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Research Article

# Metabolic Outcomes of Laparoscopic Sleeve Gastrectomy

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**Abstract**

**Background:** Laparoscopic sleeve gastrectomy is a recently developed technique for treating morbid obesity. Since it is a simple procedure, many bariatric surgeons have adopted it in recent years with good results. Laparoscopic sleeve gastrectomy (LSG) is purely gastric restrictive procedure designed to reduce appetite by decreasing the size of the stomach. **Objectives:** The aim of this study was to investigate the metabolic outcomes of Laparoscopic sleeve gastrectomy including rate of weight loss, amelioration of obesity related co-morbidities as well as the intra-operative and postoperative complications. **Methods:** From August 2011 to August 2013 (60) consecutive patients with morbid obesity (8 males and 52 females) underwent laparoscopic sleeve gastrectomy at the Ain Shams University Hospital (El-Demerdash) and Ain Shams Specialized Hospital . Follow up of the patients were done for a period of 2 years to investigate the preliminary results of this procedure including operative morbidity and mortality, short and long term complications, rates and parameters of weight loss as well as the effect on lipid and energy metabolism. **Results:** There were two cases 2/60 (3.3%) with intra-abdominal bleeding following laparoscopic sleeve gastrectomy. Staple line failure was detected in two cases 2/60 (3.3%), two early complications (2/60) (3.3%) were encountered, late complications occurred in two patients (2/30) (3.3%) with no mortality occurred. Substantial weight loss occurred in all patients. Mean excess weight loss (EWL%) was 48.04±4.34 % at end of 1st year and 67.85±3.75 % at end of the 2nd year. Complete resolution of co-morbidities was 73.3% for hypertension and 80% for diabetes mellitus at the end of 2nd year. **Conclusion:** Laparoscopic sleeve gastrectomy is a feasible and safe restrictive bariatric procedure, with good short-term results. It offers the advantages of a simple and reproducible technique with good outcome and low morbidity and mortality. LSG is accepted as a stand-alone definitive therapy as it has a high percentage of postoperative excess weight loss as well as reduction of obesity related co-morbidities.

**Keywords:** laparoscopic sleeve gastrectomy, Diabetes, Hypertension.

## Introduction

Obesity is a worldwide epidemic. Recent data show an increased prevalence of obesity in the adult and pediatric populations (1). Globally, there are more than 1 billion overweight adults, at least 300 million of them obese (1).

Bariatric surgery is the most effective treatment for long-term reduction of body weight. Bariatric surgery should at least be considered for all patients with a BMI of more than 40 kg/m2 and for those patients with a BMI of more than 35 kg/m2 with important obesity related co-morbid conditions (2).There are two major categories of weight-loss surgery: gastric restriction such as vertical banded gastroplasty (VBG), gastric banding, sleeve gastrectomy and intestinal malabsorption which include Roux-en-Y gastric bypass (RYGB), biliopancreatic diversion (BPD) (3). The Sleeve Gastrectomy (SG) is a restrictive procedure that creates a 100- to 150-mL stomach by performing a partial gastrectomy of the greater curvature side of the stomach. The last 6 to 8 cm of antrum remains intact, and thus, the pylorus is

preserved to help prevent gastric emptying problems (4).

Laparoscopic sleeve gastrectomy (LSG) is a relatively new bariatric surgery, which is gaining popularity. It was initially performed in 1998, and was then first performed laparoscopically in1999 (5).Today, LSG is accepted as a first-line treatment for the super-obese (body mass index > 55 kg/m2), before attempting more complicated procedures. In addition, surgeons have begun using it as a stand-alone definitive therapy (6).

The aim of this study was to investigate and evaluate rate of weight loss and amelioration of obesity related co-morbidities as well as the intra-operative and postoperative complications for this bariatric procedure for two years post-surgery at the Ain Shams University Hospital (El-Demerdash) and Ain Shams Specialized Hospital.

## Materials and Methods

From August 2011 to August 2013 (60) consecutive patients (8 males and 52 females) underwent laparoscopic sleeve gastrectomy at Ain Shams University Hospital (El-Demerdash) and Ain Shams Specialized Hospital for their morbid obesity. All the patients met the inclusion/exclusion criteria followed the by the National Institute of Health (NIH) Bariatric guidelines (7).

Inclusion criteria were patients' age more than 18 years old, BMI >35 with diabetes or other important co-morbidities, no alcohol abuse or concurrent psychiatric illness. With the exclusion of all patients who are sweet eaters and patients who had upper abdominal surgeries.

Ideal body weight was determined according to the Metropolitan Life Insurance height/weight tables (7). A comprehensive and multidisciplinary bariatric management program was tailored for the preoperative preparation and postoperative management of the patients. This program included support groups and ancillary personnel to provide nutritional and psychological care. Data sources included office charts, hospital charts, follow-up notes, telephone calls, and e-mail messages.

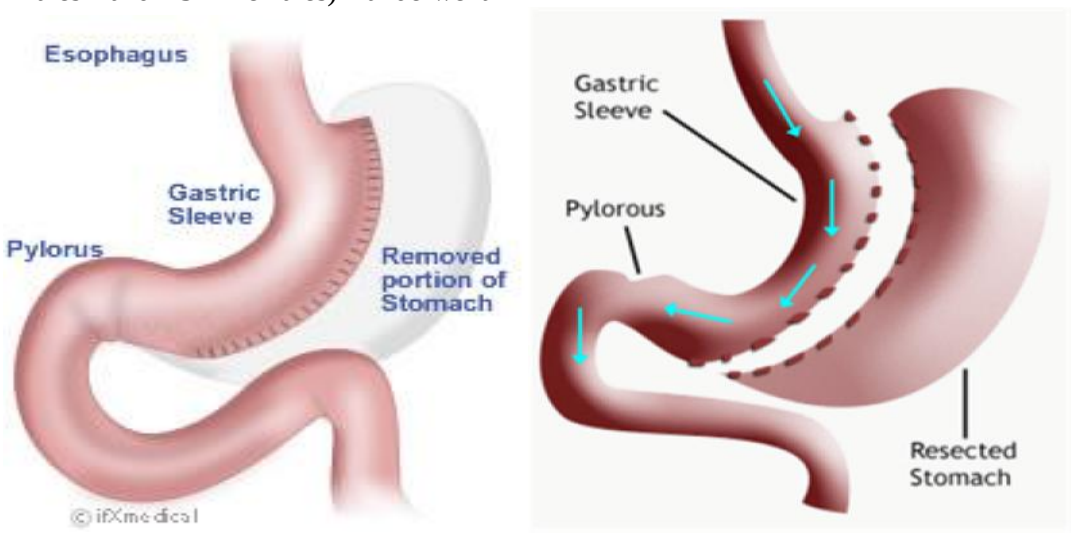



**Figure 1: Diagram show Sleeve gastrectomy procedure**

### Preoperative Evaluation

The Preoperative Evaluation includes discussing in detail the risks, benefits and long-term consequences of the procedures during the initial encounter with the surgeon, internist and dietician. Written informed consent was obtained from all patients before being assigned to surgery.

All patients were subjected to complete medical history (including eating habits, diet regimens, joint pains, chest problems including sleep apnea), full clinical examination (including Systolic and Diastolic blood pressure), measurement of body weight (Kg), height (m), BMI (Kg/m²), pelvi-bdominal U/S, Plain X-Ray both knees to detect degenerative arthritis.

All patients were subjected to laboratory tests including complete blood count (CBC), Liver function tests (AST, ALT, albumin, total Bilirubin), serum creatinine, Hepatitis markers (HBsAg and HCVAb), Fasting blood sugar (FBS) (mg/dl), 2 hours Post Prandial blood sugar (PPBS), serum glycated Hb (HbA1c%), serum uric acid (mg/dl), complete lipid profile including serum cholesterol (mg/dl), triglycerides (mg/dl) , LDL (mg/dl), HDL (mg/dl), VLDL (mg/dl). All patients received preoperative low molecular weight heparin, antibiotic prophylaxis and intravenous proton pump inhibitors two hours before surgery.

**Operative Technique**

Laparoscopic Sleeve Gastrectomy (LSG) was performed according to the technique described by Gagner (5). The division of the gastric greater curvature vascular supply, starting at 6-8 cm from the pylorus and proceeding upwards until the angle of His, is carried out with Harmonic Scalpel (Ethicon).The LSG is created using a linear stapler Endo GIA, with two sequential 60-mm green load firings for the antrum, followed by two or three sequential 60- mm blue loads for the remaining gastric corpus and fundus. The stapler is applied alongside a 36 Fr calibrating bougie strictly positioned against the lesser curve to obtain a 120-150 ml gastric pouch. The resected stomach is extracted by enlargement of the 15-mm port-site. Abdominal drainage was left in place.

**Postoperative Care**

All the patients were monitored in the recovery room and were transferred to the wards or to the intensive care unit. Early postoperative ambulation was strongly encouraged with patients getting out of bed the evening of the surgery and walking by the first postoperative day. A clear liquid diet was started on first postoperative day, was advanced to pureed food 2 weeks later, and to solid food by the fourth postoperative week.

Patients were advised to take daily multivitamins and supplemental minerals, as well as proton pomp inhibitor (PPI) prophylaxis for 6 months. Follow-up appointments with the surgeon, internist and the dietitian were scheduled at second week, 1, 3, 6, and 12 months postoperatively, then twice a year.

Laboratory tests (Fasting blood sugar (FBS), 2 hours Post Prandial blood sugar, serum glycated Hb (HbA1c%), serum uric acid, complete lipid profile including serum cholesterol (mg/dl), triglycerides (mg/dl) , LDL (mg/dl), HDL (mg/dl), VLDL (mg/dl) were repeated 2 years after surgery.

**Endpoints**

The primary endpoints included the intra-operative morbidity and mortality, early complications (complications that prolonged hospital stay and/or necessitated invasive treatment before 30 days of surgery) and late complications (occurring after 30 days of surgery). Follow-up rates and parameters of weight at each time point for this procedure were analyzed in addition to parameters of laboratory tests at the end of the 2$^{nd}$ year after the procedure.

**Statistical Methods:**

Data was collected, revised, coded, tabulated and then introduced to a PC using Statistical package for Social Science **(SPSS 15.0.1 for windows; SPSS Inc, Chicago, IL, USA, 2001)**. Data was described as mean ± standard deviation for quantitative variables and as number and percentage for qualitative variables. Student's Paired t- Test was used to assess the statistical significance of the difference between two means. A $p$ value of $< 0.05$ was used to express significant statistical difference.

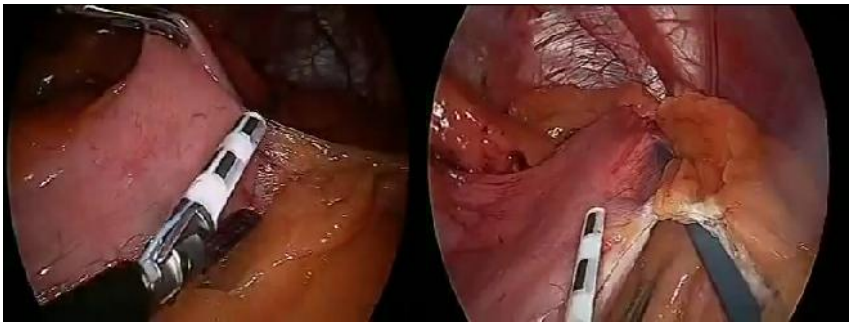
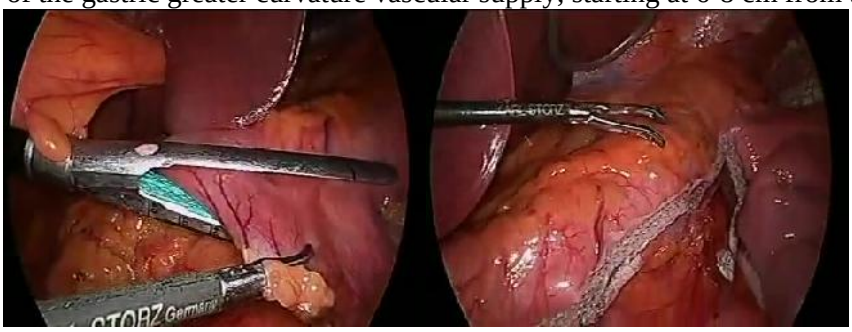


**Figure 2**: The division of the gastric greater curvature vascular supply, starting at 6-8 cm from the pylorus.



**B1** **B2**

**Figure 3**: The LSG is created using a linear stapler (Endo GIA)

## Results

Demographic distribution of the patients is summarized in table (1). The mean age was 30.7±7.1 years, average (18-44y). The mean pre-operative weight was 134.8±17.2 Kg (average 98-165 Kgs). The mean pre-operative body mass index was 46±4.8 Kg/m² (average 38-55 Kg/m²) and the mean excess weight was 67.85±15.48 Kg (average 45-95 Kg).

Table1: Demographic distribution of patients underwent Laparoscopic Sleeve Gastrectomy (LSG)

| Demographic data are described as mean ± SD (Range) | |
|---|---|
| **Age** | **30.7±7.1 (18-44)** |
| **Gender (Female/male)** | **52/8** |
| **Weight** | **134.8±17.2 (98-165)** |
| **BMI** | **46±4.8 (38-55)** |
| **Mean excess weight** | **67.85±15.48(45-95)** |

Obesity related morbidities are illustrated in table (2). 15/60 patients (25%) had hypertension and 20/60 (33.3%) had diabetes mellitus. Degenerative arthritis was found in 8/60 (13.3%) and sleep apnea was p10/60 patients (16.7%) had in sleeve gastrectomy group.

Table2: Associated Co-morbidities of patients underwent Laparoscopic Sleeve Gastrectomy (LSG)

| Co-morbid factors are described as number and percentage | |
|---|---|
| **Hypertension** | **15/60 (25%)** |
| **Diabetes mellitus** | **20/60 (33.3%)** |
| **Sleep apnea** | **8/60 (13.3%)** |
| **Degenerative arthritis** | **10/60 (16.7%)** |

The incidence of intra-operative complications is presented in table (3). Intra-abdominal bleeding occured in two patients (3.3%). It was due to injury of one of short gastric vessels in one patient. One patient (1.6%) were presented by tear in liver tissue mostly caused by liver retractor. In both cases bleeding stopped spontaneously. Staple line Failure was detected in two cases (3.3%). One case was due to stapling over Ryle tube detected intraoperatively and the patient was converted to open suturing of the staple line patient passed smoothly postoperatively. The other case was due to stapler malfunction and was detected in the first postoperative day and managed conservatively by applying endoscopic stent.

Table 3:Intra-operative complications for this procedure

| **Intra-operative complications are described as number and percentage** | |
|---|---|
| **Intra-abdominal Bleeding** | **2 (3.3%)** |
| **Injury to solid organ (liver tear)** | **1 (1.6%)** |
| **Staple line failure** | **2 (3.3%)** |
| **Injury to gastrointestinal tract** | **0** |

The incidence of early and late post-operative complications is illustrated in table (4). Two early and two late complications were encountered with no mortality occurred.

Early complications included leakage in one patient (1/60) (1.6%) arising from staple line of the stomach and fecal impaction in another patient (1/60) (1.6%). Staple-line leakage was successfully controlled by conservative measures by applying endoscopic mega stent. Fecal impaction in the other patient occurred 10 days postoperative due to inadequate fluid intake and required fecal disimpaction.

Late complications included vitamin B deficiency in one (1/60)(1.6%) and hepatic insufficiency in another one (1/60) (1.6%). The first patient presented with paraparesis 3 months postoperative. Neurological consultation was done and was diagnosed as subacute combined degeneration. The patient improved after intravenous vitamin B injections.. The other patient experienced sleepiness with elevated liver enzymes 4 months postoperative. The patient was known to have HCV. Hepatological consultation was done. Patient was diagnosed to have liver cell failure and hepatic encephalopathy. Patients improved after receiving anti-coma measures, plasma transfusion and hepatic supplements.

Table 4: Post-operative complions for the procedure

| **Post-operative complications are described as number and percentage** | | |
|---|---|---|
| **Early complications ( < 30 days)** | | |
| 1- | Staple-line leakage | 1(1.6%) |
| 2- | Fecal impaction | 1(1.6%) |
| 3- | Wound infection | 0 |
| 4- | Lung atelectasis | 0 |
| 5- | DVT & pulmonary embolism | 0 |
| 6- | Vomiting | 0 |
| **Late morbidity ( > 30 days)** | | |
| 1. | Hepatic decompensation | 1(1.6%) |
| 2. | Vitamin B deficiency | 1(1.6%) |
| 3. | Stenosis | 0 |
| 4. | Bile reflux | 0 |
| 5. | Bowel obstruction | 0 |
| 6. | No. of patients re-operated | 0 |
| 7. | Port-side hernia | 0 |
| 8. | Death | 0 |

Changes of mean weight, mean BMI, percentage of weight loss, percentage of excess weight loss are shown in table (5). Substantial weight loss occurred in all patients. Mean excess weight loss (EWL %) was 67.85 ± 3.75 at the end of second year. It can be seen that sleeve Gastrectomy shows significant mean excess weight loss.

Table 5: Weight loss parameters for 2 years after Sleeve Gastrectomy**.**

| | 0 Month | 3 Months | 6 Months | 9 Months | 12 Months | 18 Months | 24 Months |
|---|---|---|---|---|---|---|---|
| **Mean Weight (kg)** | **134.8±17.2** | **125.7±16.8** | **116.8±16.3** | **109.3±15.7** | **102.2±15.4** | **94.4±14.7** | **87.3±13.7** |
| **BMI (kg/m²)** | **46±4.8** | **42.87±3.8** | **40.75±6.1** | **38.15±5.78** | **36.88±5.51** | **32.2±6.54** | **30.62±7.94** |
| **Weight loss (%)** | **0** | **6.8±1.5** | **13.4±2** | **19±2.7** | **24.4±3.9** | **30.1±4.4** | **35.4±4.7** |
| **EWL (%)** | **0** | **13.41±4.56** | **26.52±3.7** | **37.85±3.24** | **48.04±4.34** | **59.54±5.67** | **67.85±3.75** |

Effect of Sleeve Gastrectomy on metabolic parameters are shown in table (6). Follow up of patients for 2 years after Sleeve gastrectomy caused significant reduction in Systolic Blood Pressure ( t = 2.1643, $p$ = 0.0329), Diastolic Blood Pressure ( t = 2.6055, $p$ = 0.0106), Fasting blood sugar ( t = 2.7140, $p$ = 0.0079), 2Hrs Post Prandial blood sugar ( t = 2.3645, $p$ = 0.0200), HbA1c ( t = 2.1941, $p$ = 0.0306), serum cholesterol ( t = 2.5987, $p$ = 0.0108), serum triglycerides ( t = 3.4078, $p$ = 0.0010), serum LDL ( t = 2.9247, $p$ = 0.0043) and serum uric acid ( t = 3.7999, $p$ = 0.0003). There were no significant difference regarding serum HDL ( t = 1.7859, $p$ = 0.0772) and serum VLDL ( t = 1.1198, $p$ = 0.2656).

Table 6: Changes of mean values of metabolic parameters before and 2 years after operation

| | Before Operation | 2 years After Operation | Significance |
|---|---|---|---|
| **Systolic Blood Pressure (mmHg)** | **141.10±12.51** | **135.71±12.25** | **Significant** |
| **Diastolic Blood Pressure (mmHg)** | **82.50±11.96** | **77.24±7.57** | **Significant** |
| **Fasting blood sugar (mg/dl)** | **194.26±50.15** | **170.94±34.30** | **Significant** |
| **2 Hrs Post Prandial blood sugar (mg/dl)** | **222.14±49.64** | **200.69±39.99** | **Significant** |
| **HbA1c (%)** | **8.854±1.679** | **8.196±1.273** | **Significant** |
| **Cholesterol (mg/dl)** | **266.62±53.62** | **242.69±36.12** | **Significant** |
| **Triglycerides (mg/dl)** | **243.76±98.00** | **185.67±68.75** | **Very Significant** |
| **LDL (mg/dl)** | **138.82±38.08** | **117.78±33.30** | **Very Significant** |
| **HDL (mg/dl)** | **47.44±12.49** | **52.00±12.92** | **Non Significant** |
| **VLDL (mg/dl)** | **40.80±12.71** | **37.86±13.43** | **Non Significant** |
| **Uric acid (mg/dl)** | **7.71±2.31** | **6.22±1.50** | **Very Significant** |

The rate of complete resolution of co-morbidities is shown in table (7). Follow up of patients for 2 years after Sleeve gastrectomy caused a highly significant resolution of Hypertension in 73.3% of patients ($p$ = 0.001) and a highly significant resolution of Diabetes Mellitus in 80% of patients (p = 0.001).

Table 7: The rate of complete resolution of co-morbid factors 2 years after Sleeve Gastrectomy

| Co-morbid Factors | | After 1 year | *P* value | Sig | After 2 years | *P* value | Sig |
|---|---|---|---|---|---|---|---|
| Hypertension N=15 | Cure | 8/15 (53.3%) | 0.008 | HS | 11/15 (73.3%) | 0.001 | HS |
| | No cure | 7 (46.6%) | | | 4 (26.6%) | | |
| Diabetes Mellitus N=20 | Cure | 11/20 (55%) | 0.001 | HS | 16//20 (80%) | 0.001 | HS |
| | No cure | 9 (45%) | | | 4 (20%) | | |

Figure 4: Follow up changes in mean BMI after Sleeve Gastrectomy over 2 years

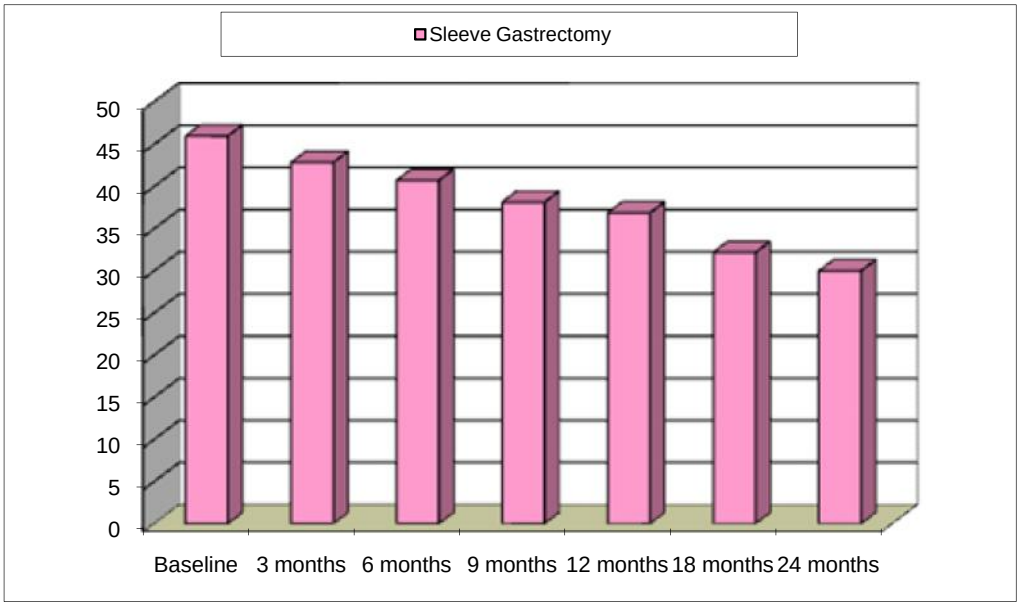



Figure 5: Postoperative percentage of weight loss after Sleeve Gastrectomy over 2 years

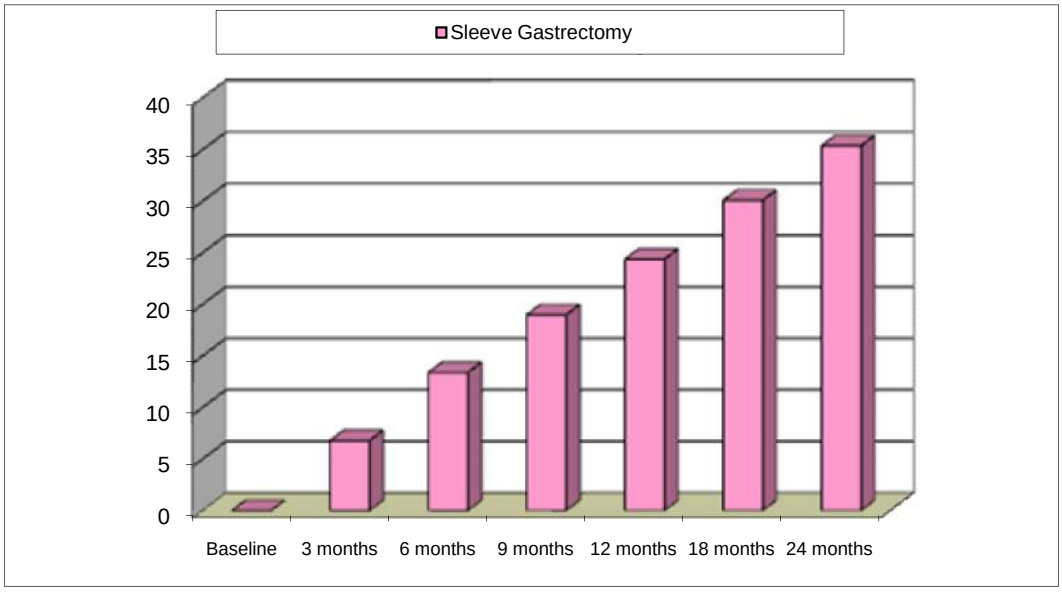


Figure 6: Postoperative Excess weight loss (EWL) after Sleeve Gastrectomy over 2 years.

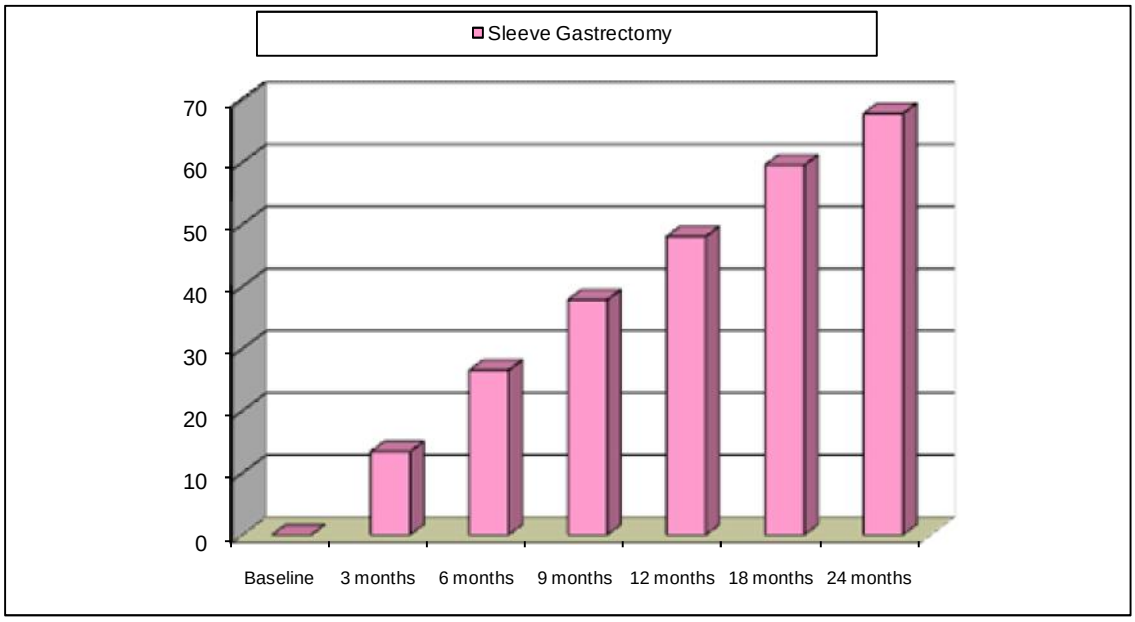
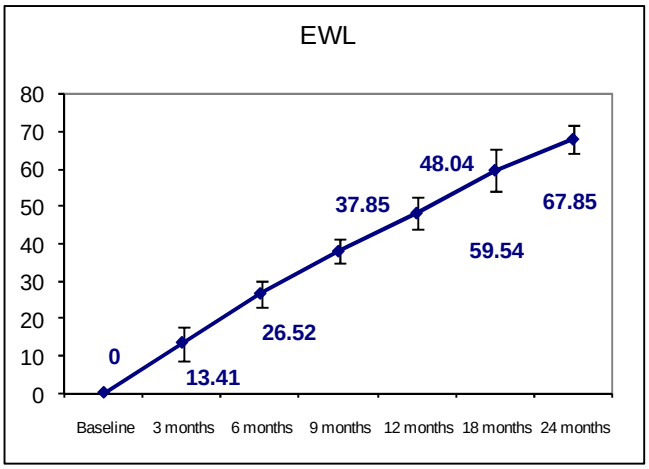
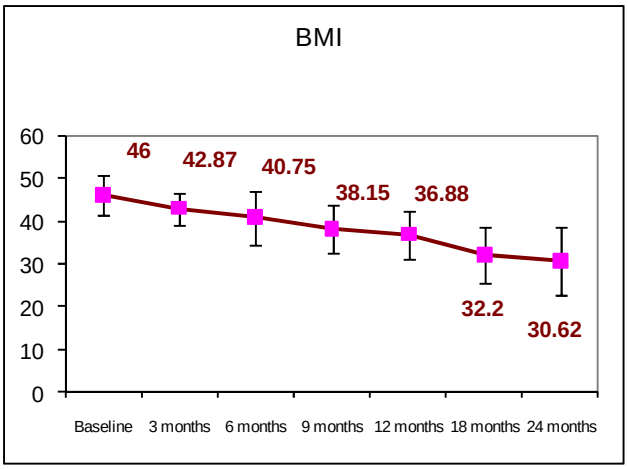



Figure 7: Postoperative EWL and BMI after Sleeve Gastrectomy over 2 years




## Discussion

It is generally accepted that there is no ideal bariatric operation and that the bariatric surgeon should choose the most appropriate procedure for each individual patient based on specific selection criteria by creating a flexible treatment algorithm (7). Restrictive procedures are generally considered safe and quick to perform, and usually lead to satisfactory short-term weight loss results (8). Laparoscopic Sleeve gastrectomy (LSG) originally proved to be a beneficial procedure for interval weight loss as the first stage of a two-staged bypass procedure (3). More recently, LSG is showing promise as a primary bariatric procedure for appropriate candidates (9).

Wiener et al. noted that LSG is not a simple procedure, and owing to the fact that the procedure is irreversible, surgeons should strive to avoid complications (14). The reported incidence of staple line dehiscence after LSG ranges from 0% to 5.5% and with overall complication rates ranging from 0% to 24% (10). In this study, the incidence of staple line dehiscence after LSG was (3.3%).

It has been evident that in LSG a subgroup of patients do regain weight after the year, and the authors speculate that this proportion will rise with a longer follow-up. Dilatation may be the first cause of failure (11). It may be a result of an excessively large pouch being created at the initial operation because of missed posterior gastric folds (12). Baltasar and colleagues reported excess body weight loss (EWL) of 56% (4–27 months after LSG) in the super obese group (15). It is proved in this study during follow up for 2 year post-operative that LSG achieved mean excess weight loss (67.85%).

In a Korean study, the excess weight loss from sleeve gastrectomy was 71.6% at 6 months and 83.3% at 1 year. When defining the success of surgery in Korea, the patient's postoperative dietary habits and long-term follow-up visits play important roles in weight loss. Koreans consume mainly carbohydrates and less protein and fat, so they tend to dine under pressure due to Confucianism which leads to fast eating and the meal (appetizer, main course, drinks) is served at once on one table not in courses (13).

There was no uniform definition of how patients were identified as having obesity-related comorbidities. Moreover, definitions of "resolution" or "improvement" or "better control" were also heterogeneous. However, most studies indicate that bariatric procedures improve or resolve many of the obesity-related comorbidities (15); hypertension (HT), insulin resistance (IR), type2 diabetes mellitus (T2DM), hyperlipidemia (HL), obstructive sleep apnea (OSA), and muscular and joint pain. In this study the rate of complete resolution of co-morbidities (hypertension and diabetes mellitus) was 73.3% and 80% respectively for 2 years follow up.

In this study, Follow up of patients for 2 years after Sleeve gastrectomy caused complte resolution of Hypertension in 73.3% of patients. significant reduction in Systolic and Diastolic Blood Pressure. There have been many recent studies that have shown improvement or resolution of hypertension following LSG. A multi-center study by Sanchez et al (21) found that hypertension was improved in 63% of LSG patients. Hutter et al (22) conducted a prospective study on 944 patients and reported that 68% had improvement or resolution of hypertension at one year follow up. In another cohort study, Basso et al (23) found that out of 100 high-risk super obese patients with a mean BMI of 54.4 kg/m2 had complete resolution of their hypertension in 62% of cases.

Obesity and the presence of adipose tissue have been associated with increased blood pressure. The precise pathophysiology to the development of hypertension in obese patients is currently unknown. However, there are several factors involved in obesity-related hypertension. It has been postulated that in the obese, activation of the renin-angiotensin-aldosterone system (RAAS) and sympathetic nervous system may contribute to high blood pressure (17). Estimates of up to 70% of hypertension in adults may be directly caused by adiposity (18). It has also been postulated that obesity-related hypertension may be in part due to increased renal sodium retention and impaired pressure naturesis (19). Recent evidence has suggested that adipocytes releasing neuroendocrine hormones may impact arterial pressure (20).

In this study, Sleeve gastrectomy caused a significant reduction in Fasting blood sugar, 2Hrs Post Prandial blood sugar and HbA1c. Complete resolution of Diabetes occurred in 80% of the patients. These results were in agreement with those of Gill et al who concluded that DM had resolved in 66.2% of the patients underwent LSG, improved in 26.9%, and remained stable in 13.1%. The mean decrease in blood glucose and hemoglobin A1c after sleeve gastrectomy was -88.2 mg/dL and -1.7%, respectively (16). Moreover, Abbatini et al. showed a 80.9% resolution of T2DM after LSG over a 3-year follow up (25). Vidal et al. presented a resolution of HbA1c levels below 6.5% in 94.6% at 1-year followup (26)

The mechanism of T2DM resolution after sleeve gastrectomy is widely discussed. Some believe that hormonal regulation plays a key role. In this regard, Peterli et al. measured higher GLP-1 levels following ISG (27). This stimulation may be caused by a progressed gastrointestinal passage after sleeve gastrectomy. Comparison of small bowel transit time from patients after LSG to controls showed a significant reduction in transit time from 298.1 ± 9.2 to 199 ± 65.7 minutes (28).

In this study, Follow up of patients for 2 years after Sleeve gastrectomy caused significant reduction in serum cholesterol, LDL and triglycerides. These results agree with those of Khalid et al, who conducted a systematic review including 26 studies and

concluded that LSG resolved or improved hyperlipidemia in a majority of patients. 83.5% of patients had improvement of their hyperlipidemia and 54% experienced complete resolution of their hyperlipidemia. There was reduction in mean levels of serum cholesterol, LDL and triglycerides with elevation in mean level of serum HDL (29). Researchers argued that the decrease in serum cholesterol and LDL observed in patients undergoing LSG could be related to the malabsorption effect produced by this technique. This hypothesis is supported by several data (30)

## Conclusion

We recommend the use of Laparoscopic Sleeve Gastrectomy as it is accepted as a first-line treatment for the super-obese (body mass index > 50–55 kg/m2), before attempting more complicated procedures. In addition, it can be used as a stand-alone definitive therapy for morbid obese patients. It offers the advantages of a simple and reproducible technique with good outcome and low morbidity and mortality with high rate of resolution of obesity related co-morbidities as hypertension, diabetes mellitus, hyperlipidemia and hyperuricemia.

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