EFFECTS OF LAPAROSCOPIC SLEEVE GASTRECTOMY ON GLYCAEMIC CONTROL: A 2 YEAR FOLLOW UP STUDY

Ramya M Vishweshwara∗,1, Mallikarjuna Manangi∗, Santhosh C S∗ and K Seshagiri Rao∗

∗Department of General Surgery, Bangalore Medical College and Research Institute, Fort, K R Road, Bangalore 560002.

ABSTRACT Introduction: Bariatric Surgery is known to cause resolution of comorbidities associated with obesity. While laparoscopic Roux-en-Y gastric bypass has well documented positive results on the resolution of type 2 diabetes, variable data exists regarding the effects of Laparoscopic Sleeve Gastrectomy on glycaemic control. We herein present our results on the impact of Laparoscopic Sleeve Gastrectomy on glycaemic control over 2 years. Methods: A prospective study was undertaken on patients undergoing Laparoscopic Sleeve Gastrectomy for morbid obesity from October 2017 to February 2019. Patients with diabetes and prediabetes were included in the study. Data consisting of demography, anthropology and investigations were collected and analysed. The effect on the glycaemic profile was studied. Results: Among the 44 obese patients, 14 were prediabetic, and 30 were diabetic. Preoperatively, the mean HbA1c and FBS were 7.74% and 120.5 mg/dl, respectively. Evaluation of postoperative glycaemic control for all diabetic patients showed that mean HbA1c changed from 7.74% preoperatively to 6.40%, 5.82%, 5.44%, and 5.32% at 3, 6, 12, and 24 months post LSG, respectively. Complete remission identified as Fasting Blood Glucose <100mg/dl, HbA1c < 6%, and medications for at least 1 year after surgery was observed in 86.66% (26/30) patients. Conclusion: Laparoscopic Sleeve Gastrectomy seems to provide a promising effect on glycaemia and reduce intake of diabetic medications. However, further long-term studies are needed to evaluate prolonged diabetic remission.

KEYWORDS Laparoscopic Sleeve Gastrectomy; Morbid Obesity; Diabetic Remission; Bariatric Surgery

Introduction

Obesity is a major independent risk factor for developing diabetes, and more than 90% of type 2 diabetics are overweight or obese.[1] Bariatric Surgery offers an effective treatment for T2DM (Type 2 Diabetes Mellitus) and Obesity.[2] Modest weight loss, as little as 5% of total body weight, can help to improve T2DM in patients who are overweight or obese.[3]

Buchwald et al., in their meta-analysis, found that T2DM was completely resolved in 76.8% of patients and resolved or improved in 86.0% who underwent Bariatric Surgery.[4] Philip R. Schauer et al., in the study comparing the metabolic effects of Bariatric Surgery combined with intensive medical therapy alone in 60 patients with uncontrolled T2DM and moderate obesity, demonstrated that glycaemic control improved in patients who underwent surgery.[5]

While laparoscopic Roux-en-Y gastric bypass (RYGB) has well documented positive results on the resolution of type 2 diabetes, data regarding diabetes remission following Laparoscopic Sleeve Gastrectomy (LSG) are variable amongst authors.

Zachariah et al., in a 5 year follow up study of 228 patients treated with LSG, found that resolution of diabetes was 66%.[6] In a systematic review conducted by Shelley et al. found no significant difference in T2DM remission between RYGB (81%) and LSG (80%) at 36 months.[7] Whereas in a systematic review by
Hayoz Christelle et al., there was a better outcome with RYGB, with lower mean fasting glucose levels at 24 months (MD -16.92 mg/dl, 95% CI -21.67 to -12.18), 36 months (MD -5.97 mg/dl, 95% CI -9.32 to -2.62) and lower mean glycated haemoglobin at 12 months (MD -0.47%, 95% CI -0.73 to -0.20%; p <0.001) and at 36 months postoperatively compared to LSG.[8]

Although LSG has become one of the most popular bariatric surgeries, sufficient information regarding the long-term effects is still limited. Therefore, this study evaluates the impact of Laparoscopic Sleeve Gastrectomy on glycaemic control over 2 years.

**Methodology**

A prospective study was undertaken on patients admitted to the Department of General Surgery of a Government Medical College Hospital for Laparoscopic Sleeve Gastrectomy between October 2017 to February 2019.

**Ethical committee Clearance**

Approval from the Institutional Ethical Committee was taken before the study.

**Informed consent**

Informed consent was taken from the patients to undergo the procedure and participate in the study.

After obtaining the Institutional Ethical Committee clearance and written informed consent, the patients who underwent laparoscopic sleeve gastrectomy were enrolled into the study.

Patients between age groups of 18 - 65 years, diagnosed as obese with body mass index (BMI) of > 35 kg/m2 with co-morbidities or BMI > 40 kg/m2 irrespective of co-morbidities, were included in the study. In addition, patients with prediabetes (Fasting Plasma Glucose 100-125 mg/dl, 2-h Post Prandial Plasma Glucose 140-199 mg/dl, HbA1C 5.7–6.4%)[9] and diabetes mellitus type 2 (Fasting Plasma Glucose ≥126 mg/dl, 2-h Post Prandial Plasma Glucose ≥200 mg/dl, HbA1C > 6.4%)[9] with or without pharmacological therapy were enrolled into the study.

Patients with prior history of bariatric surgery deemed unfit for surgery and patients with a history of malignancy were excluded from the study.

**Perioperative Management**

All patients who were planned for Laparoscopic Sleeve Gastrectomy underwent routine blood investigations (along with S. Cortisol, S Thyroid Profile, S Lipid Profile), Nutritional work up (S Iron Profile, Vit D/B 12, S Calcium), Diabetic work up (FBS, PPBS, HbA1c), UGI endoscopy, Radiological (Chest X-Ray PA view, Ultrasound Abdomen and Pelvis, B/L Lower Limb DVT screening) investigations. After consulting with the dietician, all included patients were subjected to a preoperative diet of 1000 kcal for 10 days immediately prior to surgery. After consultation with a Psychiatrist, Physician, Cardiologist, Pulmonologist (that included Pulmonary Function Test, 6 min walk test, Sleep study as and when advised) and pre-anesthetic evaluation, patients were posted for Laparoscopic Sleeve Gastrectomy. The inferior border of the Liver was marked using ultrasound to decide initial port placement. Mechanical DVT prophylaxis was practised by crepe bandage application to both lower limbs. LMWH was given preoperatively and for 3 days postoperatively. The surgery was carried out with the patient in a French position, strapping lower limbs and chest. With intravenous Cephalosporin prophylaxis, the procedure was carried out with a team consisting of a surgeon, assistant surgeons/residents and a scrub nurse with constant monitoring from an anaesthetist. 3 ports were used, and whenever liver retraction was required, or difficulty was encountered in reaching fundus, 1 or 2 rescue ports were used.

All patients were motivated to ambulate the same day. Patients were allowed the next day orally and discharged on average 3rd postoperative day. Patients were advised with calcium, multivitamin and vitamin D supplements. Patients were advised to adhere to the diet and regular follow-up at 1 month, 3 months, 6 months, 12 months, and 2-year intervals. They were monitored for nutritional deficiencies with an evaluation of Hemogram, Serum Calcium, Vit D, Iron profiles at regular intervals. Diabetic workup followed by appropriate antidiabetic medications as per physician’s advice was provided.

Data consisting of demographic details, anthropometry (Height, Weight, BMI), preoperative investigations (Fasting Blood Sugar, Postprandial Blood Sugar, HbA1C) was recorded and follow-up was done for a 2-year postoperative period. % EWL(%Excess Weight Loss) was noted and was calculated using the formula: (weight loss/baseline excess weight) X100, where excess weight = initial weight – ideal weight (ideal weight = 25 kg/m2).[10]

**Statistical Analysis**

Data entered in Microsoft Excel and exported into SPSS version 20.0.

Data is analyzed by descriptive statistics such as mean, standard deviation, percentages, tables and graphs. The student’s t-test is used to determine significant differences. Pearson correlation coefficient (r) is used to determine the relationship between qualitative variables. p-value < 0.05 is considered statistically significant.

**Results**

44 obese patients with abnormal glycaemia who underwent Laparoscopic Sleeve Gastrectomy during the study period were included after taking informed consent. The mean age group was 37.5 years, ranging from 59 years being the highest to 25 years being the lowest. The majority of the patients were females (n = 39), amounting to 88.63% of the study population, with men representing 22.72% (n = 5).

**Mean preoperative glycaemic parameters**

The mean preoperative glycaemic parameters in the study population are depicted in Table 1.

**Correlation between obesity and glycaemic parameter**

Statistically significant (at 0.05 level), a positive correlation (r = 0.365, p = 0.047) was observed between mean preoperative BMI and HbA1c.

**Diabetic profile of the study population**

Figure 1 represents the diabetic profile of the participants.

**Weight and body mass index**

Table 2 depicts the mean weight and BMI of the study population over the follow-up period.
Table 1 Mean Preoperative glycaemic parameters

| Parameters     | Mean  | SD    |
|----------------|-------|-------|
| FBS (mg/dl)    | 120.5 | 44.53 |
| PPBS (mg/dl)   | 179.06| 60.72 |
| HbA1C (%)      | 7.74  | 1.89  |

Table 2 Mean Pre Operative and Post Operative Weight and BMI

| Preoperative | Mean Weight (kg) | Mean BMI (kg/m²) |
|--------------|-----------------|-----------------|
| Pre diet     | 111.86          | 45.54           |
| Post diet    | 107.26          | 43.80           |

| Post operative | Mean Weight (kg) | Mean BMI (kg/m²) |
|----------------|-----------------|-----------------|
| 15 days        | 101.86          | 41.85           |
| 1 month        | 96.33           | 39.58           |
| 3 month        | 92.66           | 38.07           |
| 6 month        | 87.3            | 35.64           |
| 1 year         | 81.58           | 33.52           |
| 2 year         | 78.36           | 32.05           |

Figure 1 Diabetic profile of study population *Oral Hypoglycaemic Agents

Glycaemic control

a. At 1 month
A statistically significant difference was observed between mean preoperative and postoperative glycaemic parameters (FBS - 120.50 ± 44.53mg/dl vs 100.43±32.23 mg/dl, p=0.0001).

b. At 3 months
Statistical significance was observed between mean baseline and 3rd month glycaemic parameters (FBS - 120.50 ± 44.53mg/dl vs 100.43±32.23 mg/dl, p=0.0001; HbA1c - 7.74 ± 1.89 vs 6.40±1.17,p=0.001).

HbA1c returned to normal glycaemic levels (< 6.4%) in 23 (76.6%) patients and markedly improved (HbA1c < 7%) in 7 (23.3%) patients at 3 months postoperatively and the mean HbA1c reduced from 7.74% to 6.40%.

c. At 6 months
Mean baseline and 6-month values of glycaemic parameters shows statistical significance (Table 3).
For an average excess body weight loss of 42.76%, HbA1c reduced by 1.91% in the study population at 6 months of postoperative period (Figure 2).

d. 1 year
The mean HbA1c decreased from 7.74% to 5.44%, and mean FBS decreased from 120.50mg/dl to 76.33 mg/dl over 1 year and is statistically significant (Table 4, Figure 3).
Table 3 Glycaemic parameters at 6 month

|                      | Preoperative (Mean±SD) | 6 month (Mean±SD) | p      |
|----------------------|------------------------|-------------------|--------|
| HbA1c (%)            | 7.74 ± 1.89            | 5.82 ± 0.75       | 0.0001*|
| FBS (mg/dl)          | 120.50 ± 44.53         | 82.03 ± 8.94      | 0.0001*|

Table 4 HbA1c and FBS at 1 year

|                      | Preoperative (Mean±SD) | 1 year (Mean±SD) | p      |
|----------------------|------------------------|------------------|--------|
| HbA1c (%)            | 7.74 ± 2.61            | 5.44 ± 0.80      | 0.0001*|
| FBS (mg/dl)          | 120.50 ± 55.39         | 76.33 ± 5.88     | 0.0001*|

Diabetic profile

The patients who had diabetes at baseline were 30 in number.

A) Number of diabetic patients on treatment was found to be 18.

1) 8 patients were on Insulin therapy preoperatively.
   - 8 patients who were on Insulin were put on BD dose of OHA, and eventually, 6 patients were off medications at 2 years follow up. However, 2 patients were on OHA.

2) 10 patients were on OHA.
   - 4 patients were on regular treatment with OHAs for 2 years, 3 patients from 1 year and 2 patients were on irregular treatment with OHA from 2 years and 1 patient from 8 months.
   - These 10 patients on OHA had a reduction in intake of oral hypoglycaemic agents. 70% (n = 7) reduced to a single dose of OHA, and 30% (n = 3) were off medications at the end of 3 months. All patients were off medications at the end of 6 months and remained euglycemic at 2 years without medications.

B) 27.23% of patients (n = 12) among the study population who were newly detected diabetics were put on antidiabetic treatment as advised by a physician. At 6 months, 9 patients were off medications, and 3 were on OHA. All patients except for 2 remained euglycemic without medications at 2 years follow up.

C) 31.81% (n = 14) patients who were found to be prediabetic had their glycaemic parameters reduced to euglycaemia at the end of 3 months and remained euglycaemic at 2 years follow up.

Remission

Complete remission (Fasting Blood Glucose < 100mg/dl, HbA1c < 6% and off medications for at least 1 year after surgery) was observed in 86.66% (26/30) patients at 2 years follow up.
Discussion

The resolution of diabetes following bariatric surgery is immensely studied, and growing evidence is being extensively documented. A treasure of data from observational and retrospective studies attests to the efficacy and safety of metabolic surgery. However, many efforts have been made to define the exact position of surgery in the treatment algorithm for T2DM in both morbidly obese and less obese individuals. Though bariatric surgery has been confirmed to be beneficial in remission of abnormal glycaemia,[11,12] obesity remains the yardstick for performing bariatric surgery than abnormal glycaemia. Unfortunately, clear-cut guidelines on neither bariatric surgery for T2DM nor the type of surgical procedure have been formulated.

Though promising long-term effects on weight reduction and improvements in glucose homeostasis was observed following LRYGB and BPD, the wide acceptance of the procedures was obtuse because of numerous early and late complications, high risk of malnutrition and technical difficulties. LSG, however, is increasingly being accepted for simplicity of its technique, lesser-known postoperative complications and resolution of comorbidities along with weight reduction.[13,14]

Many studies have compared the results of LSG with other procedures. However, they have come up with confusing data. Convincing results of glycaemic control have been documented following LSG,[15,16] Gill et al.[17], who conducted a systematic review analysing 27 studies with 673 patients and an average follow-up period of 13.1 months, reported a mean decrease of -1.7% in HbA1c after sleeve gastrectomy. At par with this study, our study showed a decrease of 2.30% in mean HbA1c at a 1-year postoperative period.

Similar to the study by Abdelbaki et al.,[18] who reported that the preoperative mean glycated haemoglobin (7.8%) and mean FBS (155.8 mg/dl) reduced to 5.8% and 98.1mg/dl respectively at 2 years follow-up period, in our study baseline mean HbA1c and mean FBS reduced from 7.74% to 5.32% and 120.5 mg/dl to 74.20mg/dl respectively at 2 years follow up.

Interestingly, the association of weight loss with glycaemic control was recognised in our study. For an average excess body weight loss of 42.76%, HbA1c reduced by 1.92% in a span of 6 months postoperatively in contrast to observations that of Milone et al.[19] where the percent change in BMI did not correlate with changes in glycaemia and HbA1c.

Bariatric surgery has evolved to be recognised as metabolic surgery. Concerning T2DM, the most important issue in assessing the metabolic effects of bariatric surgery is the criteria for diabetes remission. Unfortunately, conflicting definitions about diabetes remission are available in literature by different authors, paving the way for considerable biases in elucidating results and thus can explain the differences found in the literature regarding remission of diabetes.

A consensus group comprised experts in endocrinology, diabetes education, transplantation, metabolism, bariatric/metabolic surgery, and (for another perspective) haematology-oncology defined Remission as achieving glycemia below the diabetic range in the absence of active pharmacologic or surgical therapy. Remission can be categorised as partial or complete. Partial remission is sub-diabetic hyperglycaemia (AIC not diagnostic of diabetes [6.5%], fasting glucose 100-125 mg/dl [5.6-6.9 mmol/l]) of at least 1 year’s duration in the absence of active pharmacologic therapy or ongoing surgical therapy. Complete remission is a return to “normal” measures of glucose metabolism (AIC in the normal range, fasting glucose 100 mg/dl [5.6 mmol/l]) of at least 1 year’s duration in the absence of active pharmacologic therapy or ongoing procedures. Prolonged complete remission is defined in the same context at a minimum 5 years’ duration.[20]

According to this new definition, Pournaras et al. reported that only 26% (5 of 19 patients) complete remission after a median of 23 (range 12–75) months in 19 patients with type 2 diabetes who underwent bariatric surgery. On the other hand, [21] Abbitini et al.,[22] in their study came across complete remission of diabetes (HbA1c < 6% without medications) in 84.6% patients (22 out of 26 patients) who completed 36 months follow up. Our study found that 86.66% (26/30) patients had FBS < 100mg/dl and HbA1c < 6% at 2 years follow-up interval indicating complete remission for 18 months. However, to determine prolonged complete remission, longer follow-up data is required, and our patients are under follow up for the same.

Conclusion

LSG benefits with significant improvement in glucose homeostasis along with considerable weight loss. Laparoscopic sleeve gastrectomy can be an appropriate procedure for obesity with type 2 diabetes mellitus. Further long term studies are needed to validate our results.

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