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NEW CONCEPT

Laparoscopic Bariatric Surgery Can Be Performed Through a Single Incision: A Comparative Study

Tomasz Rogula · Christopher Daigle · Monica Dua · Hideharu Shimizu · Jonathan Davis · Olga Lavryk · Ali Aminian · Philip Schauer

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Abstract
Background The application of single-incision laparoscopic surgery (SILS) in bariatric patients has been limited to less complex procedures. We evaluated the short-term outcomes of SILS sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB), compared to a group of well-established minimally invasive techniques.
Methods Twenty-eight morbidly obese patients who underwent SILS SG (n=14) and RYGB (n=14) were compared to a matched control group composed of 28 cases of conventional laparoscopic surgery (CLS). A single vertical 2.5–3-cm intra-umbilical incision, three-ports placed trans-fascially, and a liver suspension technique were used to perform SILS.
Results Both groups were comparable in terms of age (p=0.96), gender (p=1.0), type of procedure (p=1.0), and number of comorbidities (p=0.63). Two (7 %) SILS patients required placement of one additional port, and no conversions to CLS or open surgery were needed. The estimated blood loss (p=0.48), operative time (p=0.33), length of hospital stay (p=0.79), overall 90-day perioperative complication rate (p=1.0), and short-term weight loss (p=0.53) were comparable between the two groups. In terms of pain control, the frequency of patient-controlled analgesia use in both groups was similar. However, the pain score (assessed by visual analog scale) was significantly less for SILS patients on postoperative days 1 (5.0±2.1 vs. 6.5±1.8; p=0.007) and 2 (4.0±2.0 vs. 5.1±2.4; p=0.49). Cosmetic satisfaction with the scar was high in the SILS group. No patients required reoperation or readmission during the 90 days after surgery.
Conclusion SILS is feasible in carefully selected bariatric patients and results in short-term outcomes comparable to those observed after CLS. Improved pain and cosmesis are potential benefits of SILS.

Keywords Single-incision laparoscopic surgery · Single-incision gastric bypass · Single-incision sleeve gastrectomy · Bariatric surgery · Gastric bypass · Sleeve gastrectomy · Pain · Cosmesis · Morbid obesity

Introduction

Safety, high quality of care, and patient satisfaction are the focus of current health care. Bariatric surgery has been the most effective method of treating morbid obesity. Laparoscopic bariatric surgery has been shown to have several advantages over the open approach including decreased postoperative pain, less postoperative complications (most notably the risk of wound infection and incisional hernia), shorter hospital stay, faster recovery, and better cosmesis [1]. While laparoscopic bariatric surgery is less invasive than open surgery, it still requires several incisions for port placement. Recent developments in minimally invasive surgery have been directed toward reducing the size or number of ports to achieve the ultimate goal of minimal invasiveness. While single-incision laparoscopic surgery (SILS) is still being evaluated for its utility in the field of bariatric surgery, developments in surgical instruments and maturation in surgical technique have made it more available and appealing.

The limited reports of single-incision bariatric surgery have demonstrated that SILS is a safe and feasible procedure in

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experienced hands [2]. Better cosmesis, potential for less postoperative pain, and shorter hospital stay are advantages of SILS over conventional laparoscopic bariatric surgery [3]. Herein, we present our experience with single-incision bariatric surgery in 28 patients.

Materials and Methods

Patients

The study group comprised 28 patients who underwent single-incision laparoscopic bariatric surgery at the Cleveland Clinic Bariatric and Metabolic Institute between March 2012 and February 2013. All patients met NIH criteria for bariatric surgery and underwent the typical preoperative evaluation including medical, psychological, and nutritional assessments. Patients were selected for SILS at the preoperative visit based on physical exam and body habitus. Major inclusion criteria of concern were BMI<50 kg/m^2, abdominal wall fat distribution, and absence of prior surgical scars. Patients with a thick abdominal wall (especially around the umbilicus) and tall stature were not considered for SILS. Similarly, subjects with scars from open surgery were not offered SILS due to questionable cosmetic benefits and expected adhesions. A SILS approach was offered to all other patients who satisfied the inclusion criteria, regardless of the type of surgery they were scheduled for (Roux-en-Y gastric bypass (RYGB) or sleeve gastrectomy (SG)). Detailed informed verbal and written consent was obtained.

For the control group, a retrospective analysis of our prospectively maintained database was performed to find patients who underwent conventional laparoscopic surgery (CLS) and met the matching criteria including type of surgery, gender, age, and BMI±5 points. All patients in the study group (SILS SG and SILS RYGB) were operated on by a single surgeon (TR). Patients in the CLS group were operated on by two surgeons (TR and PS) during the same time period.

Outcomes Measured

Perioperative and 90-day postoperative outcomes including operative time, estimated blood loss, need for conversion, length of hospital stay, complications, reoperation, and readmission data were noted.

Postoperative pain was subjectively evaluated using the visual analog scale (VAS), an 11-point numeric scale with 0 representing “no pain” and 10 representing “worst pain imaginable” [4]. Patients were evaluated 6–8 h after surgery and then daily for the duration of their hospital stay. In addition, pain was assessed thereafter via telephone follow-up 3–5 days after discharge and then during the first follow-up visit 7–10 days after discharge. Objective pain levels were measured by the accumulative number of patient-controlled analgesia (PCA) pump activations necessary to achieve adequate analgesia, regardless of narcotic medication used and its dose on postoperative days (POD) 0, 1, and 2. The oral pain medication use was measured by accumulating numbers of standard doses of oral liquid narcotic taken by the patients on POD 1 and POD 2. The proportion of patients who used oral narcotics after hospital discharge was also compared. Postoperative nausea and vomiting were assessed clinically and by cumulative doses of standard antiemetics (Ondansetron) and/or Scopolamine topical patch.

Short-term weight changes were assessed at 1 and 4 months after surgery. Wound satisfaction in the SILS group was measured subjectively by asking the patients their degree of cosmetic satisfaction using a scale of 1–3 and objectively by clinically evaluating infections, presence of hernias, seromas, wound dehiscence, and size of scar.

Surgical Procedure (SILS)

Ports and Instruments

The same type of conventional ports and instruments is used in all SILS procedures. One 12-mm trocar with Optiview technology (Ethicon) and two 5-mm port (Covidien) are used. We use a 5-mm 45° angled camera in most parts of the procedure. Regular inline graspers and Endo-Stitch (Covidien) suturing devices are also used. When possible, we utilize a cordless ultrasonic dissection device (Sonicision, Covidien) with a long shaft, which reduces external cord clutter and improves overall mobility within the limited operating space. Powered articulating staplers (Ethicon) with a linear load of 60-mm white, blue, or green cartridges are used depending on transected tissue thickness.

Accessing the Abdomen

A vertical 2–3.5-cm skin incision is made starting slightly off and above the apex of the umbilicus, proceeding toward the upper umbilical edge, exceeding it as needed. A blunt and sharp dissection is carried out to create a 2–3-cm space underneath the subcutaneous fat and on top of the abdominal fascia for port placement. A Veress needle is then inserted through the lower-middle part of the exposed fascia to establish a pneumoperitoneum of 12–15 mmHg. A 12-mm Optiview trocar is then inserted under direct visualization with a 0° laparoscope. This first port is placed centrally, slightly to the lower-middle part of the exposed fascia. Next, two 5-mm ports are blindly inserted laterally toward the subcutaneous pockets, superior to the 12-mm port, to create a triangle with approximately 2-cm sides. A proximal extension of the incision is sometimes needed if the incision is too tight (Fig. 1).

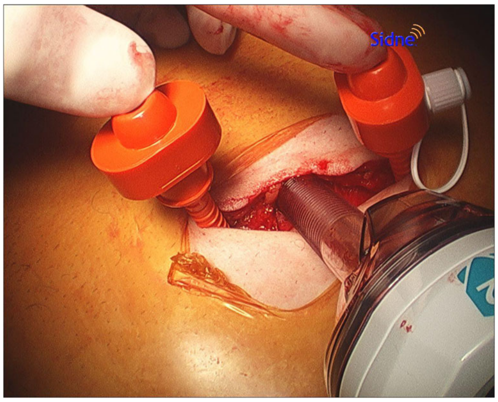

Fig. 1 Port placement for single-incision laparoscopic sleeve gastrectomy and gastric bypass

Retraction of the Liver

If the left lobe of the liver is found to be relatively small, internal retraction is applied with a 2.0 silk stitch (30 cm) on a straight cutting needle (Keith) which is passed through the mid-upper abdomen 5–7 cm below the xiphoid process. The suture is picked up with non-toothed graspers and passed through the left lobe of the liver, about 5–7 cm medially from its edge. Then, it is passed back out proximal to the first insertion (through the abdominal wall) and gently pulled up to retract the liver. Needle insertion sites are monitored for any bleeding, bile leakage, or laceration (Fig. 2). The alternative method utilizes the EndoLift Port-Free Retractor (Virtual Ports, Israel) designed to provide liver retraction within the peritoneal cavity through existing ports. It comprised a telescopic stainless steel bar positioned underneath the left liver lobe and two articulated clips on either end of the bar used to grasp and anchor it to the intra-abdominal wall (Fig. 3).

Single-Incision Sleeve Gastrectomy

Gastrosplenic attachments and short gastric vessels are taken down with an ultrasonic dissection device, starting from about 5 cm proximally from the pylorus and proceeding toward the angle of His. Prior to transecting the stomach, a 34-Fr gastroscope is passed along the lesser curvature of the stomach toward and into the pylorus. This is used to size the sleeved stomach pouch. A green stapler load is then applied about 4–5 cm proximal to the pylorus on the greater curvature of the stomach with the stapler tip completely articulated out to avoid narrowing at the incisura angularis. Consecutive stapler firings (blue load) are used heading toward the angle of His. During transection, the stomach on the specimen side is gradually retracted lateral and down with a left-sided 5-mm grasper. In the last step, the fundus is retracted down and lateral, and the gastrophrenic ligament and perigastric tissue are taken down with an ultrasonic dissection device.

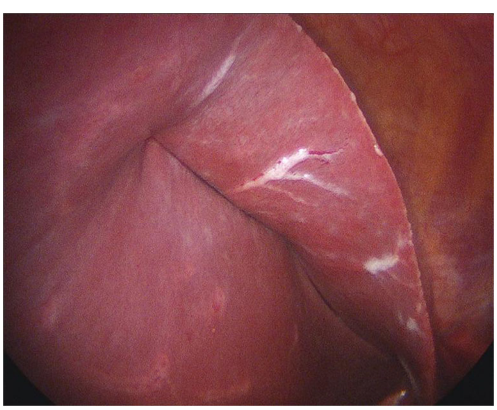

Fig. 2 Technique of liver retraction with a stitch passed through the left lobe of the liver

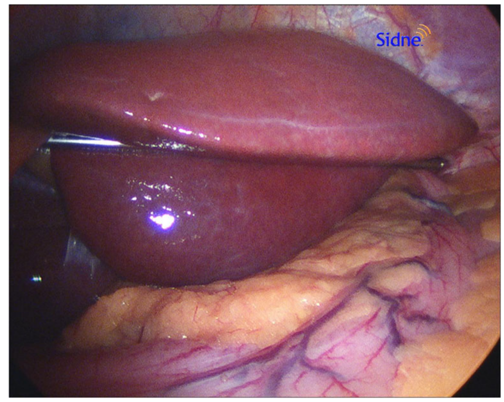

Fig. 3 Technique of liver retraction with an EndoLift device

The stomach staple line is selectively oversewn with nonabsorbable suture using the Endo-Stitch device when the staple line is oozing blood that is difficult to control with endo-clips. The specimen is then removed through an extended 12-mm port site. This site is closed with a 1-0 Vicryl in a figure-of-eight open technique. The abdominal fascia and subcutaneous tissue are infiltrated with local anesthetics. Subcutaneous tissue and skin are closed with absorbable monofilament suture.

Single-Incision Gastric Bypass

Identical instrumentation, incision size, and port configuration are applied. We start the operation with creation of the jejunojejunal side-to-side stapled anastomosis, with a standard 50-cm biliopancreatic limb and 150-cm Roux limb. Unlike traditional laparoscopy, the anastomosis needs to be positioned well away from the port site, especially in smaller patients. Our preferred site is the far upper left of the peritoneal cavity, and the placement of stay sutures is necessary. The closing of the resulting common enterotomy site with a stapler is difficult due to poor retraction; it risks narrowing the anastomosis or incomplete stapling. Therefore, we close the enterotomy site with the Endo-Stitch using a nonabsorbable suture.

The gastric pouch is created with the operative table in the steep reverse Trendelenburg position. We tend to create longer tubular-shaped pouches to facilitate a low-tension anastomosis. A stitch is passed through the tip of the Roux limb to approximate it to the horizontal portion of the pouch. A 2-cm gastrojejunal hand-sewn anastomosis is created in a two-layer fashion using absorbable suture applied with the Endo-Stitch. Sewing with the Endo-Stitch is difficult in this cranial position with only one grasper to guide the stitch and no countertraction. We think that it is important to pass the gastroscope prior to completion of the anastomosis to avoid strictures and to control bleeding. An air-leak test is always performed using a gastroscope.

Statistical Analysis

Categorical variables are expressed as frequency (%). Continuous variables are presented as mean±standard deviation (SD) or median and interquartile range (IQR). Comparative analysis was performed with Student's t test for normally distributed continues variables, Wilcoxon-Mann-Whitney test for non-normally distributed continuous variables, and chi-square or Fisher's exact tests for categorical variables. In this analysis, $p<0.05$ was considered to be statistically significant.

Results

The study groups comprised 28 patients who underwent SG ($n=14$) or RYGB ($n=14$). Both groups were comparable in terms of age ($p=0.96$), gender ($p=1.0$), and number of comorbidities ($p=0.63$) (Table 1). The mean BMI of the SILS and CLS groups at baseline was 40.2±4.6 and 44.4±6.1 kg/m^2, respectively ($p=0.005$). The most prevalent preoperative comorbidities in the SILS group included hypertension in 13 patients (46 %), hyperlipidemia in 12 (43 %), obstructive sleep apnea in 11 (39 %), type 2 diabetes in 7 (25 %), and osteoarthritis in 7 (25 %).

Table 1 Demographic characteristics

Variables	SILS ($n=28$)	CLS ($n=28$)	p value
Gender (F), n (%)	23 (82)	23 (82)	1
Age (years), mean±SD	48.1±11.3	48.2±11.1	0.96
BMI (kg/m^2), mean±SD	40.2±4.6	44.4±6.1	0.005
Comorbidities, median (IQR)	2.5 (2–4)	3 (2–3)	0.63
Operative procedure, n (%)			1
Sleeve gastrectomy	14 (50)	14 (50)	
Roux-en-Y gastric bypass	14 (50)	14 (50)	

SILS single-incision laparoscopic surgery, *CLS* conventional laparoscopic surgery

With regards to the intraoperative parameters, there was no significant difference between the groups in estimated blood loss ($p=0.48$) and operative time ($p=0.33$) (Table 2). In one patient undergoing SILS RYGB, an intraoperative air leak was detected and fixed with oversewing; this required placement of an additional 5-mm port. Another patient with extensive adhesions and a bulky liver (unexpected) required an additional 5-mm port. Overall, only two (7 %) patients required placement of one additional port, and no conversions to CLS or open surgery was needed. In one patient, a narrowing at the gastrojejunostomy was noted endoscopically. This required intraoperative revision using the same single-incision access without the need for additional ports. The length of hospital stay ($p=0.79$) and overall 90-day perioperative complication rate ($p=1.0$) were comparable between the two groups (Table 2). The other three postoperative complications in the SILS group were transient atrial fibrillation, postoperative hemoglobin drop necessitating blood transfusion, and a marginal ulcer. No patients required reoperation or readmission in the 90 days after surgery.

In terms of pain control, the frequency of patient-controlled analgesia (PCA) use in both groups was similar on POD 0, 1, and 2 (Table 3). However, the pain score (VAS) was significantly less for SILS patients on POD 1 (5.0±2.1 vs. 6.5±1.8; $p=0.007$) and POD 2 (4.0±2.0 vs. 5.1±2.4; $p=0.49$). Oral pain medication use did not statistically differ in the postoperative period ($p=0.19$) and after discharge from hospital (0.41). The frequency of postoperative antiemetic use was comparable in both groups on POD 1 and 2 (Table 3). The proportion of patients who returned to work 1 month after surgery was higher in the SILS group (58 vs. 40 %), but did not reach statistical significance ($p=0.19$).

From a cosmetic point of view, patient satisfaction was high in the SILS group (all patients scored 3/3). Objective clinical assessment showed a well-hidden vertical scar (practically invisible) measuring 2.5–3.5 cm within the umbilical niche (Fig. 4). No wound issues were noted postoperatively including wound infection, seroma, hernia, and dehiscence.

The short-term mean percent weight loss in the SILS and control groups at 1 month (10.4±3.6 vs. 10.4±2.3 %, $p=0.98$) and 4 months (19.3±5.3 vs. 18.2±4.3 %, $p=0.53$) after surgery was comparable.

Discussion

Single-incision laparoscopic approaches are emerging in the field of bariatric and metabolic surgery. Less complex bariatric procedures are typically selected for a SILS approach. In his review paper, Huang identified 46 cases of SILS gastric banding, 27 SG, and 16 RYGB [5]. Currently, the largest published series (>100 cases) reports the results of SILS gastric banding [6–8]. To our knowledge, this is the largest

Table 2 Operative outcome

Variables	SILS (n=28)	CLS (n=28)	p value
Operative time (min), mean±SD	174.4±42.0	186.2±47.9	0.33
Estimated blood loss (cc), median (IQR)	27.5 (25–50)	30 (25–50)	0.48
90-Day complication, n (%)	4 (14)	4 (14)	1.00
Length of stay (days), median (IQR)	3 (3–4)	3 (3–3)	0.79
Perioperative complications	2	0	–

SILS single-incision laparoscopic surgery, *CLS* conventional laparoscopic surgery

series comparing equal numbers of SILS SG and SILS RYGB with CLS done by a single surgeon using conventional instruments.

Appropriate surgical candidate selection is paramount to the success of single-incision bariatric surgery. Most authors do not recommend SILS for patients with a BMI more than 50 kg/m^2. According to Mittermair et al., SILS is indicated predominantly for patients with a BMI of 35–45 kg/m^2 [9]. When considering SILS candidates, the patient's body habitus is paramount. Patients with tall trunks can be challenging because of the long distance between the umbilicus and the epigastric area. Fernández et al. pay great attention to the xiphoideal-umbilicus distance, which should not exceed 22–25 cm [10]. We found that lower BMI, favorable body habitus, and lack of previous abdominal surgery are fundamental in making an appropriate procedural decision. In addition, realistic patient expectations and informed consent with a detailed explanation of the risks and benefits are necessary.

Several authors have reported on single-incision bariatric surgical technique. Reavis et al. [11], and later Saber et al. [12], reported their experience with SILS SG, and Huang et al. [13] presented their experience with SILS gastric bypass. Of note, there is a diversity of single-incision and access modifications; however, the size, shape, and location of the incision should not compromise safety and cosmetic outcomes. Huang et al. presented an omega shaped 4–6-cm incision, which is sometimes extended to almost a circular shape [14]. Ports can be placed either by introduction of multi-access port devices or conventional ports directly through separate fascial incisions. Varela reports using multi-access port devices, which require a 3-cm incision above the umbilicus [15]. His opinion is that multi-access ports allow for easy instrument insertion, lessen clashing of instruments, and provide adequate pneumoperitoneum without the need for extra incisions and additional ports. However, the 3-cm fascial defect needed for these access ports can predispose to incisional hernias [15]. Fernández et al. [10] and Merchant et al. [16] report using a gel-port device with three preinstalled trocars and one additional metal trocar for liver retraction. Morales-Conde et al. used magnetically assisted graspers for SILS SG and incorporated a magnet retracting system; this allowed them to exert dynamic force on the stomach [17]. We prefer the technique of inserting trocars into the fascia separately via a single skin incision. We have found that this relatively easy technique eliminates the need for special devices or instruments and is potentially less risky for the development of incisional hernias. Koh et al. believes that reticulating instruments may minimize instrument clashing [18]. In our experience, we have not found it necessary, especially in SG, with the longitudinal direction of action. Liver retraction can be achieved by

Table 3 Comparison of postoperative pain and nausea

Variables	SILS (n=28)	CLS (n=28)	p value
PCA activation (frequency), median (IQR)			
POD 0	22.5 (9.25–27.75)	19.0 (9.0–37.0)	0.67
POD 1	28.5 (15.75–42.0)	22.0 (10.0–35.0)	0.22
POD 2	0 (0–3.25)	0 (0–0)	0.46
Pain severity (VAS score), mean±SD			
POD 0	6.0±2.5	6.75±2.6	0.27
POD 1	5.0±2.1	6.5±1.8	0.007
POD 2	4.0±2.0	5.1±2.4	0.049
Oral narcotic use			
In hospital (number of dosage), median (IQR)	2.5 (1–3)	3 (0.25–4)	0.19
After discharge (yes), n (%)	16 (57)	19 (68)	0.41
Antinausea medication, (number of dosage), median (IQR)			
POD 1	2 (1–3)	2.5 (1–3)	0.51
POD 2	1 (0–2)	1 (0–2.75)	0.61

SILS single-incision laparoscopic surgery, *CLS* conventional laparoscopic surgery

Fig. 4 Cosmetic result of single-incision laparoscopic gastric bypass

suspending the liver without placement of additional trocars [19].

With regards to operative outcomes, Nguyen et al. reported longer operative times in SILS SG and SILS RYGB when compared to those in five-port CLS [3]. Huang et al. reported no intraoperative complications (or anastomotic leak) in his SILS RYGB series [2]. In our study, two patients undergoing SILS RYGB had intraoperative events that required a redo of the gastrojejunostomy anastomosis for leak or stricture. Most authors report similar estimated blood loss and hospital stay in CLS and SILS cases. In our series, operative time, estimated blood loss, and hospital stay were similar in SILS compared to those in CLS.

While SG tends to be relatively less challenging than RYGB, dissection at the angle of His can be difficult in larger patients with massive perisplenic and perigastric fat. Alevizoz and Lirici [20] reported a bleeding complication rate of 8.3 % after SILS SG. Mittermair et al. reported a 2.5 % leak rate, 2.5 % bleeding rate, 5 % occurrence of postoperative reflux, and no trocar-associated hernias after SILS SG [9]. In our series of SILS SG, we did not experience intraoperative or major postoperative complications (except one case of transient atrial fibrillation). On the other hand, SILS RYGB is a complex operation; Huang et al. suggests completing >400 laparoscopic RYGB procedures before considering incorporation of SILS into an experienced practice [2].

Wound complications such as seroma, infection, and hernia are frequently emphasized as potential complications of SILS. For instance, Koh et al. demonstrated an 8.3 % superficial wound infection rate which was easily managed with oral antibiotics [18]. We had no apparent wound complications in our series after closing all fascial defects greater than 10 mm, but admittedly, this rate may increase as more follow-up time passes. The SILS cholecystectomy literature has demonstrated significantly higher hernia rates using the single-incision approach, and a similar phenomenon would not be surprising in the morbidly obese SILS bariatric surgery population. For example, Marks et al. randomized 200 patients to either SILS cholecystectomy (n=119) or standard four-port cholecystectomy (n=81) and found that hernia rates were higher in the SILS group (8.4 vs 1.2 %; p=0.03) [21].

We demonstrated improved pain control after SILS on POD 1 and POD 2, as measured by PCA pump activations. Similarly, in their randomized prospective study, Lakdawala et al. demonstrated the benefits of SILS SG with respect to scar visibility and reduction of postoperative pain [22]. However, some authors did not demonstrate a significant decrease in postoperative pain using SILS versus traditional laparoscopic approaches.

Achieving superior cosmetic results is the most obvious benefit of SILS. Huang reported that up to 70 % of their patients are women, who typically consider scaring as an important factor [5]. Jolley et al. found that a cosmetic-based outcome was important to their obese patients [23]. In the series reported by Chakravartty et al., patients considered the number of scars as an important cosmetic satisfaction factor [7]. Huang et al. presented an average wound satisfaction score of 4.56 (range 4–5) for SILS RYGB and 4.67 (range 4–5) for SILS SG [13]. In our SILS series, patient satisfaction from a cosmetic point of view was high.

Our methodology had some limitations that should be noted before its findings are interpreted. The retrospective design, small sample size, short-term follow-up, and single-center experience are obvious limitations of this report. Study groups were not exactly matched in terms of BMI and operating surgeon. High-power randomized clinical trials that use larger sample sizes are needed to determine the benefits and limitations of SILS in bariatric surgery.

Conclusion

In conclusion, single-incision bariatric surgery is feasible in carefully selected patients and results in short-term outcomes comparable to those observed after CLS. The potential benefits include less postoperative pain, improved cosmesis, and patient satisfaction. Randomized trials, larger cohort studies, and/or systematic reviews will be necessary to assess the extent of the benefits and limitations of SILS in bariatric surgery.

Conflict of Interest Tomasz Rogula, Christopher Daigle, Monica Dua, Hideharu Shimizu, Jonathan Davis, Olga Lavryk, Ali Aminian, and Philip Schauer declare no conflict of interest.

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References

1. Reoch J, Mottillo S, Shimony A. Safety of laparoscopic vs. open bariatric surgery: a systematic review and meta-analysis. Arch Surg. 2011;146(13):1314–22.
2. Huang CK, Lo CH, Houng JY, et al. Surgical results of single-incision transumbilical laparoscopic Roux-en-Y gastric bypass. Surg Obes Relat Dis. 2012;8(2):201–7.
3. Nguyen NT, Smith BR, Reavis KM, et al. Strategic laparoscopic surgery for improved cosmesis in general and bariatric surgery: analysis of initial 127 cases. J Laparoendosc Adv Surg Tech A. 2012;22(4):355–61.
4. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res (Hoboken). 2011;63 Suppl 11:240–52.
5. Huang C. Single-incision laparoscopic bariatric surgery. J Minim Access Surg. 2011;7(7):99–103.
6. Park K, Afthinos JN, Razi SS, et al. Laparoendoscopic single-site surgery for the placement of an adjustable gastric band: a large cohort comparison. Surg Obes Relat Dis. 2013;9(5):1695–700.
7. Chakravartty S, Murgatroyd B, Ashton D, et al. Single and multiple incision laparoscopic adjustable gastric banding: a matched comparison. Obes Surg. 2012;22(11):1695–700.
8. Patel AG, Murgatroyd B, Ashton WD. Single incision laparoscopic adjustable gastric banding: 111 cases. Surg Obes Relat Dis. 2012;8(6):747–51.
9. Mittermair R, Pratschke J, Sucher R. Single-incision laparoscopic sleeve gastrectomy. Am Surg. 2013;79(4):393–7.
10. Fernández JI, Ovalle C, Farias C, et al. Transumbilical laparoscopic Roux-en-Y gastric bypass with hand-sewn gastrojejunal anastomosis. Obes Surg. 2013;23(1):140–4.
11. Reavis KM, Hinojosa MW, Smith BR, et al. Single-laparoscopic incision transabdominal surgery sleeve gastrectomy. Obes Surg. 2008;18(11):1492–4.
12. Saber AA, Elgamal MH, Itawi EA, et al. Single incision laparoscopic sleeve gastrectomy (SILS): a novel technique. Obes Surg. 2008;18(10):1338–42.
13. Huang CK, Tsai JC, Lo CH, et al. Preliminary surgical results of single-incision transumbilical laparoscopic bariatric surgery. Obes Surg. 2011;21(3):391–6.
14. Huang CK, Yao SF, Lo CH, et al. A novel surgical technique: single-incision transumbilical laparoscopic Roux-en-Y gastric bypass. Obes Surg. 2010;20(10):1429–35.
15. Varela JE. Single-site laparoscopic sleeve gastrectomy: preclinical use of a novel multi-access port device. Surg Innov. 2009;16(3):207–10.
16. Merchant AM, Cook MW, White BC, et al. Transumbilical Gelport access technique for performing single incision laparoscopic surgery (SILS). J Gastrointest Surg. 2009;13(1):159–62.
17. Morales-Conde S, Dominguez G, Cañete Gomez J, et al. Magnetic-assisted single-port sleeve gastrectomy. Surg Innov. 2013; 20, doi:10.1177/1553350611427548.
18. Koh CE, Martin DJ, Cavallucci DJ, et al. On the road to single-site laparoscopic adjustable gastric banding: lessons learned from 60 cases. Surg Endosc. 2011;25(3):947–53.
19. Huang CK, Lo CH, Asim S, et al. A novel technique for liver retraction in laparoscopic bariatric surgery. Obes Surg. 2011;21(5):676–9.
20. Alevizos L, Lirici MM. Laparo-endoscopic single-site sleeve gastrectomy: results from a preliminary series of selected patients. Minim Invasive Ther Allied Technol. 2012;21(1):40–5.
21. Marks JM, Phillips MS, Tacchino R, et al. Single-incision laparoscopic cholecystectomy is associated with improved cosmesis scoring at the cost of significantly higher hernia rates: 1-year results of a prospective randomized, multicenter, single-blinded trial of traditional multiport laparoscopic. J Am Coll Surg. 2013;216(6):1047–8. discussion 1047–8.
22. Lakdawala MA, Muda NH, Goel S, et al. Single-incision sleeve gastrectomy versus conventional laparoscopic sleeve gastrectomy—a randomised pilot study. Obes Surg. 2011;21(11):1664–70.
23. Jolley J, Ahmed N, Luu MB, et al. Single-incision versus conventional laparoscopic adjustable gastric banding. JSLS. 2013;17(3):385–7.