Review Article

Bariatric surgery: An overview

SANDEEP AGGARWAL, MADHUR UNIYAL

INTRODUCTION

Obesity is a global epidemic. Its prevalence is increasing rapidly and India is no exception.[1] Obesity is not only a cosmetic problem but is associated with a number of diseases including type 2 diabetes mellitus (DM), hypertension, obstructive sleep apnoea syndrome (OSAS), polycystic ovarian disease syndrome (PCOS) and non-alcoholic fatty liver disease (NAFLD). It is also a risk factor for a number of malignancies. Obese persons tend to have a shorter life span when compared to an age-matched normal population. Among the options for weight reduction, dietary and lifestyle modifications are generally advised as the first line of treatment. A large amount of scientific literature has suggested beyond doubt that non-surgical treatment of morbid obesity does not lead to a meaningful weight loss.[2–5] Almost all (90%–95%) those who do lose significant weight regain it.[3] As far as pharmacotherapy is concerned, there is almost nihilism. Most of the drugs have been withdrawn due to side-effects. Even after discounting for side-effects, these medicines lead to a nominal weight loss of only 5–10 kg. In 10-year data reported by the Swedish Obese Subject (SOS) study, weight loss in the non-surgical group was minimal compared to that in the surgical group (1.5% *v.* 25%).[4] This non-randomized study included over 4000 patients and the 5-year mortality rate in the surgical group was significantly lower than that in the non-surgical group (0.68% *v.* 6.17%).[4]

We often come across patients who initially refuse surgery due to fear of complications but later seek surgery. During this period they gain more weight and the comorbid conditions worsen. Bariatric surgery provides a means for considerable weight control and has also been effective in the resolution of obesity-related co-morbid conditions.[5] The long-term mortality due to obesity also decreases after bariatric surgery.[4]

WHAT IS BARIATRIC SURGERY?

Bariatric surgery involves altering the architecture of the gastrointestinal tract in such a way that it restricts caloric intake and/or induces malabsorption. It does not involve removal of any fat, liposuction or any body-contouring procedures. Most bariatric procedures are done using the minimal access (laparoscopic) approach.

All India Institute of Medical Sciences, New Delhi 110029, India

SANDEEP AGGARWAL, MADHUR UNIYAL Department of Surgical Disciplines

Correspondence to SANDEEP AGGARWAL; *sandeep_aiims@yahoo.co.in*

HISTORICAL PERSPECTIVE

Surgery for weight loss started in the 1950s and among the first procedures done was jejuno-ileal bypass (JIB). It involved anastomosis of the proximal jejunum to the distal ileum without removing any small intestine. This procedure remained popular for the next two decades but then fell into disrepute due to several complications including severe diarrhoea, bloating and liver failure.[6]

Dr Edward Mason from the University of Iowa popularized the gastric bypass operation in 1966. This was based on his experience of patients losing a significant amount of weight after gastric surgery for peptic ulcer disease.[7] The restrictive procedures were initiated in the 1970s to avoid the problems of malabsorption associated with gastric bypass. Vertical-banded gastroplasty (VBG) was yet another development by Dr Mason in the 1980s. Gastric banding was started in 1978 using a piece of mesh sutured around the upper part of the stomach. In 1986, Lubomyr Kuzmak invented the inflatable band which led to the popularity of adjustable bands.[8] Sleeve gastrectomy (SG) was an offshoot of the Magenstrasse and Mill procedure popularized by Dr David Johnston at Leeds, UK in the latter half of the 1980s.[9] SG was used as a restrictive part of the complex bilio-pancreatic diversion (BPD) procedure in the 1990s. However, its use as a stand-alone and primary weight loss procedure began in the 21st century. In one of the initial review articles on this subject, Aggarwal *et al.* concluded that SG will be a popular weight loss procedure in the future.[10]

Bariatric surgery started in India about a decade ago. The number of surgical procedures and centres performing these is increasing with each passing year. The All India Institute of Medical Sciences, New Delhi (AIIMS) was the first government institution to start a well-organized bariatric surgery programme. It runs a special clinic for patients who desire bariatric surgery. Every month 25–30 new patients are registered in this clinic where they undergo counselling and evaluation for bariatric surgery. Besides, data of over 500 operated patients is maintained with diligent follow-up. AIIMS also helped other academic, public sector institutions in starting their bariatric surgery programme. However, most bariatric surgical procedures are still done in private sector hospitals, mainly corporate hospitals.

The current surgical procedures for weight loss can be classified into three categories, viz. restrictive, malabsorptive and mixed (Table I). In the Indian obese population, laparoscopic sleeve gastrectomy (LSG), Roux-en-Y gastric bypass (RYGB) and adjustable gastric banding (AGB) are the most accepted surgical procedures. Purely malabsorptive procedures such as BPD and

TABLE I. Classification of bariatric surgical procedures

Restrictive	Sleeve gastrectomy (SG)
	Adjustable gastric banding (AGB)
Malabsorptive	Biliopancreatic diversion (BPD)
	Biliopancreatic diversion with duodenal switch (BPD-DS)
Combined restrictive and malabsorptive	Roux-en-Y gastric bypass (RYGB)

BPD-duodenal switch (DS) are not recommended in the Indian population as these lead to severe malnutrition. The protein intake in the Indian diet is low even among non-vegetarians. We discuss the three popular weight loss surgical procedures in the following section.

ADJUSTABLE GASTRIC BANDING (AGB)

Laparoscopic adjustable gastric banding (LAGB) is a popular weight loss procedure in Australia and Europe although its use is waning after the success of SG. It is essentially a restrictive and reversible procedure. It involves placing an inflatable band in the upper part of the stomach so as to create a small proximal pouch. The band is connected to a port implanted in the abdominal wall through a tube. The size of this pouch can be adjusted by instilling or aspirating saline from the gastric band through this port. LAGB seems to be a safer procedure as it is less invasive. It does not lead to major nutritional problems. The adjustable restriction is an added attraction for those who want freedom to eat more on some occasions such as vacations. The weight loss is gradual and can be tailored to one's requirements. However, gastric banding results in inferior weight loss than laparoscopic RYGB and LSG. The per cent excess weight loss (%EWL) at 12 months is about 50%. There is a high failure rate with as many as 25% of patients not being able to achieve an adequate (>50% EWL) weight loss.[11] Moreover, it is associated with frequent, though less severe, long-term complications including band slippage, band erosion and port-site problems.[12] The need for a high level of motivation, strict and regular follow-up and frequent adjustments does not make it a popular choice in the Indian population.

LAPAROSCOPIC SLEEVE GASTRECTOMY (LSG)

This procedure was started as a part of BPD. It was then popularized as the first stage surgery for a two-stage operation in super-obese patients by Gagner and co-workers.[13] In this subset of patients, it was found that a majority of patients achieved good weight loss and did not require the second stage surgery (RYGB/BPD).[14] It was also used in patients with inflammatory bowel disease, adhesions and other poor intraoperative conditions. Considered by many surgeons as inferior to gastric bypass (and some continue to do so!), SG as a stand-alone procedure was initially considered to be investigational. Excellent results in numerous larger series forced the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) and The American Society for Metabolic and Bariatric Surgery (ASMBS) to endorse it as recently as 2009. SG is the fastest growing weight loss surgery option. Its safety and popularity among children and adolescents has been well accepted.[15] The procedure involves a longitudinal resection of the stomach starting from the antrum 5–6 cm from the pylorus and finishing at the fundus close to the Angle of His over a bougie.[16] Most surgeons prefer to use a bougie about 36–40 French to calibrate the size of the sleeve. The average size of the stomach that remains after the procedure is about 150 ml. It is a relatively less complex procedure than RYGB. Its advantages over RYGB include absence of any anastomosis, maintenance of normal food pathway, absence of dumping, marginal ulceration and no risk of late internal hernias. There are fewer nutritional complications as well. Most patients do not require regular nutritional supplements after the first postoperative year. Based on an analysis of 19 605 SG procedures, the Third International Summit on Current Status of Sleeve Gastrectomy concluded that SG has a better impact on weight loss and diabetes than gastric banding while its impact is similar to the results achieved by RYGB.[17] The disadvantages include difficulty in managing suture line leaks, absence of long-term results, propensity for *de novo* gastro-oesophageal reflux disease (GERD) and a possible inferior impact on type 2 DM. Staple line leak (2.2%), bleeding (1.2%) and stricture formation (0.63%) are the main complications.

The weight loss is due to multiple factors. SG is a restrictive procedure involving removal of over 80% of the stomach including the distensible portion. This decrease in capacity permits intake of only a small amount of food, imparting a feeling of early satiety. Attenuation of Ghrelin levels (a hunger regulating peptide which is secreted from the fundus of the stomach) also contributes to the substantial weight loss as a major part of the fundus is done away with.[18] The %EWL at 12 months is 60%–70%. Long-term weight loss has been reported to be satisfactory in a few recent reports. It has been seen that after 6+ years the mean EWL exceeds 50%.[19]

Contrary to the initial belief, SG is not only a restrictive procedure but has a major impact on metabolic pathways especially those affecting glucose metabolism. The mechanism of action is still an area of research. It is postulated that neurohormonal changes related to gastric resection or expedited nutrient transport into the small bowel may be the cause. Gastric emptying time has been found to decrease after SG. The early presentation of food in the ileum causes an increase in glucagon-like peptide (GLP-1), a gut hormone secreted by the L cells in the ileum. GLP-1 is an incretin and causes an increase in the level of post-prandial insulin. This may explain the positive impact of surgery on type 2 DM which generally occurs before any substantial weight loss has occurred.

ROUX-EN-Y GASTRIC BYPASS (RYGB)

In morbidly obese people, RYGB is very efficacious. This procedure leads to 60%–70% of EWL in the first year.[20] Long-term weight loss extends for over 10 years.[21] This is the reason why most surgeons consider it to be the bariatric procedure of choice for severe obesity. The procedure consists of a restrictive component resulting from creation of a small gastric pouch of 20–30 ml. This small pouch is anastomosed to a Roux loop of jejunum creating a gastrojejunostomy of about 2 cm in diameter. This small anastomosis further helps in creating restriction. The malabsorptive component is created bypassing a portion of small bowel so that the alimentary limb carrying food is anastomosed to the biliopancreatic limb carrying biliopancreatic juices about 200 cm from the duodeno-jejunal junction. Thus, a major portion of the stomach and 150–200 cm of small bowel is excluded from nutrient absorption. The RYGB is currently considered the gold standard weight loss procedure. It is a highly efficient approach to morbid obesity but might result in significant perioperative complications including infection (5.6%), anastomotic leak (2.2%), respiratory complications (1.4%), stomal stenosis (1.6%), small bowel obstruction (0 .6%) and haemorrhage (0.8%).[22] The use of the laparoscopic approach has reduced perioperative complications and time of recovery. The advantages and disadvantages of the three commonly used surgical procedures are listed in Table II.

TABLE II. Pros and cons of three popular surgical procedures

Procedure	Advantages	Disadvantages
Gastric banding	Technically simple Reversible No malabsorption Low morbidity	Foreign body 15%–30% failure High reoperative rate
Sleeve gastrectomy	Technically less complex Low morbidity	Leaks difficult to manage Unknown long-term results Variable impact on GERD
Gastric bypass	Sustained weight loss Dumping in sweet eaters Resolution of GERD	Intestinal anastomosis Loss of access to gastric remnant Vitamin deficiencies Marginal ulceration Late internal hernia

GERD gastro-oesophageal reflux disease

TABLE III. National Institutes of Health guidelines, 1991 for bariatric surgery

Age >18 and <65 years
BMI ≥40 kg/m^2 with or without comorbid conditions
BMI ≥35 kg/m^2 with comorbid conditions
History of multiple failed dieting attempts
Acceptable surgical risk
Commitment to lifelong follow-up

WHO SHOULD GET BARIATRIC SURGERY DONE?

Bariatric surgery is a major undertaking with potential for morbidity and mortality. It should be done only in patients who have an indication for the procedure. The body mass index (BMI) is used to define the indications for bariatric surgery. BMI is defined as weight in kilograms (kg) divided by square of the height in metres. Though not ideal, BMI is the best possible criteria at present. The 1991 National Institutes of Health (NIH) guidelines are currently the most commonly used all over the world (Table III).

Indians have predominantly central obesity leading to more visceral fat for a given BMI than Caucasians. This is responsible for the higher prevalence of type 2 DM and metabolic syndrome at a lower BMI. Thus, metabolic and vascular complications occur at a lower BMI compared to the Caucasian population.[23,24] In India, the recommended BMI cut-offs for bariatric surgery are lower by 2.5 points, which means that surgery is indicated for those with a BMI of 37 kg/m^2 or more with or without comorbid conditions and those with a BMI >32.5 kg/m^2 with obesity associated comorbid conditions.[25]

However, since 1991, improvements in anaesthesia and perioperative care as well as introduction of laparoscopy, surgical outcomes have become better with lower mortality and morbidity rates. These developments coupled with failure of non-surgical interventions have led the ASMBS to endorse bariatric surgery in patients with class I obesity, i.e. BMI 30–35 kg/m^2. An increasing number of patients in this group are demanding surgery, being frustrated by the failure of dietary and lifestyle treatment.

The absolute contraindications to bariatric surgery are few and include severe psychiatric disorders, severe alcohol dependence, cirrhosis of the liver with portal hypertension, active cancer and prohibitively high risk of anaesthesia. The presence of uncontrolled diabetes, hypertension, obstructive sleep apnoea, hypothyroidism or stable coronary artery disease are not contraindications. Such patients deserve surgery more than others.

PATIENT COUNSELLING

Patient counselling is the mainstay of a well-organized bariatric surgery programme. The counselling should be done initially by the bariatric surgeon himself/herself and should address certain important points. First of all it should be stressed that bariatric surgery is not about removal of fat. It is neither liposuction nor abdominoplasty as is the popular belief. Patients should be informed about the nature of surgery, various surgical options including their pros and cons and the non-zero mortality. They should understand that not all excess weight is lost and long-term maintenance of weight is dependent on their commitment to exercise and dietary compliance. Patients should also be counselled by a nutritionist about the preoperative and postoperative dietary modifications. A well-prepared patient is essential for a successful outcome otherwise patients may not accept the major dietary changes which can occur after surgery. They should also be counselled about the possibility of reversible hair loss during the first year of surgery.

PREOPERATIVE PREPARATION

After the initial counselling, the patient is advised to undergo detailed investigations. The blood investigations include haemogram, liver and renal function tests, lipid profile, serum calcium, phosphate, uric acid, vitamin D and parathormone (PTH) levels, iron studies, vitamin B12 and folate levels. Other investigations include upper gastrointestinal endoscopy, chest X-ray, pulmonary function test (PFT), polysomnography, abdominal ultrasound and venous Doppler of both lower limbs. Depending on the comorbid conditions, patients may need to consult with other specialists including a cardiologist, endocrinologist, pulmonary medicine physician and psychiatrist. However, in our experience, the majority of patients opting for bariatric surgery do not have any significant cardiac issues barring uncontrolled hypertension in a few. A routine echocardiogram and, if required, stress tests such as dobutamine stress echocardiography suffice in most patients. Patients with sleep disorders, eating disorders and those on antidepressants and other psychotropic medications should be referred to a psychiatrist and psychologist. An endocrinologist may be required to rule out an endocrine cause of obesity, such as Cushing syndrome, which is an absolute contraindication to bariatric surgery. The presence of hypothyroidism is not a contraindication for surgery and in fact a decrease in the dose of thyroxine has been reported after weight loss following bariatric surgery.[26]

The patients are advised a low calorie diet of about 1200 calories at the time of initial counselling. They are further advised to start on a liquid diet of about 800 calories/day about 2 weeks before surgery. This is done to attempt a weight loss of about 5% before surgery. Such a weight loss has two advantages. First, the liver size reduces and makes surgery safer. Second, it assesses the patient's motivation and compliance. Preoperative weight loss has been shown to be an important predictor of postoperative weight loss.

Before surgery, an attempt is made to optimize the comorbid conditions especially the pulmonary dysfunction, hypertension, diabetes and sleep apnoea. Preoperative weight loss also helps in achieving this goal.

SURGERY

After a detailed assessment, the patient is usually admitted a day before surgery. The surgical procedure is done laparoscopically using four or five ports. A special self-retaining liver retractor (Nathanson liver retractor) is useful as most of these patients have a heavy and large left lobe. It takes 45–120 minutes depending on the procedure.

The blood loss is minimal and averages around 50 ml. Perioperative deep vein thrombosis (DVT) prophylaxis is initiated using heparin or low molecular-weight (LMW) heparin. Mechanical prophylaxis is done using pneumatic compression pumps.

After the surgery, patients are monitored in the recovery room. The patients do not require intensive care as is generally believed. They are usually shifted to a monitored bed or a high dependency unit.

POSTOPERATIVE COURSE

The postoperative course is usually uneventful. The patients are mobilized on the same day; often as early as 6 hours after surgery. They are continued on anticoagulation and pneumatic compression pumps for DVT prophylaxis. They are allowed oral sips the following day followed by increased intake of liquids. Most patients are discharged by postoperative day 3. During the hospital stay the clinical symptoms and signs of patients are regularly monitored to rule out any leak from the suture line or bleeding. Some centres do a routine gastrograffin study on postoperative day 1 or 2 to rule out a leak before the initiation of oral intake. In our experience, the clinical condition of the patient is the best indicator of an impending complication such as a leak.

FOLLOW-UP

The patients are followed up at one week, 1, 3, 6 and 12 months in the first year. Subsequent follow-up is yearly. Patients with poor weight loss or other complications may require a more intensive follow-up. The patient's weight is taken at each follow-up. The dose of various medications may need adjustment. Dietary evaluation is done to ensure that the patient is taking adequate amounts of protein and supplements. The importance of physical activity is stressed. The patients are advised at least 5 hours of physical activity per week. Regular patient support group meetings should be a feature of any good programme. Such meetings ensure a better follow-up, better compliance and help in maintaining the patient's motivation.

IMPACT ON WEIGHT LOSS

Bariatric surgery leads to a remarkable weight loss. The average weight loss after gastric bypass and sleeve gastrectomy is 40–45 kg at 1 year. Most patients continue to lose weight till 18–24 months after surgery. The weight loss is reported as %EWL with baseline weight taken as weight at BMI of 25 kg/m^2. An EWL >50% at 12 months is deemed as a successful result. The %EWL after RYGB at 12 months varies from 60% to 80%.[27] The %EWL is just a bit less for SG at 60%–70% at 1 year. The weight lost with gastric banding is not as much—45%–50% at 1 year. Long-term results indicate better maintenance with RYGB than with SG.

IMPACT ON COMORBID CONDITIONS

Obesity is associated with a number of comorbid conditions affecting virtually every organ in the body. These include type 2 DM, hypertension, OSAS, PCOS, osteoarthritis, non-alcoholic steatohepatitis (NASH) and others. A weight loss of about 10% has been shown to improve the control of comorbid conditions. With a weight loss of 40–45 kg at one year, it is logical that bariatric surgery would lead to a remarkable impact on comorbid conditions. The resolution of comorbid conditions occurs in 70%–80% patients with cessation of medicines.[5] The remaining patients experience an improvement and lowering of dose of medicines. The impact on type 2 DM and sleep apnoea is particularly impressive and occurs in the early postoperative period. Although RYGB has been considered to be better for patients with diabetes, numerous reports and our own experience has shown that SG is an equally effective procedure if not better. The incidence of cancer too has been reported to be lower in patients who have undergone bariatric surgery.[28]

SURGICAL CURE OF DIABETES: A REALITY

The pandemic of obesity and type 2 DM are closely associated and pose a dire health threat throughout the world.[29] The International Diabetes Federation estimated that in 2003, 194 million people were suffering from diabetes, and that by 2025, >300 million people worldwide will have the disease.[30] There is a marked increase in the rate of obese people affected with type 2 DM in Asia too. India and China have the largest population affected with diabetes, and are likely to remain in this slot in 2025, by which time each could have 20 million affected individuals.[31] Asian Indians tend to develop diabetes with a lesser degree of obesity and that too at a younger age. They suffer longer with complications of diabetes, and die at a comparatively early age.[32] Adequate glycaemic control is difficult to achieve by lifestyle modifications and medical therapy in obese patients with type 2 DM.[8] Since Pories *et al.*[21] described remission of type 2 DM after RYGB in morbidly obese patients, other research groups also have verified and advocated the benefits of bariatric procedures in people with type 2 DM.[33–35]

The emergence of a large amount of literature[34,35] supporting surgical treatment of diabetes has led the International Diabetes Federation[36] and American Diabetes Association[37] to recognize bariatric surgery as an effective treatment option for obese patients with type 2 DM.

It is postulated that one of the reasons for development of type 2 DM is that when the food is presented to the foregut it causes overproduction of glucose-dependent insulinotropic peptide (GIP) leading to hyperinsulinaemia and ultimately insulin resistance. In procedures such as RYGB the foregut is bypassed and hence there is no stimulation of K cells in the duodenum, which are responsible for GIP secretion. Moreover, there is early presentation of food to the ileum, where L cells are stimulated to release glucagon-like peptide 1 (GLP-1). GLP-1 has a potent glucose-dependent action on beta cells of the pancreas, which secrete insulin thus providing better control for type 2 DM.

IMPACT ON OBSTRUCTIVE SLEEP APNOEA

This condition is characterized by repeated pauses in breathing during sleep, which leads to the fragmentation of sleep and decrease in oxyhaemoglobin saturation.[38] The physiological spectrum of sleep-disordered breathing ranges from a partial airway collapse and an increased upper-airway resistance, manifested as loud snoring and episodes of hypopnoea, to a complete airway collapse and episodes of apnoea that last 60 seconds or more. OSAS is defined as frequent episodes of apnoea and hypopnoea and the condition can be life-threatening. OSAS has been associated with extreme day-time hypersomnolence, automobile accidents and cardiovascular morbidity and mortality.

Excess body weight is positively associated with sleep-disordered breathing (SDB). A 10% increase in weight predicted a 6-fold increase in the odds of developing moderate-to-severe SDB.[39] OSAS has been estimated to affect about 4% of the morbidly obese population. Continuous positive airway pressure (CPAP) therapy is considered to be the gold standard for treatment of patients with OSAS but it has poor long-term compliance rates of 60%–70%. Longitudinal studies have suggested that surgical

weight loss significantly improves obesity-related OSAS and parameters of sleep quality.[40]

RISKS OF BARIATRIC SURGERY

Morbidity

Surgical complications related to bariatric surgery include early and late complications. The latter are most often nutrition-related. The major complications include bleeding, leak from the staple line or anastomosis, bowel obstruction, venous thromboembolism and pulmonary complications. The less serious complications include nausea, vomiting and wound infection. The rate of serious complications is low and varies from 2% to 4.1%. The rate of complications depends on the procedure with RYGB having a higher rate than SG. Besides bleeding and leak, stomal obstruction and bowel obstruction can occur after RYGB. The gastric band has its own set of complications including band slippage, port complications and band erosion requiring reoperation in a proportion of patients. However, unlike leak and sepsis, none of these complications are considered life-threatening.

Nutritional deficiencies

It is obvious that the patients undergoing malabsorptive procedures such as RYGB have a higher risk of nutritional deficiencies as compared to purely restrictive procedures such as gastric banding and SG. Patients need lifelong follow-up and nutritional surveillance in the form of regular monitoring of levels of various vitamins and trace elements. It is pertinent to note that most of these patients have pre-existing deficiencies detected at the time of preoperative evaluation. These deficiencies should be corrected with supplementation in the perioperative period. The major deficiencies include vitamin B12, vitamin D, iron, protein energy malnutrition and other trace mineral elements. Regular monitoring, dietary intervention and adequate supplementation are of paramount importance. Patients undergoing SG also need supplementation during the first year when they are losing weight. However, most of the patients do not need life-long supplements unlike patients who have undergone RYGB. Some of the patients, especially vegetarians do require vitamin B12 supplementation. Another important deficiency is of vitamin D and it requires regular monitoring and supplementation to achieve a serum parathormone (PTH) level <100 pg/L.

Mortality

Bariatric surgical procedures are safe and effective. However, patients must be counselled about the risk of non-zero mortality. The overall mortality rate for bariatric surgery (considering 30-day mortality) averages 0.3%. The mortality rates for RYGB and SG are reported to be 0.5%[41] and 0.25%,[17] respectively. The main causes of mortality after surgery are leaks and pulmonary embolism. The mortality rate is even lower for gastric banding as the procedure does not need any resection or anastomosis. In a meta-analysis of >85 000 patients who had undergone bariatric surgery, early mortality was reported to be 0.28%, which indeed is very low.[41] This series of patients also included those who had undergone more complex procedures such as BPD-DS. The mortality rate of these procedures was about 1%. However, these malabsorptive procedures are not recommended for the Indian population. The mortality rates have improved over the past decade primarily due to laparoscopic approaches, better perioperative care and improved anaesthesia. The reported mortality rate from the Bariatric Outcomes Longitudinal Database (BOLD) is 0.09% in an analysis of 57 918 patients.[42]

Thus, it is clear that contrary to a popular perception among physicians that bariatric surgery is unsafe and has a high morbidity and mortality, weight loss procedures are as safe as any other elective surgical procedure with a remarkable impact on weight loss and associated comorbid conditions.

NEWER DEVELOPMENTS

Bariatric surgery has become popular over the past two decades primarily due to the use of laparoscopy resulting in better cosmesis, lesser pain, faster recovery and better outcomes. However, the search for less invasive options constitutes an exciting area of research. There are three directions in which research is concentrated in this field.

1. Novel surgical procedures such as ileal transposition and duodeno-jejunal bypass.
2. Endoscopic procedures such as endoscopic sleeve and endoliner which may mimic the surgical procedures.
3. Use of bariatric surgical procedures for possible surgical remission of type 2 DM in patients who have mild-to-moderate obesity.

A discussion of these topics is beyond the scope of the present review. Suffice to mention that the next decade will witness major developments in this field especially in the field of metabolic surgery and hormonal mechanisms which impact type 2 DM.

CONCLUSIONS

Bariatric surgery is one of the most rewarding fields of surgery. Though it started about 60 years ago, its popularity and acceptance has increased in the past two decades. In India, this specialty is only a decade old and is making rapid advances. Bariatric surgery leads to a significant and sustained weight loss. Obesity-related comorbid conditions are ameliorated in 70%–80% of patients and improve in the remaining. The impact on type 2 DM is especially remarkable as it occurs early after surgery even before significant weight loss has taken place. It is amazing to see patients going off multiple medications in a short span of time. Extensive preoperative counselling and a well-prepared patient lead to better outcomes. However, these surgical procedures should be conducted in a multidisciplinary hospital having a well-organized bariatric surgical programme and a team comprising trained surgeons, bariatric anaesthetists, bariatric nutritionists, bariatric coordinator and other specialists.

REFERENCES

1 Yajnik C. Obesity epidemic in India: Intrauterine origins? *Proc Nutr Soc* 2004;**63:** 387–96.
2 Sjostrom L, Lindroos A, Peltonen M, Torgerson J, Bouchard C, Carlsson B, *et al.* Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *N Engl J Med* 2004;**351:**2683–93.
3 Wadden TA. Treatment of obesity by moderate and severe caloric restriction: Results of clinical research trials. *Ann Intern Med* 1993;**119:**688–93.
4 Sjostrom L, Narbro K, Sjostrom CD, Karason K, Larsson B, Wedel H, *et al.* Effects of bariatric surgery on mortality in Swedish Obese Subjects. *N Engl J Med* 2007;**357:**741–52.
5 Buchwald H, Avidor Y, Braunwald E, Jensen M, Pories W, Fahrbach K, *et al.* Bariatric Surgery: A systematic review and meta analysis. *JAMA* 2004;**292:**1724–37.
6 Kremen A, Linner J, Nelson C. An experimental evaluation of the nutritional importance of proximal and distal small intestine. *Ann Surg* 1954;**140:**439–48.
7 Mason EE, Ito C. Gastric bypass in obesity. *Surg Clin North Am* 1967;**47:**1345–51.
8 Kuzmak LI, Yap IS, McGuire L, Dixon JS, Young MP. Surgery for morbid obesity: Using an inflatable gastric band. *AORN J* 1990;**51:**1307–24. Erratum in: *AORN J* 1990;**51:**1573.
9 Korenkov M, Millo P, Allieta R, Jun MN. The Magenstrasse and Mill procedure. In: Korenkov M (ed). *Bariatric surgery*. Berlin, Heidelberg:Springer; 2012:169–74.
10 Aggarwal S, Kini S, Herron D. Laparoscopic sleeve gastrectomy for morbid obesity: A review. *Surg Obes Relat Dis* 2007;**3:**189–94.

11 Angrisani L, Lorenzo M, Borrelli V. Laparoscopic adjustable gastric banding versus Roux-en-Y gastric bypass: 5-year results of a prospective randomized trial. *Surg Obes Relat Dis* 2007;**3:**127–32.

12 Franco J, Ruiz P, Palermo M, Gagner M. A review of studies comparing three laparoscopic procedures in bariatric surgery: Sleeve gastrectomy, Roux-en-Y gastric bypass and adjustable gastric banding. *Obes Surg* 2011;**21:**1458–68.

13 Milone L, Strong V, Gagner M. Laparoscopic sleeve gastrectomy is superior to endoscopic intragastric balloon as a first stage procedure for super-obese patients (BMI > or =50). *Obes Surg* 2005;**15:**612–17.

14 Baltasar A, Serra C, Perez N, Bou R, Bengochea M, Ferri L. Laparoscopic sleeve gastrectomy: A multi-purpose bariatric operation. *Obes Surg* 2005;**15:**1124–8.

15 Alqahtani AR, Antonisamy B, Alamri H, Elahmedi M, Zimmerman V. Laparoscopic sleeve gastrectomy in 108 obese children and adolescents aged 5 to 21 years. *Ann Surg* 2012;**256:**266–73.

16 Karmali S, Schauer P, Birch D, Sharma AM, Sherman V. Laparoscopic sleeve gastrectomy: An innovative new tool in the battle against the obesity epidemic in Canada. *Can J Surg* 2010;**53:**126–32.

17 Deitel M, Gagner M, Erickson A, Crosby RD. Third International Summit: Current status of sleeve gastrectomy. *Surg Obes Relat Dis* 2011;**7:**749–59.

18 Karamanakos S, Vagenas K, Kalfarentzos F, Alexandrides T. Weight loss, appetite suppression, and changes in fasting and postprandial ghrelin and peptide-YY levels after Roux-en-Y gastric bypass and sleeve gastrectomy. *Ann Surg* 2008;**247:**401–7.

19 Himpens J, Dobbeleir J, Peeters G. Long-term results of laparoscopic sleeve gastrectomy for obesity. *Ann Surg* 2010;**252:**319–24.

20 Sugerman HJ, Kellum JM, Engle KM, Wolfe L, Starkey JV, Birkenhauer R, *et al.* Gastric bypass for treating severe obesity. *Am J Clin Nutr* 1992;**55:**560–6.

21 Pories W, Swanson M, MacDonald K, Long S, Morris P, Brown B, *et al.* Who would have thought it? An operation proves to be the most effective therapy for adult-onset diabetes mellitus. *Ann Surg* 1995;**222:**339–52.

22 Schauer P, Ikramuddin S, Gourash W, Ramanathan R, Luketich J. Outcomes after laparoscopic Roux-en-Y gastric bypass for morbid obesity. *Ann Surg* 2000;**232:** 515–29.

23 Gopalan C. Obesity in the Indian urban middle class. *NFI bulletin* 1998;**19:**1–5.

24 Misra A, Khurana L Obesity and the metabolic syndrome in developing countries. *J Clin Endocrinol Metab* 2008;**93** (11 Suppl 1):S9–S30.

25 Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, *et al.* Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asians Indians and recommendations for physical activity, medical and surgical management. *J Assoc Physicians India* 2009;**57:**163–70.

26 Aggarwal S, Modi S, Jose T. Laparoscopic sleeve gastrectomy leads to reduction in thyroxine requirement in morbidly obese patients with hypothyroidism. *World J Surg* 2014;**38:**2628–31.

27 Maggard MA, Shugarman LR, Suttorp M, Maglione M, Sugerman HJ, Livingston EH, *et al.* Meta-analysis: Surgical treatment of obesity. *Ann Intern Med* 2005;**142:**547–59.

28 Sjostrom L, Gummesson A, Sjostrom CD, Narbro K, Peltonen M, Wedel H, *et al*; Swedish Obese Subjects Study. Effects of bariatric surgery on cancer incidence in obese patients in Sweden (Swedish Obese Subjects Study): A prospective, controlled intervention trial. *Lancet Oncol* 2009;**10:**653–62.

29 Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, *et al.* Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003;**289:**76–9.

30 King H, Aubert R, Herman W. Global Burden of Diabetes, 1995–2025: Prevalence, numerical estimates, and projections. *Diabetes Care* 1998;**21:**1414–31.

31 Roglic G, King H. Diabetes mellitus in Asia. *Hong Kong Med J* 2000;**6**:10–1.

32 Mohan V, Sandeep S, Deepa R, Shah B, Varghese C. *Epidemiology of type 2 diabetes: Indian scenario. Indian J Med Res* 2007;**125:**217–30.

33 Schauer PR1, Burguera B, Ikramuddin S, Cottam D, Gourash W, Hamad G, *et al.* Effect of laparoscopic Roux-en Y gastric bypass on type 2 diabetes mellitus. *Ann Surg* 2003;**238:**467–84.

34 Dixon JB, O'Brien PE, Playfair J, Chapman L, Schachter LM, Skinner S, *et al.* Adjustable gastric banding and conventional therapy for type 2 diabetes: A randomized controlled trial. *JAMA* 2008;**299:**316–23.

35 Gill RS, Birch DW, Shi X, Sharma AM, Karmali S. Sleeve gastrectomy and type 2 diabetes mellitus: A systematic review. *Surg Obes Relat Dis* 2010;**6:**707–13.

36 Dixon JB, Zimmet P, Alberti KG, Rubino F, on behalf of the International Diabetes Federation Taskforce on Epidemiology and Prevention. *International Diabetes Federation Position Statement on Bariatric Surgery*. Available at *http://www.idf.org/publications/idf-position-statement-bariatric-surgery* (accessed on ...)

37 American Diabetes Association. Standards of Medical Care in Diabetes—2011. *Diabetes Care* 2011;**34** Suppl 1:S11–S61.

38 Partinen M, Guilleminault C. Daytime sleepiness and vascular morbidity at seven-year follow-up in obstructive sleep apnea patients. *Chest* 1990;**97:**27–32.

39 Peppard PE, Young T, Palta M, Dempsey J, Skatrud J. Longitudinal study of moderate weight change and sleep-disordered breathing. JAMA 2000;**284:**3015–21.

40 Haines KL, Nelson LG, Gonzalez R, Torrella T, Martin T, Kandil A, *et al.* Objective evidence that bariatric surgery improves obesity-related obstructive sleep apnea. *Surgery* 2007;**141:**354–8.

41 Flum DR, Salem L, Elrod JA, Dellinger EP, Cheadle A, Chan L. Early mortality among medicare beneficiaries undergoing bariatric surgical procedures. *JAMA* 2005;**294:**1903–8.

42 DeMaria EJ, Pate V, Warthen M, Winegar DA. Baseline data from American Society for Metabolic and Bariatric Surgery-designated Bariatric Surgery Centers of Excellence using the Bariatric Outcomes Longitudinal Database. *Surg Obes Relat Dis* 2010;**6:** 347–55.