Single Anastomosis Duodeno-ileostomy

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Chapter Objectives

1. History of the single anastomosis duodeno-ileostomy (SADI) procedure.
2. Describe surgical technique with attention to the steps to prevent common as well as rare complications.
3. Summarize the outcomes in terms of weight loss, complications, nutritional outcomes, and type 2 diabetes mellitus resolution.
4. Describe SADI as a revision procedure following failed sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and adjustable gastric banding (AGB).
5. Review of literature.

History

In 1986, Dr. Douglas Hess modified the biliopancreatic diversion (BPD) in order to retain the pylorus as a functioning part of the digestive system. The new procedure was called a biliopancreatic diversion with duodenal switch (BPD-DS) [1]. This procedure includes removing a significant portion of the stomach as well as bypassing a segment of the small intestine. The new procedure was more effective for long-term weight maintenance than a Roux-en-Y gastric bypass (RYGB) or a vertical banded gastroplasty (VBG). However, it became associated with complications such as chronic diarrhea, smelly stools, flatulence, vitamin deficiencies, and protein-calorie malnutrition.

Because of the complication profile, the BPD-DS did not gain widespread adoption. Most surgeons gravitated to the RYGB as the best balance of weight loss and procedural related side effects. The RYGB suffered from ulcers, perforations, anastomotic dilation, vitamin and protein deficiencies, dumping syndrome, anastomotic strictures, gastro-gastric fistula, and internal hernias [2]. The complications of the RYGB are almost all associated with the formation of the Roux limb.

To eliminate the problems with Roux limb formation, Drs. Torres and Sanchez-Pernaute from Spain introduced a variant of BPD-DS that involved one anastomosis instead of two. They named it "Single anastomosis duodenoileal bypass with sleeve gastrectomy" (SADI-S) [3]. The SADI-S involved preservation of pylorus like BPD-DS but eliminated the Roux limb found in RYGB and BPD-DS. They used a 54-size Fr bougie for sleeve creation with a 200-cm common channel. However, this length was later enlarged to 250 cm to reduce the risk of hypoproteinemia [4].

In order to reduce a prohibitive risk of short bowel syndrome and provide a margin if the bowel is inaccurately measured, Drs. Cottam and Roslin from the United States further modified the SADI-S procedure. Their variant included a 40-size Fr bougie (vs. 54-size Fr bougie) for better weight loss along with a common channel of 300 cm (vs. 250 cm). This variant was called "Stomach intestinal pylorus-sparing surgery" (SIPS) [5]. However, the basic concept of preserving the pylorus and having a single anastomosis was the same.

The SIPS, being a fairly new concept in 2015, was considered experimental in the United States [6]. However, by 2018, based on clinical knowledge, expert opinion, and published peer-reviewed scientific evidence, the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) considered the SADI-S (and its SIPS variant) an established bariatric procedure [7]. In addition, the IFSO proposed a nomenclature for surgery that combines a partial gastrectomy with a single anastomosis between the small bowel regardless of bougie size or common channel length as SADI-S or one anastomosis duodenal switch (OADS).

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Surgical Technique

Retrograde Tracing and Temporary Tacking

The first step of the procedure is to locate the ileocecal valve (Fig. 15.1). Once this is located, the small bowel is traced retrograde to the desired common channel length (this varies greatly between authors and around the world) and tacked up to the gastrocolic omentum (Fig. 15.2).

Sleeve Creation

With the creation of the SADI-S, the consensus among surgeons who perform this procedure making the sleeve too "tight" is a problem. By tradition, surgeons have not made sleeve's smaller than 40 F. However, just as there are many ways to create a sleeve, the same applies to the creation of the sleeve during SADI-S. This would include oversewing,

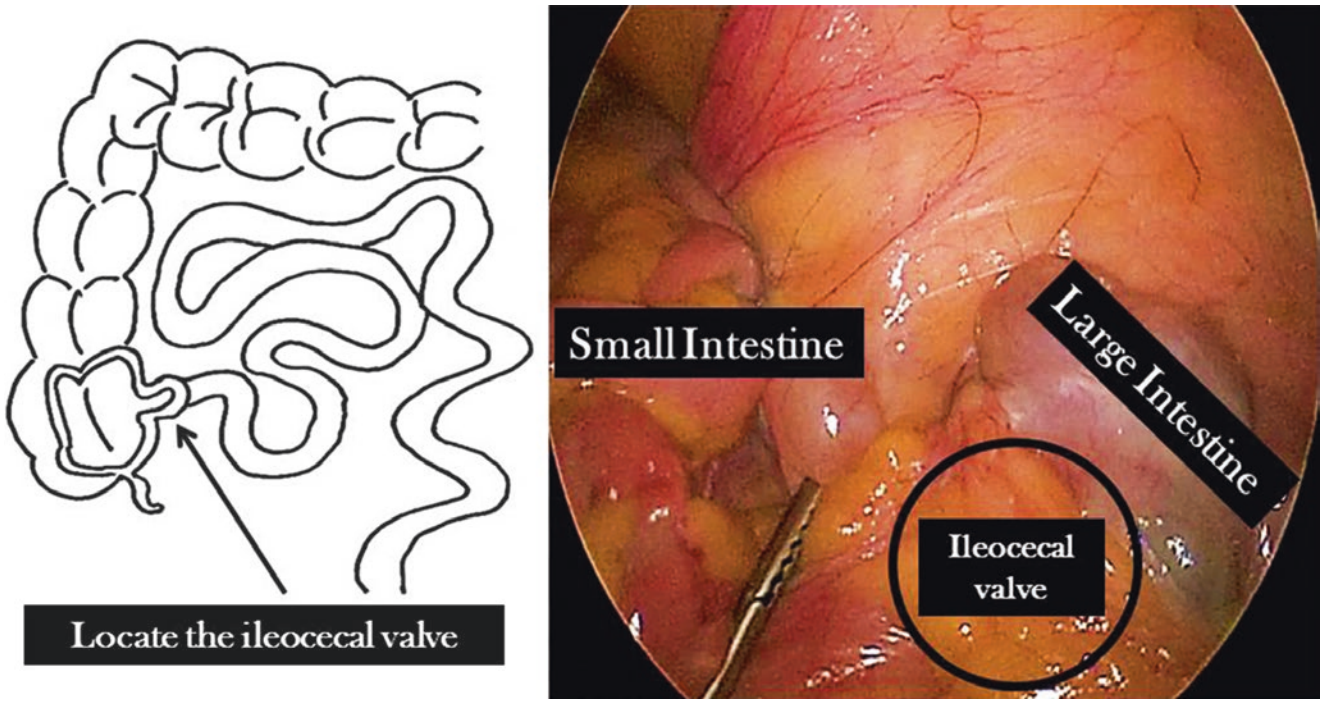


Fig. 15.1 Location of the ileocecal valve

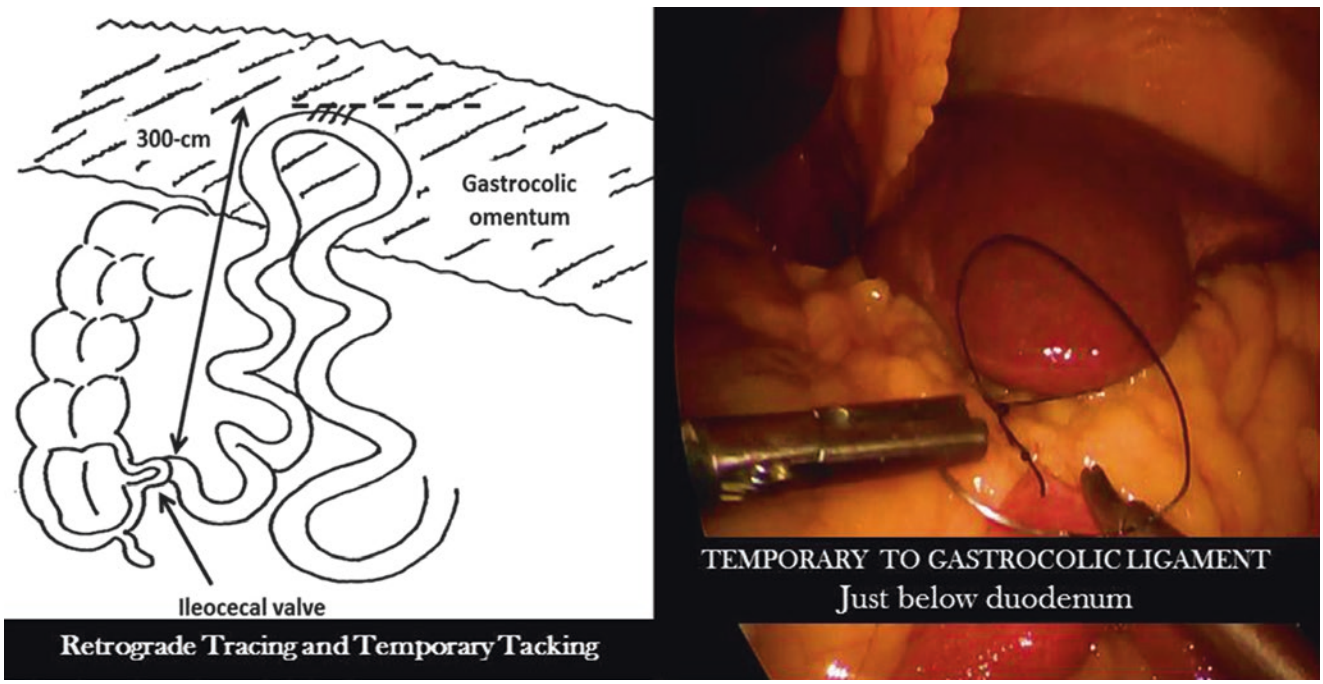


Fig. 15.2 Temporary tacking of the ileal loop limb to the gastrocolic omentum of varying lengths

staple line reinforcement, the distance from the pylorus, and treatment of the hiatus (Fig. 15.3).

Duodenal Dissection and Transection

There are two equally popular techniques for the dissection of the proximal duodenum. The more traditional technique involves starting the dissection 4 cm distal to the pylorus and gently retracting the duodenum taking down attachment between the colon, pancreas, and liver before division.

The other equally popular technique relies on adequate blood supply from the right and left gastric vessels on the lesser curve and was popularized by Cottam and Roslin. Once the sleeve is created, they continue taking down the gastroepiploic perforators after the formation of the sleeve until the attachments from the duodenum to the pancreatic head stops easy progress [8]. This is usually 3 cm beyond the pylorus. This technique spares vessels from the pancreaticoduodenal arch from injury but sacrifices the gastroepiploic perforators to do so (Fig. 15.4). A band passer is passed through the space created under the duodenal bulb, toward the liver, and through

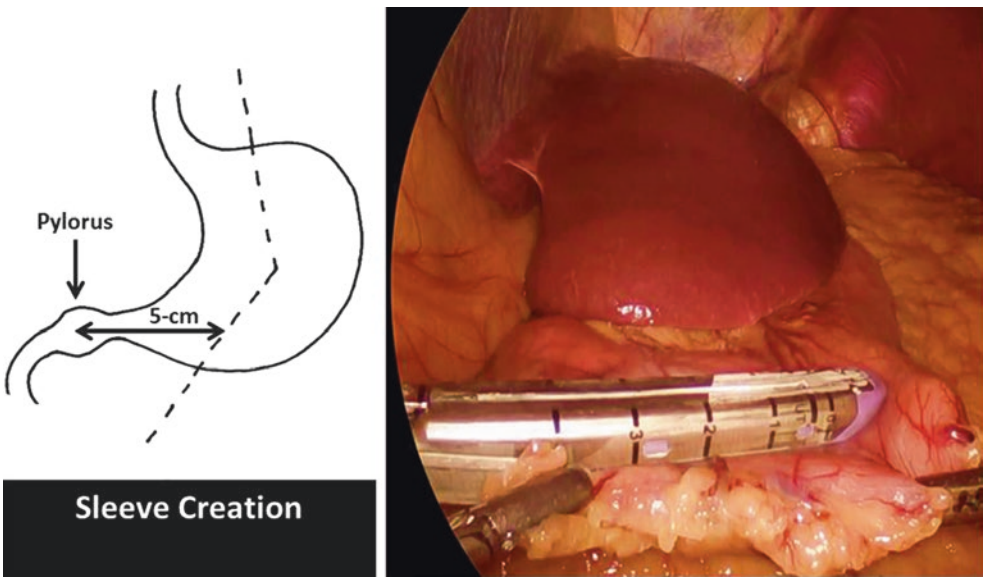


Fig. 15.3 Sleeve creation with variable sized bougie

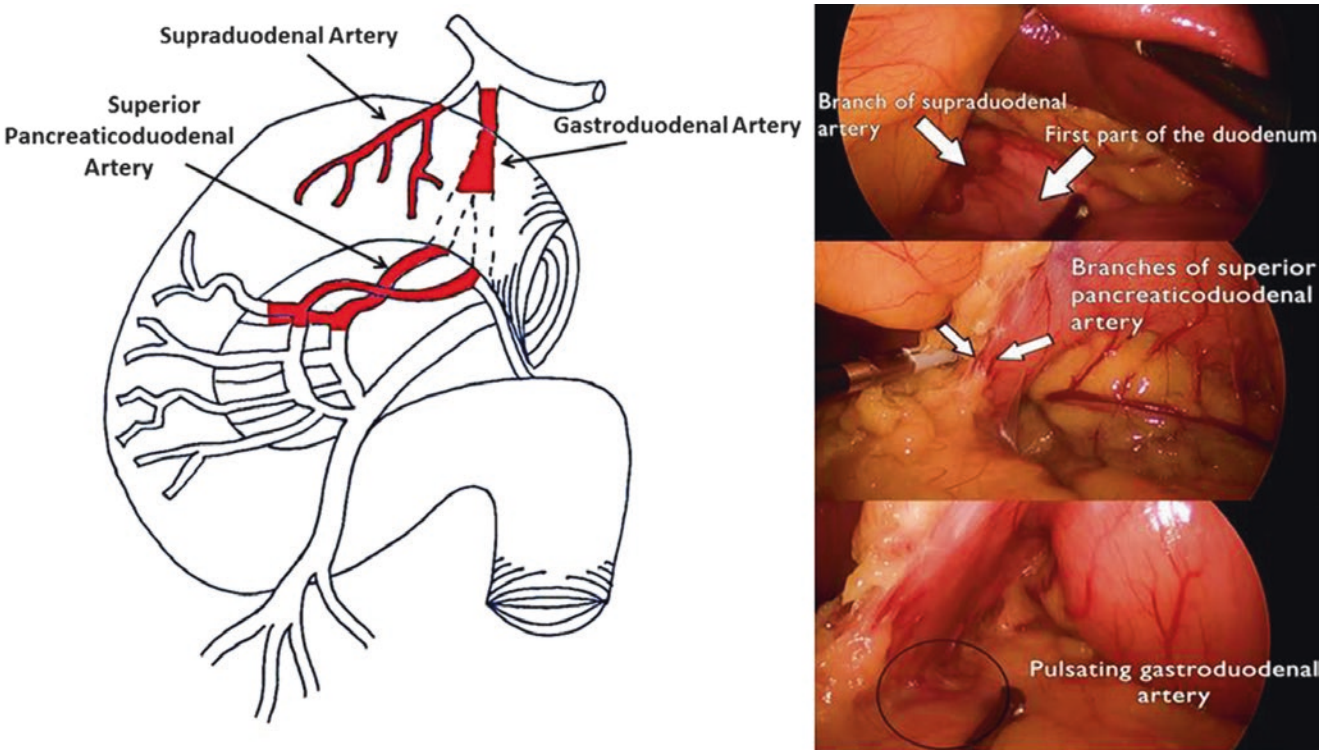


Fig. 15.4 Important blood supply to the duodenum that needs to be preserved during duodenal dissection and transection

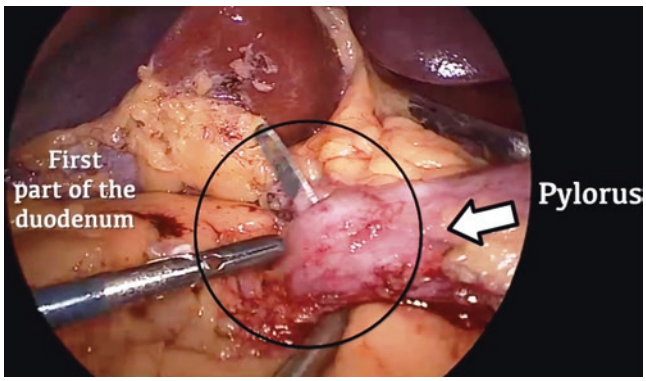


Fig. 15.5 Creation of space under duodenal bulb through the gastrohepatic ligament

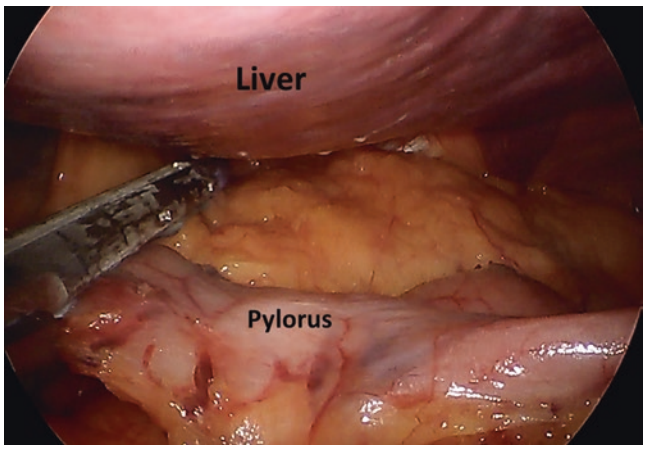


Fig. 15.6 Transection of the duodenum

the gastrohepatic ligament, with care taken to preserve the blood vessels (Fig. 15.5). This technique also results in a linear gastric tube since the gastropancreatic ligaments are responsible for the curve of the stomach, and when you eliminate them, the antrum assumes a linear shape.

Once the duodenum is dissected free with either technique, a linear stapler is placed across the first part of the duodenum (Fig. 15.6). Before firing the stapler, always try to feel the pylorus to make sure the stapler is distal to the pylorus since it is not always easy to visualize the pylorus.

Duodeno-ileostomy (DI)

Unlike the gastrojejunal anastomosis in the gastric bypass, practitioners of duodenal switch surgery do not believe the duodenal small bowel connection plays any role in short- or long-term weight loss or maintenance. Therefore, the emphasis is not on size but safety.

Currently, the most popular technique worldwide is the totally hand-sewn technique. For the hand-sewn technique, the mesenteric border of the loop limb is sewn to the duodenal stump staple line to relieve tension with a running suture (Fig. 15.7). Then enterotomies are made as large as possible and approximately the same size on both the small bowel and the duodenum (Fig. 15.8). A posterior row and an anterior row are sewn closed with running suture. Some surgeons also perform a second anterior row.

Other surgeons have perfected a three-stapler technique to transect the duodenum, connect the small bowel, and close the enterotomy. This involves dilating the proximal duodenum using air from the sizing tube. Then enterotomies are made in both the small bowel and proximal duodenum. The duodenum enterotomy is made 1 cm from the pylorus. The stapler is fired on the anterior portion of the duodenum away from the staple line. Next sutures are placed on the proximal and distal ends of the enterotomy and elevated to apply the stapler.

Anti-reflux Stitch

Some patients can experience nausea when food goes primarily down the afferent limb of the loop. To prevent this rare complication, an anti-reflux stitch is placed (Fig. 15.9). This involves placing an interrupted suture between the afferent limb to the antrum of the stomach to prevent retrograde filling of the afferent limb [9]. The entire SADI-S procedure can be seen in Fig. 15.10.

Postoperative Care

The care of the SADI-S patient does not differ substantially from the care of the sleeve patient or the gastric bypass patient. Follow-up is similar as well except greater emphasis is placed on the patient's postoperative supplementation. Current recommendations for postoperative labs are at 6 months, 1 year, and then yearly thereafter. The recommended yearly nutritional evaluation includes folate, ferritin, parathyroid (PTH), vitamins A, D, E, K, B1, and B12, copper, and zinc. Depending on circumstances, we may also measure hemoglobin A1C, complete blood count (CBC), comprehensive metabolic panel (CMP), lipid panel, prealbumin, phosphorus, fasting insulin levels, thyroid-stimulating hormone (TSH), and free T4.

Weight Loss Outcomes with SADI-S

Following the procedure, the patients can lose 78–95% of the excess weight at 18 months (weight loss peak) depending on their starting BMI [4, 10–15]. These results seem to be maintained out 4–6 years from surgery [10, 14].

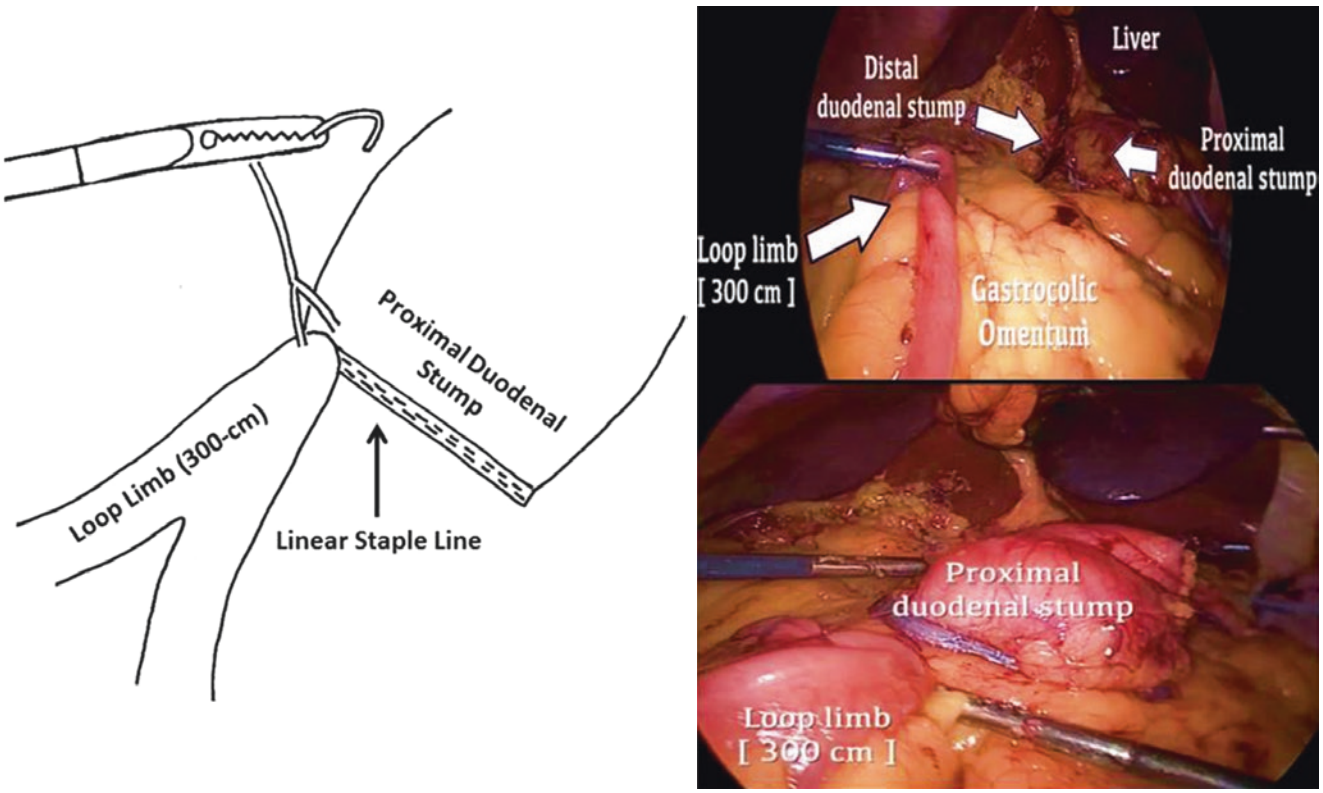


Fig. 15.7 Approximation of the loop limb to the proximal duodenal stump

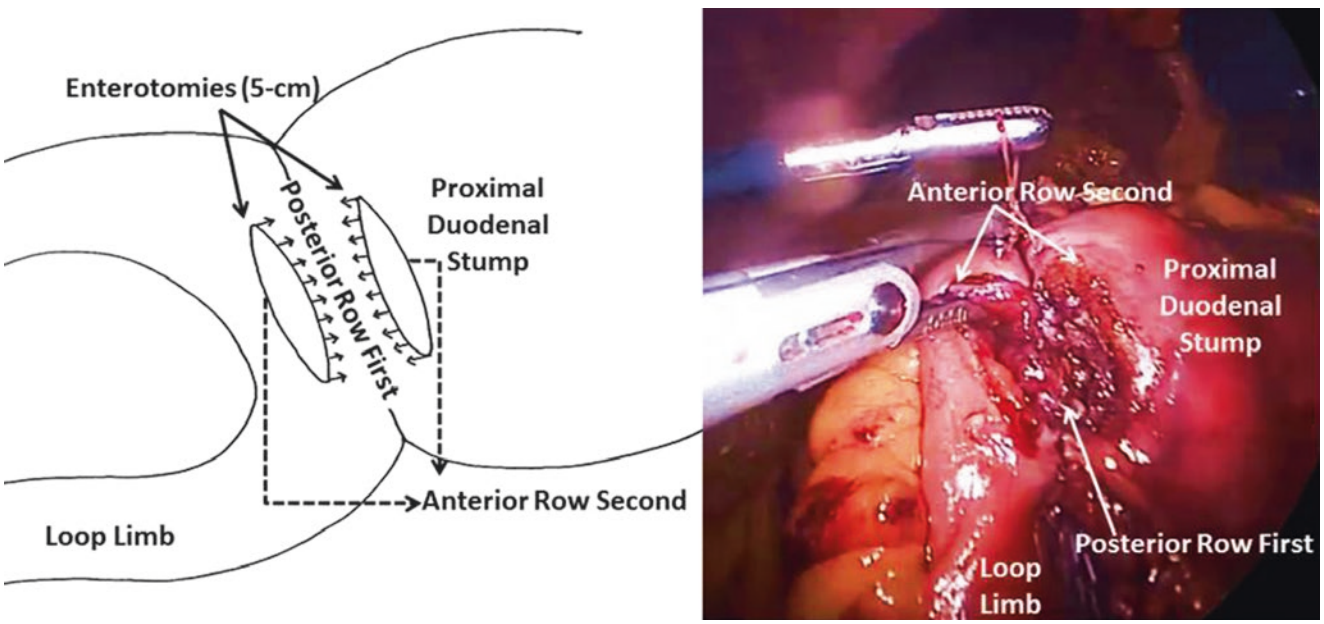


Fig. 15.8 Creation of the hand-sewn duodeno-ileostomy

Complications

One of the reasons Drs. Torres, Sanchez-Pernaute, Cottam, and Roslin introduced the SADI-S procedure and its variant was to minimize the complications seen with BPD-DS and RYGB. The primary advantage of SADI over BPD-DS is that there is no distal anastomosis or Roux limb. They postulated that with one anastomosis and no Roux limb, the complications related to

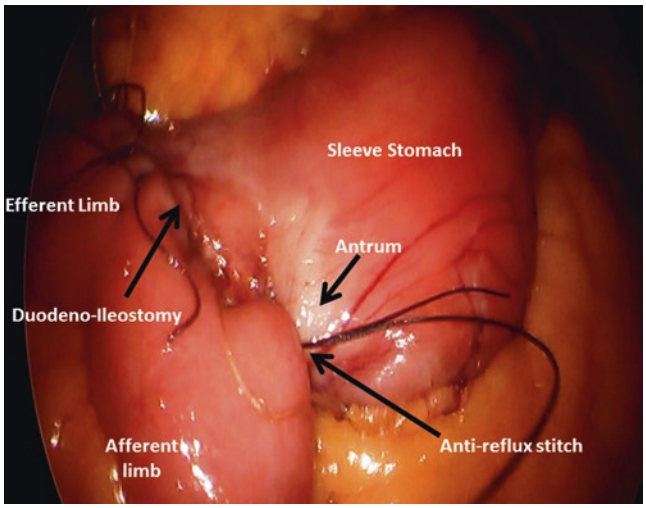
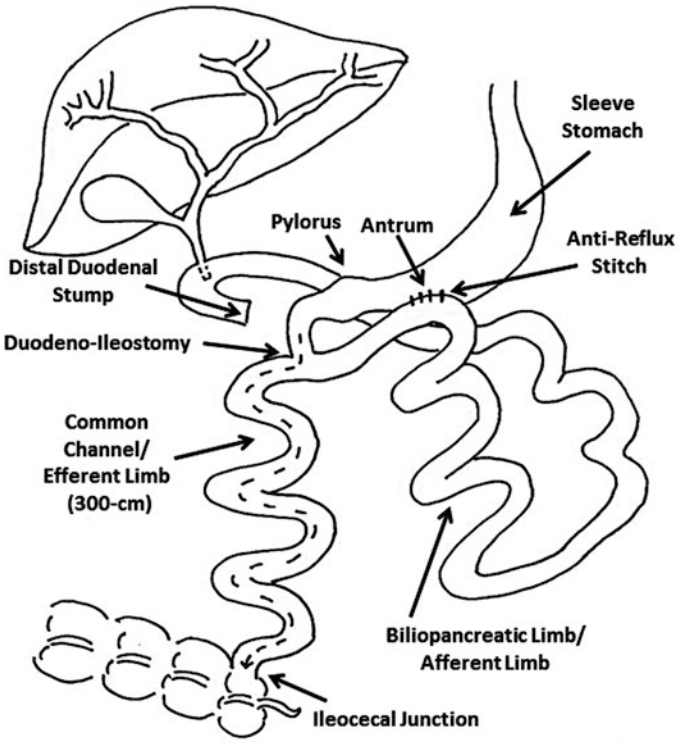


Fig. 15.9 Creation of the anti-reflux stitch

anastomoses could be lowered. In a recent study, Surve et al. specifically studied the incidence of complications related to one anastomosis (loop DI) following 1,328 SADI-S cases as well as compared the anastomotic complication rates to the reported rates following BPD-DS and RYGB in the literature [16]. They found that the anastomotic leak, ulcer, and bile reflux occurred in 0.6%, 0.1%, and 0.1%, respectively. None of the patients experienced volvulus at the DI or an internal hernia. The overall incidence of complications associated with loop DI was far lower than the reported incidence of anastomotic complications following BPD-DS and RYGB. These numbers from the study included the learning curve of each practitioner; so long-term results are expected to be even better than those reported in the study.

The most common short- and long-term complications one can expect are nausea (2.2%), wound infection (2.2%), and sleeve stricture (2.9%), respectively [10, 12]. However,



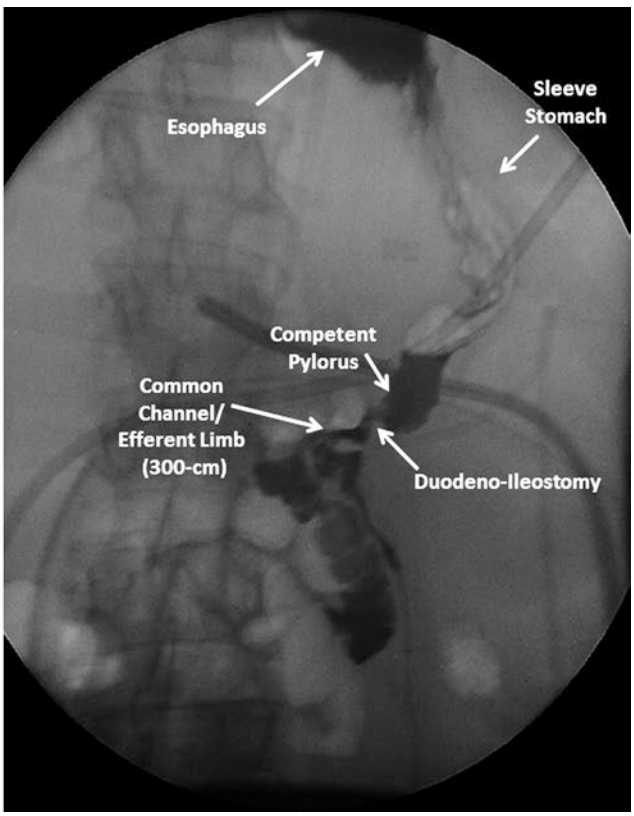


Fig. 15.10 Hand-drawn sketch of a single anastomosis duodeno-ileostomy with sleeve gastrectomy procedure along with an upper gastrointestinal series

these complications are not explicitly related to the SADI-S procedure.

The most common complication related to the SADI-S procedure is chronic diarrhea that is seen in approximately 2% patients [10]. Not all the patients that experience chronic diarrhea require limb lengthening. In some patients, it can be treated with dietary manipulation, probiotics, and Lomotil as well. With 300 cm approximately, 1% of the patients will need limb lengthening over a 5-year period [10].

The overall short- and long-term complication rates seen following SADI-S were 7.7% and 10.9%, respectively [10].

Rare Complications and Their Management

Retrograde Filling of Afferent Limb

So far there have been only two cases reported in the literature [9]. In both cases, scar tissue was found distal to the DI that pulled the efferent limb superior to the DI, causing the flow of food and secretions down the afferent limb. Tacking the afferent limb to the antrum of the stomach hopefully can prevent such complication.

Miscounted Bowel

Miscounted common channel could be a part of the learning curve. Usually, such patients present with chronic diarrhea and are usually treated by lengthening the common channel. The length of the additional common channel depends on the miscounted bowel. The symptoms are usually resolved following this procedure [17].

Reversed Loop

The reversed loop is another rare complication that can occur as a part of learning curve. The patients usually present with persistent nausea and vomiting. The ideal way to fix this complication is redoing the duodenal small bowel anastomosis [10].

Nutritional Outcomes

Contrary to popular belief, there is minimal nutritional malabsorption seen following the SADI-S procedure, and no author has presented evidence of primary malnutrition with 250–300 cm of small bowel for absorption [18].

Typically, in a patient with a 300-cm common channel, 65% fat malabsorption can be seen. Even though the percentage of fat malabsorption with SADI-S is higher when compared to the RYGB procedure [11], with the recommended postoperative multivitamin regimen, the patients usually do not experience fat-soluble vitamin deficiency.

Zaveri et al. in the 4-year outcome paper on SADI-S studied the fat-soluble vitamin levels, pre- and postoperatively [10]. At 4 years, even though 7.5% patients had a vitamin A deficiency, there was no statistically significant difference when compared to the preoperative abnormal levels. Prevalence of vitamin D deficiency is reported to be as high as 90% in patients with obesity. In their study, 48.2% had vitamin D deficiency preoperatively. However, at 4 years, only 23% patients experienced vitamin D deficiency. This shows that despite the shorter bowel lengths, vitamins can still be replete.

Vitamins E and K are fat-soluble but are far easier to absorb with any vitamin regimen. At 1 year in a recent study, no patients experienced vitamins E and K deficiency [10]. The nutritional deficiencies that are reported in the literature can be seen in Table 15.1 [4, 11, 13–15, 19–23].

To conclude, the SADI-S procedure is not associated with apparent nutritional changes; however, postoperative supplementation with iron, multivitamins, calcium, and vitamin D may be required continuously to prevent nutritional deficiency.

T2DM Resolution

The SADI-S procedure is a variant of the DS procedure. As such, it retains the expected long-term diabetes mellitus (DM) resolution seen in DM. Sanchez-Pernaute et al. studied the effect of SADI-S on patients with obesity and DM. Absolute remission for patients with oral therapy was seen in 92.5% in the 1st year and 75% in the 5th year [14], while absolute remission for patients under insulin therapy was seen in 47% in the 1st year and 38.4% in the 5th year. Overall remission rate (HbA1c <6%) was seen in 71.6%, 77%, 75.8%, 63.3%, and 52% at one-fifth year, respectively. A short DM history and no requirement for insulin therapy were related to higher remission rate, while Zaveri et al. found the complete remission rate (HbA1c < 6% without antidiabetic medication) of 78.6%, 77.8%, 81.3%, and 81.3% after one-fourth year, respectively [10]. Similarly, 97.6% of the patients were able to maintain HbA1c < 6% with or without the medication at 4 years.

Cottam et al. compared the DM resolution rate at differing levels of HbA1c between RYGB and SADI-S [12]. At each differing level, SADI-S had a statistically higher amount of diabetic resolution compared to RYGB. At 1 year, HbA1c < 6% was controlled in 88% of SADI-S patients versus 58% of RYGB patients without any antidiabetic medications.

Table 15.1 Published nutritional deficiencies following SADI-S

Author	Post-op year	Protein Def (%)	Albumin Def (%)	Calcium Def (%)	PTH Def (%)	Vitamin def (%)						Mineral def (%)			
						A	D	E	K	B12	Folate	Zn	Cu	Fe	Se
Nelson (2016) [21]	1	8	13	13	–	–	46			0	–	–	–	–	–
Sanchez-Pernaute (2013) [4]	2	16	6	0	42	–	6	–	–	20	10	–	–	4	2.5
Sanchez-Pernaute (2015) [14]	3	29	12	–	54	53	23	7	–	8	3	33	11	–	28
Cottam (2016) [11]	1	8	11	5	–	–	31	–	–	29	16	–	–	–	–
Cottam (2017) [15]	1	10	8	5.1	–	–	40.5	–	–	38	–	–	–	–	–
Enochs (2015) [22]	1	7.6	3.1	–	–	45	10.8	–	–	15.3	–	–	–	–	–
Neichoy (2016) [23]	1	13	12	18	–	–	29	–	–	10.4	–	–	–	–	–
Surve (2017) [13]	2	8	8	6	–	–	34	–	–	0	–	–	–	–	–

SADI-S single anastomosis duodeno-ileostomy with sleeve gastrectomy, *Def* deficiency, *Zn* zinc, *Cu* copper, *Fe* iron, *Se* selenium

The overall T2DM remission rates following SADI-S can be around 81–90% without antidiabetic medication [10, 14, 23].

SADI as Revision Procedure

SADI Following Failed SG

Weight loss failure and weight recidivism over the long term have been a common concern following SG. Moreover, SG has also shown poor results in patients with BMI >50 kg/m^2 [24]. This is one of the reasons why revision procedures following failed SG have been increasing in recent years. The question that remains for the bariatric surgeons is what revision options are now available for patients who fail SG?

The SADI-S procedure is increasingly becoming popular as a second step revision procedure or as a staged procedure, primarily for weight loss failure following SG. The mean EWL at 1 and 2 years following the second step SADI has been around 69% and 72%, respectively [25]. More importantly, postoperative complications have been minimal with no reported incidence of small bowel obstruction or internal hernias, which are commonly seen following RYGB and BPD-DS. Zaveri et al. showed that if SADI is performed within the 1st year of performing SG, the patients could lose a similar amount of weight as a primary SADI-S procedure [26]. However, this approach will need a longer follow-up to understand its limitation.

SADI-S Following Failed RYGB

The RYGB has been associated with long-term good weight loss outcomes. However, approximately 25% of patients have weight recidivism [2, 27].

Various techniques such as resizing the pouch or lengthening the Roux limb have been used but with limited or no success [28, 29]. The SADI-S is an effective option for failed RYGB patients due to its pyloric preserving capacity. Most of the patients who fail RYGB usually eat small, frequent, high-carbohydrate meals. This is a physiologic response to vacillating blood sugar levels causing hunger [30]. The SADI-S with its pylorus preserving capacity plays an important role in maintaining blood sugar levels and satiety. Although technically possible this revision is challenging and has been shown to have high complication rates [31]. Although the data are limited, the initial data have shown to have favorable outcomes. The EWL following revision SADI-S for failed RYGB at 1 year has been reported between 53% and 61% and at 2 years has been reported around 55% [31]. This is similar to patients who have an RYGB to traditional DS [32].

SADI-S Following Failed Adjustable Gastric Band

Multiple studies have demonstrated a high incidence of weight recidivism and long-term complications with AGB [33–35]. In addition, multiple reports have been published on the different approach to revising the failed AGB patients to SG, RYGB, or BPD-DS. However, EWL has not been that favorable, and complications have been high [36–38]. Therefore, the controversy exists regarding the choice for patients with failed LAGB.

The outcomes of SADI-S as a revision option following failed AGB have been only reported by Surve et al. in the literature [39]. Technically, it is simpler than BPD-DS and RYGB. Three years report showed 90% EWL following revision of AGB to SADI-S. The weight loss mirrors the weight loss seen following primary SADI-S procedure. The only caveat with this procedure is careful dissection to avoid leaks and strictures from scar tissue below the band.

Review of Literature

The outcomes with primary and revision SADI/SADI-S that have been published in the literature are summarized in Table 15.2. Unique data sets have been included [4, 5, 10, 18, 21, 23, 25, 31, 39–43].

Conclusion

Effective weight loss, high T2DM resolution rates, low anastomotic complication rates compared to other established procedures, minimal nutritional changes, effective second stage, or revision option following failed bariatric procedures make SADI/SADI-S one of the best options for patients with morbid obesity and coexisting conditions.

Table 15.2 Published outcomes with primary and revision SADI/ SADI-S

Article	Procedure	Bougie size and common channel	Sample size	Follow-up	Weight loss	T2DM Rem. rate	Complication	Fat-soluble vitamin deficiency
Primary SADI-S procedure								
Mitzman et al. [5]	SIPS	42 F and 300 cm	123	1 year	72.3%EWL	N/A	6.5%	N/A
Zaveri et al. [10]	SADI-S	40 F and 300 cm	437	4 years	85.7%EWL	81.3%	Early = 7.7% Late = 10.9%	Vit A = 7.5% (4 years) Vit K = 5.8% (1 year)
Sanchez-Pernaute et al. [4]	SADI-S	54 F and 200 cm (50 patients) 250 cm (50 patients)	100	3 years	>95% EWL	>90%	5–9%	Vit D = 6% Def 40% Ins
Neichoy et al. [23]	SIPS	40 F and 300 cm	225	2 years	88.7% EWL	88.8%	Early = 4.8% Late = 8%	N/A
Morales et al. [40]	SESDID	34 F and 300 cm	100	N/A	N/A	N/A	12%	N/A
Abd-Elatif et al. [18]	SADI-S	36 F and 250 cm	37	1 year	23 kg/m^2 BMI red	N/A	2.7%	N/A
Gebelli et al. [41]	SADI-S	36 F and 300 cm	67	1–1.5 years	N/A	N/A	12.8%	N/A
Nelson l et al. [21]	SADI-S	34 F and 250 cm	69	1 year	61.6% EWL	50% Rem, 33.3% Imp	10.1%	Vit D = 45.8%
SADI procedure following failed SG								
Sanchez-Pernaute et al. [25]	SADI	42–54 F and 250 cm	16	2 years	32.5% EWL (SADI) 72% EWL (SADI+ SG)	88%	6.2%	Vit A = 25%, Vit D = 6% Def, 50 Ins, Vit E = 0%
Vilallonga et al. [42]	SADI	Bougie size is unk and 300 cm	3	3–9 months	N/A	33.3% Imp	0%	N/A
Balibrea et al. [43]	SADI	32 F and 200–300 cm	30	2 years	44.2%EWL (SADI) 78.9% EWL (SADI+ SG)	71.4%	Early = 13.3% Late = 50%	Vit D = 55.5%
SADI procedure following failed RYGB								
Surve et al. [31]	SADS	40 F and 300 cm	23	2 years	54.5% EWL	N/A	Early = 17.3% Late = 13%	Vit D = 9%
SADI procedure following failed AGB								
Surve et al. [39]	SIPS	40 F and 300 cm	27	3 years	90% EWL	75%	Early = 40.7% Late = 25.9%	Vit A = 0% Vit D = 41.1%, Vit E = 5.8%, Vit K = 0%

SESDID Single end-to-end anastomosis duodenoileal, *Def* deficiency, *Ins* insufficiency, *mos* months, *Rem* remission, *Imp* improvement, *DIOS* distal loop duodeno-ileostomy, *SADS* single anastomosis duodenal switch, *SIPS* stomach intestinal pylorus-sparing surgery, *SG* sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass, *AGB* adjustable gastric banding

Question Section

1. Which of these is false about SADI surgery?
   A. Technically it is more difficult than BPD-DS.
   B. There is an alimentary as well as biliopancreatic limb involved.
   C. Conversion of failed RYGB to SADI is a feasible option.
   D. It has fewer ulcers than BPD-DS.
2. One of the main advantages of SADI over RYGB
   A. Nutritional deficiencies
   B. Weight loss
   C. Dumping syndrome
   D. Protein-energy malnutrition
3. The weight loss between SADI-S with a 300-cm common channel and BPD-DS with a 150-cm common channel and 150 cm Roux limb is
   A. The same amount of weight loss between the two
   B. Less weight loss with SADI-S
   C. Much better weight loss with SADI-S
   D. Much worse weight loss with SADI-S

4. What is the percentage of bile reflux seen following SADI surgery in the literature?
   A. 0.1%
   B. 1%
   C. 0.8%
   D. 2%

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