidly obese person. Diabetes may be cured or improved in majority of patients after weight loss surgery.
- Heart disease (coronary artery disease and myocardial infarction) and sudden death syndrome. Heart disease is 7 times more common in obese persons but they are 40 times more at risk to have sudden death during a cardiac event.
- Cardiovascular [6] (hypertension, atherosclerotic peripheral vascular disease, and cerebral vascular accidents, peripheral venous insufficiency, thrombophlebitis, pulmonary embolism).
- Respiratory problems (asthma, disturbed sleep, obstructive sleep apnoea [7], obesity-hypoventilation syndrome). Sudden death may occur during sleep apnoea.
- Metabolic (impaired glucose tolerance, hyperlipidemia). Nearly 30% of overweight adolescents meet the criteria for metabolic syndrome, which increases risk of type 2 diabetes and coronary heart disease.
- Musculoskeletal [8] (back strain, disc disease, weight bearing osteoarthritis of the hips, knees, ankles, feet).
- Gastrointestinal (Cholelithiasis, gastro-esophageal reflux disease, nonalcoholic fatty liver disease [non-alcoholic steato-hepatitis], hepatic cirrhosis, hepatic carcinoma, colorectal carcinoma).
- Urologic (stress incontinence).
- Endocrine and reproductive [9] (polycystic ovary syndrome, increased risk of pregnancy disorders and fetal abnormalities, male hypogonadism, cancer of the endometrium, breast, ovary, prostate, pancreas).
- Dermatologic (intertriginous dermatitis).
- Neurological (pseudotumor cerebri, carpal tunnel syndrome).
- Psychological (depression, eating disorders, body image disturbance).
- Obesity, in particular morbid obesity, is also a social and economic problem. Obesity bias and discrimination starts in the earliest social contacts of preschool children and progresses through childhood and adolescence into adulthood. This prejudice may contribute to depression, eating disorders, body image disturbance, and other suffering.

Practical social implications of morbid obesity are manifold e.g., inability to ambulate, limited selection in clothing, stress incontinence, and difficulty with personal hygiene. A direct consequence of social bias is economic disadvantage with decreased monetary and educational opportunities.

Management of morbid obesity

Obesity requires long-term management [10]. The goal of treatment is weight loss to improve or eliminate related health problems, or the risk for them, not to attain an ideal weight.

Treatment consists of modifying eating behaviors, physical activity, monitoring behavior, such as understanding what may trigger eating. If this treatment does not help to lose weight, medications may be considered. In severe cases surgical procedures can reduce the size of the stomach and limit how many calories the intestines absorb.

Treatment also covers the psychological and social components of obesity. Stress management and counseling may be helpful. Family support and creating community contacts help to deal with the stereotypes and other social issues that are associated with obesity.

NON SURGICAL TREATMENT

Restricting calories and increasing activity are the major

components of treatment for obesity. Few studies have specifically examined the effects of nonsurgical treatment in patients with morbid obesity, so conclusions about nonsurgical therapy in this population are based on inference. In studies of Class I (minimal) and Class II (moderate) obesity, medical therapy can achieve >10% body weight loss (equivalent to >25% excess body weight loss) in 10-40% of patients depending on study design, use of medications [11], and duration of the intervention. Duration of the weight-loss response increases with duration of treatment and with use of medications and behavior modification. Moderate weight loss of as little as 5% of body weight can have considerable health benefits. Long term weight loss is difficult to achieve with diet, exercise, and pharmacotherapy. Most patients who present for bariatric surgery have already failed multiple attempts to achieve a sustained weight loss by using non-surgical treatment options.

SURGICAL TREATMENT OF MORBID OBESITY

In patients with morbid obesity, lifestyle changes and drugs are generally not effective in the long term [4]. Though initially there may be good weight loss, most persons are unable to maintain weight at 7 years and generally there is unacceptably high weight gain in 2 years after peak weight loss. Surgical treatment of morbid obesity (bariatric surgery) has been well established as being safe and effective. Bariatric surgery is the most effective therapy available for the morbidly obese (BMI ≥40 kg/ m^2) population. It markedly lowers body weight, reverses or ameliorates the myriad of obesity co-morbidities [12] and improves quality of life.

The 1991 NIH Consensus Conference Panel recommended:

(*i*) Patients seeking therapy for severe obesity for the first time should be considered for treatment in a non-surgical program with integrated components of a dietary regimen, appropriate exercise, and behavioral modification and support.

(*ii*) Gastric restriction or bypass procedures should be considered for well-informed and motivated patients with acceptable operative risks.

(*iii*) Patients who are candidates for surgical procedures should be selected carefully after evaluation by a multidisciplinary team with medical, surgical, psychiatric and nutritional expertise.

(*iv*) The operation should be performed by a surgeon substantially experienced with the appropriate procedures and working in a clinical setting with adequate support for all aspects of management and assessment.

(*v*) Life-long medical surveillance after surgical therapy is a necessity.

Many of these guidelines are viable today, others have been modified, and new guidelines are needed in the dynamic field of morbid obesity management by bariatric surgery. Certain critical events have occurred over the past 15 years since the 1991 NIH Consensus Conference that mandated conducting a new Consensus Conference to develop a new Consensus Statement as a directive in bariatric surgery. These events include:

1. Marked increase in the incidence of obesity, in particular, morbid obesity.
2. Expansion of available operative procedures.
3. Improved safety of bariatric procedures with an acceptable operative mortality and morbidity (less than comparable operative procedures), reoperation rate and long-term complications.
4. Introduction of laparoscopic techniques to bariatric surgery [13-16].
5. Increased experience with a team management approach.
6. Increased experience with bariatric surgery in adolescent and elderly patients.
7. A more complete elucidation and verification of obesity co morbidity outcomes with demonstration of reversal or improvement in diabetes, hypertension [12], hyperlipidemia, obstructive sleep apnoea, gastro esophageal reflux disease, cardiac function, osteo-arthritic orthopaedic conditions and bone fractures, nonalcoholic fatty liver disease, intertriginous dermatitis, stress incontinence, and symptoms of depression. Long-term improvement of co-morbid conditions has been well documented.
8. Documentation that delaying bariatric surgery diminishes the chances for full reversal of diabetes.
9. Demonstration that bariatric surgery improves the life expectancy of patients.
10. Data demonstrating that bariatric surgery can be cost effective less than 4 years after bariatric surgery (i.e. less expensive than the care of a morbidly obese patient who has not had bariatric surgery).

Patient selection and surgical options

Surgical therapy should be considered for individuals who:

- Have BMI above 40
- Have BMI above 35 with diabetes
- Are unable to reduce weight or maintain weight on medical t/t
- Have obesity for at least 5 years
- Have no history of alcohol abuse or drug dependence
- Have no depression or major psychiatric illness.

Since Asian Indians have more fat content in their body and are more prone to diabetes at a lesser BMI then their western counterparts, the criteria for candidature to surgery need to be considered separately. The consensus conference for defining guidelines for obesity in Asian Indians recommended surgery for patients with BMI 37.5 without co-morbidity and with a BMI of 32.5 in patients with associated co-morbidities (e.g. diabetes) [17].

Currently available surgical procedures for treating morbid obesity are:

Restrictive

These procedures restrict the food intake and achieve weight loss by limiting the portion size due to early and prolonged satiety after a solid meal. The procedure include:

(*a*) Laparoscopic Adjustable Gastric Banding (LAGB) [16,18] where the degree of restriction can be adjusted.

(*b*) Gastroplasty: Laparoscopic sleeve resection (gastrectomy) [19].

The popularity of Vertical Banded Gastroplasty (VBG), a restrictive procedure popular two decades back, has now been on the decline because of the poor long-term weight loss and complications.

Mal-absorptive

These procedures bypass a certain length of intestine so that the food and digestive juices come in contact in only a short length of bowel causing mal-absorption of the food and thus weight loss. The procedures include

(*a*) Bilio-pancreatic diversion [20]

(*b*) Bilio pancreatic diversion with duodenal switch [21]

Combined Restrictive and Malabsorptive

Roux en Y gastric bypass [14-16] with a standard limb, long-limb or a very long-limb is a procedure which has been used for the longest time with known long term results. The gastric bypass causes gastric restriction but also relies on varying amounts of intestinal malabsorption as an additional weight loss mechanism.

Certain surgeons perform one operation exclusively; other surgeons offer the full range of operations. There is an ever-increasing effort to match a particular patient to a particular operation. To this end, several selection approaches or algorithms have been suggested, although randomized trials that test these algorithms have not been conducted.

Increasingly, hormonal changes are being recognized as an important mechanism of post surgical weight loss; recent studies have demonstrated that gastric bypass results in altered release of hunger-causing hormones, such as Ghrelin.

Peri operative and long-term considerations

Regardless of whether restrictive or combined restrictive-malabsorptive procedures are utilized, follow up is imperative to monitor for potential serious sequelae and operative failure. These operations should only be performed within the setting of an obesity treatment program committed to maintaining long-term follow up for evaluation of outcomes.

Careful preoperative evaluation and patient preparation are critical to success. Patients should have a clear understanding of expected benefits, risks, and long-term consequences of surgical treatment. Surgeons must know how to diagnose and manage complications specific to bariatric surgery. Patients require lifelong follow-up with nutritional counseling and biochemical surveillance. Surgeons also must understand the requirements of severely obese patients in terms of facilities, supplies, equipment and staff necessary to meet these needs, and should ensure that the specialized staff and/or multi-disciplinary referral system is included in treatment of these patients. This multi-disciplinary approach includes medical management of co-morbidities, dietary instruction, exercise training, specialized nursing care and psychological assistance as needed on an individual basis. Post-operative management of co-morbidities should be directed by a practitioner familiar with relevant bariatric operations.

Introduction of laparoscopy

Minimally invasive approaches have been used in bariatric surgery since 1993 when Balechew reported first laparoscopic adjustable gastric Banding [21]. Witgrove and Clark [13] reported first laparoscopic gastric bypass from the USA in 1994. The benefits of a laparoscopic approach appear to be similar to those realized with laparoscopic

cholecystectomy, including but not limited to minimal incisional scars, less postoperative pain, increased mobility, shortened hospital stay and shorter convalescent time. In addition, wound complications such as infection, abdominal wall hernia, seroma and hematoma are significantly reduced. Open bariatric operation had certain advantages over laparoscopic procedures. But in the present era of advanced laparoscopy, greater ease and speed for lysis of adhesions, freedom to use fine suture technique and materials, greater facility to perform ancillary procedures, possibly a lower incidence of certain peri-operative complications (e.g., leaks, hemorrhage), and decreased risk of specific long term complications (e.g., anastomotic strictures, internal hernias, bowel obstructions) make laparoscopy a preferred option. By 2003, nearly two-thirds of bariatric procedures worldwide were performed laparoscopically. The indications for laparoscopic treatment of obesity are the same as for open surgery, and have been outlined earlier.

Virtually all bariatric operations can be performed with laparoscopic techniques. Operative times vary between open and laparoscopic procedures from surgeon to surgeon. Costs are similar; the cost of additional operative equipment/disposables needed for laparoscopic surgery equals the cost of longer hospital stay for open procedures. Long term weight loss and amelioration of co-morbid conditions are essentially the same for open and laparoscopic bariatric operations. In the present era of advanced laparoscopy, better anesthetic techniques and surgical expertise; laparoscopic bariatric surgery is fast becoming the 'gold standard' for most bariatric procedures.

Open and laparoscopic bariatric operations are not competitive; they are complementary.

For certain conditions, the surgeon may initially select a staged or modified procedure or electively convert e.g., super obese (BMI $\geq$ 50 kg/ m^2), central obesity, presence of congenital anomalies, anticipated severe adhesions, certain abdominal wall hernias, management of complications, hepatomegaly, inability to tolerate pneumoperitoneum and some planned revision procedures.

Laparoscopic adjustable gastric banding

Gastric banding is the least invasive of the purely restrictive bariatric surgical procedures. It consists of a small pouch and a small stoma created by a band high on the stomach. The stomach is not cut or crushed by staples, and no anastomosis is made. Laparoscopic adjustable gastric banding (LAGB) is the most common procedure performed outside of the United States, primarily in continental Europe, Australia and South America. It is the second most commonly performed procedure worldwide.

The concept of adjustable gastric banding was pioneered by Austrian surgical researchers G. Szinicz and G. Schnapka in 1982 [22]. They used a balloon on the inner surface of silicone elastomer, connected to a subcutaneous port to alter the space within the band. This idea was adapted for clinical use by Lubomyr Kuzmak, a Ukranian surgeon working in the USA from June 1986. He found that, when compared with a non-adjustable silicone band patients fared better losing more weight with fewer complications [23].

The adjustable silicone gastric band was then modified for laparoscopic placement by creation of a self-locking mechanism. Guy Bernard Cadiere performed the first laparoscopic placement of an adjustable gastric band in 1992 using the unmodified Kuzmak band. The first placement of a BioEnterics® Lap-Band® System (SAGB/ LAGB®) was by Drs Mitiku Belachew and Marc Legrand in September, 1993 [24]. There are now at least six versions of the laparoscopic adjustable gastric band available commercially. However, published data is available only for Inamed band and Swedish adjustable gastric band. Since its introduction in the United States, it has gained greater acceptance in that country and its relative use in the United States is increasing. The main attractions for the rapid popularity are safety (safest bariatric procedure), adjustability and reversibility by laparoscopic means if required.

Current techniques

After a period of evolution of technique, certain operative principles have been established. The upper gastric pouch is made very small (the "virtual pouch"), approximately 15 mL in volume, and placed primarily anteriorly. A gastric calibration tube with a inflatable balloon at the tip is used the measure the exact size of the pouch (*Fig.*1).The dissection on the lesser curvature of the stomach includes the neurovascular bundle of the lesser omentum—the *pars flaccida* approach. The final position of the band is about 1.5 to 2 cms below the G E junction (*Fig.*2). At least 3-4 gastro-gastric sutures completely cover the anterior part of the band to prevent slippage of the anterior stomach under the band (*Fig.*3). The system is assembled and the port for inflation and deflation of the band is secured onto the rectus fascia of the anterior abdominal wall just below the xiphoid process. Adjustment of the band through the access port is an essential part of laparoscopic adjustable gastric banding therapy. Appropriate adjustments, performed up to six times annually, are critical for successful outcomes.

Operative mortality and morbidity

Operative (30-day) mortality for laparoscopic adjustable gastric banding when performed by skilled

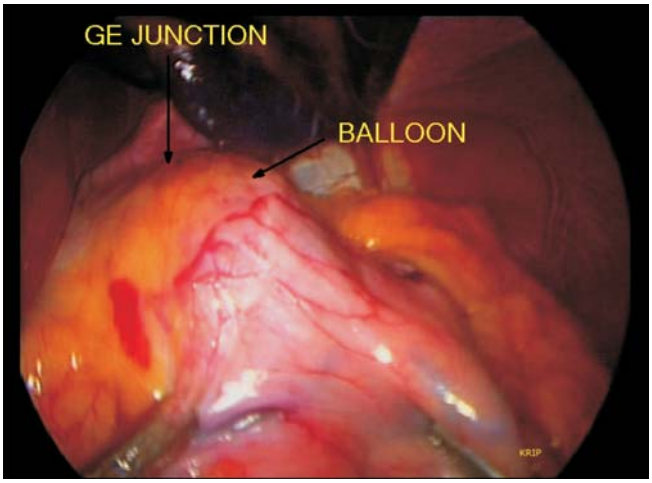

Fig. 1. The gastric calibration tube within the stomach. The balloon of the calibration tube is inflated with 20 mL saline and the tube pulled out till it meets resistance so that the balloon is at the gastro-esophageal junction. The tube will be placed at the middle of the balloon after deflation (about 1.5 to 2 cms below esophago-gastric junction.

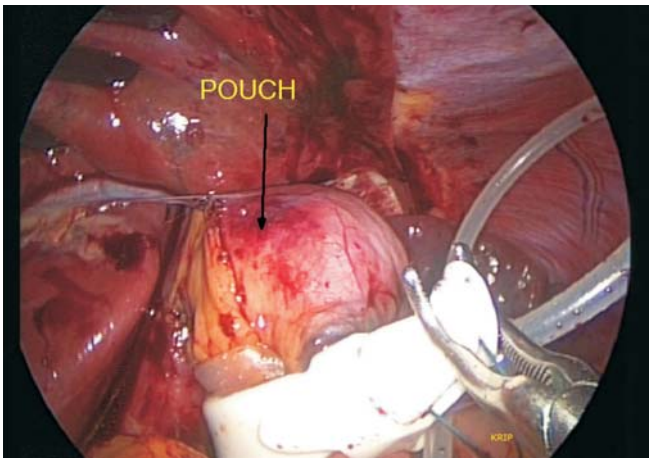

Fig. 2. The band locked in place below the inflated balloon of the gastric calibration tube.

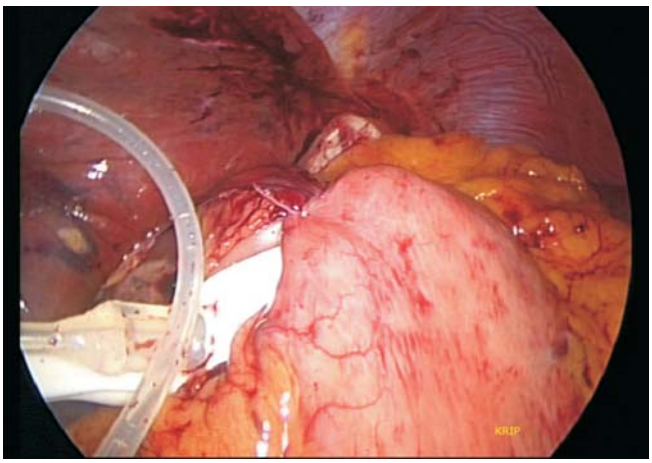

Fig.3. Gastro-gastric sutures on the anterior wall of the stomach in place to stabilise the band and prevent slipping of the gastric wall underneath the band.

surgeons is about 0.1%. Operative morbidity is about 5%.

Long-term complications (*Table* 1)

There are unique long-term complications of laparoscopic adjustable gastric banding, which include gastric prolapse, stomal obstruction, esophageal and gastric pouch dilation, gastric erosion and necrosis, and access port problems. Experience and improved design has markedly reduced the incidence of these complications. The older low volume (3 mL) high pressure bands have been replaced with high volume (10 mL) low pressure design. The inner balloon now encircles the stomach 360 degree so the hard buckle does not come in contact with the stomach wall. These improvement in the design decrease incidence of erosion. However, use of a prosthetic device introduces problems of malfunction and infection.

Weight loss

Weight loss after laparoscopic adjustable gastric banding is about 50% of the excess body weight (EBW) (*Table* 2) and about 25% of the BMI at 2 years (*Fig.*4 and *Fig.*5). Because weight loss with LAGB is progressive over time, these figures in Table 1 may represent an underestimation.

Reversal and revision

Laparoscopic adjustable gastric banding can be completely reversed with removal of the band, tubing, and port. For failed weight loss, revision procedures include removal of the device and performance of a restrictive-malabsorptive procedure (e.g. gastric bypass) or a primarily malabsorptive procedure (e.g. bilio-pancreatic diversion and duodenal switch).

THE ATTRIBUTES OF THE LAPAROSCOPIC ADJUSTABLE GASTRIC BAND (LAGB)

The LAGB has several particular attributes which potentially may enable it overcome the community's resistance to bariatric surgery.

Firstly, it is safe. It has proved to be remarkably safe for a major surgical procedure in a high-risk population. Second, it is effective. It is effective in achieving good weight loss, effective in leading to major improvements in health and effective in restoring quality of life. Third, it achieves these effects in a gentle way. The operation does not generate major pain or disability. Day patient treatment or overnight stay is becoming routine. It is gentle in the follow-up phase because of the adjustability which is the key to the long-term effectiveness. There is not the need to create excess tightness and excessive weight loss early as the adjustability permits smooth progression towards the weight goals.

Table 1. Summary of recent lap-band results in the literature

Author	Year	No	BMI pre/post(1year follow up)	Complication rate (%)	Reoperation rate
Angrisan [25]	2003	1863	43.7/33.7	10.2	N/I
O'brien [26]	2002	709	45/35	19	19
Angresani [27]	1999	40	45/33	20	10
Furbetta [28]	1999	201	43/35	4.4	4.4
Angrisani [29]	1999	31	45/29	26	23
Greenstein [30]	1998	50	N/I	N/I	18
Foresteiri [31]	1998	62	50/38	N/I	3.3
Favretti [32]	2002	830	46/37	15	3.9
Abu-abeid [33]	1999	391	43/31	4.1	6.6
Miller [34]	1999	158	44/34	8.2	7
DeMaria [35]	2001	36	45/36	N/I	41

Table 2. Weight loss after LAGB (as percent excess weight loss)

Study	N	Months after surgery							
		12	18	24	36	48	60	72	84
Belachew 2002 [36]	763	40		50		50-60			
O'brien 2002 [37]	706	47	51	52	53	52	54	57	
Cadiere 2000 [38]	652	38		62					
Vertruyen 2002 [39]	543	38		61	62	58	53		52
Dargent 1999 [40]	500	56		65	64				
Toppino 1999 [41]	361	42							
Fielding 1999 [42]	335	52	62						
Paganelli 2000 [43]	156	43							
Zinzindohoue 2003 [44]	500	43		52	55				
Niville 1998 [45]	126	48	58						
Berrevoet 1999 [46]	120	46	53						
Mean		46	56	59	61	56	53.5	57	52

Fluid can be removed as well as added, enabling removal of restriction if desired, as with pregnancy, major illness or operation or remote travel. The ability to provide further adjustments years after operation should provide a durability of weight loss that has not been available with the gastric stapling procedures. Finally, it is easily reversible. There is no intention of reversing the procedure but it is highly probable that, within 15-20 years, better options for weight reduction will be available. Especially for the young and middle-aged, the ability to be able to turn to a new approach is potentially important and attractive.

Laparoscopic sleeve Gastrectomy

Laparoscopic sleeve gastrectomy (LSG) is a relatively new option being used in the treatment of morbid obesity. This procedure was originally published by Marceau, *et al* [47] in 1998 as a restrictive part of a duodenal switch mal-absorptive operation, in an attempt to improve the results of bilio-pancreatic diversion, without performing a distal gastrectomy. The procedure involves removing 75-80% of the stomach, leaving behind only a sleeve of stomach in the shape of a banana (*Fig.*6) using a 52 F bougie. This small stomach pouch restricts the amount of food that a patient can eat giving early satiety and leads to initial significant weight loss. LSG was designed as the restrictive component of the duodenal switch to minimize the problems of alkaline gastritis and anastomotic ulcer that were cause of significant morbidity after bilio-pancreatic diversion. Sleeve

Fig.4. Before and after laparoscopic adjustable gastric banding.

Fig.5. Before and after laparoscopic adjustable gastric banding.

gastrectomy is a physiological procedure since the pylorus is intact and there is no need to divide the vagus nerves hence the gastric emptying also remains normal.

Subsequently, LSG was proposed as the first-step in the treatment of super-obese patients or in patients with high operative risk before performing more complicated procedures such as laparoscopic bilio-pancreatic diversion with duodenal switch (BPD-DS) or laparoscopic Roux-en-Y gastric bypass (LRYGBP) [48]. High-risk patients include super-super-obese patients with BMI >60 kg/m^2 and patients with severe multiple co-morbidities. Surgical treatment of high-risk patients remains a challenge even in specialized centers. These patients have higher peri-operative morbidity [49,50] after bariatric operations and the complications are more likely to be fatal [50,51]. Sleeve

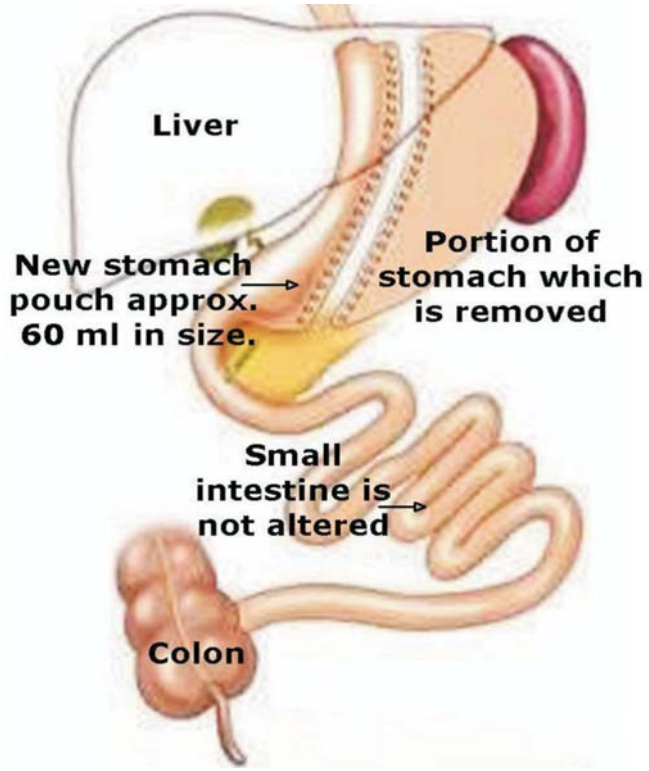

Fig.6. Sleeve gastrectomy showing a tubularised stomach along the lesser curvature and the part of stomach with fundus which is removed.

gastrectomy is a simpler procedure associated with significantly reduced risk even for patients with multiple co-morbidities in super-super obese patients. After sleeve gastrectomy, weight loss and improvement in co-morbidities make the patients a better candidates for a subsequent BPD-DS or gastric bypass [48].

Sleeve gastrectomy is followed by significant reduction in appetite since it removes gastric fundus which is the predominant area of human Ghrelin production [19]. Thus, LSG has a physiological advantage to achieve sustained weight loss over other restrictive procedures such as LAGB or vertical banded gastroplasty, that do not influence the Ghrelin-producing cell mass and this explains better results after LSG. Many of the patients who underwent LSG as a first stage procedure has such significant weight loss that they did not require a second stage procedure [52]. This prompted use of LSG as a primary weight loss procedure. Technical modification was suggested using a smaller size, 32 F bougie to make a smaller stomach pouch for better long term results [52].

Surgical Technique

All operations were performed laparospically using the French position (legs abducted with the surgeon standing between the patient's legs). Each procedure required 6

trocars (*Fig.*7). The pylorus is identified as the first step of the procedure. The dissection begins on the greater curvature at 5 cm from the duodenum. The branches from the gastro-epiploic vessels along the greater curvature of the stomach are divided using the Ultracision, taking care to preserve the gastro-epiploic arcade. Once the lesser sac has been entered, the dissection continues in a cephalad direction till the lower pole of the spleen is reached. At the level of the spleen, the short gastric vessels are carefully coagulated separately using the Ultracision. The dissection continues till the root of the left pillar of the hiatus is reached. Posterior adhesions of the stomach in the lesser are divided, if any.

The division of the stomach is performed with a linear stapler-cutter device (Echelon 60, Ethicon).The linear cutter is introduced through the right midclavicular port with a 4.1-mm green load for the antrum, starting from 5 cms from the pylorus at the level of the incisura, proceeding towards the angle of His. Before firing, a 32-French plastic tube is introduced per orally by the anaesthetist and advanced into the stomach. Further division of the remaining gastric corpus and fundus is performed using 3.5-mm blue loads through the left midclavicular port. The stapler is then positioned so that it loosely pushes the oro-gastric tube against the lesser curvature with the jaws of the linear cutter parallel to the lesser curve just to the left of the visible endings of the lesser curvature vessels. Hence, the diameter of the gastric tube will at least 34 French. The linear cutter is fired, reloaded and the manoeuvre repeated. Finally, after four or five firings of the stapler, the greater curvature is completely detached from the stomach. A 15-mm retrieval bag is used to remove the sleeve gastrectomy specimen. The gastric suture-line is checked for bleeding. The staple-line is inverted by placing a sero-serosal continuous absorbable suture over the bougie from the angle of His. A methylene blue test may be performed to rule out staple-line leakage. A Jackson-Pratt drain was placed along the staple-line. We do not use any naso-gastric tube postoperatively. The mean operative time is 90 minutes.

The patient is taken to the recovery room and from there back to the room. A water-soluble upper GI contrast study is performed on the second postoperative day to check for any leak, gastric emptying and the size of the pouch (*Fig.*8). Oral fluids is allowed if no leakage is demonstrated. Oral fluid intake is increased on the next day. The patients are discharged on third postoperative day after the drain is removed. The average length of post operative hospital stay is 3 to 4 days.

Staple-line leakage and bleeding are two complications that may be encountered with LSG. Using absorbable

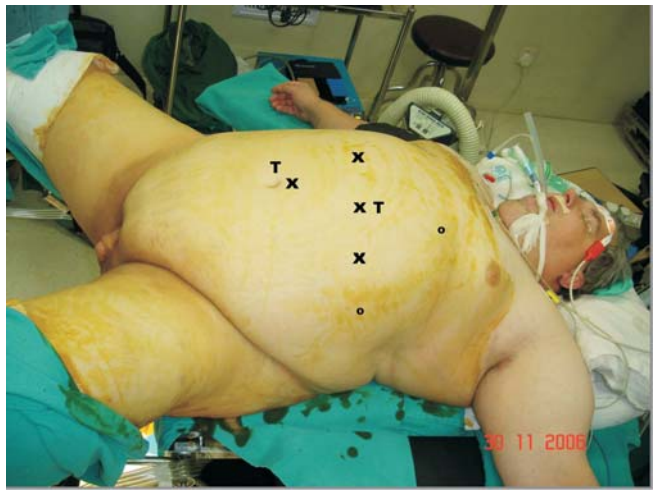

Fig.7. Port positions for sleeve gastrectomy. X indicates 10 mm ports. The Telescope (T) is initially at the umbilical port but is shifted to the midclavicular port for the fundus dissection. O indicates 5 mm ports. A Nathensan retractor or a fan retracter can be used through the epigastric port for retracting the left lobe of the liver.

Fig.8. Gastrograffin study after sleeve gastrectomy showing a narrow gastric pouch with antrum and smooth passage of contrast into the duodenum.

polyglyconate polymer membrane to buttress the stapler may reduce these compications [53].

Lalor, *et al.* [54] reported 2.8% major complication rate and one (0.7%) late major complication in 148 patients undergoing LSG as a primary procedure. Laparoscopic SG is a safe one-stage restrictive technique as a primary procedure for weight loss in the morbidly obese with an acceptable operative time, intra-operative blood loss, and

peri-operative complication rate.

Weight loss results have been good [19], particularly after the use of 32 F bougie [52] (*Figs* 9 and 10). At 3 year follow up, the results are better the gastric banding [55]. However, follow-up and number of patients are still low. Long-term results have been published with a similar operation (Magenstrasse and Mill procedure) in 100 patients [56], where %EWL was 60% at 5 years.

LSG is fast becoming an accepted primary weight loss surgery because of its excellent weight loss results, simplicity and safety. On one hand, patients do not require to be on vitamin and mineral supplements as in it does not cause any malabsorption and on the other, the problems of foreign body like erosion, slippage and infection as seen with the band are avoided. Its safety is comparable to lap band. Weight loss is faster than band is almost equal to gastric bypass at one year. Being a onetime procedure, patient compliance is better and the maintenance cost is low (no refills or vitamin supplements). It can be recommended for patients who are very young and therefore are not candidates for a gastric bypass procedure or lifelong foreign body. It can also be recommended for elderly patients who are high risk for gastric bypass and are unsuitable for gastric banding as they cannot increase physical activity due to joint problems. Sleeve is effective as a weight loss surgery in this group of patients also. It can be performed on patients who have anaemia or inflammatory bowel disease and hence are not suitable for gastric bypass or patients with gastric polyps who need regular endoscopic surveillance of the stomach. Similarly, it is a better procedure for patients who need to take NSAID or other critical medication (transplant or cardiac medication) which is not advisable with a small pouch of gastric bypass.

Fig. 9. Before and after laparoscopic sleeve gastrectomy.

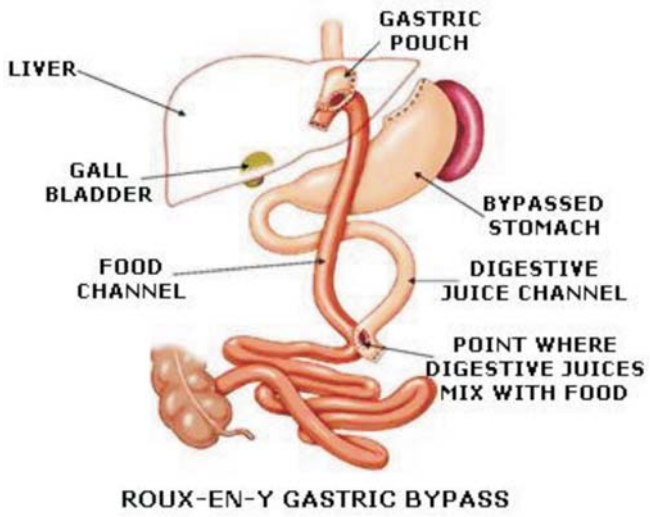

Fig. 10. Gastric bypass: vertical gastric pouch with Roux-en-Y gastro-jejunostomy.

Laparoscopic gastric bypass Roux-en-Y

Gastric bypass is currently the most popular procedure performed in the United States and worldwide. Gastric bypass, developed by Mason and Ito in 1966 at the University of Iowa, was the first of the combined restrictive mal-absorptive operations for morbid obesity. The restrictive element of the operation consists of the creation of a small gastric pouch with a small outlet that, on distention by food, causes the sensation of satiety. This restrictive element is combined with a gastrointestinal bypass as the malabsorptive element. The extent of the bypass of the intestinal tract determines the degree of macronutrient malabsorption. The minimal amount of intestinal tract bypassed consists of the distal stomach, the entire duodenum, and about 50 cm of the proximal jejunum. The standard Roux limb is about 100 cm. More extensive mal- absorptive variations consist of gastric bypasses with a 150-cm Roux limb (long-limb) or with a very long limb (distal gastric bypass).

Current techniques

The laparoscopic technique, introduced by Witgrove *et al.* [57] has become the more popular approach. The stomach is divided using a stapler about 3 cms below the Gastro-oesophageal junction to fashion a vertically constructed upper pouch, which is 15 to 25 mL in capacity and the distal stomach is disconnected from this pouch. The jejunum is divided 50 cms from the duodeno-jejunal ligament (bilio pancreatic limb). The cut end of the proximal jejunal limb is then anastomosed side to side with the distal jejunal limb about 100 cms from the cut end (the Roux limb or the alimentary limb). The distal jejunum is then brought up to the gastric pouch to fashion a gastro-

jejunostomy. The gastro-jejunostomy stoma is about 1.2 cm or less in diameter. In the laparoscopic approach, the gastro-jejunostomy can be performed with the end-to-end circular stapler, the linear stapler, or it can be hand-sewn. The advantage of the circular stapler is that each time a stoma of standard size is made and if a stricture occurs, it is easily dilatable since the jejunum is in straight line with the stomach pouch and the stoma. The jejunal limb is now being placed more often antecolic, a position which decreases the chances of internal herniation. At the end of the procedure a leak test is performed using methylene blue or an endoscope. Post operatively no naso gastric tube is placed. We generally keep a drain near the gastro-jejunostomy. On the next day of surgery, a gastrograffin study is performed (*Fig.*11) to see the size of the pouch, presence of any leak and gastric emptying. Liquid diet is started after a satisfactory study.

Operative mortality and morbidity

Operative (30-day) mortality for gastric bypass when performed by skilled surgeons is about 0.5%. (*Table* 3). Operative morbidity (e.g. pulmonary emboli, anastomotic leak, bleeding, and wound infection) is about 5%. Compared with open procedures, laparoscopic gastric bypass has a lower rate of intra-abdominal complications whereas duration of hospitalization is shorter, wound complications are lower, and postoperative patient comfort is higher.

Long-term complications

Gastric bypass can be associated with the dumping syndrome, stomal stenosis, marginal ulcers, staple line disruption, and internal hernias. Life-long oral or intramuscular vitamin B12 supplementation, and iron, vitamin B, folate, and calcium supplementations are recommended to avoid specific nutrient deficiency conditions, such as anemia.

Ventral hernia formation was more prevalent after open gastric bypass (20%) and the incidence has decreased significantly (2%) after the laparoscopic approach. A unique complication of gastric bypass is dilation of the bypassed distal stomach in the event of a small bowel obstruction, which can lead to rupture and death if not rapidly managed by distal gastric decompression.

Weight loss

Weight loss after a standard 100 cm Roux gastric bypass usually exceeds 45 Kgs, or about 65-70% of the excess body weight (EBW) and about 35% of the BMI (*Fig.*12). The longer-limb bypasses are used to obtain comparable weight reductions in super obese (BMI $\geq$50 kg/m^2) patients.

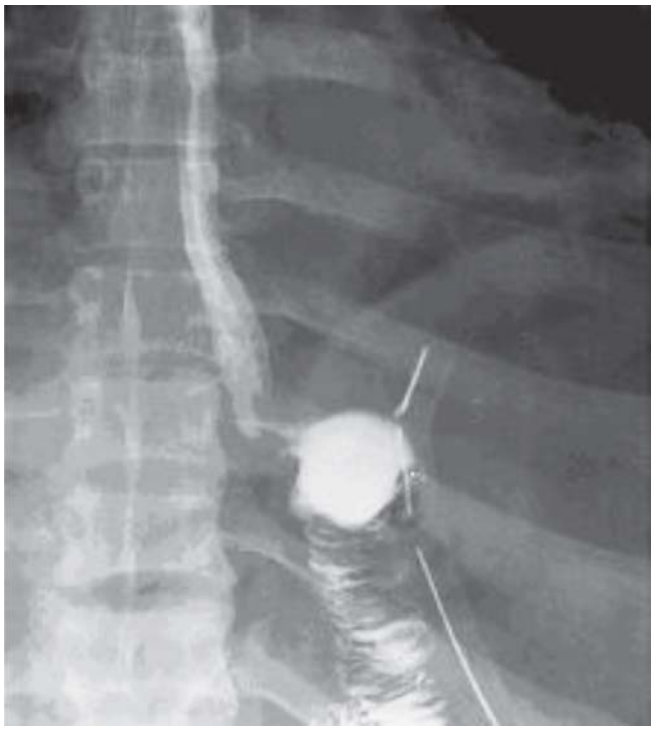

Fig.11. Gastrograffin study on the 1st postoperative day after Laparoscopic gastric bypass. Note extremely small size of the gastric Pouch with contrast going into the jejunum and a drain which is removed after the study.

Weight loss generally levels off in 1 to 2 years, and a regain of up to 20 lb from the weight loss nadir to a long-term plateau is common.

Reversal and revision

Gastric bypass can be functionally totally reversed, though this is rarely required. For all bariatric procedures, pure reversal without conversion to another bariatric procedure is almost certainly followed by a return to morbid obesity. A standard Roux gastric bypass with failed weight loss can be revised to a very long-limb Roux-en-Y procedure.

Bilio-pancreatic diversion and duodenal switch

Bilio-pancreatic diversion (BPD) (*Fig.* 13) and duodenal switch (DS) (*Fig.* 14) are primarily malabsorptive procedures. The bilio-pancreatic diversion originated in Genoa, Italy by Scopinaro in 1976 and is widely used in Europe and sparingly in the United States. The duodenal switch is a US adaptation of the bilio-pancreatic diversion to avoid marginal ulcerations and iron deficiency anaemia and is gaining popularity in that country. Both procedures involve a partial gastrectomy leaving a gastric pouch of 100 to 150 mL, which is considerably larger than that of gastric bypass or the restrictive procedures and thereby allows larger meals in comparison with those of the other

Table 3. Complications after laparoscopic gastric bypass (2,805 patients)

Type	Complication	(N)	Male	Female	(%)
Anastomotic stenosis	Gastrojejunostomy	146	33	113	5.21
	Mesocolon	15	1	14	0.53
	Jejuno-jejunostomy	2	0	2	0.07
		Total:	5.81		
Hernia	Trocar	4	3	1	0.14
	Internal	128			4.6
		Total:	4.7		
Leaks	Staple line	21	9	12	0.75
	Gastrojejunostomy	2	0	2	0.07
	Jejuno-jejunostomy	1	0	1	0.04
		Total:	0.86		
Infection(non-leak)	Wound	3	1	2	0.11
	Pneumonia	2	1	1	0.07
	Hepatic abscess	1	1	0	0.04
		Total:	0.21		
Bleeding	Intervention required	13	7	6	0.46
	Transfusion only	11	1	10	0.39
	Observation	7	1	6	0.25
		Total:	1.1		
Thrombo-embolic	Pulmonary embolism	5	0	5	0.18
	Deep venous thrombosis	2	1	1	0.07
		Total:	0.25		
Biliary	Gallstones	77	7	70	2.75
	Acalculous cholecystitis	5	0	5	0.18
		Total:	2.92		
Marginal ulcer	Treated medically	17	3	14	0.61
	Perforation	9	0	9	0.32
	Revision required	3	0	3	0.11
		Total:	1.03		
Death	Perioperative	4	1	3	0.14
TOTAL:478/2805=17%					

bariatric operations. Both procedures avoid leaving a nonfunctioning intestinal segment by dividing the intestine into a long enteric limb joining a long bilio-pancreatic limb to form a common channel 50 to 100 cms from the ileo-caecal valve. This modification avoids the toxic problems seen with the old jejuno-ileal bypass procedure.

Current techniques

For the bilio-pancreatic diversion, a horizontal gastrectomy is performed with a retrocolic gastro-jejunostomy. This long Roux limb, carrying enteric contents, is anastomosed to the bilio-pancreatic limb emanating from the closed post pyloric duodenum 50 cms proximal to the ileo-caecal junction. (*Fig.* 13).

For the duodenal switch, a pylorus-sparing vertical sleeve gastrectomy is performed with anastomosis of the proximal duodenal cuff to the enteric limb. Comparable with bilio-pancreatic diversion, the enteric limb of the duodenal switch is anastomosed to the bilio-pancreatic

Fig.12. Before and after laparoscopic gastric bypass.

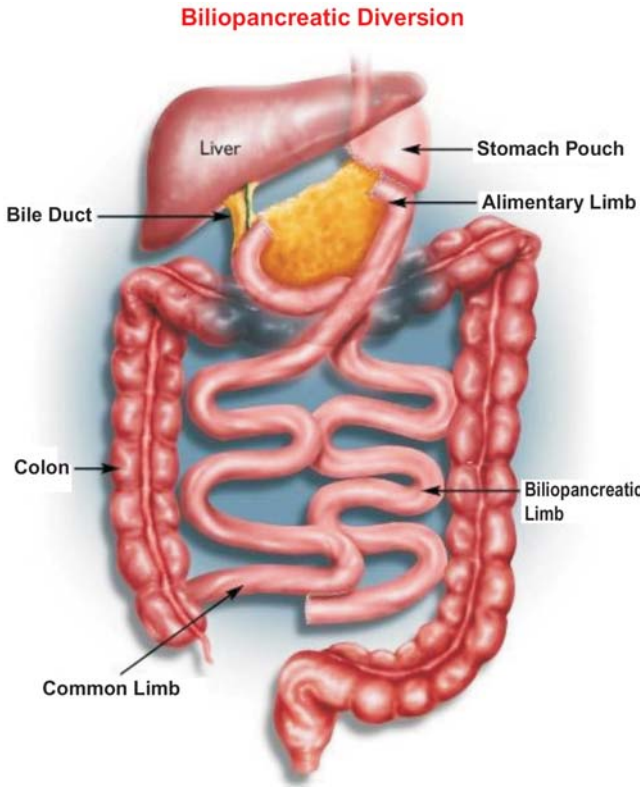

Fig.13. Bilio-pancreatic diversion with distal partial gastrectomy and gastro-jejunostomy. The common limb is 50 cms.

limb emanating from the post pyloric duodenum. Length of the common channel formed by joining of the enteric and bilio-pancreatic limbs governs the malabsorptive outcomes of these procedures and is 100 cms (*Fig.* 14).

Open bilio-pancreatic diversion and duodenal switch are long and difficult procedures requiring skilled surgeons

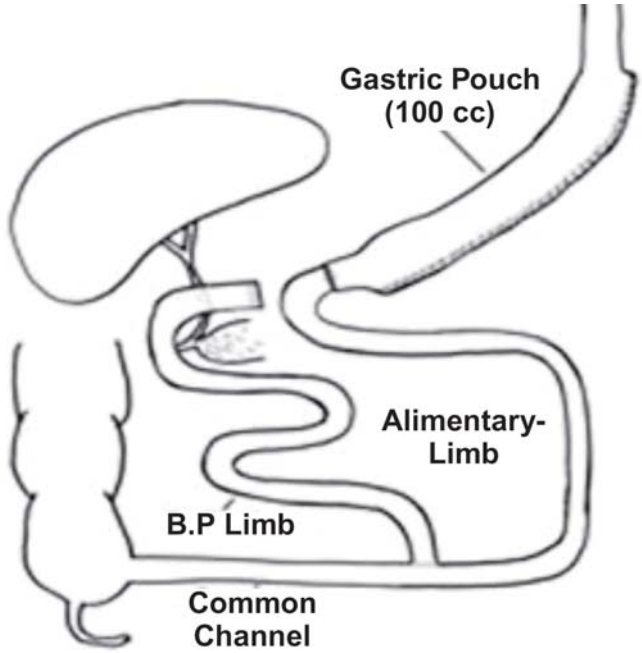

Fig.14. Bilio-pancreatic diversion with duodenal switch. The common channel is about 100 cms long.

and adequate experience. Both procedures have been performed by hand assisted or by total laparoscopic techniques. A two stage laparoscopic duodenal switch with initial subtotal gastrectomy (sleeve resection) has been used in high-risk, extremely obese (BMI ≥60 kg/m^2) patients.

Operative mortality and morbidity

Operative mortality for bilio-pancreatic diversion and duodenal switch when performed by skilled surgeons is about 1%. Operative morbidity is about 5%.

Long term complications

On occasion, these procedures are associated with diarrhea. Some patients report malodorous stools and flatus. Long-range complications can consist of vitamin, mineral, and nutrient deficiencies, in particular, protein deficiency. These contingencies need to be anticipated and properly managed by dietary supplements with about 75 to 80 g of dietary protein and B vitamins, calcium, and iron. Bilio-pancreatic diversion may be associated with postoperative dumping; the duodenal switch is not.

Weight loss

Weight loss after bilio-pancreatic diversion and duodenal switch is impressive and is about 80% excess body weight loss at 2 years and 70% of the EBW at 8 years or about 35% of the BMI. Weight loss with these procedures

is at the upper end of the efficacy range. Weight loss may be sustained without a rise from the weight nadir. These consistent results are particularly important in super-obese patients (BMI >50) where obtaining an optimal BMI of less than 35 is less likely after gastric bypass or LAGB. Because of the consistent results, laparoscopic BPD with DS is gaining popularity for patients with a BMI of 50 or more.

Reversal and revision

Normal intestinal continuity can be restored, but the partial gastrectomy cannot be reversed. For failed weight loss after these procedures, shortening of the common channel has produced a desired result in some, but not all patients.

OVERVIEW

There is no single or standard procedure for management of morbid obesity and probably there never will be. There never was a single procedure for peptic ulcer disease, and there is no standard inguinal hernia repair. Ingenuity and investigation will lead to changes in the procedures used, e.g. the current work-in-progress testing the efficacy of gastric pacing. The next bariatric surgery consensus conference on the state-of-the-art will, undoubtedly, discuss new procedures and modifications of existing ones. This continuous evolution in operative approaches will result in continued improvement in patient management.

CARE OF THE BARIATRIC SURGERY PATIENT

Patient selection

The 1991 NIH Consensus Conference weight criteria for bariatric surgery of a BMI $\geq$ 40 kg/m^2 or a BMI of 35 kg/m^2 to 39.9 kg/m^2 in the presence of severe co-morbidities are still reasonable today. High-risk co-morbid conditions that can justify reducing the BMI to 35 kg/ m^2 include type 2 diabetes, life-threatening cardiopulmonary problems (e.g., severe sleep apnea, Pickwickian syndrome, obesity-related cardiomyopathy), obesity-induced physical problems interfering with a normal lifestyle (e.g., joint disease treatable but for the obesity), and body size problems precluding or severely interfering with employment, family functions, and ambulation.

Certain data demonstrate that bariatric surgery can ameliorate obesity co-morbidities (e.g. type 2 diabetes) in patients with a BMI <35 kg/m^2. Extending bariatric surgery to patients with Class I obesity (BMI 30 kg/m^2 to 34.9 kg/m^2) who have a co-morbid condition that can be cured or markedly improved by substantial and sustained weight loss may be warranted; this BMI change requires additional data and long-term risk-to-benefit analyses.

Successful and safe bariatric surgery has been performed in patients in their 70s and in adolescents. Patient variables of gender, race, and body habitus may influence outcomes and may dictate operative selection. Co-morbidities, as a rule, are affirmative indicators for patient selection for bariatric operations.

Mental status is a difficult area in which to define standards for patient selection. Selected screening for severe depression, untreated or under treated mental illnesses associated with psychoses, active substance abuse, bulimia nervosa, and socially disruptive personality disorders may help to avoid adverse postoperative outcomes. History of compliance with non-operative therapy may be beneficial in assessing the risk-to-benefit ratio of bariatric surgery.

Preoperative care

The bariatric surgery patient needs to be well-informed, motivated, willing to participate in the long term care, change dietary patterns, and embrace a revised lifestyle. The bariatric patient is best evaluated and subsequently cared for by a team approach involving the surgeon, a nurse practitioner or nurse, a dedicated dietician, office personnel (scheduling and triage), and other specialists when needed.

In addition to a preoperative history, physical, and laboratory evaluation, a preoperative discussion or teaching seminar that provides information on postoperative recovery, dietary changes, activity, and clinical outcomes, by the dietician, the bariatric nurse, and the bariatric surgeon, is critical. Availability of a support group is recommended, as is distribution of literature describing procedures, postoperative diets, exercise, and so forth. Availability of a full spectrum of expert consultants (e.g. cardiologists, pulmonologists, psychiatrists and psychologists) is mandatory.

Peri-operative care

Expert anesthesiology support, knowledgeable in the specific problems of the bariatric patient, is necessary. The anesthesiology support includes an understanding of patient positioning, blood volume and cardiac output changes, airway maintenance, and drug pharmacokinetics in the morbidly obese. It is advisable to have preoperative, intra-operative, and postoperative written protocols.

The bariatric surgeon must be able to manage, and have coverage to manage, the postoperative patient and any problems and complications that may occur. A facility that practices bariatric surgery must be equipped with appropriate operating room equipment, including operating

tables that can handle large patients; bariatric instruments, including large retractors, special staplers, long laparoscopic instruments; special equipment to transfer the patient; extra-large beds, commodes, chairs, and wheelchairs; and diagnostic facilities and equipment that can accommodate the morbidly obese patient.

Postoperative care

Care of the postoperative bariatric surgery patient is recommended for the lifetime of the patient with at least three follow up visits with the bariatric surgery team within the first year. Laparoscopic adjustable gastric banding will require more frequent visits for band adjustment.

Postoperative dietary (including vitamin, mineral and possibly liquid protein supplementation), exercise, and lifestyle changes should be reinforced by counseling, support groups, and working with the family physician. Favorable outcomes of bariatric surgery can lead to socioeconomic advancement, which may require patient guidance. Postoperative care may include planning for reconstructive operations after weight stabilization for certain patients.

Care of the adolescent patient

Bariatric surgery has been performed in morbidly obese adolescents for more than a decade. In these small series, surgical weight loss resulted in considerable improvement, if not complete resolution, of most obesity-related co-morbidities, supporting the position that bariatric surgery in adolescents is reasonable. Long term efficacy, potential adverse consequences related to decreased absorption of nutrients, and degree of recidivism remains unknown. BMI guidelines for adolescents should be identical to those advocated for adults. Deferring surgery to a higher BMI standard may increase operative mortality and morbidity, and possibly prevent reversal of co-morbid conditions.

To be considered for bariatric surgery, the adolescent's physiologic maturity should be complete and, ideally, the adolescent should have obtained ≥ 95% of predicted adult stature. Adolescents should indicate their desire for the operation and should have sufficient cognitive and psychological development to participate in decision-making. The adolescent needs to have a general understanding of the procedure to be performed and its lifestyle consequences.

Adolescents considered for bariatric surgery should be referred to specialized centers with a multidisciplinary bariatric team capable of providing long term follow up care.

These adolescents should first undergo a trial of dietary and behavior modification for at least 6 months. The bariatric team must be expert in the technical aspects of bariatric surgery, and capable of addressing the unique cognitive, psychosocial, and emotional needs of the adolescent prospectively, as well as the long term nutritional consequences of bariatric surgery.

Clinical investigations

Over the past 10 years, the field of bariatric surgery has been enriched by data from numerous clinical investigations and experience. Directions for future clinical investigations are manifold and include: (*i*) Controlled, prospective, intervention studies. (*ii*) Establishment of a major prospective database to study bariatric surgery outcomes. (*iii*) Establishment of a pediatric (adolescent) bariatric surgery registry. (*iv*) Performance of randomized clinical trials to compare the safety and efficacy of different operative procedures. (*v*) Controlled studies of new operative modalities (e.g. gastric pacing) and non-operative modalities of treatment. Study by meta analysis of outcomes of co-morbid conditions of morbid obesity. (*vi*) Study of the socioeconomic outcomes of bariatric surgery. (*vii*) Study by stratified risk assessment of the risk-to benefit ratio of treating morbid obesity with bariatric surgery and without bariatric surgery.

BASIC RESEARCH

Availability of thousands of bariatric patients for basic research studies, involving minimal risk (e.g. blood drawing), can considerably enhance our basic knowledge of the pathogenesis and pathophysiology of obesity. Directions for future basic research are manifold and include: (*a*) Study of the interrelationships among specific bariatric surgical procedures, marked weight loss, gastrointestinal hormones (e.g. ghrelin), adipokines (e.g. leptin), and inflammatory markers. (*b*) Exploring the mechanisms by which different types of bariatric procedures work (e.g. purely restrictive, restrictive and malabsorptive, primarily malabsorptive); and application of new and safe technology in these studies (e.g. brain PET scanning). (*c*) Learning the mechanisms by which various bariatric surgical procedures impinge on the co-morbid conditions of morbid obesity. (*d*) Gaining insight into the basic cause(s) and mechanisms(s) of overweight, obesity, and morbid obesity.

SUMMARY

Laparoscopic bariatric surgery is the most effective weight loss therapy available for patients with morbid obesity. Bariatric surgery results in marked and long-lasting weight loss and elimination or improvement of most obesity-related medical complications, including diabetes,

hypertension, hyperlipidemia, obstructive sleep apnea, gastro-esophageal reflux disease, cardiac dysfunction, osteoarthritis and low back pain, nonalcoholic fatty liver disease, intertriginous dermatitis, stress incontinence, symptoms of depression, and eating disorders; bariatric operations can also prevent obesity related diseases (e.g. type 2 diabetes). There is no single or standard surgical procedure for management of morbid obesity, and future studies will likely lead to modifications in current procedures and new surgical approaches.

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