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Review

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Laparoscopic sleeve gastrectomy: Technique and results

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ABSTRACT

Laparoscopic sleeve gastrectomy (LSG) has gained popularity as stand-alone procedure. The objective of this study was to describe the surgical technique and evaluate the outcomes of LSG published in the literature. Twenty-six studies with 1 to 5 years of follow-up after LSG were analyzed. Of the 26 studies, 22 reported patient gender (n=2765) and 69.1% of the patients were women. Mean age of the patients was 41.05 years (22 studies; n=2483 patients). Mean preoperative body mass index in all twenty-four studies was 48.2 kg/m^2 (range: 37.2-65.3 kg/m^2). Overall mean percentage of excess weight loss after LSG reported in 17 studies was 57.7%. Postoperative complication rate ranged from 0% to 15.3%. Leak rate ranged from 0.7% to 5.1%, and mortality rate ranged from 0% to 1.4%. Eleven studies reported remission rate of postoperative co-morbidity data with follow-up period of 12 to 60 months. Existing data have identified that LSG is comparable to other accepted bariatric procedures, but long-term data is limited.

Keywords: Laparoscopic sleeve gastrectomy; obesity; outcomes; technique.

Introduction

The incidence of obesity and related comorbidities are the most significant problems in developed and developing countries.[1] Bariatric surgery is an option for severely obese people who cannot lose weight with diet and exercise. There are different types of operative techniques for the surgical treatment of obesity including adjustable gastric band (AGB), Roux-en-Y gastric bypass (RYGB), mini-gastric bypass (MGB), biliopancreatic diversion with a duodenal switch (BPD-DS), and laparoscopic sleeve gastrectomy (LSG).[2]

LSG is an effective treatment for morbid obesity introduced as a first step in weight loss interventions in high-risk patients by Gagner et al. in 2000.[3] Initially, LSG was performed as a part of BPD-DS.[4] However, LSG has been regarded a primary procedure in bariatric surgery due to its several advantages such as excellent weight loss outcomes, relative technical ease, short operating time, and low rate of complications.[5–7]

LSG is a longitudinal gastrectomy including the resection of the whole fundus, greater curvature and partial antrum. As a restrictive technique, it protects gastrointestinal tract continuity and does not cause malabsorption.[3] LSG limits food intake and causes a reduction in the levels of the ghrelin hormone leading to weight loss.

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Surgical Technique

The operation is performed in reverse Trendelenburg and French position in which the surgeon is positioned between the legs of the patient. Elastic stockings and intermittent pneumatic compressing device are applied. Generally, five-trocar approach is used for optimal visibility (Figure 1). First trocar with a diameter of 10 mm or 12 mm is placed to the upper abdomen, 1–2 cm above the umbilicus by Visiport ™ Plus optical trocar (Covidien, Mansfield, MA, USA). The upper pressure limit for CO_2 pneumoperitoneum is set as 15 mmHg. Later, this trocar is used for the camera. A 5 mm trocar is positioned at the subxiphoid area for the insertion of the Nathanson liver retractor (Cook Medical Inc., Bloomington, IN) to lift the left lobe of the liver and obtain optimal view of the stomach. 12 mm or 15 mm trocars are placed in the left and right upper quadrants as working channels. One 5 mm trocar is placed to the left subcostal anterior axillary line to retract the omental tissues and the resected part of the stomach to ease the placement of the linear reticulating stapler.

Initially, the stomach is decompressed with a nasogastric tube by the anesthesiologist. Using a Harmonic scalpel (UltraCision, Ethicon Endo-Surgery) or any other energy-based device, the omentum is released from the greater curvature, starting at the opposite of the incisura angularis since it is easier to enter the lesser sac at this area. The gastroepiploic vessels and the short gastric vessels are divided using the LigaSure device (Covidien, Mansfield, MA, USA).

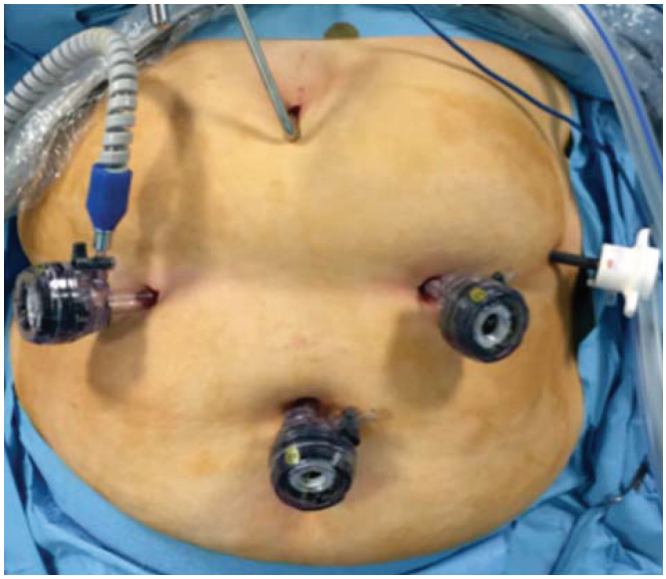

Figure 1. Localization of the trocars and the liver retractor for LSG.

Next, the greater curvature is dissected up to 1 cm lateral to the angle of His and 2–4 cm proximal to the pylorus. After finishing the dissection of the greater curvature, the left crus should be exposed for the presence of hiatal hernia. If a hiatal hernia is identified, it should be repaired. Complete mobilization of the fundus including removal of the fat pad located at the gastroesophageal junction before the transection is regarded as the critical point for the success of the technique. While holding up the stomach with 5 mm grasper, the surgeon carefully dissects the gastro-pancreatic area preserving the left gastric artery and its branches.

A calibrating bougie (not less than 32F) is inserted by the anesthesiologist into the stomach and passed through the pylorus after the stomach had been fully mobilized. The stomach is divided using linear reticulating stapler with a 60 mm cartridge (Echelon, Ethicon Endo-Surgery) inserted into the abdomen via the right sided 10 to 12 mm trocar. In order to create a straight staple line, a good lateral traction of the stomach should be performed via the grasper inserted at the left upper quadrant trocar. First stapler is fired at a point 2–4 cm proximal to the pylorus, followed by the remaining staplers fired in cranial direction along the greater curvature of the stomach (Figure 2). The closed height of the stapler should be higher than 2 mm due to fact that the thickest part of the stomach is in the antrum. Therefore, green or black cartridges are used for the first two firings. Blue or purple cartridges (closed height should be 1.5–2.25 mm) are used for the resection of the upper stomach. Approximately, 5-7 cartridges are necessary for completing the transection (Figure 3).

Any staple line bleeding is strengthened with clips. The calibrating bougie is removed and changed to a nasogastric tube. Methylene blue is injected from the tube to test for leakage. Staple line reinforcement is performed using Tisseel. The resected stomach is removed via 12 or 15 mm left quadrant trocar and a closed-suction drain is placed near the staple line. The fascia of the openings is not closed. The incisions are sutured after removing the liver retractor and the trocars.

Results

Patient Characteristics

Of the twenty-six studies, twenty-two reported patient gender (n=2765) and 69.1% of the patients were women. Mean age of the patients was 41.05 (22 studies, n=2483 patients).

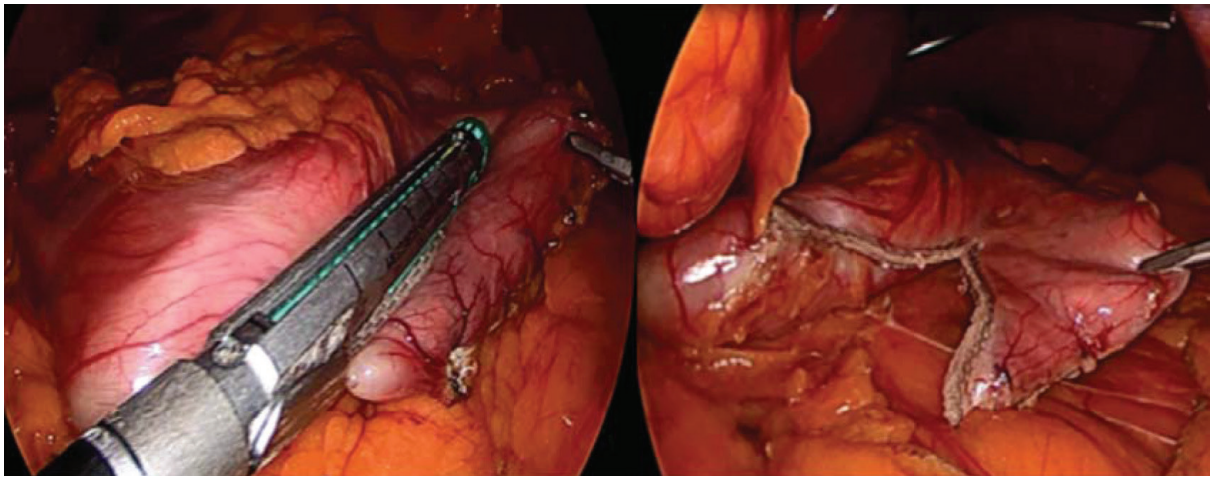

Figure 2. Creation of the gastric tube.

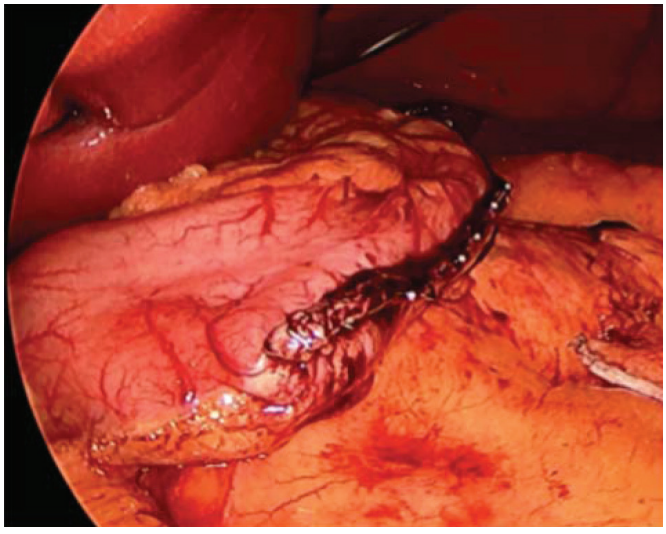

Figure 3. The gastric tube after resection.

Mean preoperative body mass index (BMI) in all twenty-four studies was 48.2 kg/m^2 (range=37.2 to 65.3 kg/m^2).

Weight Loss

Overall mean percentage of excess weight loss (%EWL) after LSG was reported 57.7% in seventeen studies (range=46 to 86%) (Table 1). The follow-up period for the weight loss data was 11-60 months. The long-term (≥60 months after surgery) mean % EWL was 64.8% in six studies.

Effect on Co-Morbidities

Eleven studies (n=1539) included improvement or remission rate of the postoperative co-morbidity data with a follow-up period of 12–60 months (Table 2). Significant improvements were seen in comorbidities including type II diabetes mellitus (T2DM), arterial hypertension, hyperlipidemia, and sleep apnea.

Complications and Operative Mortality

The postoperative complication rate ranged from 0% to 15.3% (Table 3). The leak rate ranged from 0.7% to 5.1% in sixteen studies (n=1981 patients). The rate of 30 day postoperative mortality was reported as from 0% to 1.4% in twenty-three studies.[12,19,23,27]

Discussion

LSG has been performed increasingly as a new and primary bariatric procedure worldwide. In the past, LSG was performed as a planned staged procedure before RYGB or BPD/DS. Initial reports showed that LSG reduced surgical risks and co-morbidities as a staged approach in super obese and high-risk patients. Durable weight loss and co-morbid condition remission were seen in the longterm follow-up after LSG. Most studies showed that rates of the complications such as leak, bleeding, stricture, and mortality were less after LSG compared with other bariatric procedures.

In the study published by Cottam et al., one hundred and twenty-six patients (53% female), regarded high-risk with a mean BMI of 65.3 kg/m^2, underwent LSG as a first stage approach. American Society of Anesthesiologists physical status score (ASA) was III or IV in most patients (94%) and the mean number of co-morbidities per patient was 9.3 (range: 3 to 17).[7] After one-year follow-up period, the mean %EWL was 46% and the average number of comorbid conditions per patient had decreased to six. In this study, the complication rate was 14% including stricture, leak, pulmonary embolism, respiratory distress (requiring >24 h ventilator support), and renal insufficiency not requiring dialysis. Only thirty-six patients underwent

Table 1. Weight loss outcomes after LSG

Reference	Year	Patients (n)	Preoperative BMI (kg/m²)	Follow-up (mo)	%EWL
Cottam et al.[24]	2006	126	65.3	12	46
Hamoui et al.[5]	2006	118	55	24	47.3
Lee et al.[21]	2007	216	49	24	59
Nocca et al.[20]	2007	163	45.9	24	61.5
Weiner et al.[13]	2007	120	60.7	60	NR
Yang O et al.[8]	2008	138	50.6	24	46
Parikh et al.[12]	2008	135	60.1	12	47.3
Felberbauer et al.[18]	2008	126	48.1	19	NR
Rubin et al.[15]	2008	120	43.5	11	NR
Fuks et al.[24]	2009	135	48.8	12	49.4
Stroh et al.[25]	2009	144	54.5	24	NR
Bobowicz et al.[26]	2011	112	44.6	22	46.6
Chopra et al.[9]	2011	174	48.9	36	58.9
Rawlins et al.[27]	2012	49	65	60	86
Catheline et al.[28]	2013	45	49.1	60	50.7
Sieber et al.[29]	2013	54	43	60	57.4
Zachariah et al.[10]	2013	228	37.4	60	63.7
Bellows et al.[30]	2014	63	51.8	17	47.2
Boza et al.[22]	2014	161	34.9	60	62.9

Table 2. Co-morbidity remission and improvement rate after LSG

Reference	Year	Patients (n)	Follow-up (mo)	T2DM*	HTN*	Hyperlipidemia*	Sleep apnea*
Hamoui et al.[5]	2006	118	24	47/22	15/116	NR	NR
Cottam et al.[31]	2006	126	12	81/11	78/7	73/5	80/7
Moon Han et al.[32]	2005	60	12	100/0	93/7	45/30	100/NR
Weiner et al.[11]	2007	120	60	14/86	42/55	5/77	39/61
Yang O et al.[8]	2008	138	24	39/49	29/48	48/39	52/33
Bobowicz et al.[26]	2011	112	22	41/27	33/28	NR	0/100
Chopra et al.[9]	2011	174	36	33/51	26/23	NR	23/67
Basso et al.[11]	2011	200	12	88/12	57/31	NR	56/33
Zachariah et al.[10]	2013	228	60	66/NR	100/NR	50/NR	NR
Zhang et al.[33]	2013	200	12	58/NR	38/NR	63/NR	91/NR
Bellows et al.[30]	2014	63	17	50/20	48/33	96/NR	NR

T2DM: Type 2 diabetes mellitus, HTN: Arterial hypertension. *Remission/Improvement rate (%).

second-stage LRYGB after a mean interval of 12 months (range: 4–22 months). The mean %EWL was 33% in this subgroup after 6 months follow-up period.

Another study by Parikh et al. included one hundred and thirty-five high-risk patients with a mean BMI of 60.1 kg/m².[13] The greater number of these patients (79%) underwent LSG as a planned staged procedure before RYGB or BPD-DS within 11 months. In their series, after a follow-up period of 12 months, the mean %EWL and BMI was 47.3% and 44.3 kg/m², respectively. This study demonstrated that weight loss was not related to the bougie size at mid-term follow-up. However, some studies showed that larger bougies cause weight regain. Therefore, it is thought that

Table 3. Surgical outcomes after LSG

Reference	Year	Patient	Follow-up (mo)	Leak (%)	Bleeding (%)	Stricture (%)	Readmission (%)	Complications (%)	Mortality (%)
Himpens et al.[34]	2006	40	36	0	2.5	0	5	NR	0
Yang O et al.[8]	2008	138	24	1.5	2.2	0.7	NR	5.07	0
Chopra et al.[9]	2011	174	36	2.1	2.1	2.1	NR	14	0
Basso et al.[11]	2011	200	12	2.5	2.5	NR	NR	6	0.6
Albanopoulos et al.[35]	2012	90	NR	4.2	2	0	1	6.2	0
Helmiö et al.[36]	2012	121	NR	0	5.1	0	2.5	13.2	0
Gentileschi et al.[37]	2012	120	NR	1.7	1.7	0	0.8	3.3	0
Catheline et al.[28]	2013	45	60	3.8	1.9	0	NR	5.7	0
Zachariah et al.[10]	2013	228	60	1.3	0	1.3	3.07	4.3	0.43
Bellows et al.[30]	2014	63	17	0	0	0	5	11	0
Boza et al.[22]	2014	161	60	0.6	0	0.6	NR	3.7	0

the size of bougies is one of the important factors contributing to durable weight loss.[11,34]

The other important point to the weight loss outcome after LSG might be the changes in the plasma levels of ghrelin. Ghrelin-producing cells are mainly located in the gastric fundus and this part of the stomach is completely resected in LSG, and some studies showed that the plasma ghrelin levels decreases after LSG.[34,35]

LSG results have been reported a primary procedure since 2006.[36] Felberbauer et al. reported one hundred and twenty-six patients who underwent LSG as a primary bariatric operation.[14] Mean preoperative BMI and excessive weight of the patients were 48 kg/m^2 and 70.4 kg, respectively. After a mean follow-up of 19.1 months, patients had lost between 6.7% and 130% of their excessive weight.

The complication rate was found 3.17% and no mortality was seen.

Some studies reported that LSG might be a revisional procedure for insufficient weight loss after LAGB.[14,38] A prospective multicenter study reported by Noccademonstrated that 13.4% of the one hundred and sixty-three patients were performed LSG after failed LAGB.[37]

In the study of Lee et al. in 2007, LSG was compared to LAGB, LRGB and duodenal switch (DS). Of these eight hundred and forty-six patients, 271 (32%) had LAGB, 216 (25%) LSG, 303 (36%) LRGB, and 56 (7%) DS.[9] LSG patients had higher mean BMI level (49 kg/m^2) than LRGB (46 kg/m^2) and DS (47 kg/m^2) patients. However, LAGB patients were less obese (mean BMI= 42 kg/m^2) than the other patients. Percentage of EWL was greater in the LRGB and DS patients (75% and 79%, respectively) and the least in the LAGB patients (47%). Mean %EWL in LSG group was 59% in one year. The complication rate was lower in the LSG group (16%) and there was no mortality in any groups.

Some studies have demonstrated that an important benefit of LSG is durable weight loss within five years after surgery.[23,25,34] The mean %EWL ranged from 43% at 84 months after surgery in the study by Eid et al. to 69% at >96 months after surgery in the study from Sarela et al., but two studies had very small number of patients.[13,38,39] Boza et al. reported long-term outcomes after LSG when performed as a primary bariatric procedure.[25] They described surgical success as EWL% > 50% and remission of co-morbidities without any medication at fifth year. In

this study, mean preoperative BMI of one hundred and sixty-one patients was 34.9 kg/m^2, 70% of the patients completed 5 years follow-up period and the mean of BMI at the postoperative fifth year was 28.5 kg/m^2. Postoperative complications included surgical wound infection, portomesenteric thrombosis, haemoperitoneum, staple-line leak and antral stenosis which was seen six patients (3.7%). Only four patients (2.5%) required a reoperation due to antral stenosis and weight regain in one and three patients, respectively, at 5 years follow-up.

Most of the studies showed that co-morbid conditions like arterial hypertension, T2DM, dyslipidemia, sleep apnea and insulin resistance reduced after LSG.[11,12,27] In these series, it was shown that T2DM remission rate was between 33 to 100% in mid-term follow-up.[19,27] Zachariah et al. published long-term follow-up (60 months) outcomes including T2DM and arterial hypertension resolution rate, which were found 66% and 100%, respectively.[23] In an-

other study published by Boza et al., T2DM and arterial hypertension remission rate were found to be lower than that of the others (57% and 40%, respectively).[25] In a prospective review published by Yang et al., 48% of the patients had resolution in dyslipidemia and 52% of the patients were cured from obstructive sleep apnea (OSAS).[12] A prospective study by Basso et al. compared results of LSG (200 patients) and BPD-DS (100 patients).[25] OSAS was present in 19% and 29% of the patients in LSG and BPD-DS groups, respectively. In this study, resolution rate of OSAS was identified in each group after one-year follow-up (56% and 50%, respectively).

Conclusion

The results of recent studies demonstrate that LSG is an effective weight loss procedure with an excellent co-morbid reduction rate. Therefore, it can be performed with a low complication rate as a primary procedure. The existing data have identified that LSG is comparable to the other accepted bariatric procedures but long-term data is limited.

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