

## Review

# Laparoendoscopic Single-Site Bariatric Surgery: A Review of Single-Port Laparoscopic and Endoscopic Bariatric Treatments

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Bariatric surgery is an established and effective treatment, not only to combat morbid obesity, but also to address associated metabolic comorbidities. At this time, the cutoff for bariatric or metabolic surgery in terms of body mass index (BMI) is decreasing, making it more feasible for certain individuals to consider minimally invasive surgical options. Innovations in the technique have led to the application of laparoendoscopic single-site surgery (LESS) in the field of bariatrics, which uses a single or no incision in the performance of weight-reducing surgery. To date, there is no consensus regarding patient selection though most candidates for single-port bariatric surgery are female. Some doctors suggest that single-port bariatric surgery may not be recommended in patients with BMI of more than 50 kg/m<sup>2</sup>, height of more than 180 cm, and xiphoid-umbilicus distance of more than 20 cm. Sleeve gastrectomy (SG) is now the most widely performed bariatric surgery worldwide and single-port SG (SPSG) is already established as a routine procedure in various institutions. Current evidence shows that SPSG is less painful and demonstrates higher rates of patient satisfaction regarding the wound. SPSG is feasible and is recommendable in patients who meet certain criteria. Furthermore, endoscopic treatment modalities such as intragastric balloons and endoluminal malabsorptive devices are being developed to bridge the gap between medical and surgical treatments. Nevertheless, there is still insufficient evidence to prove the superiority of LESS bariatric surgery over conventional laparoscopic surgery. Large, well-designed prospective analyses are needed to determine the criteria for selecting patients suitable to undergo LESS bariatric surgery and to predict the procedure's role in the growth of bariatric surgery.

**Key words:** Bariatric surgery, Obesity, Laparoscopy, Endoscopy

## INTRODUCTION

Morbid obesity has been an increasingly serious medical issue for decades, with recent studies indicating the growing need for surgical treatment in affected individuals. Currently, bariatric surgery is the most effective treatment for morbid obesity and its associated comorbidities, providing faster body weight reduction and better glycemic control as compared with traditional medical therapies.<sup>1-3</sup> The most commonly performed surgical therapies include

adjustable gastric banding (AGB), sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and biliopancreatic diversion (BPD) surgery. Laparoscopic surgery was initially applied in conjunction with AGB starting in the early 1990s.<sup>4</sup> Now, many of these procedures are being performed laparoscopically, providing better cosmesis and a weight loss rate of more than 50% in long-term studies.<sup>2,5,6</sup> As technology and innovation in the surgical field continue to evolve, more minimally invasive methods are being developed. Procedures such as reduced port laparoscopic surgery and even

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single-incision laparoscopic surgery (SILS) are now being completed worldwide as bariatric procedures.<sup>7,8</sup> Single-incision transumbilical surgery uses the umbilicus as the only port-site and is considered to be a bridge to natural orifice transluminal endoscopic surgery, due to having a similar cosmetic outcome whilst enabling the use of conventional laparoscopic instruments.<sup>8,9</sup> The ultimate goal of any bariatric procedure is scarless, painless surgery, and advancements in this area are growing faster than ever before.

With the escalating number of single-incision surgeries among various surgical disciplines, the term “laparoendoscopic single-site surgery” (LESS) was discussed during the 2008 meeting of the Laparoendoscopic Single-Site Surgery Consortium for Assessment and Research<sup>10</sup> to provide a consistent and precise nomenclature for its principles. LESS encompasses concepts regarding single-entry port laparoscopic or robotic surgery as well as endoscopic surgery. There are some reviews that have been published to date regarding the application of reduced port or single-incision surgery for the treatment of morbid obesity<sup>8,11</sup>, but none have encompassed both endoscopic and laparoscopic approaches. This review aims to address and summarize LESS treatment modalities for morbid obesity and to describe some of the experiences in our center.

## PRIMARY TECHNIQUE

Conventional laparoscopic bariatric surgery employs five to eight incisions for trocar placement. Due to the thickness of the abdominal wall in obese patients, a small incision creates a “fulcrum effect,” which hinders range of motion.<sup>12</sup> Hence, the incision must be made in a larger fashion in obese patients so as to avoid this effect. Reduced port laparoscopic surgery refers to laparoscopic surgery with less than the traditional number of port incisions. Most often, two to three incisions are made during reduced port surgery. The liver must be then retracted upward to provide the surgical field of view for bariatric surgery. In multiport laparoscopic procedures, the liver can be lifted with the help of another operator or assistant using a second port. However, in SILS, the collision of instruments and lack of space makes the use of an assistant impossible. Huang et al.<sup>13</sup> reported a method of “liver suspension tape,” which uses a modified Jackson-Pratt drain tube and involves needle penetration to lift the liver. Saber et al.<sup>14</sup> noted the high incidence of fatty liver

in obese patients and used transdiaphragmatic sutures for traction. In some morbidly obese patients, the insertion of a liver retractor through a 5-mm subxiphoid puncture was necessary. In our center, we typically use the combined suture retraction<sup>15</sup> for most, if not all, of our cases. Proper retraction of the liver is crucial in successfully securing the surgical field of view and in competently performing SILS.

## LAPAROSCOPIC PROCEDURES

### Single-port adjustable gastric banding

Gastric banding is the first reported example of LESS bariatric surgery, with the first known procedure performed by Nguyen et al.<sup>16</sup> in 2008. Despite the lower rate of weight loss seen with gastric banding in comparison with that accompanying other surgical procedures, it still remains a popular procedure, since there is no need to perform a resection or anastomosis of the gastrointestinal tract.<sup>2</sup> In AGB, a pars flaccida approach is used to place a synthetic band around the proximal cardia. Since its first attempt, several cases of single-port AGB (SP-AGB) have been reported. A few comparative studies have shown that SP-AGB has a similar or even faster typical operative time versus that of conventional laparoscopic AGB.<sup>17,18</sup> However, reports of complications—even life-threatening ones—after gastric banding have been increasing. A report of 1,000 cases by Chevallier et al.<sup>19</sup> showed a complication rate of 19.2%, while Suter et al.<sup>20</sup> found a 40% of 5-year failure rate and a 43% of 7-year success rate. Although AGB may seem an ideal technique for single-port surgery due to its less-invasive nature, its practice is decreasing throughout the world due to associated surgical complications and reoperation rates.

### Single-port Roux-en-Y gastric bypass

Recent trends have shown a decrease in the number of RYGB operations, yet it remains one of the most performed bariatric surgeries in the world, being mostly actively performed at this time in Latin America.<sup>2,21</sup> Obesity is often accompanied with metabolic diseases such as diabetes mellitus, and gastric bypass causes hormonal changes that enables better glycemic control.<sup>22,23</sup> In RYGB, the stomach is transected to create a 25 to 30 mL volume of gastric pouch. It is then connected to the Roux limb of the jejunum. Due

to its comparatively higher complexity, only a few reports of single-port RYGB (SP-RYGB) are available in the literature. Still, early case reports of SP-RYGB have shown it to be feasible and safe in the short-term follow-up.<sup>12,24</sup> A systematic review by Doulamis and Economopoulos<sup>25</sup> of 10 studies of transumbilical RYGB, including four cases of SP-RYGB, demonstrated an average operative time of 128.5 minutes (range, 60–240 minutes). Cosmesis was good, but rates of 1.2% for anastomosis leak and 1.2% for wound infection were present. The complication rates were comparable or even less than those seen with traditional laparoscopic RYGB.<sup>26,27</sup> We previously reported a case of single-incision resectional gastric bypass using a scope holder.<sup>9</sup> Due to the high incidence of gastric cancer in Korea, resectional RYGB is selectively being performed in our center after sufficient patient counseling is completed. Often, the specimen can be easily removed through a 3-cm transumbilical incision. SP-RYGB requires more complex surgical skills as compared with SG, but it is still feasible and may be a suitable choice for patients with diabetes. More long-term studies and well-designed randomized trials are needed to fully provide evidence on this topic.

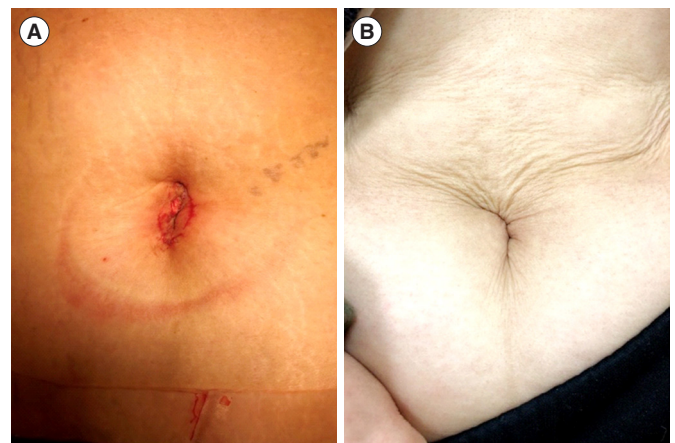
### Single-port sleeve gastrectomy

According to the 2014 survey of the International Federation for the Surgery of Obesity and Metabolic Diseases, SG is now the most commonly performed bariatric surgery worldwide and is increasing in prevalence.<sup>21</sup> In SG, the greater curvature of the stomach is mobilized and the stomach is transected vertically using gastrointestinal staplers. Most SG procedures are done laparoscopically in several institutions, and single-port SG (SPSG) is also actively being performed.<sup>28,29</sup> Pourcher et al.<sup>30</sup> reported a series of 60 consecutive SPSG patients, with a median operating time of 86 minutes, and found no differences in weight loss or comorbidity between these individuals and those who had undergone conventional laparoscopic SG. Saber et al.<sup>14</sup> reported on both the transabdominal and transumbilical single-port approaches for SG. As compared with multiport SG, SPSG showed no difference in operation time or blood loss and demonstrated a lower pain score and hospital stay length. A 2-year prospective study of 600 patients showed no differences in surgical outcome or excess weight loss between patients undergoing SPSG and those undergoing multiport SG.<sup>31</sup> Lakdawala et al.<sup>31</sup> composed a scar satisfaction score to

assess cosmesis, and the SPSG group displayed significantly higher satisfaction. In this study, the need for analgesics after surgery was significantly less in the SPSG group. SG is also the most commonly performed bariatric surgery in our center and, most often, it is done with a single 2.5 to 3 cm transumbilical incision. The liver is retracted using the Prolene (Ethicon, Somerville, NJ, USA) suture method described earlier and automatic staplers are used to make the resection. Although studies show that gastric bypass allows for better glycemic control, according to a randomized study by Schauer et al.<sup>1</sup>, SG also has a significant effect on the treatment of diabetes as compared with medical therapy alone. The fact that SG is technically less demanding than RYGB, yet provides adequate control of body weight and combined metabolic disorders, makes it and especially SPSG the most preferred type of bariatric surgery in our department. To our knowledge, we are the only Korean institution to have contributed cases of SPSG to the literature.<sup>32</sup> Fig. 1A shows the transumbilical wound immediately after the operation, while Fig. 1B shows the almost invisible surgical wound at 3 months postoperation. Fig. 2 is a sample of the extracted sleeve specimen in the routine SPSG performed in our department.

### Single-port biliopancreatic diversion

BPD surgery is not a specific operation but rather a concept represented by a malabsorptive technique that requires the diversion of the gastric contents to delay its interaction with the digestive juice. BPD surgery can include distal gastrectomy or SG accompanied by jejunioileal bypass. It is also being routinely performed lapa-



**Figure 1.** Surgical wound after single-port bariatric surgery. (A) Immediate postoperative wound. (B) Surgical wound after 3 weeks.

roscopically<sup>33</sup>, and the first single-port BPD (SP-BPD) procedure was reported by Tacchino et al.<sup>34</sup> using the transumbilical approach. The operating time for this case was 130 minutes with no immediate postoperative complications. BPD is not often performed in our institution and it is only really considered in cases of extreme morbid obesity. Known reports of single-port bariatric procedures



**Figure 2.** Extracted specimen after sleeve gastrectomy.

are briefly summarized in Table 1.<sup>9,13,14,17,24,28,30,31,34-41</sup>

## ENDOSCOPIC PROCEDURES

### Intragastric balloon

With the evolution of endoscopic and percutaneous procedures, patients who are mild to moderately obese are seeking methods that require no surgical intervention. Although the introduction of intragastric balloons occurred in 1980s<sup>42</sup>, it was not until the early 1990s that the procedure became efficient and popular through the development of the BioEnterics intragastric balloon (BIB; Allergan, Dublin, Ireland), which is now currently known as the Orbera intragastric balloon (Apollo Endosurgery, San Diego, CA, USA) (Fig. 3).<sup>43</sup> Studies employing the BIB reported stability with up to 6 months of use, with subsequent retrieval via endoscopy. A study of 2,515 patients with an average body mass index (BMI) of  $44.4 \pm 7.8$  kg/m<sup>2</sup> showed a BMI reduction of  $4.9 \pm 12.7$  kg/m<sup>2</sup> after insertion of the BIB.<sup>44</sup> Among the procedures, there were five cases (0.19%) of gastric perforation and 19 cases (0.76%) of gastric obstruction. A meta-analysis described the safety and effectivity of the BIB in

**Table 1.** A brief summary of major papers that have been published on the subject of single-port bariatric surgery

Surgical procedure	Author	Year published	No. of cases	Incision	Age (yr)	BMI (kg/m <sup>2</sup> )	Sex (male:female)	Operation time (min)	Complication rate (%)
Adjustable gastric banding									
	Teixeira et al. <sup>35</sup>	2009	10	PU	47.0	42.0	1:9	70.0	0
	Raman et al. <sup>36</sup>	2011	24	TU	39.7	41.7	0:24	62.6	0
	Patel et al. <sup>37</sup>	2012	111	TA	43.0	40.0	18:93	70.0	0
	Schwack et al. <sup>17</sup>	2013	710	PU	40.0	42.8	233:477	44.3	5.6
	Pitot et al. <sup>38</sup>	2014	34	TU	42.6	41.9	10:24	111.8	0
Sleeve gastrectomy									
	Saber et al. <sup>14</sup>	2010	14	TU	44.2	53.8	7:7	128.0	0
	Pourcher et al. <sup>30</sup>	2013	60	TU	40.1	46.5	6:54	86.0	3.3
	Sucher et al. <sup>39</sup>	2014	40	TU	41.0	40.8	0:40	85.0	5.0
	Lakdawala et al. <sup>31</sup>	2015	300	TU	35.5	39.9	22:278	45.0	2.3
	Gaillard et al. <sup>28</sup>	2016	1,000	TA	40.1	42.6	155:845	112.0	14.7
Roux-en Y gastric bypass									
	Huang et al. <sup>13</sup>	2010	25	TU	29.9	41.9	4:21	99.8	0
	Saber et al. <sup>24</sup>	2009	1	TU	34.0	38.7	0:1	133.0	0
	Morales-Conde et al. <sup>40</sup>	2013	22	TU	41.0	42.7	1:21	114.1	0
	Fernández et al. <sup>41</sup>	2013	3	TU	33.7	37.2	0:3	166.7	0
	Kang et al. <sup>9</sup>	2017	1	TU	22.0	44.9	1:0	160.0	0
Biliopancreatic diversion									
	Tacchino et al. <sup>34</sup>	2010	1	TU	57.0	43.0	1:0	139.0	0

BMI, body mass index; PU, periumbilical; TU, transumbilical; TA, transabdominal.



the short-term, reporting an excess weight loss of 32.1% (range, 26.0%–37.4%).<sup>45</sup> Other intragastric balloons have been developed over the years and the less invasive nature of this technique is appealing to many patients, causing it to be an area of exploration and interest.

### Endoscopic sleeve gastroplasty

Similar to laparoscopic SG, endoscopic sleeve gastroplasty is a technique that reduces the gastric volume. A U.S. Food and Drug Administration-approved endoscopic suturing device (OverStitch Endoscopic Suturing System, Apollo Endosurgery) is entered transorally to create a full-thickness suture from the antrum to the cardia in the greater curvature side (Fig. 4).<sup>46</sup> In one study, four patients with uncomplicated BMI between 30 kg/m<sup>2</sup> and 40 kg/m<sup>2</sup>

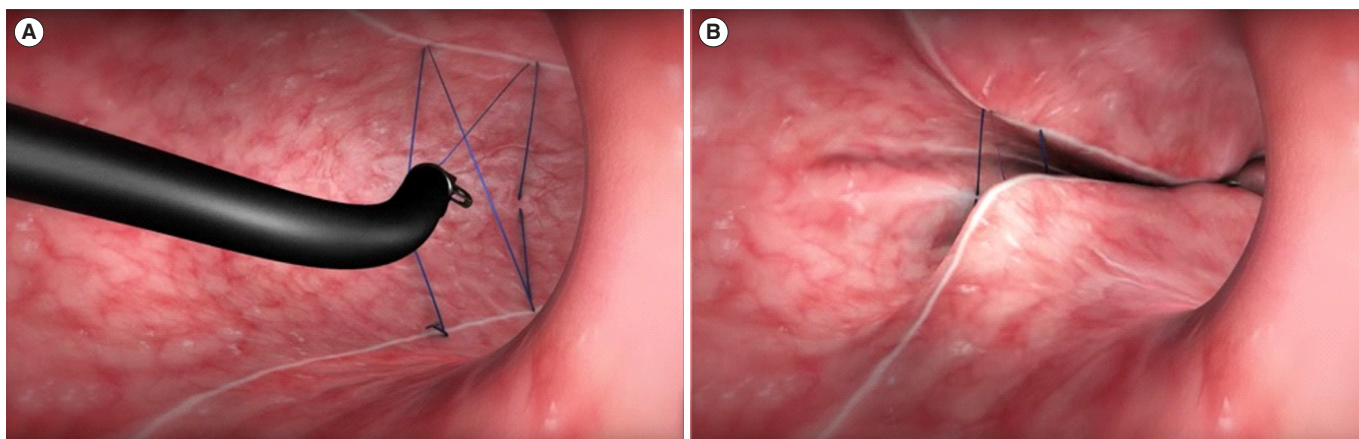


**Figure 3.** The Orbera intragastric balloon (Apollo Endosurgery, San Diego, CA, USA).

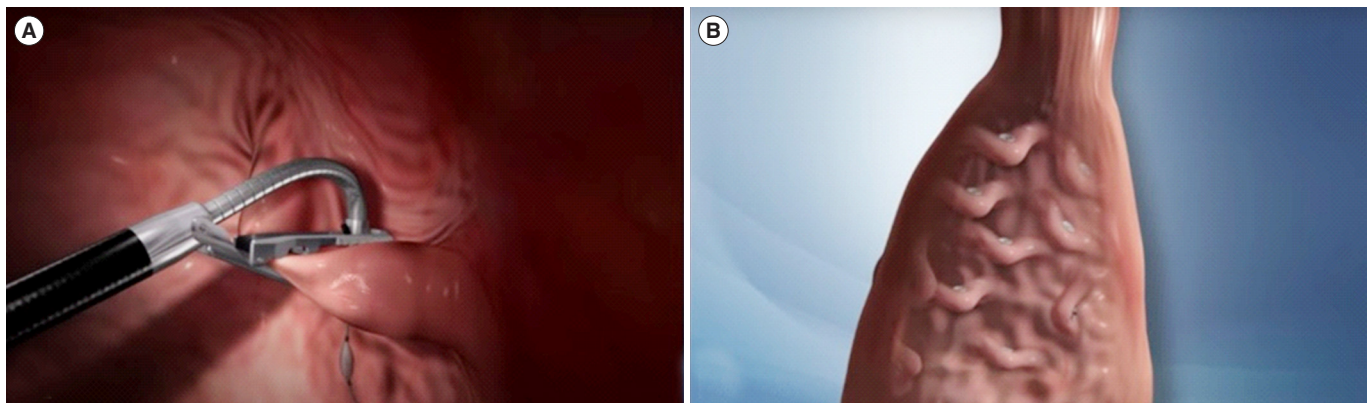
underwent the procedure, and the reported operating time was 172 to 245 minutes. The Primary Obesity Surgery Endolumenal (POSE) procedure is also an endoscopic gastroplasty technique that uses specific instruments to place suture anchors at the gastric fundus and antrum to decrease fundal volume and cause delayed gastric emptying. It uses the g-Cath EZ delivery catheter with Snowshoe Suture Anchors (USGI Medical, San Clemente, CA, USA) delivered through a specialized endoscopic device (Fig. 5). A study of 147 patients with a mean BMI of  $38.0 \pm 4.8$  kg/m<sup>2</sup> who underwent the POSE procedure, at a follow-up of 1 year, showed an excess weight loss of 45% and an average of 15% reduction in total weight.<sup>47</sup> Novel procedures are being reported in this area; however, large cohort results and long-term data remain lacking and are thus an area of consideration.

### EndoBarrier

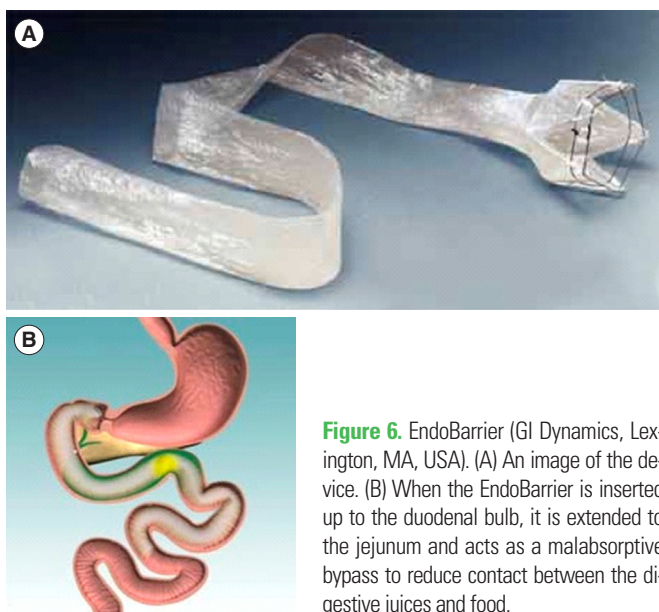
The EndoBarrier Gastrointestinal Liner (GI Dynamics, Lexington, MA, USA) is an endoscopically inserted impermeable sleeve made of Teflon (Chemours Company, Wilmington, DE, USA) that creates an malabsorptive duodenojejunal bypass (Fig. 6A). Once inserted up to the duodenal bulb, it is extended toward the proximal jejunum, allowing for food material to bypass the duodenum without meeting the digestive juices (Fig. 6B). Schouten et al.<sup>48</sup> performed a randomized trial involving 30 patients in an EndoBarrier group and 11 patients in a control group. Weight loss in the EndoBarrier group was significantly higher as compared with that in the control group (19.0% vs. 6.9%,  $P < 0.002$ ) and no proce-



**Figure 4.** Endoscopic sleeve gastrectomy using the OverStitch Endoscopic Suturing System (Apollo Endosurgery, San Diego, CA, USA). (A) An endoscopic suturing device is used to create full-layer sutures in the greater curvature of the stomach. (B) This gastroplasty technique reduces intragastric volume.



**Figure 5.** The Primary Obesity Surgery Endolumenal (POSE) procedure. (A) Snowshoe Suture Anchors (USGI Medical, San Clemente, CA, USA) are introduced using specialized catheters. (B) Intermittent placement of the sutures reduces intragastric volume.



**Figure 6.** EndoBarrier (GI Dynamics, Lexington, MA, USA). (A) An image of the device. (B) When the EndoBarrier is inserted up to the duodenal bulb, it is extended to the jejunum and acts as a malabsorptive bypass to reduce contact between the digestive juices and food.

procedure-related adverse events were found. A meta-analysis of 15 studies including five randomized trials also noted a significant degree of weight loss associated with EndoBarrier use (GI Dynamics), but no difference in glycemic control.<sup>49</sup> More long-term studies are needed to fully evaluate this device's potency and safety.

## SUMMARY

Morbid obesity was once considered to be a contraindication for laparoscopic surgery but, with the increasing application of bariatric surgery for metabolic diseases, the mean BMI of patients undergoing these surgeries is decreasing, making the application of novel

minimally invasive techniques more feasible. In this review, we have listed some of the most popular LESS bariatric surgeries being performed throughout the world and explored their efficacies and applications.

## Indication and benefits of LESS in bariatric patients

Good patient selection and adequately defining the indications for single-port bariatric surgery are important concerns to ensure patient safety and the success of the procedure. In some literature, BMI of more than 50 kg/m<sup>2</sup>, height of more than 180 cm, and xiphoid-umbilicus distance of more than 20 cm have been mentioned as unsuitable criteria for single-port bariatric surgery.<sup>8,11</sup> Patel et al.<sup>37</sup> commented on the possible need of an additional port placement in male patients for SP-AGB. To date, most of the candidates in single-port bariatric surgery have been female, and Sucher et al.<sup>39</sup> attributes this to the shorter height and smaller left liver of female patients. With the scope of bariatric surgery now broadened to cover metabolic diseases as well as obesity, the average BMI of suitable patients is decreasing. In our department, we recommend that single-port techniques be performed in patients with BMI of less than 50 kg/m<sup>2</sup>, regardless of sex.

The current consensus in laparoscopic bariatric surgery is heading towards SG. SG is more feasible and has a lower learning curve as compared with RYGB.<sup>50,51</sup> A randomized trial by Karamanakos et al.<sup>52</sup> of 16 patients in each arm showed a higher degree of excess weight loss and appetite suppression in the SG group versus in the RYGB group. Though more studies with larger patient cohorts are needed to fully compare the efficacies of these two popular proce-

dures, the feasibility, safety, and effectiveness of SG makes it an appealing candidate for the widespread application of single-port techniques. Our institution selects SPSG as the first choice of procedure in obese patients. Patients with BMI of more than 50 kg/m<sup>2</sup> and those with comorbidities such as uncontrolled diabetes mellitus are also given other options to consider.

Confidentiality also leads to patient confidence. Whenever possible, SILS is best done in a transumbilical fashion to achieve great results in terms of cosmesis and patient satisfaction. Lakdawala et al.<sup>31</sup> provided a scar satisfaction score to quantify patient satisfaction with the visibility of the surgical wound. Most obese patients have lower self-esteem and having better cosmesis, such as having no obvious signs of surgery at all, may lead to better motivation and quality of life.

### Technical concerns of LESS

The performance of SILS is technically difficult due to limitations in the operator's range of motion, collision of the instruments, and unstable field of view. To overcome these obstacles, first, liver retraction should be done sufficiently. Several techniques report various liver retraction methods, but we prefer the suture retraction method due to the fact that it does not require an additional incision and it effectively and safely retracts the left lobe of the liver upwards.<sup>15</sup> Secondly, we use a scope holder to stabilize the camera and reduce collisions between the operator's and scopist's arms. The procedure is generally done safely without prolongation of the operation time.<sup>9</sup> Although the advancements in laparoscopic surgery have been exceptional, more tools must be developed and tested to allow for LESS bariatric surgery to be more readily employed throughout institutions.

There is a major concern regarding the onset of incisional hernia in single-incision surgery. Port-site hernia rates are reported to be as high as 5.8% in single-incision cholecystectomy, and high BMI ( $\geq 30$  kg/m<sup>2</sup>) is a known risk factor for incisional hernia.<sup>53-55</sup> However, it's worth noting that, in the prospective study by Lakdawala et al.<sup>31</sup> mentioned previously, only three patients (1%) in the SPSG group had incisional hernia—a much lower rate than that expected. Long-term evidence regarding the presentation of port-site hernia after LESS bariatric surgery is still lacking and, hence, careful measures must be taken during the closure of the wound.

## CONCLUSION

With the prior and ongoing technological innovations in minimally invasive surgery, the era of LESS in bariatric surgery has commenced. Several cases of single-port bariatric surgery have been reported in the literature, with the performance of SPSG as the leading trend. Various endoscopic techniques have also been employed, but still require further controlled studies to fully assess their usefulness. Currently, it can be said that LESS appears to be a safe and applicable method in patients requiring bariatric surgery. More attempts to apply LESS in bariatrics may allow for the buildup of additional long-term data regarding its use.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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