Mini Gastric Bypass

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Introduction

Obesity is a problem of pandemic proportions in both developed and developing countries. Numerous procedures have been described and many such as jejuno-colic, jejuno-ileal bypass and Mason's loop gastric bypass have been abandoned due to various complications. Various operations performed as surgical treatment for obesity nowadays are: Roux-en-Y gastric bypass (RYGB), laparoscopic sleeve gastrectomy (LSG), Mini-gastric bypass (MGB) to name a few. These procedures have their short and long-term benefits and complications. Fear of these complications make a surgeon or a patient, think and rethink before undertaking a bariatric procedure [1].

MGB was first performed by Dr. Robert Rutledge in 1997 [2, 3]. The procedure faced a lot of criticism from the time of its inception but now it is regarded as one of the most popular and widely practiced metabolic surgical procedure. The adoption of correct technique for performing MGB ensures best results and also avoids any short and long term complications.

MGB is primarily a malabsorptive procedure unlike LSG or RYGB which are restrictive procedures. The gastric pouch and the gastrojejunostomy (GJ) in MGB are intentionally designed to be a non-obstructive conduit for food from its inlet to its outlet. The diameter of the gastric pouch is made similar to the oesophageal lumen. A moderate size bypass is made between the gastric pouch and jejunum which induces rapid gastric emptying into the mid-jejunum and produces an exaggerated post gastrectomy syndrome that makes sweet and liquid calories induce discomfort and passage of moderate to large number of fatty foods relatively

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intolerable [2]. Here in the chapter we will try to focus on the correct technique in creation of the gastric pouch, the Bilio-Pancreatic limb and end to side gastro-jejunostomy during Mini Gastric Bypass.

Principles and Technique

A procedure is regarded as a "safe procedure" when its pre-operative preparations are simple, the procedure is easily reproducible and with minimum incidence of complications [3].

Ergonomics and Patient Position

Patient is placed in supine position and is under general anesthesia. Urethral catheterization is done and dynamic limb compression device is applied. Patient is strapped to the table and all pressure areas padded with soft cotton. The surgeon and the camera surgeon are on the right side of the patient and assistant surgeon on the left. The patient is placed in steep head rise and a tilt of 45° towards the right [4].

Port Position (Fig. 1)
5-port technique is commonly used. The port positions are as underlined [4]:

- A—12 mm, subxiphoid 2 cm below the xiphoid process
- B and D—12 mm, Right and Left subcostal 2 cm below costal margin at MCL

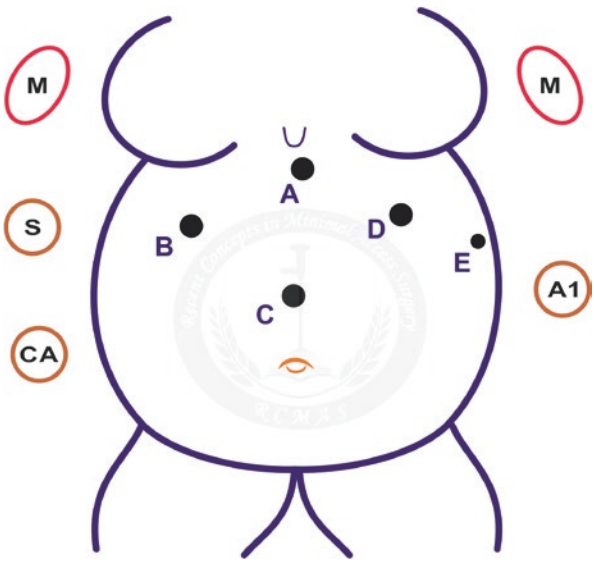

Fig. 1 Port placement

- C—12 mm, 18 cm below xiphoid
- E—5 mm, Left anterior axillary line below costal margin

M—Monitor, S—Surgeon, CA—Camera assistant, A1—Assistant.

Creation of Lesser Omental Window

Diagnostic laparoscopy is performed followed by creation of the lesser omental window. Dissection is started beyond the crow's foot on the lesser curvature of the stomach about 3–4 cm proximal to the pylorus. All the adhesions of the stomach are released and a window is created for about 2–4 cm to enter the lesser sac [4] (Fig. 2).

Antral Division

A 45-mm gold/green cartridge stapler is engaged across the antrum of the stomach at right angles to its axis. More than 60% of the antral width should not be transected in the first firing. This takes care of the passage of the contents from the bypassed remnant stomach. Twist should be avoided by grasping both the walls of the stomach equally which will also help to avoid "bird beaking" of the edges thereby avoiding trouble during gastro-jejunostomy as well in the next subsequent firing [4].

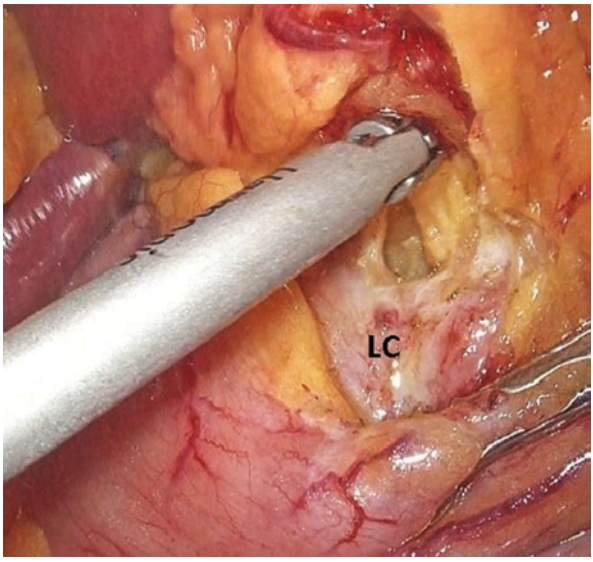

Fig. 2 Creation of lesser omental window. *LC* Lesser Curve

Creation of MGB Gastric Pouch

The MGB pouch in contrast to RYGB pouch is different in the respect that it is restrictive not obstructive. In contrast to RYGB, it also has a large pouch with a wide GJ [2]. The MGB pouch is again different from the sleeve gastrectomy tube in the respect that it's a wide tube with no stress on OG junction dissection. The MGB pouch is designed for relatively rapid non-obstructive transport of food from the esophagus into small intestine which results in post gastrectomy syndrome. The pouch length, GJ and loop Billroth II or GJ are designed to recapitulate the surgical analogue of antrectomy and Billroth II reconstruction. The pouch should start just distal to crow's foot as this helps in prevention of Gastro-esophageal Reflux Disease (GERD), pouch should lie as such that the medial aspect, formed by the mesentery of the lesser curvature points directly to the 9 o'clock to the patient's right and the neo greater curvature points to the patient's left at 3 o'clock with anterior and posterior walls of the pouch being equal. Proper control of bleeding during pouch creation is a necessity; hence the prime maneuver is proper compression by the stapler for around 30 seconds before firing. Rapid firings of stapler should be avoided as it may lead to oozing and subsequent compromise of the staple line. After antral division, gastric pouch creation is started by second firing, done from the right hypochondrial port. The axis of division is kept perpendicular to the first firing (Antral division) and parallel to lesser curvature [3] (Fig. 3).

Bougie of 36-Fr is then inserted and engaged until it reaches the tip of the pouch Subsequent firings are done with the bougie as a guide. Care should be taken to create a moderate-sized gastric pouch which is never too tight on the bougie (Fig. 4).

Dissection during MGB should be lateral to the left crus of the diaphragm and a proper and safe dissection around the hiatus is mandatory to create an adequate

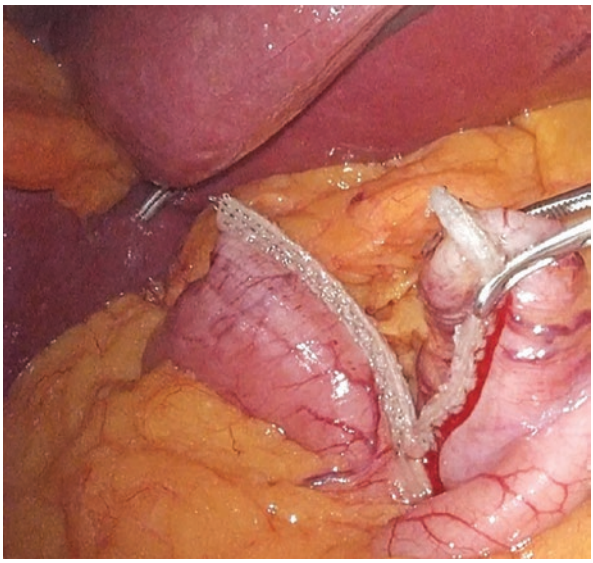

Fig. 3 First transverse firing (Antral division)

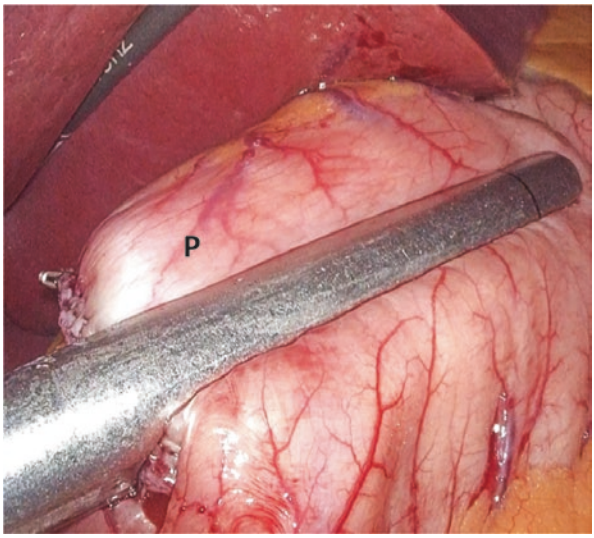

Fig. 4 Second stapler firing for creation of gastric pouch (P)

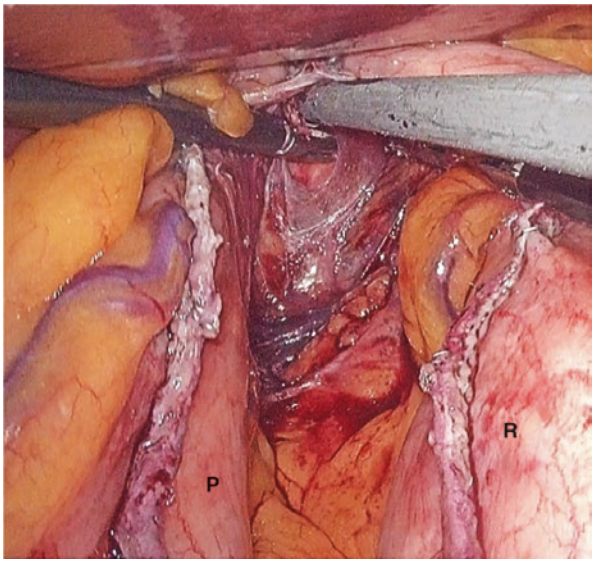

Fig. 5 Creation of window near the angle of his. MGB Pouch (P), Remnant stomach®

space for stapler engagement. Care is taken to avoid inadvertent injury to short gastric, inferior phrenic vessels and the spleen (Fig. 5). The final staple firing is to be placed at least 2 cm lateral to the GE junction to avoid leaks near the junction in spite of the fact that it is a low-pressure drainage system at the GJ (Fig. 6), so back pressure at GE junction is minimum. During MGB it is even acceptable to leave a small amount of fundus in exchange for leak prevention [5].

Bowel and stomach should be checked to avoid any kink or twist. One should avoid a Bird's beak deformity at the distal tip of gastric pouch and try to create a

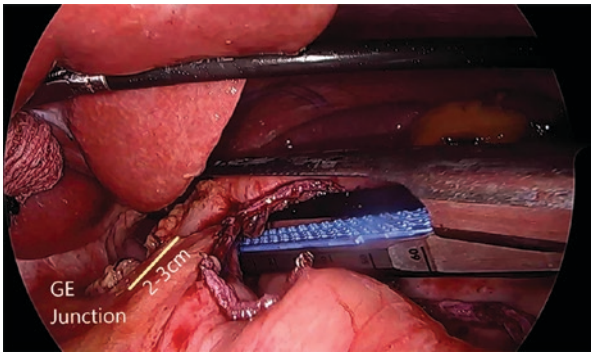

Fig. 6 Image showing the distance from GE junction which should be maintained while firing the last stapler (*Image Courtesy: Dr Deborshi Sharma*)

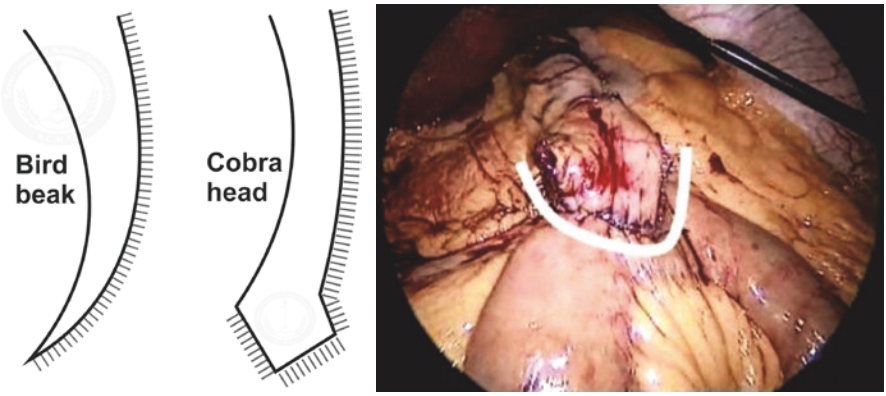

Fig. 7 Cobra head shape of distal end of gastric pouch

wide cobra head effect of the distal tip to provide a wide perfusing field for the lateral aspect of the distal gastric portion of the GJ [4] (Fig. 7).

Bilio-Pancreatic Limb (BPL) Length

The performance of MGB in general never requires division of the omentum as it might increase the risk of internal hernia and bowel obstruction [2]. The omentum should be retracted medially and the small bowel length should be measured with the help of marked atraumatic bowel grasper. The small bowel being a dynamic organ changes its length and so the perfect bowel length is impossible to determine at operation. It is important to leave atleast 3 metres of small intestine distal to gastrojejunostomy to avoid malnutrition [2]. The length of the BPL should be tailored according to the patient's profile and co-morbidity with 150 cm for obese and 180 cm for super obese being mostly favored.

BPL length of >200 cm should be reserved for revision cases. A longer bypass results in more malnutrition without significant effect on co-morbidity resolution [6].

Creation of Gastro-Jejunostomy (GJ)

Creation of GJ is one of the most important steps in MGB. The goal is a wide open and non-obstructive GJ that allows easy, rapid emptying of the gastric pouch which is similar to the passage of food through esophagus. GJ thus created contributes to the induction of post gastrectomy syndrome which ultimately modifies the type of food intake, amount of foods along with timing of foods [2].

After identifying the site on jejunum for GJ, the small bowel loop is moved to the left upper quadrant making sure not to twist the afferent and efferent limbs.

Anterior gastrostomy is made just above the gastric staple line midway between the medial and lateral angle but the GJ anastomosis is always posterior. The size of the gastrostomy should be equal to the diameter of the stapler anvil. The bougie can be used to stabilize the pouch during gastrostomy and also act as a guide by stenting the pouch (Fig. 8).

Since the gastrojejunostomy is posterior (i.e. made between the posterior wall of stomach pouch and jejunum) the jejunostomy should be made 5 mm away from the anti-mesenteric border of the jejunum towards the posterior wall to avoid twist. The opening again should be made equal to the stapler cartridge [4] (Fig. 9).

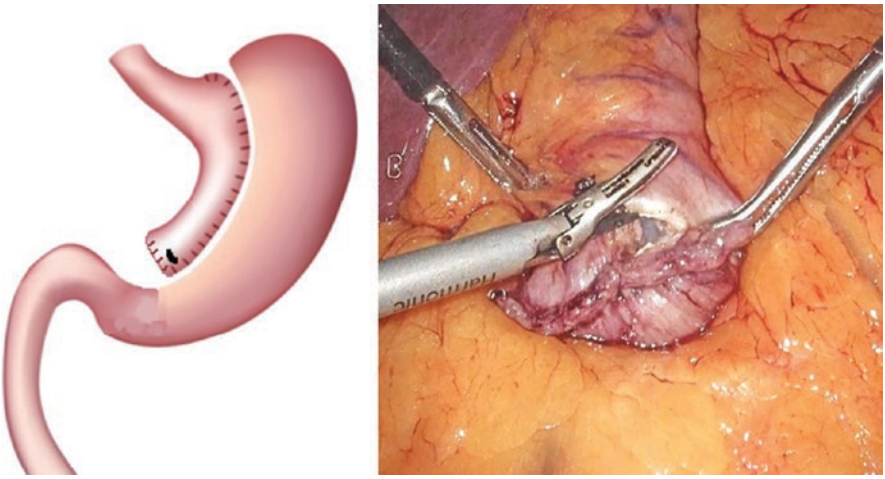

Fig. 8 Creation of gastrotomy (Anterior to the stapler line)

Positioning of GJ Stapler

Invariably a posterior gastro-jejunostomy is performed using a 45-mm blue cartridge. The GJ staple line should never cross anterior to the lateral staple line of the gastric pouch as it will compromise the security of the staple line (Fig. 9). While GJ is being done it should be kept in mind to have jaws of the GJ stapler more than 1 cm from the GJ anastomosis staple line, basically there should be visible space on the posterior gastric wall between the lateral gastric staple line, the staple cartridge and anvil [2, 4]. One should also be careful to keep the gastric mesentery out of the GJ staple line (Fig. 10). The staple-line should always be inspected for bleeding [4] (Fig. 11).

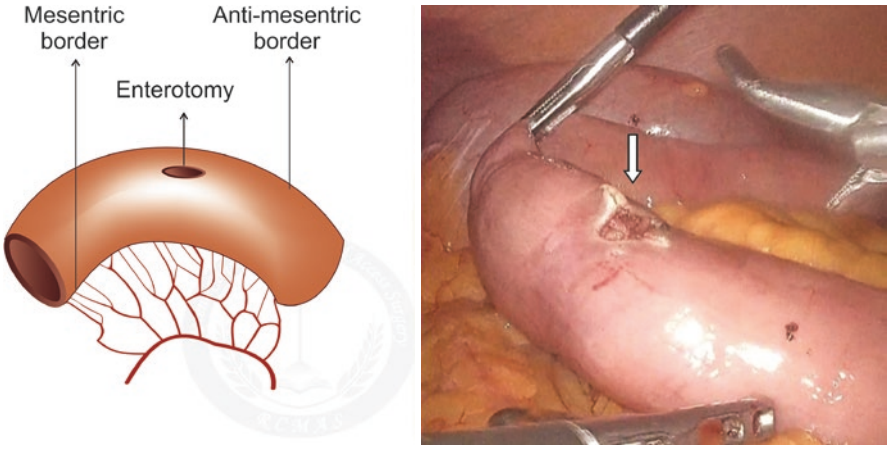

Fig. 9 Creation of jejunotomy 5 mm posterior to anti mesenteric border (White arrow)

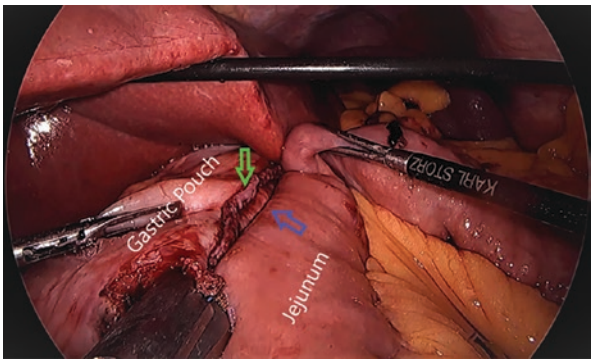

Fig. 10 Gastrojejunostomy done to posterior wall of gastric pouch. Lateral stapler line of gastric pouch (Green Arrow) should be anterior to the GJ (Blue arrow) as shown in image (*Image Courtesy: Dr Deborshi Sharma*)

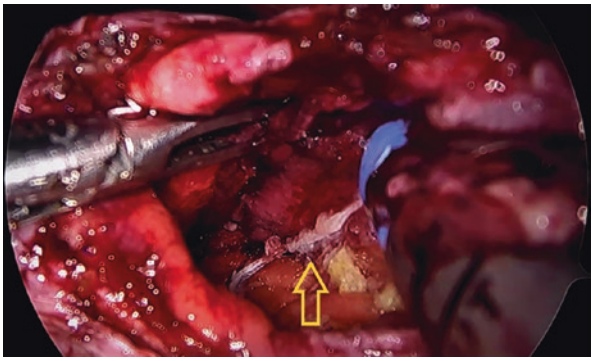

Fig. 11 Stapple line (Orange arrow) should be always inspected for any bleeding (*Image Courtesy: Dr Deborshi Sharma*)

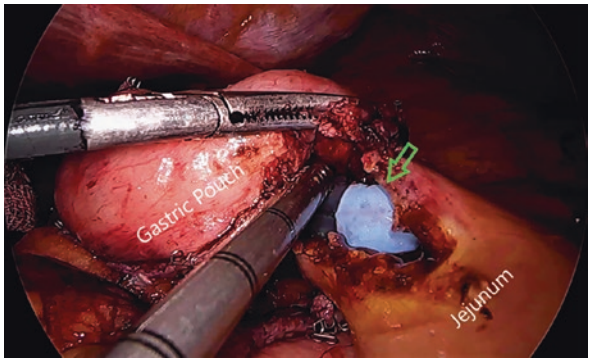

Fig. 12 Posterior Gastrojejunostomy and the gastric calibration tube being pushed into jejunum before closure (Green Arrow) (*Image Courtesy: Dr Deborshi Sharma*)

GJ Closure

Final step is closure of gastro-jejunostomy. Both stapled or a hand-sewn closure anastomosis of the GJ is acceptable. Sutured closure is done in either one or two layers, and if done properly one-layer anastomosis gives best results, as it avoids GJ narrowing [2]. One can also insert the gastric calibration tube through the anastomosis into jejunum to a avoid tight closure (Fig. 12). The completed anastomosis should be checked for any kinks or obvious leaks (Figure 13).

Hemostasis

A perfect hemostasis is mandatory for better outcome of both intra-operative and post-operative stages after MGB. Hemostasis can be attained by hemostatic clips, sprays, foam or by suturing. Bleeding signifies loose improperly fitted staplers which later might give way for leaks if not taken care on table during procedure.

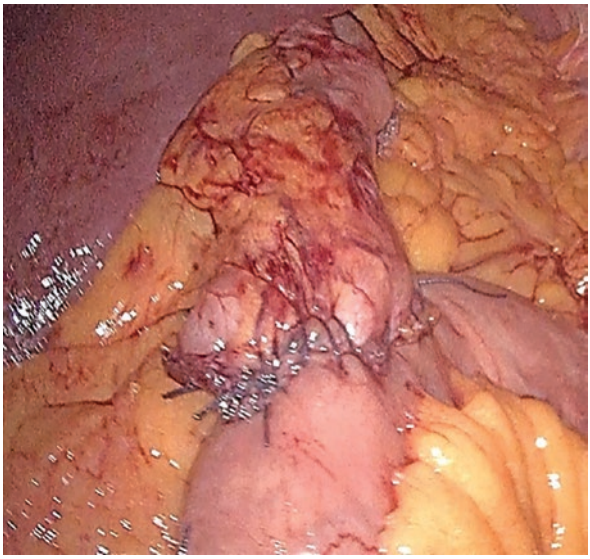

Fig. 13 Final closure of gastrotomy and enterotomy

Leak Test

Leak test after MGB though not mandatory is done either by using intraluminal 75 mL diluted methylene blue or air leak test, after clamping both the efferent and afferent loop. Recently Intraluminal ICG also has been used to check for any extravasation. Recognizing leaks as early as possible is preferable and the mainstay for any successful bariatric surgery, hence on table detection if any is the cornerstone of management. A flat drain is placed between the gastric pouch and the bypassed stomach [2, 4].

Advantages and Disadvantages of MGB [7]

Mini Gastric Bypass is an attractive option of choice for metabolic surgery as it offers many advantages to the patient as well as to the surgeon:

(a) Single Anastomosis
(b) Shorter operative time
(c) Less chances of anastomosis leaks due to fewer possible sites for leaks
(d) Extremely low risk of internal herniation
(e) Shorter learning curve
(f) Easier to reverse to normal anatomy

All the above advantages are the reasons why MGB is becoming one of the fastest acceptable metabolic procedures.

But it also has its share of disadvantages, as fear of:

(a) Symptomatic biliary gastritis andoesophagitis
(b) Increased risk of barrett's oesophagus
(c) Increased risk of gastric/oesophageal cancer

Complications

The complications of MGB are basically divided into two groups

(a) Early complications—those occurring within the first 30 post operative days [8].
(b) Late complications—beyond 30 days to 10 years after surgery [9].

Early Complication

1. **Bleeding**: It is the most common complication which is either endo-luminal or intra-abdominal in nature.
   (a) Endoluminal bleeding (0.93%) is either from gastric pouch or anastomosis. Mostly it is managed by conservative methods or endoscopic intervention may be required.
   (b) Intra-abdominal bleeding (0.78%) occurs in sites where stapler cartridge of size >1.5 mm is used or interrupted closure of anastomosis is done or in patients having pre-operative hypertension. It often needs laparoscopic revision with surgical haemostasis [10].
2. **Leaks**: These are the second most common complication (0.44%) and include both anastomotic and gastric pouch leaks. The treatment of choice is a surgical revision which varies from laparoscopic revision and defect repair, to a laparoscopic revision with a Braun's anastomosis to a complete reversal operation [10]. Though rarely done, conservative management can be tried as MGB anastomosis creates a low pressure gastric pouch, with no sectioning of bowel and completely intact jejunal vascular arcade.
3. **Small bowel perforation**: Marginal ulcer perforation though rare is also noted in MGB (0.22%) like RYGB. It is more prevalent in smokers and can be treated laparoscopically. Suture closure of the perforation is the treatment of choice. In few cases conversion to RYGB might be necessary [11].
4. **Anastomotic stenosis**: MGB has 4.5–6 cm anastomosis in comparison of 1.2–1.5 cm in RYGB, hence anastomotic site stenosis is rarely reported after MGB. In general any anastomosis of ≥2.5 cm is highly recommended to prevent stenosis. Endoscopic pneumatic dilatation is the initial treatment of choice for anastomotic site stenosis and later RYGB conversion might be needed rarely [12].

Late Complication

Late complications are seen in around 11% cases after primary surgery and 7% after redosurgery.

1. **Gastro Esophageal Reflux Disease (GERD)**: Gastro esophageal reflux disease is defined as the presence of duodenal contents in the esophagus [13, 14]. It results in heart burn, regurgitation and esophagitis. In the presence of symptoms—Upper GI endoscopy is used to detect any damage caused by alkaline reflux in an acidic environment [13, 14] and 24 hr pH impedance studies can quantify the severity of reflux. Treatment includes dietary and life style modifications, PPI and sucralfate as first conservative line of management [15]. If it fails a surgical revision to RYGB or Braun's side to side anastomosis between afferent and efferent limb might be required [10].
2. **Weight Regain**: Weight regain is measured as both post-operative Body Mass Index (BMI) and Excess Weight Loss (EWL) % changes. It is mostly due to abnormal pouch and loop size particularly during the learning curve. A surgical approach to refashion the pouch and loop limb length resizing might be required in some cases [10].
3. **Marginal ulcer**: The incidence of Marginal ulcer in MGB is low as compared to RYGB. It is commonly diagnosed with endoscopy [16]. The first line of treatment is PPIs, Sucralfate and Helicobacter pylori eradication. When the conservative management fails, surgical therapy is undertaken invariably when the mucosal ischemia is suspected [9].
4. **Nutritional deficiencies**: MGB might result in a range of nutritional deficiencies and may also predispose to malnutrition in case of inappropriate limb length selection mostly within 2–3 years of surgery. Most common deficiency following MGB is iron deficiency leading to anemia. It is common in female of reproductive age [17–21]. One-third requires oral supplements beyond the expected time for intestinal adaptation, and up to 1.3% may require parenteral iron. Longer lengths of by passed limbs result in hypoglycemia and hypoproteinemia [22, 23]. Vit-D3 and Vit-B12 deficiencies are also prevalent following MGB [22, 23].

   Most patients are generally controlled and treated on an ambulatory basis and recover with dietary recommendations once intestinal adaptation is complete. Excess weight loss due to bypassed limb length of >250 cm is also common [6]. The number of patients developing severe malnutrition requiring hospitalization and parenteral nutrition is very low. The causes of nutritional deficiencies are malabsorption, psychological, social, family and even economic issues (Tables 1 and 2). Conversion to sleeve for malnutrition might be rarely required.
5. **Rare complications**: Internal hernias are extremely rare (0.1–0.4%) after MGB. However the occasional abdominal wall port site hernia is seen, incidence of which is similar to any other laparoscopic bariatric procedure.

Table 1 Nutritional deficiencies after MGB—Indian data

Criteria	
Number	100
Anemia	–
Serum iron	43%
Serum ferritin	26%
Vitamin B12	10%
Albumin	5%
Vitamin D3	23%

Table 2 Multivitamin and mineral supplementation values

	Amount per serving		Amount per serving
Vitamin A	1875 IU	Pantothenic acid	2.5 mg
Vitamin C	45 mg	Calcium	300 mg
Vitamin D3	750 IU	Iron	11.25 mg
Vitamin E	7.5 IU	Iodine	37.5 mcg
Vitamin B_1	3 mg	Magnesium	100 mg
Vitamin B_2	425 mcg	Zinc	7.5 mg
Vitamin B_3	5 mg	Selenium	17.5 mcg
Vitamin B_6	500 mcg	Copper	0.5 mg
Vitamin B_9	200 mcg	Manganese	0.5 mg
Vitamin B_{12}	140 mcg	Chromium	30 mcg
Biotin	150 mcg	Molybdenum	18.75 mcg

Effect of MGB on Type-2 Diabetes Mellitus (T2DM)

T2DM is one of the most common non-communicable diseases and is the fourth leading cause of death in first world countries. Now it is also reaching epidemic propositions in developing countries [24]. The global prevalence of T2DM is on the rise because of the increase in the factors which favors obesogenic environment, like sedentary lifestyle and easier access to calorie dense foods [24].

Medications and lifestyle modifications require patient compliance but still control over T2DM remains elusive. Metabolic surgery is effective in the treatment and prevention of T2DM, thereby reducing the mortality rate in the long term when compared with medical treatment.

Metabolic surgery involves any intervention that alters the passage of food through the GI tract resulting in improved control of T2DM. The control of T2DM is not related to weight loss precluding a direct antidiabetic effect [25].

Various mechanisms have been put forward as the possible explanation for improvement in T2DM after bariatric surgery. They are:

1. There is upregulation or increased availability of insulin receptors, after calorie restriction, which results in increased insulin sensitivity [26, 27].

2. The ghrelin secretion from stomach also decreases which results in decreased appetite and hence better T2DM control [28].
3. Foregut theory—There is an improvement or augmentation of the action of Gastro Intestinal Peptide (GIP) from the foregut following metabolic surgery which in turn helps to control the blood glucose level [28].
4. Hindgut theory—Post metabolic surgery there is an increase in secretion of incretins such as Glucagon Like Peptide I (GLP-I) from the L-cells in the lower ileum due to duodenal bypass, which results in early transit of nutrients to the ileum and stimulation of β cells, which then results in good diabetic control [29–31].

T2DM remission has been reported to be of varying degrees after all current bariatric operations. However, after sleeve gastrectomy (leaks, weight regain, GERD) and after RYGB (weight regain, malnutrition, internal hernias and others) numerous complications can occur [21, 31]. MGB has been documented to be a dependable bariatric procedure in large series. It has shown superiority in resolution of comorbidities in comparative studies to RYGB and sleeve gastrectomy. MGB has resulted in T2DM resolution in 85–95% of diabetic patients followed >5 years, requiring no medication, which is superior to sleeve gastrectomy and RYGB [32–36].

Following MGB with the rapid passage of food into the small bowel, rapid elevation of GLP-I levels have been found compared to other operations. MGB and sleeve gastrectomy can rapidly augment the incretin effect which persists upto 5 years. However, the MGB has a better effect than sleeve gastrectomy at longer follow-up due to the increase in serum GLP-I levels [31].

Future Perspective

Robotic surgery is one of the most rapidly developing and upcoming techniques in the field of surgery. It offers 3D vision and gives the control of the camera to the surgeon. Along with the degrees of freedom, the robotic arms provide a distinct advantage while suturing in small confined spaces. Robotic MGB is possible without hybrid or dual docking as all dissection and anastomosis is in the supracolic compartment, hence MGB is suitable technically for robotic surgery [37].

Initial studies show no difference between robotic assisted and conventional laparoscopic surgery with respect to surgical time, post operative hospital stay, complications or rate of conversion to open surgery but the anastomosis leaks have been shown to be significantly less after robotic surgeries. Use of the robot has reduced the ergonomic challenges of bariatric surgery in comparison to conventional laparoscopy. The robot controlled telescope, tissue manipulator with alignment, robotic suturing etc are easier along with being more accurate. The time taken for the procedure in both the techniques is equivalent. The main disadvantage of robotic

surgery is its increased cost which is especially important in developing countries like India. At present Robotic MGB is to be reserved to tackle cases which are assessed to be difficult pre-operatively, like super obese or revision surgery [37].

Revision to MGB from Other Procedures

Laparoscopic Adjustable Gastric Banding (LAGB) to MGB

Gastric banding was one of the most popular bariatric surgeries during 1990s and early 2000s, because of its various complication like band slippage/erosion, inadequate weight loss to name a few, a large percentage of patients required a revision surgery from LAGB. The various options for revision are LSG, LRYGB and MGB. It has been seen that revision from an earlier restrictive procedure to a malabsorptive procedure leads to a more consistent and satisfactory weight loss. Hence MGB is gaining consensus as a revisional surgery after LAGB.

The patient should learn dietary and behavioral changes atleast 3–6 months prior to revision. A lack of willingness on the patient's part for these changes should be considered a contraindication for revision. The band has to be completely emptied a few weeks before surgical procedure. Upper GI gastrograffin series, Upper GI endoscopy and other routine necessary pre-operative bariatric investigations should be done.

The surgeon may choose to go for a one stage or two stage surgery. The standard technique for MGB is followed barring the following changes:

(a) Band is removed and the fibrous capsule is cut to prevent dysphagia in future.
(b) The vertical resection line while creating the gastric pouch is moved towards the spleen to avoid the inflammatory tissue and band fibrous capsule in the last stapler line. This helps to prevent complications in future and gives best results post-operatively. Revision for LAGB to MGB can be a single and relatively safe procedure which results in valid weight loss, rapid recovery with high level of patient satisfaction [38].

Laparoscopic Sleeve Gastrectomy to Mini Gastric Bypass

Conversion from LSG to MGB is a safe, feasible and effective option and results in significant weight loss. It is the operation of choice for morbidly obese patients who are compliant in taking calcium and iron supplements. Patients having inadequate weight loss following LSG due to non-anatomical causes are primary candidates for conversion to MGB or RYGB, but the former is preferred because of its simple technique, efficacy and reversibility [39].

Conclusion

Mini gastric bypass is a malabsorptive type of metabolic surgery which helps in weight loss and co-morbidity resolution, especially diabetes remission. It has a single anastomosis and there is no breach in the continuity of the omentum which reduces various complications like leak, internal hernias etc. as compared to other procedures like RYGB. The most important aspect of MGB is the selection of requisite BPL length as per the patient's profile. This can reduce the occurrence of nutritional deficiencies in the post-operative period markedly. Long term follow up data shows it to be superior to LSG and RYGB in regards to its outcome. The role of robotics in MGB is only going to augment its future prospects.

Few Clinical Points

1. Obesity is a problem of pandemic proportions in both developed and developing countries.
2. MGB is primarily a malabsorptive procedure of single anastomosis, described by Dr Robert Rutledge with a short learning curve.
3. The MGB pouch in contrast to RYGB pouch is a larger pouch with a wide GJ, while in comparison to sleeve gastrectomy tube, MGB has a wide tube with no stress on OG junction dissection. During MGB it is even acceptable to leave a small amount of fundus in exchange for leak prevention
4. The length of the BPL should be tailored according to the patient's profile and co-morbidity with 150 cm for obese and 180 cm for super obese.
5. BPL length of >200 cm should be reserved for revision cases.
6. Longer BPL length results in more malnutrition without significant effect on co-morbidity resolution
7. Bleeding is the most common complication after MGB which can be either endo-luminal or intra-abdominal.
8. MGB might result in a range of nutritional deficiencies and may also predispose to malnutrition in cases of inappropriate limb length selection, which mostly happens within 2–3 years of surgery.
9. T2DM resolution after MGB is seen in 85–95% of diabetic patients followed >5 years, who require no medication, making it a superior procedure to sleeve gastrectomy and RYGB
10. Robotic MGB presently advised for super obese and revision surgeries is possible without hybrid or dual docking as all dissection and anastomosis is in the supracolic compartment.

Editor's Note[1]

Late Complications

Gastro eosophageal reflux disease: Main concern over the years for MGB has been the fear of increased GERD and is reported to vary from 0.5 to 4%. A shorter gastric pouch of <9 cm and presence of preoperative GERD can be inciting factors while de novo GERD after MGB is seen in 2% [1]. Rate of revision for GERD is very rare (0–0.7%) due to intractable bile reflux, if standard operating protocol is followed [2–4]. Intragastric pressure is significantly diminished after MGB hence GE reflux is not increased. Endoscopy sometimes reveals bile in the stomach with mild to moderate pouch gastritis, however evidence of any esophagitis on endoscopy after MGB is rare [LC 3–5].

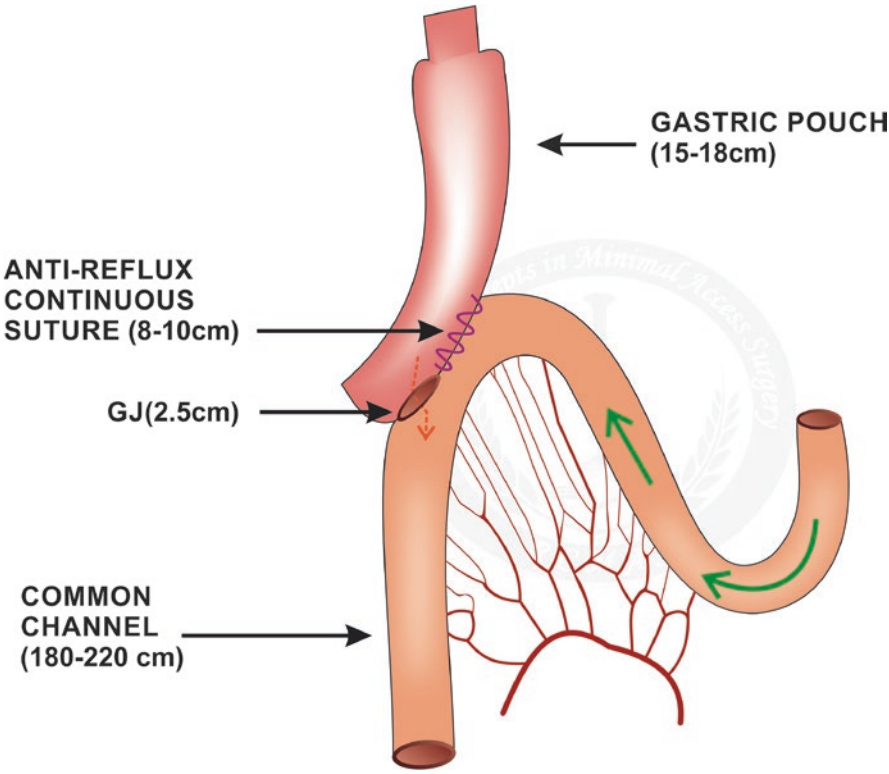

Fig. EN1 Schematic diagram of OAGB

[1] References: Main chapter references are included after the "References Editor's Note" section.

One Anastomosis Gastric Bypass-Mini-Gastric Bypass (OAGB)

Essentially, both MGB & OAGB is similar in theory, where main idea it is to avoid two anastomosis and two limbs. Still MGB & OAGB differs in many aspects technically. In OAGB (Figure EN1) the following steps are stressed upon over MGB

Total small bowel measurement (TSB): Starting from DuodenoJejunal Junction (DJ) downward to Ileocaecal junction (IC) total small bowel measurement is done in OAGB [6]. This is done with the view point that differences will remain in the metabolic setup of a younger vs older patient, obese vs super-obese, male with central obesity vs female with gynecoid obesity and all these with a patient with severe metabolic syndrome. After knowing the TSB, both BP limb and common channel (CCh) can be tailored and a ratio of 0.37–0.44 (CCh/TSB) is regarded to give best weight loss success rate and improve co-morbidities [7]. Length of CCh can be maintained between 180 and 220 cm [8].

Bi-Valving the greater omentum: As more length of small bowel is bypassed in OAGB compared to MGB, the greater omentum might exert more tension on anastomosis. Omentum from its attachment on transverse colon upto the greater curve is opened longitudinally to make it into two halves.

Complete dissection of "Angle of His": Left side of Phreno-esophageal membrane is dissected until the left crus of diaphragm, almost up to the posterior border of spleen. Thick fat "Belsey's fat" pad which surrounds the esophago-gastric junction (EGJ) is also dissected down. This manoeuvre allows creation of a wide aperture of the retro-gastric window avoiding the short gastric vessels and any splenic tissue injury. Ultimately endostapler is also optimally positioned at this demanding position [6, 9].

Gastro-hepatic ligament dissection: Dissection starting at the Pars flaccid upto right crus is done along with remains of right Phreno-esophageal membrane. This release helps in lengthening of gastric pouch and decreasing anastomotic tension. Any hiatal hernia if present is also selectively repaired [10].

Creation of long and narrow gastric pouch: In OAGB a long narrow pouch of about 15–18 cm is made which usually lies over the gastric antrum of remnant stomach with its tip at the level of the transverse colon [7].

Anti-reflux mechanism: Continous suturing for 8–10 cm using reabsorbable material of anti-mesenteric border of small bowel to the vertical staple line of gastric pouch is done. This continous suturing also is advantageous as it creates permanent posterior fixation of small bowel and gastric pouch creating proper alignment of two lumens, preventing twisting of pouch later on and ensures no gap between them for any internal hernia [7].

GJ over anterior wall of pouch: The anterior wall of gastric pouch and small bowel is anastomosed for 2.5 cm using linear endo stapler, anterior to the continous anti reflux suture in a lateral-lateral fashion. The enterotomies are closed in standard fashion.

This vertical 2.5 anastomosis makes the BP limb content to go down into afferent limb (CCh channel) directly due to gravity preventing reflux or marginal ulcers [11].

OAGB vs RYGB RCT: OAGB is a technically easier procedure and features better glycemic control than RYGB, but has a mal-absorptive effect. However, the bile reflux and abdominal pain controversies persists [12].

OAGB vs Laparoscopic Sleeve gastrectomy: RCTs have shown that both are efficacious bariatric methods. While OAGB in the long term (5 years) is better than LSG in terms of weight loss, comorbidity resolution and improvement in QoL [13].

Diverted Mini Gastric Bypass (dMGB)

RYGB is still considered by many to be the most effective and well balanced metabolic/bariatric surgical technique [14]. RYGB is pulled down by some for its significant unique complications such as internal hernias, marginal ulcers or hyperinsulinemic hypoglycemias. Intermediate-term weight regain following RYGB is also a concern [15, 16]. Weight regain or not maintaining 50% EWL on follow up contributes to the overall failure rate [17]. dMGB proposes OAGB-MGB procedure with a Roux-en-Y anastomosis added to the long narrow pouch.

After MGB-OAGB, a 100 cm into the efferent limb, from proximal to distal beyond the gastro-jejunostomy a new side-to-side ileoileostomy or ileojejunostomy is created between the afferent and efferent loop. The afferent is then disconnected to the gastric pouch (Fig. EN2). The inter-mesenteric spaces hence created need closure to prevent internal hernias. Initially this procedure was also called the Sleeve gastric bypass. (Fig. EN3).

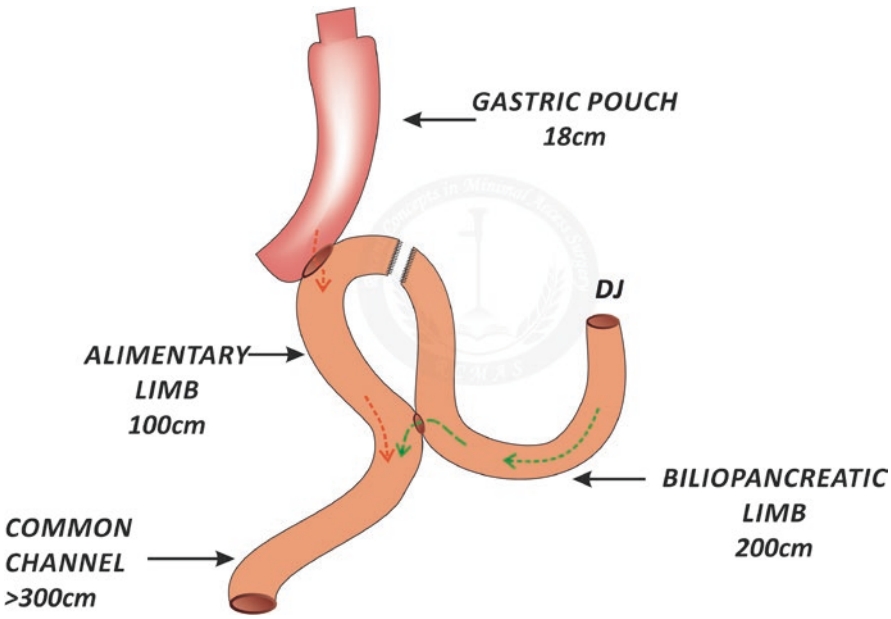

Fig. EN2 Schematic diagram of dMGB showing the limb lenghts

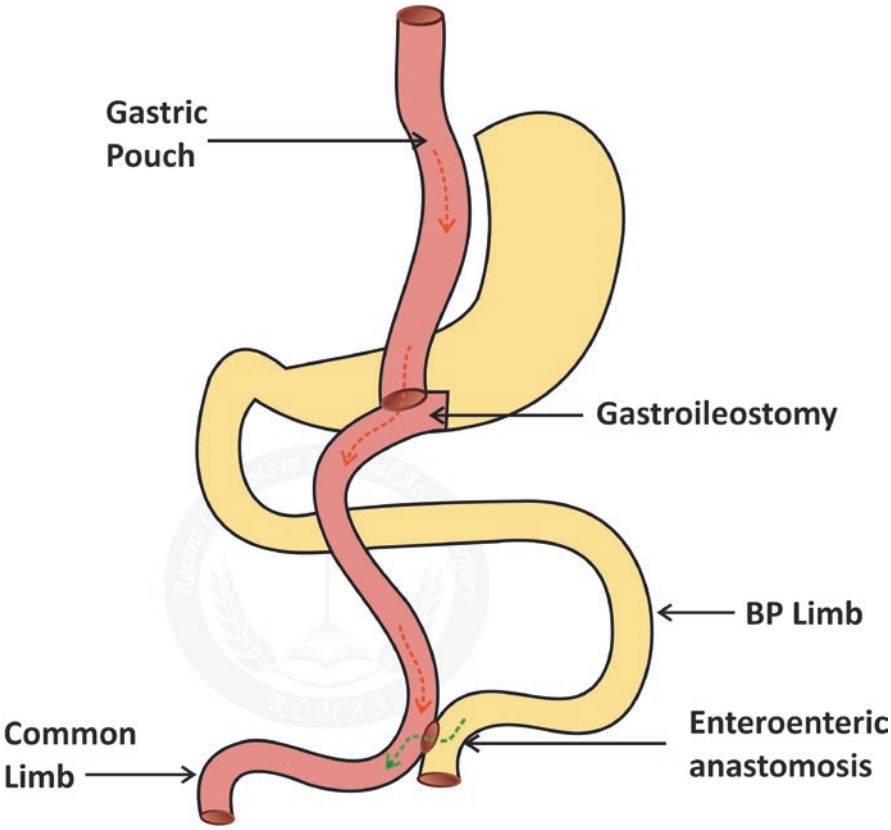

Fig. EN3 Schematic diagram of Sleeve Gastric bypass (*Image Courtesy Dr. Gautam Anand*)

Table EN1 Metaanalysis comparing various bariatric surgical procedures outcomes as: primary procedure, for diabetes remission and as revisional procedure

Topic	Study, author (first), year	Result
Laparoscopic sleeve versus mini gastric bypass	Comparison of safety and effectiveness between laparoscopic mini-gastric bypass and laparoscopic sleeve gastrectomy: A meta-analysis and systematic review. Wang F, 2017 [19]	Advantages of MGBP over LSG • Higher 1-year EWL% (excess weight loss), • Higher 5-year EWL%, • Higher T2DM remission rate, • Higher hypertension remission rate, • Higher obstructive sleep apnea (OSA) remission rate, • Lower osteoarthritis remission rate, • Lower leakage rate, • Lower overall late complications rate, • Higher ulcer rate, • Lower gastroesophageal reflux disease (GERD) rate, • Shorter hospital stay and • Lower revision rate.

Table EN1 (continued)

Topic	Study, author (first), year	Result
RYGB versus MGB	Outcomes of Mini vs Roux-en-Y gastric bypass: A meta-analysis and systematic review. Wang FG, 2018 [20]	Advantages MGBP over RYGBP • A higher 1-year EWL% ($P < 0.05$), • Higher 2-year EWL% ($P < 0.05$), • Higher type 2 diabetes mellitus remission rate, • Shorter operation time ($P < 0.05$). No significant statistical difference was observed in hypertension remission rate, mortality, leakage rate, GERD rate, or hospital stay between mini gastric bypass and Roux-en-Y gastric bypass.
Comparative analysis MGB and other bariatric surgeries in remission of type 2 DM	Network meta-analysis of the relative efficacy of bariatric surgeries for diabetes remission. Kodama S, 2018 [21]	BPD and MGBP achieved higher diabetes remission rates than the other procedures viz: LAGB, LSG, RYGBP, DJ Bypass, duodenal switch greater curvature plication.
	Comparative effectiveness of bariatric surgeries in patients with obesity and type 2 diabetes mellitus: A network meta-analysis of randomized controlled trials. Ding L, 2020 [22]	• MGBP has greatest probability of achieving diabetes remission in adults with obesity and T2DM, • BPD was the most effective in long-term diabetes remission. • RYGBP most favourable alternative treatment
	Efficacy of Laparoscopic Mini Gastric Bypass for Obesity and Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. Quan Y, 2015 [23]	MGBP compared with LAGB, LSG, and RYGBP, • MGBP showed significant weight loss [WMD, −6.58 (95% CI, −9.37, −3.79), $P < 0.01$ and comparable/higher T2DM remission • MGBP also had shorter learning curve and less operation time than RYGBP [WMD, −35.2 (95% CI, −46.94, −23.46)].

(continued)

Table EN1 (continued)

Topic	Study, author (first), year	Result
MGB as revisional surgery after restrictive bariatric surgery	Roux-en-Y gastric bypass versus one anastomosis-mini gastric bypass as a rescue procedure following failed restrictive bariatric surgery. A systematic review of literature with metanalysis. Velotti N, 2021 [24]	OAGBP/MGBP vs RYGBP MGBP showed • Lower rate of bleedings • Better weight loss (comparing pre vs post revision BMI) • Shorter operative time • Similar rate of leaks
	One Anastomosis/ Mini-Gastric Bypass (OAGB/MGB) as Revisional Surgery Following Primary Restrictive Bariatric Procedures: a Systematic Review and Meta-Analysis. Kermansaravi M, 2021 [25]	MGBP/OAGBP • BMI/Weight loss mean initial BMI was 45.70 kg/m^2, which decreased to 31.52, 31.40, and 30.54 kg/m^2 at 1, 3, and 5-year follow-ups, respectively. • Remission of type-2 diabetes mellitus (T2DM) following OAGB/MGB at 1-, 3-, and 5-year follow-up was 65.16 ± 24.43, 65.37 ± 36.07, and 78.10 ± 14.19%, respectively. • Remission/improvement rate from gastroesophageal reflux disease (GERD). • 7.4% of the patients developed de novo GERD following OAGB/MGB. • Leakage was the most common major complication. OAGB/MGB

MGBP minigastric bypass, *LSG* laparoscopic sleeve gastrectomy, *RYGBP* Roux en Y gastric bypass, *LAGB* laparoscopic adjustable gastric banding, *BPD* biliopancreatic diversion, *OAGBP* one anastomosis gastric bypass, *EWL* excess weight loss, *T2DM* type 2 diabetes mellitus, *GERD* gastroesophageal reflux disease, *BMI* body mass index

MGB-OAGB is thought to provide better results with fewer complications compared to RYGB. This diversion solved weight regain and hyperinsulinemic hypoglycaemia associated with RYGB and it is as effective as the MGB-OAGB with almost no incidence of GERD [18].

Table EN1 enlists various meta-analysis comparing MGB/OAGB with other bariatric surgical procedures as primary surgery for obesity as also revisional surgery after failed restrictive procedures.

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