# Single-port sleeve gastrectomy, a valuable procedure in the treatment of morbidly obese patients

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**Background**
Laparoscopic sleeve gastrectomy has recently been proposed as a sole bariatric procedure because of the considerable weight loss that is achieved in morbidly obese patients. Single-incision laparoscopic sleeve gastrectomy has recently gained acceptance in bariatric surgery as the procedure has possible benefits. The aim of our study was to evaluate the feasibility and safety of a laparoscopic single-incision sleeve gastrectomy for morbid obesity.

**Patients and methods**
From January 2011 to March 2014, single-port laparoscopic sleeve gastrectomy through a special single-port silicon device that is flexible and reusable with a novel method for liver retraction was performed on 30 consecutive morbidly obese patients enrolled from Ain Shams University hospitals. The patients were 22 women (73.3%) and eight men (26.7%), mean age 31 years (range: 23–45) years. The patients recruited in this study had a mean BMI of 41.3 kg/m$^2$ (range: 35–45) kg/m$^2$. The operative technique, operative time, postoperative hospital stay, and early and late postoperative complications were monitored, and the percentage of excess weight loss (%EWL), which was measured at 3, 6, and 12 months, respectively, was determined.

**Results**
A total of 30 single-incision laparoscopic sleeve gastrectomies were performed. The procedure was performed successfully in 27 patients (90%), with three conversions (10%) to traditional laparoscopic sleeve gastrectomy. The mean operative time was 92 min (range: 80–135) min, whereas the mean hospital stay was 2.4 days (range: 2–4) days. In terms of morbidities, there were six cases of vomiting (20%), one case of wound infection (3.3%), and two cases of incisional hernia (6.6%). The %EWL was 26, 38.3, and 61.43 at 3, 6, and 12 months, respectively. There were no mortalities in our study.

**Conclusion**
Laparoscopic single-incision sleeve gastrectomy seems to be safe, technically feasible, and reproducible. Our technique for liver retraction provides adequate exposure. However, additional work must be carried out before these techniques achieve the level of standardization. More flexible articulating instruments, high-illumination, high-magnification, flexible endoscopes, and free-standing insertable retractors need to be developed.

**Keywords:**
primary outcome, secondary outcome, single port, sleeve gastrectomy

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## Introduction

Obesity is now considered an epidemic; projections of the WHO indicate that, in 2006, at least 400 million adults were obese [1].

Bariatric surgery has proved to be the most effective treatment for morbid obesity, resulting in excellent weight loss and correcting the associated comorbidities, with a marked survival advantage [2].

Worldwide, the most widely used surgical procedures are the Roux-en-Y gastric bypass and gastric banding. Sleeve gastrectomy has recently been identified as an attractive procedure for the surgical management of obesity [3].

The recent American Society for Metabolic and Bariatric Surgery position statement on the sleeve gastrectomy has also confirmed its use as a sole bariatric operation [4].

Laparoscopic sleeve gastrectomy has gained popularity in the surgical armamentarium for treatment of obesity because it does not require gastrointestinal anastomosis or intestinal bypass. Furthermore, there is no dumping because preservation of the pylorus and resection of the stomach minimizes the risk of gastric ulcer and cancer. It also yields, in addition to the restrictive effect, hormonal regulation of appetite, because of reduced levels of ghrelin, a hormone produced by cells in the gastric fundus that stimulates hunger [5]. This technique is typically performed laparoscopically, which reduces access morbidity and recovery time; it requires five to seven ports [6].

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Over the past 20 years, minimally invasive surgery has progressed from surgery with minimal incisions, which includes laparoscopic surgery to transorifice surgery, with no skin incisions, using natural orifices such as the mouth, vagina, and rectum as ports of entry. However, this technique is highly demanding from a technical point of view. Besides, the proper technology has to be available in the operating room and the learning curve is slow. Moreover, this technique has the significant disadvantage of going through healthy organs to gain access to the peritoneal cavity; because of this disadvantage, transorifice surgery is still in its initial stages and will probably require a long time to become acceptable [7].

Transumbilical surgery has emerged as an intermediate procedure in the evolution of surgery as it allows abdominal surgery to be performed with only one port at the umbilicus, which is almost invisible, most likely with less trauma to the abdominal wall, faster recovery, and a decrease in the use of analgesics [8].

The first single-incision laparoscopic sleeve gastrectomy was described in 2008 by Saber *et al.* [9]. This new approach minimized scars and was considered minimally invasive. Today, single-port surgery can be performed with existing technology using refinements of traditional laparoscopic instruments [10].

A series of prospective studies of single-incision laparoscopic sleeve gastrectomy were carried out in 2013 by Pourcher *et al*. [10] that confirmed the efficacy and feasibility of this technique. Single-port surgery is acceptable now as a result of advances in equipment, laparoscopic skills, and a positive evolution of conventional laparoscopic surgery [10].

This is a prospective study that aimed to evaluate laparoscopic single-port sleeve gastrectomy in the treatment of morbidly obese patients in terms of the choice of the type of patients, intraoperative challenges, postoperative outcomes, advantages, and disadvantages.

## Patients and methods

This is a prospective study that includes 30 morbidly obese patients. Surgical procedures and follow-up were performed at Ain Shams University hospitals. An approval from the surgical ethical committee was obtained and validated to carry out this study. Written informed consent was signed by each patient participating in this study.

From January 2011 to March 2014, single-port laparoscopic sleeve gastrectomy through a special single-port silicon device that is flexible and reusable with a novel method for liver retraction was performed on 30 consecutive morbidly obese patients enrolled from Ain Shams University hospitals. The patients were 22 women (73.3%) and eight men (26.7%), mean age 31 years (range: 23–45) years. The patients recruited in this study had a mean BMI of 41.3 kg/m$^2$ (range: 35–45) kg/m$^2$. Patients with major cardiac, respiratory, renal, or hepatic comorbidities interfering with anesthesia or laparoscopy were excluded as were patients younger than 18 years of age and older than 60 years of age. The operative technique, operative time, postoperative hospital stay, and early and late postoperative complications were monitored, and the percentage of excess weight loss (%EWL), which was measured at 3, 6, and 12 months, respectively, was also determined.

### Preoperative evaluation

(1) Full assessment of history and examination.
(2) Accurate measurement of the BMI and waist contour.
(3) Questionnaire for the psychological assessment of the patient.
(4) Routine laboratory studies.
(5) Pulmonary function test.
(6) Pelvi-abdominal ultrasound.

### Operative details

*Positioning*

All procedures were performed under general anesthesia in the supine antitrendelenburg position with the legs apart after the patient was positioned on the table with a belt and application of compression bandage around both legs up to the mid thigh. The main surgeon stood between the patient's legs, with assistants standing on both sides. A monitor was located at the head of the patient.

### Single-port application

A 2.5 cm transumbilical incision was performed to introduce the multichannel port using a Kocher clamp. We used a special single-port silicon device that had two 5 mm and one 12 mm trocars in addition to two insufflation channels. The port was flexible and reusable (Fig. 1).

Once pneumoperitonium was achieved with carbon dioxide, we used a 5 mm angled scope to visualize the peritoneal cavity.

In all patients, we used a laparoscopic Babcock, which was introduced through a 5 mm port in the epigastrium for liver retraction.

**Procedure**

The operative steps were similar to those of a conventional laparoscopic sleeve gastrectomy. However, we used a group of long, straight, and curved articulating instruments in this procedure to improve ergonomics and overcome the swording and overcrowding of instruments during surgery (Fig. 2).

Traction on the greater curvature of the stomach was achieved using a 5 mm articulated clamp, and then the stomach was mobilized at 3–4 cm proximal to the pylorus using a vessel sealing device, 5 mm (Harmonic scalpel (Ethicon, Cincinnati, Ohio, USA), Ligasure TM Vessel SealingSystem (Vallylab, Boulder Co, USA), Kocher clamp is a surgical tool which can be made anywhere Sonicision (Vallylab, Boulder Co, USA)). The lesser sac was entered, and remaining close to the wall of the stomach, the greater curvature ligaments (gastrosplenic and gastrocolic) were divided all the way up to the angle of His. It is important to identify and mobilize the angle of His with exposure of the left crus of the diaphragm to delineate the gastroesophageal junction and to facilitate complete resection of the gastric fundus. Retrogastric adhesions were taken down to allow complete mobilization of the stomach (Fig. 3).

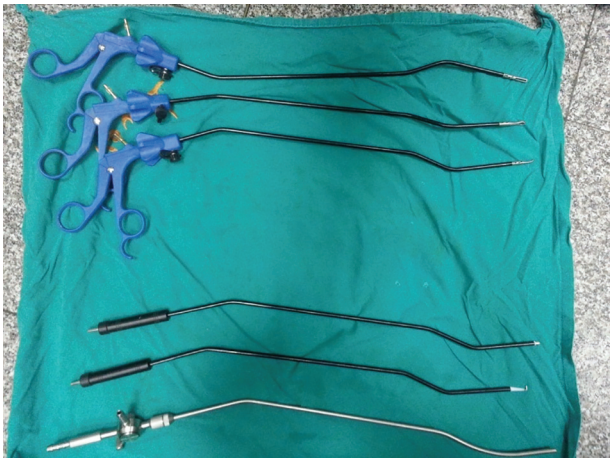
Once the stomach had been completely mobilized, a 36 Fr bougie was introduced into the stomach by the anesthetist and directed medially along the lesser curvature into the distal stomach. Gastric transaction was then started at a point 3–4 cm proximal to the pylorus using an articulating long laparoscopic stapler with 60 mm loads. The first stapling fire was performed by green load, followed by sequential fires by blue loads along the length of the bougie till complete separation of the stomach. The staple line was then carefully inspected for bleeding and the methylene blue test was performed to exclude leakage (Fig. 4).

Then, an intra-abdominal drain was inserted along the staple line and the stomach remnant was exteriorized

**Figure 1**

The reusable multichannel port.

**Figure 2**

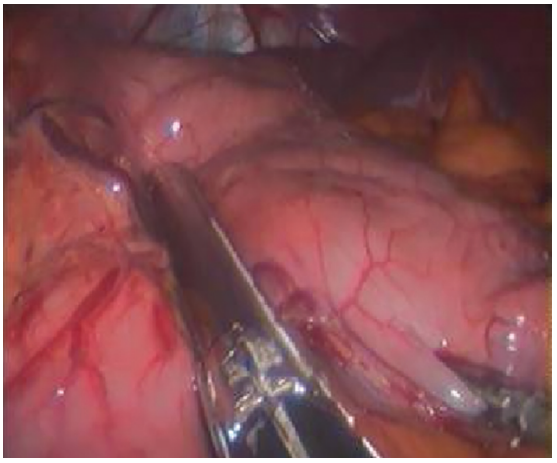


Curved instruments for the single-port procedure.

**Figure 3**

Division of the short gastric vessels near the spleen to free the fundus.

**Figure 4**



Laparoscopic stapling of the stomach.

from the same fascial incision. The defect was then carefully closed with a nonabsorbable one suture to prevent incisional hernia (Figs 5 and 6).

### Patients' care and follow-up

Routine postoperative care was performed for all patients, with the initiation of a prophylactic dose intravenous anticoagulant on the night of the operation. Patients were monitored for short-term complications (hemorrhage, leakage, infection, deep venous thrombosis, infection, vomiting). Patients were discharged home after they demonstrated that they were ambulatory, could tolerate a liquid diet, and had achieved pain control with oral narcotics. Patients were followed up 2 weeks after surgery and subsequently at 3, 6, and 12 months.

### Outcome measures

#### *Primary outcome measures*

The primary endpoint was the intraoperative assessment of the procedure in terms of technical challenges, operative time, incidence of bleeding, quality of the instruments used, and the rate of conversion either to conventional laparoscopy or open surgery.

#### *Secondary outcome measures*

The secondary endpoint was the assessment of postoperative sequelae of the procedure performed such as postoperative pain, cosmoses, psychological impression of the patient, length of hospital stay, incidence of complications, and mean %EWL after 3, 6, and 12 months. The percentage of EWL was calculated as the ratio between postoperative weight loss and excess weight over the ideal body weight, which was calculated according to a BMI of 25 kg/m$^2$.

### Statistical analysis

Demographic, clinical, morbidity, and weight loss data were collected, recorded, and stored in a secure prospective bariatric surgery database. The data were collected, coded, revised, and entered into the statistical package for social science, version 20 (IBM, Armonk, New York, USA). The data were presented as number and percentages for the qualitative data and mean with ranges for the quantitative data.

## Results

### Demographic data

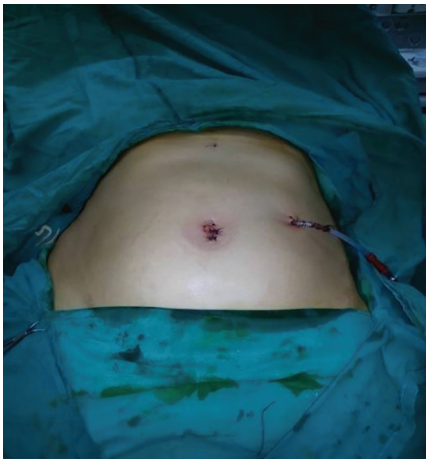
Thirty patients were included in the study, 22 women (73.3%) and eight men (26.7%), mean age 31 years (range: 23–45) years. The patients recruited in this study had a mean BMI of 41.3 kg/m$^2$ (range: 35–45) kg/m$^2$. Their mean preoperative body weight was 109 kg (range: 99–150) kg (Fig. 7).

Conversion to multiport laparoscopy occurred in three cases (10%): in two cases, to control bleeding at the gastrosplenic area and one because of technical difficulties in the dissection and endostapler. However, no conversion to open surgery was observed. Otherwise, no other intraoperative complications occurred.

The mean operative time was 92 min (range: 80–135 min) (Fig. 8). In the initial 15 cases, the mean time was 110 min (range: 96–135) min, whereas in the last 15 cases, the mean time was 85 min (range: 80–100) min.

The mean hospital stay was 2.4 days (range: 2–4) days. All the patients reported mild postoperative pain, which was controlled by intravenous analgesics, and improved markedly upon discharge of the patients from the hospital.

**Figure 5**



Final shape after wound closure and intra-abdominal drain.

**Figure 6**

Stomach remnant.

Early postoperative complications included six cases of vomiting (20%) starting on day 1, which was controlled by medications and antiemetic drugs and improved in all patients maximum by the third day. There was one case of wound infection, which was managed by oral antibiotics and resolved.

Otherwise, there were no other early morbidities such as leakage or hemorrhage. The mortality rate was 0%.

Late complications occurred in two cases that developed incisional hernia at the umbilical scar after 9 and 11 months and needed surgical repair with mesh. There was no evidence of late stenosis, psychological disturbance, or nutritional deficiencies in any patient (Table 1).

The mean %EWL was measured at 3, 6, and 12 months. At 3 months, %EWL was 26%, whereas at 6 months, %EWL was 38.3%, reaching 61.43% by the end of the 12th month (Fig. 9).

## Discussion

Laparoscopic sleeve gastrectomy is a comparatively new technique that is safe and effective especially in superobese patients. It involves resection of two-thirds of the stomach, including the fundus, whereas the remaining part from the gastroesophageal junction to the pylorus along the great curvature is used to form a 'sleeve'. This procedure decreases the volume of the stomach to about 100 ml, which is easier to fill and thus leads to lower food intake [11].

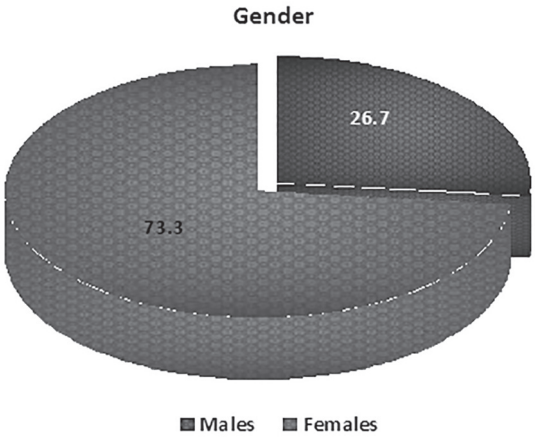
The last decade witnessed some of the most spectacular innovations in the field of surgery. The aim has been to deliver more through less. The basic idea behind every new development has been reduction of pain, better cosmetic results, and reduction in the hospital stay, with comparable results and complication rates as the conventionally accepted procedures [12].

**Table 1 Summary of postoperative complications**

| Complications | SILS Sleeve |
|---|---|
| Early | |
| Leakage | 0 |
| Hemorrhage | 0 |
| Vomiting | 6 |
| Wound infection | 1 |
| DVT | 0 |
| Late | |
| Stricture | 0 |
| GERD | 0 |
| Nutritional Deficiency | 0 |
| Incisional Hernia | 2 |
| Psychological | 0 |

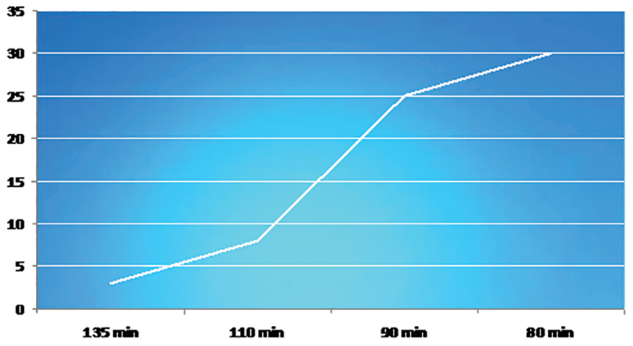
Whenever a new technology is put forward, questions on its feasibility, safety, efficacy, and reproducibility are raised. The risk versus benefit ratio of any new procedure must be weighed before it can be promoted as a standard procedure that can stand the test of time [12].

**Figure 7**




Sex distribution among the studied sample.

**Figure 8**




Mean operative time.

**Figure 9**

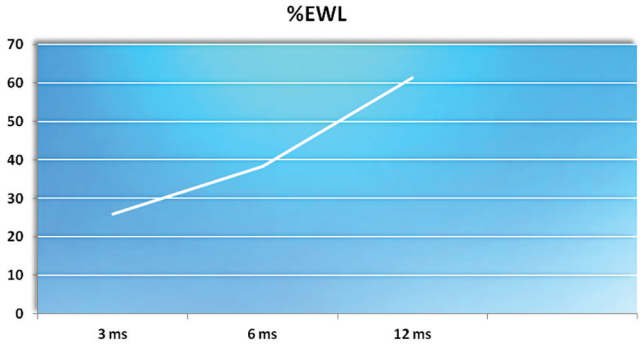



Chart showing the percentage of excess weight loss over 1 year.

Ever since laparoscopic surgery has been considered the new standard in abdominal surgery, a permanent question has remained on further reduction in the number of ports for abdominal access routes. The search has mainly occurred in two directions: surgery through natural orifices and exclusive access using the transumbilical route [13].

Morbid obesity was initially considered a disadvantage in single-incision surgery. Increasing BMI with very high intra-abdominal fat content and large fatty livers, in addition to the inherent difficulty of single-incision surgery, proved to be hurdles for the application of this technique to bariatric surgery. Thus, case selection is of paramount importance, especially in the first few cases [12].

In this study, we report our initial experience with laparoscopic single-port sleeve gastrectomy. This is not a novel approach as it has been described by other authors and discussed the challenges of the technique and their impression about it.

In our study, we recruited 30 obese patients for the procedure; their mean BMI 41.3 ranged from 35 to 45 kg/m$^2$. In our opinion, the choice of patients was very important, especially considering that this was our initial experience with this technique. We decided to use this technique on patients with a relatively low BMI particularly in the first few cases. The patients had undergone no previous abdominal operations and we excluded patients with extremes of age as well as patients with major cardiac, respiratory, renal, or hepatic comorbidities that could interfere with anesthesia or laparoscopy. This was to minimize the risks during operation until we established a safety protocol for single-incision surgery. This is in agreement with the study carried out by Delgado *et al.* [3], in which the mean BMI of the patients in their initial series was 40.1 kg/m$^2$ (35.6–55.6 kg/m$^2$), lower than that reported by Saber *et al.* [9] and the same as that published recently by Huang *et al.* [14].

We believe that in obese patients, enlarged fatty liver poses a major difficulty for laparoscopic bariatric surgery and single-port surgery; it is a true technical challenge. For this reason, we used a 5 mm port in the epigastric region to introduce a laparoscopic Babcock for liver retraction. Using this technique, we observed marked improvement in the visualization of the operative anatomy, especially at the region of the gastroesophageal junction and short gastric vessels.

In one of the first case reports, Raevis *et al.* [15] successfully performed a single-incision surgery on a 54-year-old male patient with a BMI of 38 kg/m$^2$. They suggested that without any kind of liver retraction, the use of single-incision surgery in bariatric surgery will be limited only to patients with lower BMI. In the same year, Saber *et al.* [16] reported a series of seven single-access laparoscopic sleeve gastrectomy patients. They used an additional Nathanson's liver retractor through a small subxiphoid incision in all patients. In 2010, Saber *et al.* [16] extended the use of this technique to include super obese patients and performed single-incision surgery in four super obese with a mean BMI of 62.5 kg/m$^2$. Huang *et al.* [14] described the placement of a band for liver suspension, prepared personally by the authors, with a double puncture to the liver using the end of a Jackson–Pratt drain.

Muffazal *et al.* [12] carried out a similar study on 50 patients. In that series, they retracted the liver using monofilament sutures on straight needles with a pledget to retract the liver to the anterior abdominal wall. Delgado *et al.* [3] also reported on a series of 20 patients and they used a small 2–3 mm port in the epigastric region for liver retraction.

In the study carried out by Pourcher *et al.* [10], 13 patients (21.6%) had a large left lateral lobe requiring the use of an additional trocar, probably corresponding to the use of a fourth trocar in the three-port laparoscopic technique. The use of an additional trocar facilitated the adaptation of the LESS surgical technique without the need to extend the operating time or convert to open surgery.

The main principle of single-incision laparoscopic surgery is to perform the entire procedure through a single approach in the skin through a multiport device. In our series, we used this technique and introduced the multiport through the umbilicus. The distance between the umbilicus and the xiphisternum was another operative challenge particularly in tall patients, in whom long instruments had to be used to reach and manipulate the operative field.

Compared with conventional laparoscopic surgery, single-incision surgery defies the standard surgical principles of traction and counter-traction. The shortcomings of the siljgle insicion sleeve gasterctomy (SISG) compared with laparoscopic sleeve gasterctomy (LSG) are as follows:

(a) Clashing of instruments,
(b) Crossing of hands during surgery,
(c) Difficulty in repairing the hiatal defects, and
(d) The fact that oversewing of the staple line, if needed, is technically very demanding.

The lack of triangulation and parallel vision of the scope are additional hurdles [12].

Coordination between the surgeon and the camera person and switching the 5 mm instrument between

the laparoscopic ports are essential to optimize the instruments' range of motion for better ergonomics and to avoid clashing of the instruments and the laparoscope during the procedure. Confident, multiport laparoscopic skills are critical to safely introduce this new technique without added complications. This approach has a unique learning curve, principally to overcome the technical challenges of navigating instruments within a limited range of motion [9].

In our study, three cases were converted to conventional laparoscopic surgery. All these conversions occurred in the first 15 patients. Two of these cases were to control bleeding from the short gastric vessels; these patients had a large liver and needed proper counter-traction with additional ports. The other case was converted because of technical difficulties in the use of instruments and stapler. However, in the last 15 cases, the procedure was smooth and technical challenges were nearly eliminated. There was no conversion to open surgery in our series. In the series reported by Delgado *et al.* [3], one case was converted (5%)($N$ = 1/20 patients) because of technical problems with the length of the endostapler and a large liver steatosis, rendering sleeve gastrectomy technically impossible; however, Maluenda *et al.* [13] and Gentileschi *et al.* [2] reported no conversions to open or conventional laparoscopic surgery.

In our study, we used a group of long, straight, and curved laparoscopic instruments in addition to a rigid 5 mm 45° scope. It took some time in the first few cases to achieve the best harmony between the instruments used and standardize a technique for the procedure. This was reflected on the operative time, which was 110 min on average for the first 15 cases and reduced to 85 min on average in the last 15 patients. Our overall mean operative time was 92 min. Saber *et al.* [9] reported a mean surgical duration of 125 min in their series of seven cases of sleeve gastrectomy performed through a single transumbilical incision. The operating time reported by Gentileschi *et al.* [2] was 128 min (range 84–140 min), whereas Delgado *et al.* [3] reported 79.2 min (range 50–130 min), Pourcher *et al.* [10] reported 86 min (range 52–205 min), and finally Maluenda *et al.* [13] reported an average operative time of 127 min (range 90–170 min). We believe that with increased experience, the operative time would decrease proportionally.

No other intraoperative complications were reported.

Our observation was that the patients had less pain after the first 8 h postoperatively and did not require regular analgesics during hospital stay and upon discharge, and none of them developed significant pain after 7 days. Maluenda *et al.* [13] reported that patients who had undergone single-port sleeve gastrectomy had considerably less pain from the eighth hour after surgery, resulting in a decrease in the use of analgesics. In the study carried out by Lakdawala *et al.* [15], single port sleeve gasterctomy (SPSG) and conventional laparoscopic sleeve gastrectomy were compared in 50 patients per group, and similar results were found. They also confirmed the results of pain reduction and better cosmesis. The pain reduction probably resulted from the use of single-site incision, with effect on the abdominal wall.

The mean hospital stay was 2.4 days (range 2–4 days), which is comparable with the other case series reported by other centers. Pourcher *et al.* [10] reported a median length of hospital stay of 4 days (range 3–9), whereas Gentileschi *et al.* [2] reported a median hospital stay of 2.4 days (range 1–3 days).

In our study, we divided the postoperative complications into early and late.

(1) Early: leakage, hemorrhage, infections, vomiting, and deep venous thrombosis (DVT).
(2) Late: stricture, gastro esophageal reflux disease (GERD), incisional hernia, nutritional deficiency, and psychological disturbance.

There was one case of wound infection at the umbilical scar that appeared on the fourth postoperative day and this was managed by oral antibiotics without readmission to the hospital.

Another early complication was vomiting, which occurred in six patients (20%) within the first 72 h. This was resolved by the administration of intravenous antiemetics and proton pump inhibitors during hospital stay, and all these patients showed an improvement and were discharged; none of them complained of significant vomiting after discharge.

In terms of late complications, two patients developed incisional hernia at the umbilical scar. They developed the hernia at 9 and 11 months, respectively. One patient already had a weak abdominal wall at the time of the operation and the other patient developed wound infection. Both patients underwent repair of the hernia with mesh.

No other complications were encountered. There were no cases of mortality in our study.

There was no morbidity or mortality up to 30 postoperative days in the study carried out by Maluenda *et al.* [13], whereas Pourcher *et al.* [10] reported a complication rate of (3.3%) ($N$ = 2/60 patients). The first was a leak on the upper gastric zone,

which was treated by a covered endoscopic prosthesis. The second was hand parasaethesia because of cubital nerve compression, which disappeared spontaneously 6 h after surgery. They did not observe any incisional hernia during the follow-up period. Also, no death occurred in the postoperative period.

Delgado *et al*. [3] reported a complication rate of 10% (two cases) in the form of postoperative hemoperitoneum, which required early reoperation 1 day after surgery. There was no operative wound infection, evidence of late stenosis, or other complications during follow-up. The 30-day mortality was 0%.

Gentileschi *et al*. [2] reported only one postoperative complication ($n$ = 1/8, 12.5%) of wound infection, which was treated with drainage and antibiotic therapy. No postoperative trocar site hernia development was encountered in this study as well as in the study carried out by Pourcher *et al.* [10].

Efficacy is a very important aspect of any new procedure. It must be implemented only if the results of the conventional procedure can be duplicated or improved. The most important factor for assessment of the efficacy of our procedure is the %EWL, which was measured at 3, 6, and 12 months.

At 3 months, %EWL was 26% whereas at 6 months %EWL was 38.3%, reaching 61.43% by the end of the 12th month. Maluenda *et al*. [13] reported that a mean EWL at 6, 12, and 24 months after surgery of 99, 118, and 114% respectively. Pourcher *et al.* [10] reported a mean reduction in excess weight of 65.8%, with all 60 patients losing more than 50.0% of their excess weight. Delgado *et al*. [3] and Muffazal *et al.* [12] published in their series of patients who underwent single-port sleeve gastrectomy a mean %EWL of 52% and 64.38% at 6 months, respectively. Our results were also comparable with other studies on conventional laparoscopic sleeve gastrectomy. Baltasar *et al.* [17] have reported a mean percent EWL of 56.1% from 4 to 27 months after surgery. Lakdawala *et al*. [15] also reported a mean percent EWL of 50.8% at the end of 6 months.

All the patients were satisfied with the cosmetic results of the operation in the sequential follow-up visits as, using the single-access approach, we could combine all of the standard laparoscopic entry points into one port of entry, that is, the umbilicus, thus decreasing the number of incisions required for laparoscopic sleeve gastrectomy from six or seven incisions to two incisions. Fewer incisions ultimately result in minimal discomfort, fast recovery time, and a hidden scar [9].

The limitations of this study were that these were short-term results in a small patient pool. We acknowledge that this is a pilot study, and the aim was to establish the feasibility and safety of this new single-incision technique after determining the weight loss results and complication rates. Another limitation of our study was that the feeling of satisfaction related to the superior cosmetic scar after surgery was a purely subjective feeling expressed in the opinion of most of our patients. We hope to record this on a validated patient outcome questionnaire in our future series. The limitations of the technique are the benefits of this procedure may not extend to patients who are super obese or have a scarred abdomen. In addition, a larger randomized study on larger numbers of patients with a long-term follow-up of 5 years is recommended to determine its applicability in comparison with conventional laparoscopy and to detect any additional complications.

Additional work must be carried out before these techniques can be standardized. More flexible articulating instruments, high-illumination, high-magnification, flexible endoscopes, and free-standing insertable retractors need to be developed. Introduction of robotically controlled flexible instruments through the single port might be the ultimate solution to improve technical performance.

## Acknowledgements

### Conflicts of interest

None declared.

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