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# Sleeve-Plus Procedures in Asia: Duodenojejunal Bypass and Proximal Jejunal Bypass

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## Abstract

Laparoscopic sleeve gastrectomy (SG) is the most commonly done bariatric procedure worldwide due to its technical ease. However, the physiologic effects of this procedure have limitations on glucose homeostasis for patients with type 2 Diabetes Mellitus (T2DM). This is due to the insufficient physiologic modulations from intestinal hormones. The Roux-en-Y gastric bypass (RYGB) has been proven to have better T2DM remission than SG due to more pronounced physiologic changes from foregut and hindgut hormone modulations. However, RYGB is technically challenging to perform and is accompanied by many potential postoperative complications, especially in terms of nutrition. The addition of an intestinal bypass to SG also induces said intestinal hormone changes to enhance diabetes remission. This chapter discusses the intestinal bypass that may be added to SG as surgical options for the treatment of obesity and T2DM with focus on duodenojejunal and proximal jejunal bypass.

**Keywords:** sleeve gastrectomy with bypass, sleeve-plus, duodenojejunal bypass, proximal jejunal bypass, morbid obesity, type 2 diabetes, bariatric surgery in Asia

## 1. Introduction

Obesity rates continue to increase globally, as well as the number of bariatric surgeries done. The RYGB is considered the gold standard bariatric surgery due to its satisfactory weight loss and remission of T2DM and other morbidities. However, the technical complexity and its long-term complications have led to a decrease in popularity over SG, which is easier to do with also satisfactory outcomes in weight loss and resolution of morbidities. However, SG also has its own shortcomings such as long-term weight regains and recurrence of co-morbidities. In an attempt to improve outcomes and decrease complications, new procedures are developed. Supplementing an intestinal bypass to an SG results in a simpler technique that has the physiologic advantages of RYGB but minimized adverse effects. The term for such procedures was coined as “sleeve-plus” by Dr. Chih-Kun Huang in the Taiwan Surgical Society of Gastroenterology meeting on October 24, 2015 [1]. As there have been several types of sleeve-plus techniques, this chapter will give a more comprehensive discussion on sleeve-plus procedures more commonly done in the Asia-Pacific region: the duodenojejunal bypass (DJB) and the proximal jejunal bypass (PJB).

## **2. World statistics and census**

Obesity is a major non-communicable epidemic disease and has been increasing worldwide for both developed and developing countries. It has tripled in number since 1975 according to the World Health Organization (WHO), with the latest data showing more than 1.9 billion adults classified as overweight; 650 million of which are considered as obese. In 2016, obesity accounted for 13% of the world's population (11% of men, 15% of women) [2]. In the Asia-Pacific region, the obesity in Gulf countries is greater than 30%, with T2DM frequency at 8-14.7%. This is in contrast to most of the other Asian countries where diabetes was more frequently seen than obesity [3].

Bariatric surgery is recognized as the most efficacious treatment for morbid obesity and its accompanying co-morbidities [4]. The International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) 5th Global Registry Report in 2019 recorded 520,983 bariatric operations performed from 2015 to 2018. The predominating bariatric surgery was SG (58.6%) followed by RYGB (31.6%) [5]. The Asia-Pacific Bariatric and Metabolic Surgery Society 2018 Congress reported 95,125 surgeries in Asia-Pacific countries, with most being performed in Australia and the Gulf countries, reflecting the highest obese populations in Asia. The most commonly performed was SG (68%), followed by the different bypass procedures (19.5%), and other surgeries, including revisional surgery (12.5%). Sleeve gastrectomy is being done at more than 50% of the procedures in most countries. The reported bypass surgeries included RYGB, one-anastomosis gastric bypass, SG with duodenojejunal bypass (SGDJB), and biliopancreatic duodenal switch (BPPDS). The bypass procedures were more than 30% only in Thailand and India. The OAGB was the leading bypass procedure in Taiwan, India and the Gulf countries. The SGDJB was more common in Japan, while RYGB was more common in the other countries [3].

The gold standard in bariatric surgery is still RYGB; but due to its technical difficulty and more severe complications such as marked malnutrition and marginal ulceration, SG has become the more popular bariatric procedure.

## **3. Brief evolution of bariatric surgery**

Bariatric and metabolic surgery originated in the early 1950s, first performed by Kremen: the jejunoileal bypass. To treat obesity-associated hyperlipidemia, the proximal jejunum was anastomosed to the distal ileum to limit absorption. However, this was associated with post-operative severe malnutrition and liver complications [6]. Taiwan was the first country in Asia recorded to perform the jejunoileal bypass for obesity treatment in 1974 [7]. The initial bariatric surgery was modified to limit malabsorption. In 1960s, Mason developed the first gastric bypass procedure utilizing a transverse gastric pouch remnant anastomosed to a loop of jejunum. Severe bile reflux prompted revision to a Roux-en-Y reconstruction of gastric bypass in the 1970s, which resulted to less diarrhea, kidney stones and gallbladder stones [6]. Taiwan was the first to perform a gastric partition in 1981. Vertical banded gastroplasty then began in Japan in 1982, and then Singapore in 1987 [7].

Biliopancreatic diversion (BPD) by Scopinaro and duodenal switch (DS) by Hess were also developed subsequently in 1976 and 1988; but the high incidence of potential metabolic complications and prolonged follow-up made these procedures less common. The RYGB eventually became the gold standard procedure for bariatric surgery [4].

In an attempt to breakdown RYGB and laparoscopic DS to decrease the operative time, SG was initially performed as a first step of a staged procedure [8]. The achievement of weight loss after SG made it an adequate stand-alone procedure.

Laparoscopic bariatric surgeries were first performed in 1994: laparoscopic adjustable gastric banding (LAGB) by Belachew, and laparoscopic RYGB by Wittgrove and Clark. Asia also started laparoscopic bariatric surgeries during the 1990s [3]. In 1999, laparoscopic BPDDS was initiated by Gagner; and laparoscopic classical BPD by Scopinaro. By 2000, McMahon and Gagner performed the first isolated laparoscopic SG, which was the time that majority of bariatric surgeries were already being done laparoscopically [5, 9].

Advancements in minimally invasive surgery lead to the application of single incision laparoscopic surgery (SILS) to bariatric surgery. In 2008, Nguyen reported the first case of bariatric SILS with adjustable gastric banding, [10] while Saber performed SILS SG [11]. Huang documented the first single incision transumbilical (SITU) RYGB in 2009, [12] followed by a series in 2010 comparing surgical outcomes of patients undergoing 5-port LRYGB with the novel SITU RYGB. The SILS has been shown to improve patient satisfaction in terms of cosmesis with comparable weight loss and morbidity rate. However, technical challenges due to the restricted surgical field, longer operative time, and increased post-operative pain have limited its popularity [13]. These procedures are technically feasible and reproducible with proper patient selection, performed by an experienced surgeon.

Restrictive and malabsorptive anatomic conceptualization of bariatric surgical procedures are continually under investigation. Modifications to the accepted standards are being made to further improve the treatment of obesity-related co-morbidities and reduce the impact of surgery.

#### **4. Types of sleeve-plus procedures**

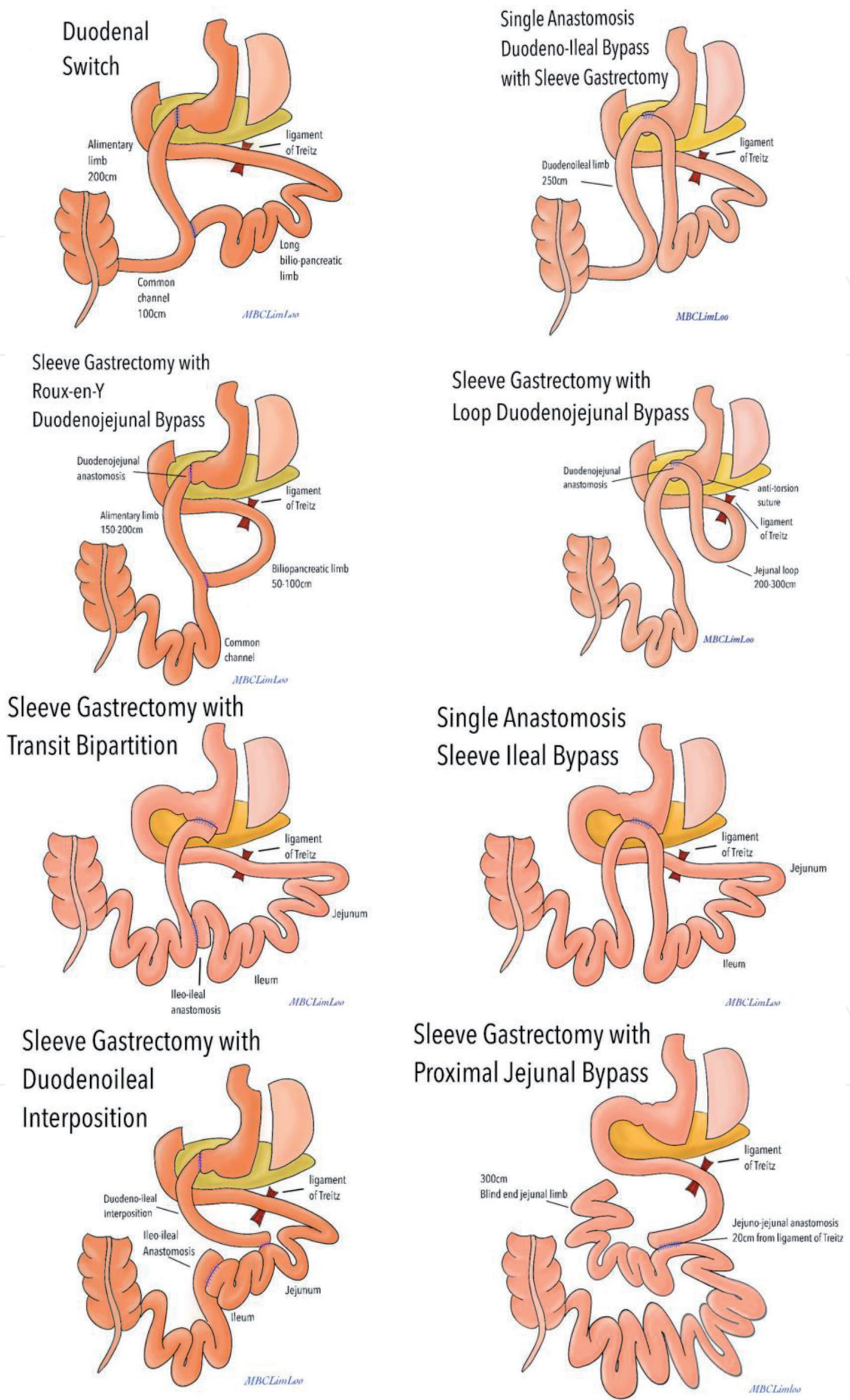
The earliest sleeve-plus procedure is the BPDDS which was developed in 1998 by Hess and Marceau [14, 15]. Many of the sleeve-plus procedures were patterned after the BPDDS. The procedure consists of a Roux-en-Y reconstruction of the bowel with a duodeno-ileal anastomosis for the alimentary limb, a lengthy biliopancreatic limb for malabsorption, and a short common limb. Changes in the location of the limb anastomosis and the limb lengths resulted in the different sleeve-plus techniques reported today (**Figure 1**).

In 2007, Sanchez-Pernaute reported a modification of the BPDDS into a loop fashion of limb reconstruction with a longer common channel. He described it as a single anastomosis duodenoileal bypass with sleeve (SADI-S) [16]. Santoro developed the SG with transit bipartition as an ileal anastomosis to the SG antrum with a Roux-en-Y reconstruction. This technique was then revised by Mui into a loop fashion and was called single anastomosis sleeve ileal bypass (SASI) [17, 18].

The sleeve gastrectomy duodenojejunal bypass (SGDJB) was first developed in Asia as an alternative to RYGB to allow the stomach to be screened for gastric cancer in areas with a high-risk population. The procedure may be done in the Roux-en-Y or loop fashion and was developed by Kasama in Japan and Huang in Taiwan, respectively [19, 20].

The ileal interposition with sleeve gastrectomy (IISG) was introduced by Aureo De Paula. The procedure included a segment of the ileum placed between the transected proximal duodenum and to the proximal jejunum, or interposed into the proximal jejunum [21]. The complexity of the procedure limits its widespread application.





**Figure 1.**  
*Types of sleeve-plus procedures.*

The proximal jejunal bypass (SGPJB) is probably the simplest sleeve-plus procedure to perform. It was developed by Alamo in 2004, where the proximal 20 cm of the jejunum is transected and anastomosed to the distal 300 cm bowel, leaving a blind-ended segment of the jejunum [22].

## 5. Advantages of sleeve-plus procedures

Several advantages can be gained from sleeve-plus procedures. First, it allows the remaining stomach to be screened for gastric cancer, which is frequently done in areas of high gastric cancer prevalence such as Japan and Korea [23]. Screening will be difficult to do in RYGB.

In the techniques where anatomical and functional preservation of the pylorus is done, the gastric mucosa is protected against pancreatic and biliary fluids; hence, preventing bile acid gastritis [24]. The pylorus also regulates gastric emptying which results to a lower incidence of dumping syndrome [25]. The larger gastric mucosal contact to food in SG compared to that in RYGB also improves the absorption of iron, calcium, vitamin B<sub>12</sub> and protein leading to less nutritional deficiencies [26].

Sleeve-plus procedures are quite versatile if a conversion to another procedure become warranted, whether due to weight regain, or complications of leaks and strictures. The loop SGDJB may be converted to a DS by transecting the afferent limb and anastomosing it to the distal segment of the efferent limb. The Roux-en-Y SGDJB can also be converted into DS by lengthening the alimentary limb from the biliopancreatic limb. Conversion to RYGB of any sleeve-plus procedure is also feasible. Index sleeve-plus procedures with a transected duodenum requires the proximal duodenal anastomosis to be taken down to allow resection of the distal gastric tube. The previous alimentary limb is then anastomosed to the remaining gastric pouch. In an SGPJB, a gastric pouch is simply created and anastomosed to the blind limb to construct the alimentary limb. In SG with bipartition, the gastroenteric anastomosis is transected, a gastric pouch is created, and a Roux-en-Y reconstruction of the bowel is done.

Loop techniques of sleeve-plus procedures have an additional advantage over the Roux-en-Y techniques. The single anastomosis in loop procedures allow for a shorter operative time and less potential complications that may arise from every additional anastomosis. The number of anastomoses also translates to the number of man-made hernial defects that necessitates closure. Another advantage of the loop techniques is that marginal ulcers have not been reported [20]. This may be due to the immediate neutralization of the gastric fluid by the bile juices once in the duodenum.

## 6. Hormonal effect of sleeve-plus procedures

When food is ingested, there are changes in the entero-insular axis which involve the gastrointestinal, endocrine and pancreatic secretions that contribute to insulin production. The main hormones in this mechanism includes ghrelin, glucagon-like polypeptide (GLP-1), peptide YY (PYY), gastric inhibitory peptide, oxyntomodulin, and cholecystikinin. Anatomical alterations of the food passage-way can affect these entero-hormones which can both influence the central regulation of body weight homeostasis, and make glycemic control more efficient. The hormones affect the hypothalamic-appetite regulation and suppress food intake. The enhanced glucose homeostasis can be explained by “foregut” and “hindgut” theories. The foregut theory hypothesizes that exclusion of food contact with the

duodenum prevents secretion of “anti-incretin” substances. Incretins are metabolic hormones that promote a decrease in blood glucose by making the pancreas more efficient. On the other hand, the hindgut theory explains that contact of undigested food immediately into the distal bowel stimulates production of incretins. The more relevant incretins involved are the GLP-1 and the PYY. These are produced from the L-cells in the distal ileum and colon after immediate contact with nutrients. The postprandial GLP-1 levels are significantly increased after both RYGB and LSG [27–29].

The sleeve-plus procedures are comprised of a sleeve gastrectomy and an intestinal bypass component. Sleeve gastrectomy has been shown to significantly decrease ghrelin, an orexigenic hormone predominantly secreted in the stomach. Ghrelin is also known to suppress insulin and have a modulating effect on glucose homeostasis, hence the decreased levels after SG also helps improve blood sugar control [30]. The SGPJB and SGDJB both have additional glycemic control effect by allowing food to be in early contact to the distal jejunum, stimulating earlier incretin production. The SGDJB has the added benefit of bypassing the duodenum and averts secretion of anti-incretin substances [31].

### 6.1 Hormonal study

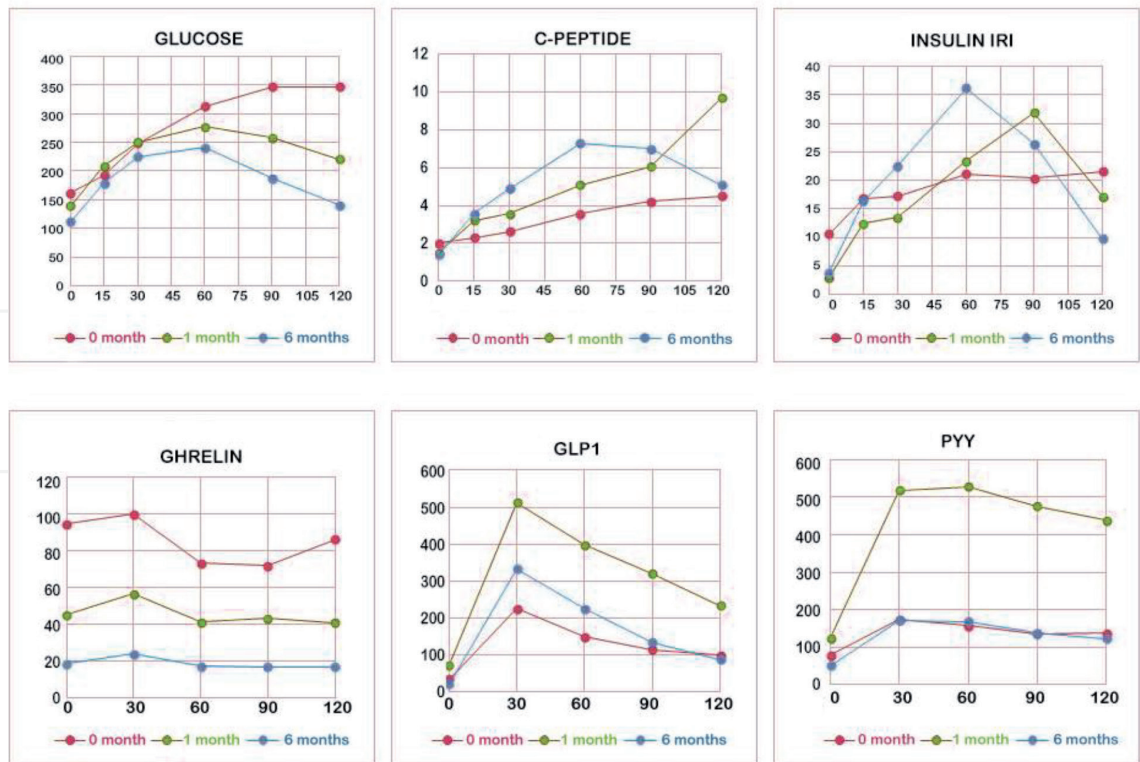
A prospective observational study was conducted by Dr. Chih-Kun Huang on the incretin effect of SGDJB in type II diabetic patients with BMI <35 kg/m<sup>2</sup> from May 2013 to March 2014. The study included 27 patients, 23 females and four males, mean age of 51, mean weight at 74.5 kg and mean BMI 28.4 kg/m<sup>2</sup>. All patients have T2DM for a mean duration of 10 years and underwent SGDJB with an afferent limb of 200 cm. The C-peptide, ghrelin, GLP-1, PYY were measured over time together with an oral glucose tolerance test (OGTT).

Hormone levels were analyzed by time courses, area under the plasma concentration time profile (AUC) and maximum plasma concentration (C<sub>max</sub>). Follow-up hormone levels were compared using the paired t-test. The Fisher exact test was used when 20% of the cells had expected values of less than 5. A p-value of less than 0.05 denoted statistical significance. All statistical tests were 2-tailed and calculated using the SPSS statistical software (version 15.0; SPSS Inc., Chicago Il.)

The surgery resulted in substantial weight loss with good glycemic control. At six months, the mean BMI had decreased to 22 ( $p < 0.01$ ), fasting glucose from 160 to 111 gm/dL, and mean glycosylated hemoglobin levels from 9.3 to 6.28% ( $p < 0.01$ ). Fasting ghrelin assays over time alongside OGTT was significantly lower with an AUC-120 of  $82.13 \pm 49.36$  pg./mL/min dropping down to  $17.90 \pm 9.01$  pg./mL/min ( $p < 0.05$ ). The GLP-1 showed an exaggerated response with an AUC-120 increase from  $139.37 \pm 109.93$  pg./mL/min preoperatively to  $349.10 \pm 187.35$  pg./mL/min at one month ( $p < 0.05$ ) and to  $185.75 \pm 118.81$  pg./mL/min at six months ( $p = 0.06$ ). The PYY also showed significant postprandial response at one month postoperatively with an AUC-120 change from  $137.10 \pm 93.20$  pg./mL/min to  $454.50 \pm 134.85$  pg./mL/min ( $p < 0.05$ ). However, this dropped to  $136.57 \pm 134.53$  pg./mL/min at six months ( $p = 0.987$ ) postoperatively (**Figure 2**).

The results in this hormonal study can infer that SGDJB leads to the immediate decrease in hunger, increase in satiety and better glycemic control. However, the decrease in PYY levels after six months is different from that of other hormonal studies where GLP-1 and PYY were shown to be elevated up to one year after bariatric surgery [32, 33]. Further research is needed to confirm how long the elevated incretin levels can persist postoperatively and how the body eventually adapts to it.





**Figure 2.**  
*C-peptide and hormone assays at zero, one and six months after SGDJB against time in minutes alongside an oral glucose tolerance test.*

## 7. Indications and contraindications

The National Institute of Health (NIH) Consensus Conference in 1991 established the indications in performing bariatric surgery, at the height of the obesity epidemic. Since then, a few modifications were made differing from country to country. The National Institute of Health and Care Excellence (NICE) in UK, as well as the Asian Pacific Metabolic and Bariatric Surgery Society (APMBSS), extended the indications further in relation to presence of other co-morbidities and adjusted the BMI threshold in accordance to inherent differences in body composition [34, 35]. In 2016, the 2nd Diabetes Surgery Summit convened with leading international diabetes organizations and developed new recommendations for metabolic surgery with a lower BMI threshold for Asians due to the higher risk for diabetes despite lower BMI values [36, 37] (**Table 1**).

Contraindications to bariatric surgery include physiological, medical and surgical, and psychological factors; few are considered to be absolute contraindications (**Table 2**).

Physiological factors include age and BMI. Initial NIH guidelines have limited surgery to 18-65 years of age, but recent studies have shown that bariatric surgery is considered safe for the elderly population [38–41]. There are limited well-designed prospective studies on bariatric surgery for children and adolescents, and an important factor to take into consideration is the psychological maturity required in accepting the lifestyle changes accompanying surgical intervention.

Obstructive sleep apnea, diabetes, hypertension and cardiovascular problems are some of the health conditions that should be screened and controlled pre-operatively prior to contemplating bariatric surgery. Previous abdominal surgery including abdominal wall hernias would influence practicality and applicability of any laparoscopic approach [4].



Criteria	NIH	NICE	APMBSS	DSS-II <sup>i</sup>
BMI	≥ 40	≥ 40	> 37	≥ 40 <sup>i</sup>
BMI with co-morbidities	≥35-	<ul style="list-style-type: none"><li>• ≥ 35</li><li>• ≥ 35 with new onset diabetes</li><li>• 30 with new onset diabetes*</li></ul>	≥ 32**	<ul style="list-style-type: none"><li>• ≥35<sup>****</sup></li><li>• ≥30<sup>****</sup></li></ul>

<sup>i</sup>BMI criteria is decreased by 2.5 for Asians.  
<sup>\*</sup>Bariatric surgery can be considered in BMI 30-34.9 with new onset diabetes.  
<sup>\*\*</sup>Presence of diabetes or two other obesity-related co-morbidities.  
<sup>\*\*\*</sup>Inadequately controlled hyperglycemia despite lifestyle and optimal medical therapy.  
<sup>\*\*\*\*</sup>Inadequately controlled hyperglycemia despite optimal medical treatment.

**Table 1.**  
Indications for bariatric surgery.

Absolute Contraindications
Poor functional status
Uncontrollable psychiatric disease
Drug or substance abuse
Malignancy
Relative Contraindications
Extremes of age
Type 1 Diabetes Mellitus
Smoking
Liver cirrhosis
Previous abdominal surgery

**Table 2.**  
Contraindications for bariatric surgery.

Active psychiatric disease and psychological instability are absolute contraindications; while poorly controlled eating disorders being a negative predictor of post-operative weight loss, is a relative contraindication [42, 43]. Smoking has been associated with development of post-operative marginal ulceration after gastric bypass, increased risk of poor wound healing and impaired health, and should be stopped at least 6 weeks before surgery [4, 44].

7.1 Selection of sleeve-plus procedure

The SGDJB and SGPJB are both relatively more recent than the RYGB and the data is still too young to provide specific indications for either procedures. Both patient and surgical factors must be considered when choosing the appropriate procedure for a safe outcome with optimal weight loss and resolution of co-morbidities. Any contraindications to SG obviously preclude both SGDJB and SGPJB such as severe gastroesophageal reflux disease and Barrett’s esophagus.

All patients who are suitable candidates for SG may benefit from an additional bypass component if the BMI and diabetic history are considered. Higher BMIs such as 45 or more may benefit from a malabsorptive component but also reflect thicker visceral fat. This may pose difficulties during duodenal dissection for SGDJB. Hence, SGPJB may be a safer and easier option. Patients with long standing diabetes may also benefit from a bypass component because of the additional incretin response. Those with poorer glycemic control due to a more decompensated

pancreas may consider SGDJB over SGPJB due to the combined glycemic effects from the foregut and hindgut theory. However, SGDJB is a challenging procedure and requires a more experienced surgeon's skill set.

Intraoperative findings may also influence the choice of procedure. Any evidence of vascular perfusion concerns on otherwise normal tissues may hint potential anastomotic problems. An SGPJB may be a more practical option, as the leaks from jejunio-jejunal anastomosis is easier to manage than leaks from a duodenojejunal anastomosis. The patient's current medical condition must also be considered. Severe co-morbidities such as cardiac issues may preclude contemplation for SGDJB as this requires a longer operative time compared to SGPJB.

Each surgery has its own advantages and disadvantages. However, a safe outcome is still the most important factor to consider when choosing not only between sleeve-plus procedures, but for any type of bariatric surgery.

## **8. Preoperative considerations**

A multidisciplinary team is necessary for screening and evaluating a patient's medical condition including psychological capability to undergo bariatric surgery. One of the crucial facets in the success of bariatric surgery is a comprehensive medical history, physical examination, preoperative work-up, with patient education playing an integral part.

A complete history should include a detailed diet history, physical activity, medication review, social history, psychological history, and psychosocial factors that can affect the surgical outcome. All body systems are assessed. A full endocrinologic evaluation is done to rule out other causes of obesity. Other obesity-related co-morbidities are screened and managed accordingly.

Psychological evaluation is necessary to identify any undiagnosed psychiatric disorders, and to assess if a candidate will be able to undergo the lifestyle changes necessary to sustain long-term weight loss. Any significant psychiatric problems must be treated and controlled prior to any contemplated procedure. Counseling for smoking and alcohol cessation, as well as pregnancy must be included.

## **9. Operative technique**

The addition of a bypass component to a simple SG would entail a more technically challenging surgery. Advanced laparoscopic skills are essential to safely perform organ manipulations, adequate dissection, landmark identifications, suturing and anastomosis to ensure a complete and successful surgery. Although several procedures are mentioned above, this chapter will give a more comprehensive discussion to SGDJB and SGPJB, which are the more commonly performed sleeve-plus procedures in the Asia-Pacific region.

### **9.1 Duodenojejunal bypass**

There have been two operative techniques describing SGDJB: the Roux-en-Y (RNY) and the loop technique. The RNY SGDJB was first described by Kasama in 2009 as an alternative option to RYGB which precludes screening of the remnant stomach for gastric cancer in high-risk populations as in Japan [19]. The loop technique was then described by Huang in 2013 in an attempt to mitigate some long-term complications associated with RYGB [20].

### *9.1.1 Roux-en-Y technique*

After induction of anesthesia, the patient is placed in the French position. Five ports are inserted, the camera port at the supra-umbilicus, a 5-mm port at the subxiphoid for liver retraction, two 12-mm ports at the left subcostal margin and 10 cm caudally, and a 15 mm port at the right upper abdomen.

A standard SG is done over a 36 French bougie using linear staplers beginning 4 cm from the pylorus and proceeding proximally. Dissection of the posterior wall of the duodenum is done and transected at 1-2 cm distal to the pylorus. The jejunum is transected at 50-100 cm from the ligament of Treitz serving as the biliopancreatic limb. The transected distal jejunum to serve as the alimentary tract is measured to 150-200 cm where the jejunojejunostomy anastomosis of the biliopancreatic limb is done. The mesenteric defect is closed by hand-sewn technique. The omentum is divided to avoid tension on the antecolic reconstruction of the duodenojejunal end-to-side anastomosis [19] (**Figure 3**).

### *9.1.2 Loop technique*

After anesthesia is initiated, the patient is placed in supine position. Five ports are also used. Two 12-mm ports at the left and right of the umbilicus at the midclavicular line; the left serving as the camera port. A 15-mm port is inserted into the umbilicus and two 5-mm ports at both subcostal margins.

A standard sleeve gastrectomy is done over a 36 French bougie using a linear stapler beginning at 4 cm proximal to the pylorus and proceeding cranially. At the duodenum 2 cm distal to the pylorus, the posterior wall is dissected creating a tunnel where the linear stapler is inserted and used for transection. The jejunum is then measured 200-300 cm from the Ligament of Treitz where an enterotomy is created. A 1.5 cm duodenotomy is created at the proximal limb and anastomosed to the enterotomy by hand-sewn technique. The jejunum 4 cm proximal to the duodenojejunostomy is anchored to the antrum serving as an anti-torsion suture. The Petersen's defect is closed. The remnant stomach is fixed posteriorly to the retroperitoneal fat and a Jackson-Pratt drain is placed behind the duodenojejunal anastomosis [20] (**Figure 4**).

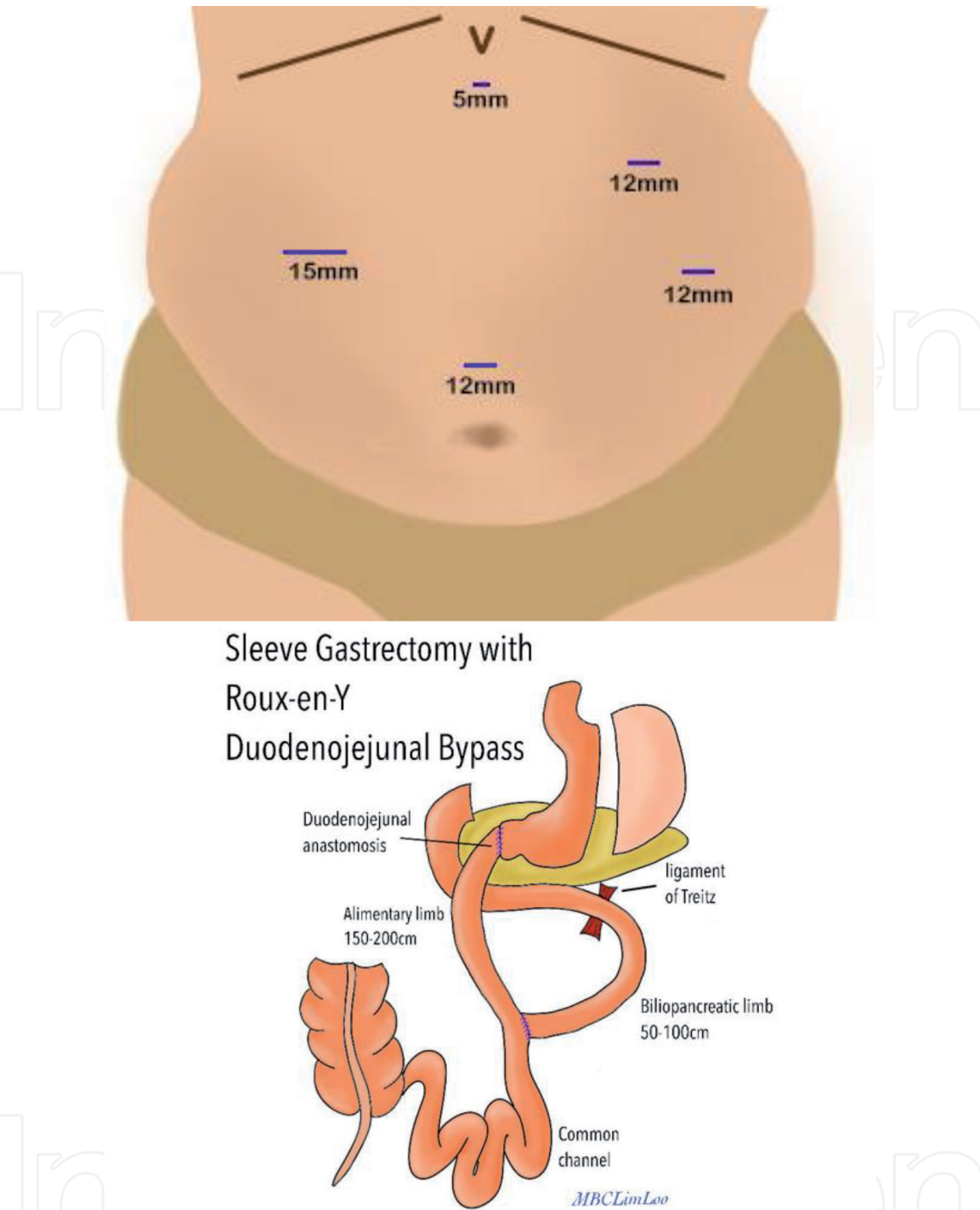
### *9.1.3 Pearls*

The SGDJB can be quite intimidating to some surgeons due to the intimate relationship of the duodenum to the surrounding structures. Proper identification of landmarks to guide dissection is important to avoid mishaps.

The location of the common bile duct running behind the first portion of the duodenum, serves as a boundary to the second portion where the transection is done. The gastroduodenal artery (GDA) is also located in this area just to the left of the common bile duct (**Figure 5**). Hence, dissection of the duodenum from the pancreas must be done carefully to avoid injury and bleeding due to the proximity of the GDA and high vascularity of the area.

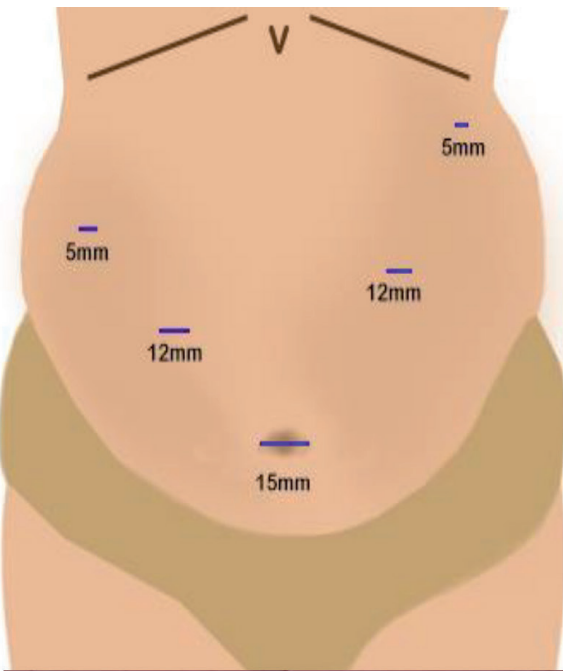
To facilitate the dissection, counter-traction of the duodenum may be done by pulling the stomach laterally to the left using a traction suture over the gastric antrum. In patients with excessive periduodenal fat, the dissection of a tunnel below the duodenum becomes difficult. In these cases, the right gastroepiploic vessels may be sacrificed. Once a clear tunnel between the duodenum and pancreas has been created, a vascular tape may be inserted and used to lift the duodenum to assist insertion of a stapler for the duodenal transection (**Figure 6**). The surgeon must take care not to injure the common bile duct, pancreas and vasculatures around the first part of the duodenum. A side-to-side or end-to side duodenojejunal



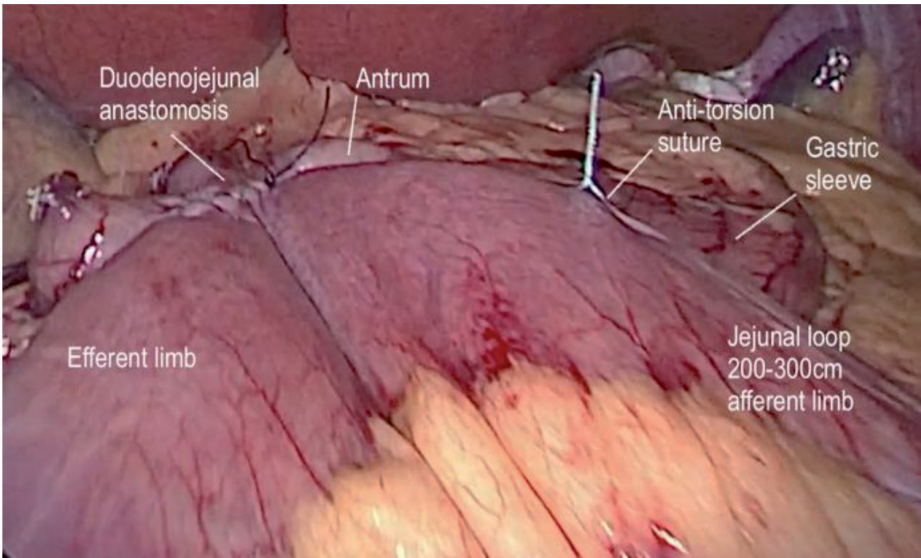
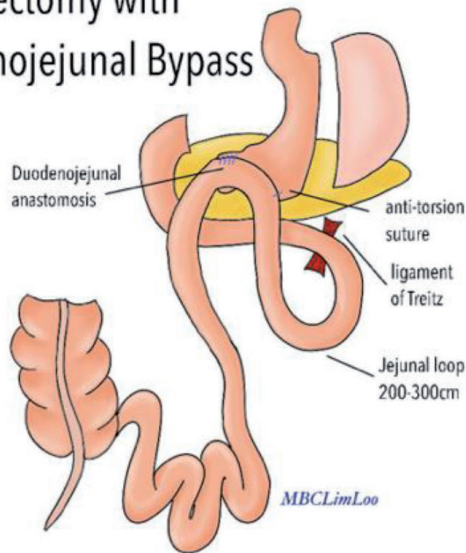


**Figure 3.**  
*SGDJB roux-en-Y technique.*

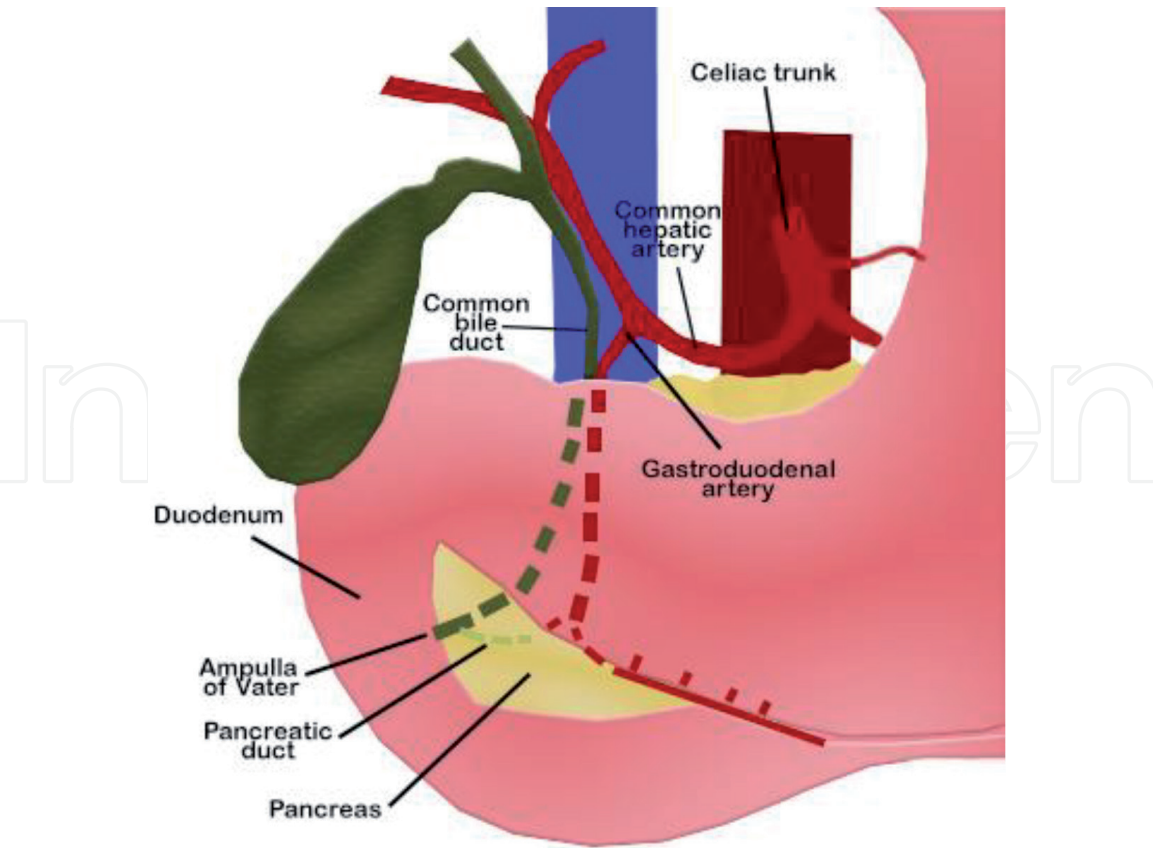
anastomosis may be done, each having its own precautions. A side-to-side anastomosis must be done 1 cm distal to the pylorus to avoid its injury. A temporary stay suture between the pylorus and proximal jejunum allows for easier hand-sewn anastomosis. The other option of an end-to-side anastomosis would require the posterior wall of the proximal duodenum to be partially devascularized to allow some tissue clearance for the hand-sewn anastomosis. Use of a stapler in both orientation of anastomosis may risk pyloric injury. The loop technique requires only a single anastomosis, and an anti-torsion suture anchoring afferent limb of the jejunal loop to the stomach. This is done to avoid torsion or kinking of the jejunal limbs. The RNY technique would require another entero-enteric anastomosis which would translate to more operative time. Closure of both the Petersen and mesenteric defect prevents potential internal herniation of bowel.



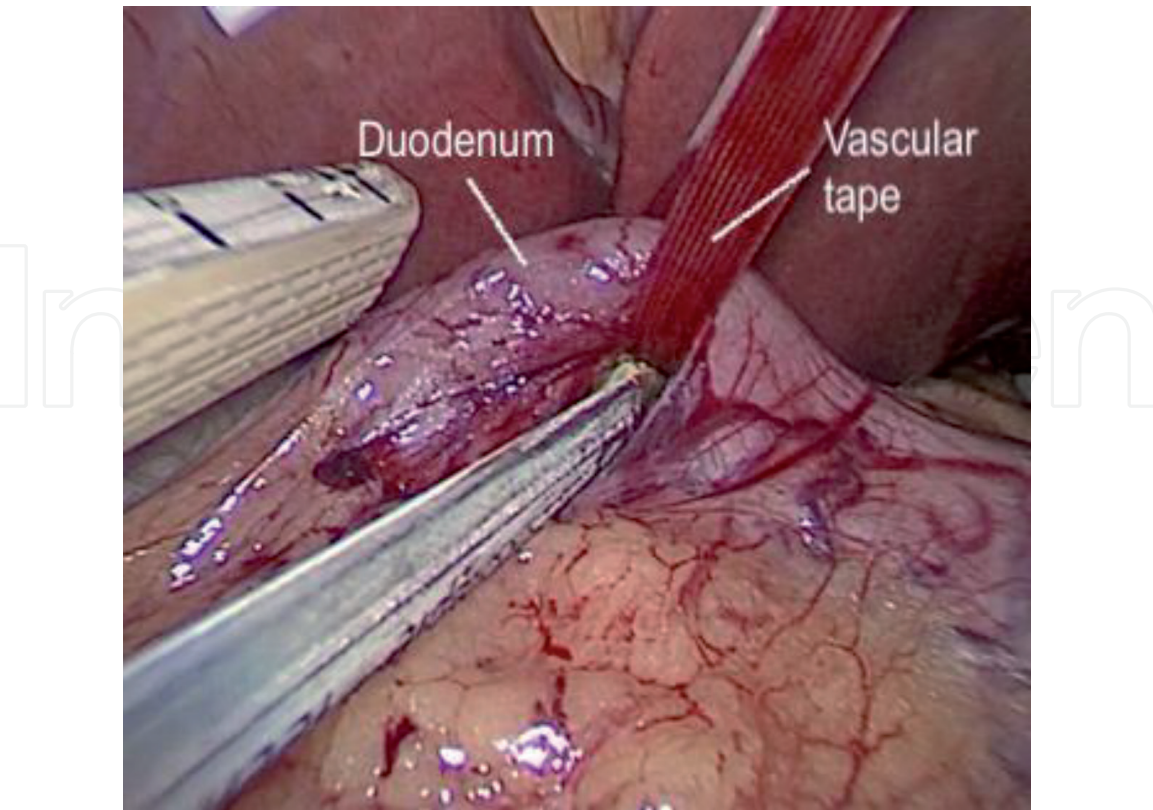
Sleeve Gastrectomy with  
Loop Duodenojejunal Bypass



**Figure 4.**  
*SGDJB loop technique.*

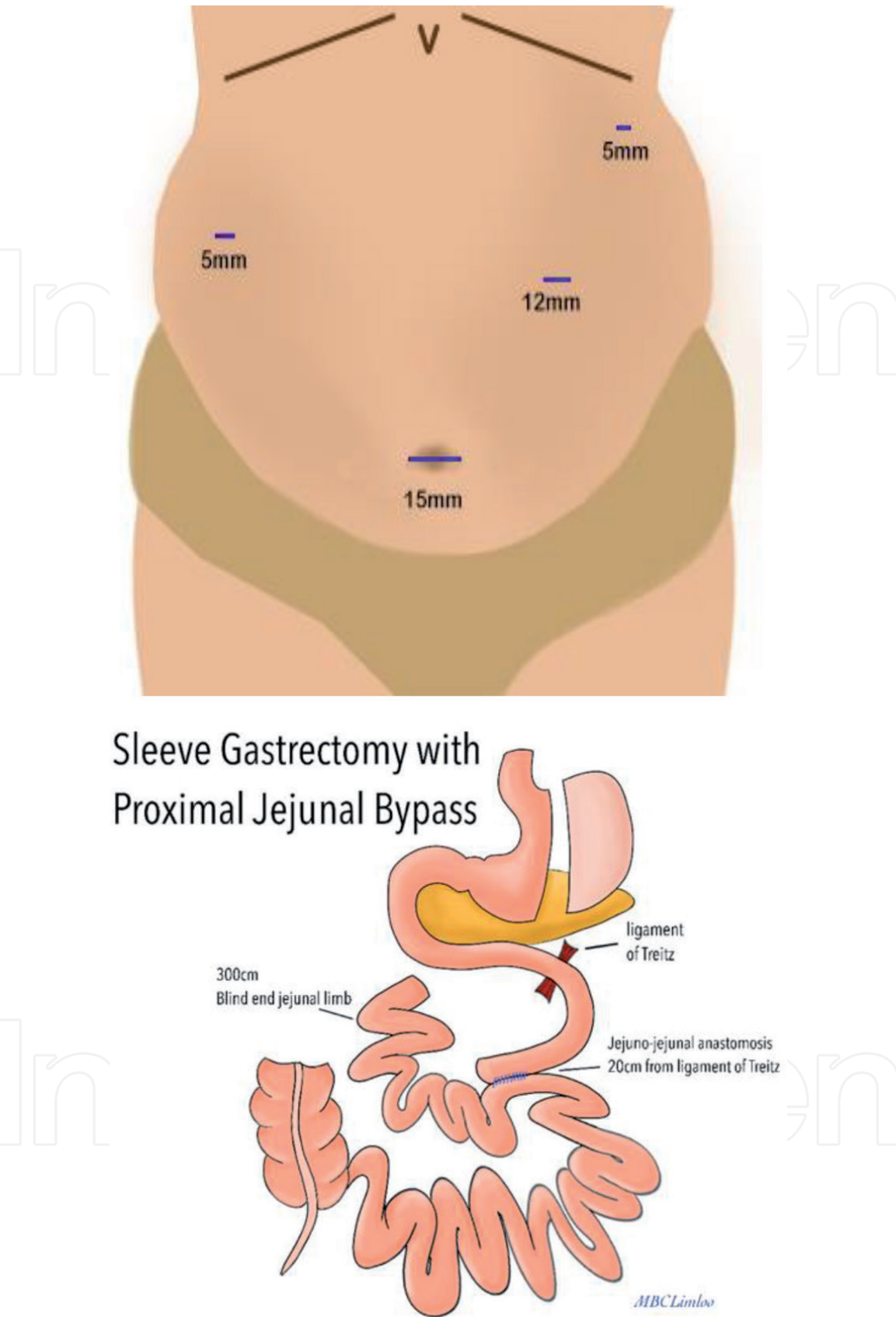


**Figure 5.**  
*Anatomical landmarks and relationships of the proximal duodenum.*



**Figure 6.**  
*Use of a vascular tape to maneuver the duodenum facilitates application of the stapling device.*





**Figure 7.**  
*Sleeve gastrectomy with proximal jejunal bypass.*

9.1.4 Challenges

Apart from being an irreversible procedure with no long-term data available yet to compare it to RYGB, the procedure is technically demanding and might preclude super obese patients. It also requires a fastidious surgeon with

meticulous skills in manipulating an area of intimately-related vital structures, so as to have an uneventful surgery.

Duodenal dissection and manipulation must be done carefully to avoid inadvertent damage to the duodenal wall. Injury to the duodenum proximal to the dissection is resolved with the duodenojejunal anastomosis. But injury distal to the transection may result in a leak if not repaired properly.

Bile duct injury may occur if the duodenal transection is done too distally. Avulsions and lacerations are repaired over a T-tube inserted into the bile duct. Complete transections would require a biliary reconstruction.

Bleeding is not infrequent due to the vascularity around the proximal duodenum and may range from oozing to torrential. Oozing due to multiple small vessels is controlled with simple packing until hemostasis is achieved. Added manipulation is avoided to prevent more tissue injury and aggravate hemorrhage. Severe bleeding from an injured gastroduodenal artery may necessitate suture repair, ligation or conversion to an open laparotomy.

Another shortcoming of the SGDJB is the inaccessibility to the Ampulla of Vater for endoscopic management of biliary obstructions. Therefore, patients with cholelithiasis preoperatively are offered cholecystectomy concomitantly with the bariatric surgery or subsequently if it develops postoperatively, regardless of symptoms.

## **9.2 Proximal Jejunal bypass**

The surgery is performed under general anesthesia with the patient in reverse Trendelenberg position. Initial entry and camera port is done along the left upper quadrant followed by the other working ports: 15 mm at the umbilicus, 5 mm at the right upper quadrant, and 5 mm at the left subcostal area.

A standard SG is done over a 36 French bougie using linear staplers beginning 4 cm from the pylorus and proceeding proximally. The ligament of Treitz is identified and jejunum is divided at 20 cm. The distally transected jejunum is measured to a distance varying from 250 to 300 cm and is anastomosed to the proximal biliopancreatic jejunal limb. The mesenteric defect is closed to avoid internal hernia and the remnant stomach is fixed posteriorly to the retroperitoneal fat [45] (**Figure 7**).

## **10. Postoperative care and follow up**

Once the surgery has been concluded, extubated and recovered from anesthesia, the patient is then returned to the ward. Clear liquids are initiated once the patient is fully awake. Deep breathing exercises and chest physiotherapy are done. Early mobilization is encouraged and opioid analgesics are used for pain control. If there are no remarkable events, the patient is discharged and is scheduled to follow up after one week at the out-patient clinic. Diet progression is then continued as with any routine bariatric diet, with a progressive exercise program in place. Maintenance medications for diabetes and other co-morbidities are adjusted accordingly. Prophylactic proton pump inhibitors may be given. Subsequent follow-ups include dietary counseling, and is done every three months after the surgery for the first two years and then annually.

## **11. Therapeutic outcomes**

Review of literature has reported RYGB to have better results than LSG in terms of weight loss and T2DM remission. However, complications are also reported to

be higher after RYGB [46, 47]. Up to 97% of morbidly obese SG patients have been reported to have improvement or remission of T2DM at 13 months but drops to 60.8% at five years with a recurrence rate of 13% [48]. Early reports of DJB in non-obese diabetic patients have shown improvement in sugar control albeit without remission of diabetes [49, 50]. Since there was no SG done, this suggests that weight loss is a strong factor for diabetes remission. The combination of SG with an intestinal bypass results to a synergistic combination of weight loss and sugar control.

The SGDJB was first reported by Kasama et al. in 2009, in comparison with gastric band, RYGB and SG. At one year, the excess weight loss (EWL) was similar to RYGB, and better than SG or gastric banding. Diabetes resolution of SGDJB was better than SG at 93% versus 67%. There was also resolution of dyslipidemia (100%) and hypertension (85.7%) [19]. Raj et al. published a randomized controlled trial between SGDJB and RYGB showing no statistical difference in percent EWL, diabetes remission, and resolution of hypertension and dyslipidemia [51]. Lee et al. also compared SGDJB with RYGB showing better EWL with SGDJB (80.3% vs. 63.4%) but with higher cholesterol levels than RYGB [26]. He also compared SGDJB to SG alone and reported SGDJB to have better weight loss (EWL 87.2% versus 67.5%) and diabetes remission (93% versus 87%) [52].

Kasama's group also reported the effect of SGDJB on glucose metabolism in morbid obesity with associated diabetes. Glucose monitoring showed decreasing insulin requirements on the first postoperative day to no diabetic medications on the second day. At one month, 91% of the subjects achieved an HbA<sub>1c</sub> below 7%. A meal tolerance test conducted at six months showed the subjects to have lower glucose and increased insulin area under the curve. This was reflected in the decreased requirement of oral hypoglycemic agents and insulin [53]. At one year, fasting blood sugar and HbA<sub>1c</sub> levels improved at 194 to 105 and 8.9 to 6.0, respectively, and found to be sustained up to five years with a reported remission rate of 63.6% [54].

In diabetic patients within the lower BMI range of obesity, Huang et al. reported that SGDJB resulted in a BMI drop to 22.4 from 28.4 in six months, and HbA<sub>1c</sub> levels below 7.0 without medications in 91% of the subjects [20]. On two-year follow-up, diabetes remission was found to be at 54% and glycemic control in 77% [55]. In comparison to RYGB, there were no statistical difference in the outcomes for diabetic patients with BMI less than 35 in terms of weight loss and glycemic control [56].

Studies on SGPJB have shown to the weight loss outcomes to be better than SG [57]. The EWL in one year is 96.7% and has been found to be sustained to more than 80% even after 10 years of follow-up [58]. Good glycemic control is also achieved after SGPJB. In 2016, the first Asian series was reported by Huang et al. showed 66% EWL at six months, with 66.7% of diabetic patients achieving an HbA<sub>1c</sub> less than 6 without medications [45]. A study on diabetics with BMI of <35 showed 97% of the subjects on preoperative oral hypoglycemic agents had complete remission and all of the subjects on insulin to be in partial remission [59]. When compared with RYGB, the outcomes at one and three years showed weight loss and diabetes remission to be similar, with both groups requiring less medications [60, 61].

## **12. Complications**

The overall morbidity associated with bariatric surgery complications ranges from 3.4-13% and may vary depending on the procedural type, surgical approach, patient age, BMI and co-morbidities [62–64]. Literature will show that SG has an overall complication rate lower than RYGB [65, 66]; however, potential complications associated with SG remains worrisome, including post-operative hemorrhage and staple line leak.



## 12.1 Hemorrhage

Significant post-operative hemorrhage after bariatric surgery has been described up to 3.4%, [67] with the most common presenting symptom as tachycardia (46%), followed by melena (32%). Sleeve gastrectomy bleeding can happen from the short gastric vessels or along the staple line after transection of the stomach [68]. Bleeding can also occur from an anastomotic site intraluminally in patients with an additional bypass procedure which typically may be managed medically or endoscopically. Surgery should be considered for hemodynamic instability and failure of endoscopic therapy [67].

## 12.2 Leak

One of the most dreaded complication after bariatric surgeries are anastomotic leaks or staple-line leaks. Leaks from SG can occur along the staple-line, with an average incidence of 1.5% [69]. Risk factors that contributed to gastrointestinal leak include oxygen dependency, hypoalbuminemia, sleep apnea, hypertension and diabetes. Additional factors that contributed to a higher leak rate include intraoperative provocative testing and placement of drain [70].

Clinical presentation of patients with leaks range from completely asymptomatic, to frank peritonitis, septic shock, and death. Unexplained tachycardia has been shown to be an initial sign of early leak [71]. Other potential signs that should cause a high index of suspicion should include fever ( $>38^{\circ}\text{C}$ ), diffuse abdominal tenderness, cough, and persistent hiccups [72]. A concern about a leak should be investigated urgently with imaging modalities such as upper gastrointestinal series with water-soluble contrast or abdominal CT scan IV and oral contrast. Urgent reoperation is warranted for unstable patients with signs of sepsis. Stable patients with controlled leaks may undergo percutaneous drainage, antibiotic therapy and nutritional support, in conjunction with endoluminal therapies (stenting, clipping) [4, 72].

## 12.3 Sleeve gastrectomy related complications

### 12.3.1 Gastroesophageal reflux disease

Another SG related complication is new-onset gastroesophageal reflux disease (GERD), or worsening of previous GERD symptoms. A meta-analysis by Yeung et al. demonstrated significant worsening of GERD post-operatively at 19%, with de novo GERD at 23% [73]. Long-term follow up of patients show 28% of LSG patients develop esophagitis, and 8% develop Barrett's esophagus. Endoscopic assessment for presence of hiatal hernia is recommended pre-operatively, as its concomitant repair during SG can help reduce incidence of post-operative GERD [74].

### 12.3.2 Gastric tube stenosis

Post-SG stenosis is a rare complication with a reported incidence of 1% – 3.5% [75, 76]. The most common site for stenosis is at the incisura angularis, [76] usually presenting with gastric outlet obstruction symptoms with marked weight loss and malnutrition [4]. Diagnosis can be done with upper gastrointestinal series or contrast enhanced CT scan of the upper abdomen. Factors that contribute to development of stenosis include bougie size and oversewing of the staple line. Endoscopic dilatation is the first line of treatment which usually require multiple sessions. Failure of endoscopic intervention, long segment stenosis, or presence of delayed leakage, abscess or fistula formation necessitates surgical intervention [75, 76].

## **12.4 Intestinal bypass related complications**

### *12.4.1 Hernia*

Reconstruction of the intestinal continuity leads to man-made defects that may potentially result in internal hernias if not closed. Patients would present signs and symptoms of bowel obstruction and gangrene which are supported with radiologic findings. The incidence in SGDJB and SGPJB has been reported to be at 1-2% [51, 54, 60]. Despite the low incidence, defect closure still prevents the potential morbidities of internal hernia including necrosis and ischemia in 7-42% and associated mortalities [8].

Trocar site hernias are also a potential morbidity if fascial defects more than 10 mm are not closed. When trocar sites were dilated to allow extraction of specimens, this must also be closed [77].

### *12.4.2 Malnutrition*

The addition of an intestinal bypass to sleeve gastrectomy has implications to the patient's nutritional status as it alters the natural absorption of nutrients. The larger stomach in sleeve-plus procedures allow more acid and intrinsic factors to have better absorption of iron, calcium, and vitamin B<sub>12</sub> compared to an RYGB.

Comparison of SGDJB to SG alone has not shown any difference in nutritional status at one year [22, 52]. Investigational studies of SGDJB done in Chinese diabetic patients with BMI <25 kg/m<sup>2</sup> has shown an increased incidence of becoming underweight and deficiencies in iron, vitamin B<sub>12</sub>, vitamin D and calcium [78].

In SGPJB, despite a defunctionalized intestinal segment, nutrient deficiency levels are comparable to SG. The preserved pyloric function and duodenal exclusion omitted in SGPJB also results to a lower incidence of nutritional deficiencies, diarrhea (6% vs. 21.5%), dumping syndrome (0 vs. 7.6%) and fatigue (25.3% vs. 40.5%) [61].

Postoperative supplementation of vitamins and minerals are necessary to prevent post-operative malnutrition. More studies are needed to determine the nutritional deficiency of sleeve-plus procedures to properly guide supplementation of these patients.

### *12.4.3 Dumping syndrome*

Reconstruction of the digestive anatomy also alters the glucose metabolism which may result to dumping syndrome. This occurs in 15-76% after RYGB and may be potentially debilitating. Preservation of the pylorus in both SGDJB and SGPJB allows for a more regulated gastric emptying and a lower reported incidence of dumping syndrome at 4% and 0%, respectively [53, 61].

### *12.4.4 Marginal ulcer*

Marginal ulcers of the gastrojejunal anastomosis of the RYGB has been reported to occur up to 12% and can lead to bleeding, perforation or stenosis. This is in contrast to low incidence reported in SGDJB Roux-en-Y technique at 0.49%, and no reported incidence in the loop technique [39, 54].

### *12.4.5 Blind loop syndrome*

The creation of a blind loop of intestine could cause bacterial overgrowth, the so-called 'blind loop syndrome' or 'bacterial overgrowth syndrome' (BOS).

However, the SGPJB has the benefit of a blind jejunal limb without passage of food or bile, and an isoperistaltic loop [79]. This helps mitigate against the possibility of BOS. Unlike in JIB having a shorter common channel, the SGPJB enteral anastomosis has a longer common channel, in which bacterial concentration is significantly lower [60]. Incidence of BOS after SGPJB is still unknown, but intestine continuity can be easily reversed in case BOS develops.

### 13. Conclusion

The addition of a malabsorptive component to LSG has been coined as “sleeve-plus”. The sleeve-plus procedures more commonly done in the Asia-Pacific are the SGDJB and SGPJB. The said procedures have both shown satisfactory outcomes in the treatment of obesity and related co-morbidities that are comparable to other bariatric procedures but with less adverse outcomes than that of RYGB and may be considered as alternative options. However, more studies are necessary to assess long-term outcomes in terms of diabetes remission, nutrition, and applicability to other racial populations.

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### Conflict of interest

The authors declare that they have no competing interest.

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