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# Effectiveness and safety of sleeve gastrectomy and adjustable gastric banding in morbidly obese patients single centre study

## Skuteczność i bezpieczeństwo rękawowej resekcji żołądka i regulowanej opaski żołądkowej u pacjentów otyłych w badaniu jednoośrodkowym

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**Abstract**

**Introduction:** This retrospective study aimed to compare short- and long-term outcomes between laparoscopic sleeve gastrectomy (SG) and laparoscopic adjustable gastric banding (LAGB).

**Material and methods:** This retrospective one-centre study included patients who underwent bariatric surgery in the form of LAGB and SG.

**Results:** %BMIL was significantly higher in the SG group than in the LAGB group during postoperative follow-up months ($p < 0.001$). LAGB patients had a lower %EWL compared to SG at each postoperative follow-up month ($p < 0.05$). After LAGB, 25.0% patients had %EW ≥ 50%; in the LSG group, 44.8% patients achieved %EWL ≥ 50% ($p < 0.0001$). The LAGB group's %EWL ≥ 50 was dependent on BMI before operation ($p = 0.049$). There are no postoperative complications after LAGB. A total of 221 patients in the SG group 6 (2.7%) had postoperative surgical complications within 30 days after surgery. Postoperative complications in the long term were significantly higher for LAGB than for LSG ($p = 0.0062$). Reoperation was performed in 16 (7%) patients after LAGB compared to 2 (0.9%) patients after LSG.

**Conclusions:** LSG is a more effective procedure than LAGB, contributing to greater improvement of weight loss. LAGB is associated with lower surgery-related complications in the early postoperative period, but long-term outcomes contributing to a higher late complication rate led to a higher reoperation rate than SG procedure.

**Key words:** sleeve gastrectomy, adjustable gastric banding, obesity

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## Introduction

The prevalence of obesity worldwide has rapidly increased over the last three decades [1]. The worldwide age-standardized prevalence of obesity has increased from 3.2% to 10.8% in men and from 6.4% to 14.9% in women [2]. At the same time, 2.3% of the world's men and 5% of women are severely obese. Obesity is a major public health concern. Excess body weight is an important risk factor for mortality due to the increased risk for cardiovascular diseases, diabetes, and cancers, and it causes nearly four million deaths annually worldwide [3]. Weight loss surgery is the most effective treatment for morbidly obese patients and obesity-associated comorbidities [4, 5]. There is a recent study showing that weight loss surgery, including restrictive and malabsorptive procedures, is associated with reduced mortality and obesity-related comorbidities compared to medical treatment [6, 7]. The number of bariatric procedures is still growing because of good surgical outcomes associated with excellent weight loss outcomes, the safety of the surgical procedure and the beneficial effects on comorbidities [8].

Recent data indicate that laparoscopic sleeve gastrectomy (SG) is one the most performed surgical procedures for treating obese patients worldwide, with weight loss and complication rates [9] comparable to those of gastric bypass (LRYGB) [10, 11]. Laparoscopic adjustable gastric banding (LAGB) is the most popular bariatric procedure because of its simplicity and a lower rate of early complications, but due to its long-term weight loss record and high rate of complications and reinterventions, it has become a less popular procedure than LRYGB and SG [12, 13]. On the other hand, recent literature has shown successful long-term weight loss results with acceptable complication rates and lower reinterventions with LAGB [14, 15].

This retrospective study aimed to compare short- and long-term weight loss between SG and LAGB as well as evaluate data related to procedure outcomes and reoperation rates.

## Materials and methods

This retrospective one-centre study included patients who underwent bariatric surgery in the form of LAGB and SG. Initially, 507 patients were analysed. From the analysis, 49 patients were excluded because of a leak during follow-up, and 9 patients had incomplete postoperative data. A total of 449 patients were included and followed for 4 years with complete pre- and postoperative data. Of these patients, 228 underwent laparoscopic adjustable gastric gastrectomy, and 221 underwent laparoscopic sleeve gastrectomy. Baseline characteristics of the population, such as age, sex, body mass, BMI and comorbidities, were extracted. The primary outcome was weight loss, % BMI and %EWL during follow-up. Secondary outcomes were early and late complications resulting from the surgical procedures. Any of the following events were considered major in the early postoperative period: the need for transfusion of at least 2 units of red blood, bleeding leading to reoperation, complications leading to reoperation or readmission, or death. Surgical complications were evaluated in the hospitalization period and post-operation during the follow-up period. Early complications were defined as complications occurring < 30 days after surgery, while late complications occurred more than 30 days after surgery and needed a secondary bariatric procedure or readmission. Weight loss efficiency was documented as the change in body mass, BMI, percentage of BMI lost (%BMIL) and excess weight lost (%EWL) from preoperatively to 1, 3, 6, 12, 18, 24, 36, and 48 months postoperatively. The number (percentage) of patients in follow-up after 1, 3, 6, 12, 18, 24, 36, and 48 months was 382 (85%), 314 (69,9%), 328 (73%), 225 (50%), 153 (34%), 192 (42%), and 83 (18,5%), respectively. The good result of the operation was defined as %EWL $\geq$ 50%.

The study protocol was accepted by the ethical committee of the Medical University of Silesia. Written consent was not needed for this retrospective study. All procedures performed in studies involving human participants were following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

### Surgical procedures

LAGB was performed by the pars flaccida technique. The first step was exposing the His angle. The gastric fundus was retracted inferiorly, and covering fat was dissected until the left crus of the diaphragm was exposed. Second, a small incision in the gastrohepatic ligament opened the lesser omentum, and retro gastric space for the band was created from the right to the left branch of the crus to the angle of His. The band was implanted around the gastroesophageal junction and fixated using 4 stitches.

LSG was performed according to the commonly used technique. Greater curvature vessels were divided. A longitudinal resection of the stomach was created using a linear cutting stapler beginning from the point 5 to 6 cm proximal to the pylorus and continuing to the angle of His, tightly abutting the bougie (36-French) that was placed transorally into the pyloric channel along the lesser curvature.

## Statistical analysis

Continuous variables are presented as the means ± s.d. or, if not normally distributed, the medians with interquartile ranges. Categorical variables are presented as absolute numbers and percentages. The Anderson-Darling test was used for all continuous variables to test for their normal distribution. Differences between the morbidly obese and control groups before surgery were assessed using the unpaired Student's t-test or, for nonnormally distributed data, the Mann-Whitney U-test. The $\chi^2$ test was performed to compare differences among the categorical data. Differences in each paired variable at all time points after surgery were calculated by analysis of variance (ANOVA) Friedman tests with acceptance of lack of data (Skillings-Mack test), followed by the Dunn-Bonferroni post hoc test.

Independent predictors of weight loss were determined with a multivariate regression model using the stepwise selection of included parameters, with an entry criterion of $P < 0.1$. Variables considered to be potential predictors for multivariate modelling were identified with univariate analyses and subsequently selec-

**Table I. The baseline characteristics of the study population**

| | LAGB (n = 228) | SG (n = 221) | P |
|---|---|---|---|
| Age [years] | 41.4 ± 10.1 | 46.2 ± 10.7 | < 0.0001 |
| Weight [kg] | 120.0 (20.0) | 140.0 (30.0) | < 0.0001 |
| BMI [kg/m²] | 42.6 (5.5) | 48.4 (6.4) | < 0.0001 |
| Sex (% female) | 180 (78.9) | 142 (64.3) | 0.005 |
| Smoking (%) | 28 (12.3) | 30 (13.6) | 0.683 |
| Hypertension (%) | 90 (39.5) | 132 (59.7) | < 0.0001 |
| Diabetes mellitus (%) | 56 (24.6) | 64 (29) | 0.292 |
| Hyperlipidemia (%) | 12 (5.3) | 12 (5.4) | 0.937 |
| Coronary artery disease (%) | 5 (2,2) | 10 (4.5) | 0.266 |
| Hypothyreosis (%) | 23 (10.1) | 27 (12.2) | 0.473 |
| Gallstone (%) | 12 (5.2) | 18 (8.1) | 0.532 |
| Sleep apnoea (%) | 33 (14.5) | 31 (14.0) | 0.921 |

LAGB — laparoscopic adjustable gastric banding; SG — laparoscopic sleeve gastrectomy

ted with stepwise backward selection. Variables that showed strong intercorrelations with covariates were excluded from the multivariate regression model. A regression analysis was performed for the following covariates: sex, age, BMI, comorbidities and type of operation. A P value < 0.05 was considered to be significant. This statistical analysis was performed using Statistica 13 (StatSoft Inc., Tulsa, OK, USA).

## Results

A total of 449 patients were included: 228 patients underwent LAGB, and 221 patients underwent SG. The baseline characteristics of both groups are presented in Table I. Patients who underwent SG were older, had higher BMI and more often suffered from hypertension. In the LAGB group, there were more women compared to the SG group (80% vs. 64%). Other comorbidities had the same rates in both groups of patients. The mean percentage of weight loss in the follow-up after LAGB was 23.3% and after SG was 31.4%. At the 48-month follow-up, the rates after LAGB and SG were 21.7% and 28.6%, respectively. Both operations led to reduced %BMIL and %EWL, but SG was more effective than LAGB. %BMIL was significantly higher in the SG group than in the LAGB group during all postoperative follow-up months ($p < 0.001$), except 48 months, when %BMIL tended to be higher after SG ($p = 0.08$, Table II). Similar results were obtained for %EWL, and the LAGB patients had lower %EWL compared to SG at each postoperative follow-up month (Table II, $p < 0.05$ for each time point). A %EWL ≥ 50% was achieved in 156/449 patients (34.7%). After LAGB, 57 (25.0%) patients had %EWL ≥ 50%; in contrast, in the LSG group, 99 (44.8%) patients achieved %EWL ≥ 50% ($p < 0.0001$). The results of %EWL ≥ 50 based on preoperative BMI and operation type are presented in Table III. The SG group %EWL ≥ 50 was independent of

**Table II. Weight loss outcomes in the form of %BMIL and %EWL in follow-up**

| %BMIL | | | 1M | 3 M | 6M | 12M | 18M | 24M | 36M | 48M | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | LAGB (n = 228) | n | 195 | 162 | 171 | 106 | 101 | 59 | 70 | 44 | |
| | | %BMIL | 7.5 | 11.6 | 13.9 | 14.1 | 15.2 | 16.8 | 18.5 | 17.7 | < 0.001 |
| | SG (n = 221) | n | 187 | 122 | 157 | 119 | 100 | 52 | 61 | 39 | |
| | | %BMIL | 9.4 | 16 | 22 | 26.1 | 27.9 | 27 | 28.2 | 23.6 | < 0.001 |
| | ***p (LAGB vs. SG)*** | | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.081 | |
| **%EWL** | LAGB (n = 228) | n | 199 | 162 | 171 | 106 | 101 | 59 | 70 | 44 | |
| | | %EWL | 15 | 23.5 | 27.7 | 28.2 | 29.9 | 37 | 41.5 | 38 | < 0.001 |
| | SG (n = 221) | n | 187 | 122 | 157 | 118 | 101 | 52 | 61 | 39 | |
| | | %EWL | 16.6 | 28.9 | 39.5 | 49.1 | 52.7 | 52.1 | 52 | 43.5 | < 0.001 |
| | ***p (LAGB vs. SG)*** | | < 0.001 | 0.018 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.01 | 0.014 | |

%BMIL — percentage of BMI loss; %EWL — percentage of excess weight loss; LAGB — laparoscopic adjustable gastric banding; SG — laparoscopic sleeve gastrectomy

**Table III. Results of %EWL ≥ 50 based on preoperative BMI and operation type**

| | | BMI > 40 | BMI 40–44.9 | BMI 45–49.9 | BMI ≥ 50 | p |
|---|---|---|---|---|---|---|
| LAGB (n = 228) | n | 60 | 109 | 51 | 8 | |
| | %EWL ≥ 50 | 36.7 (n = 22) | 18.3 (n = 20) | 27.5 (n = 14) | 12.5 (n = 1) | 0.049 |
| SG (n = 221) | n | 7 | 33 | 95 | 86 | |
| | %EWL ≥ 50 | 42.9 (n = 3) | 51.5 (n = 17) | 47.4 (n = 45) | 39.5 (n = 34) | 0.61 |
| ***p (LAGB vs. SG)*** | | 0.93 | 0.0001 | 0.02 | 0.13 | |

For abbreviations, see Table 2

**Table IV. Multivariate analysis of predictors for %EWL ≥ 50 in the whole sample. The model included sex, age, BMI, comorbidities and type of operation**

| | OR | 95% CI | P |
|---|---|---|---|
| Sleeve gastrectomy | 2.54 | 1.69–3.82 | < 0.0001 |
| Smoking | 2.09 | 1.17–3.73 | 0.009 |
| Diabetes mellitus | 0.53 | 0.32–0.85 | 0.013 |

BMI before the operation, and there were no differences in the percentage of %EWL ≥ 50 between BMI groups (p = 0.61). The %EWL ≥ 50 was found in 42–51% of patients with BMI < 50 before operation. Patients with BMI ≥ 50 had slightly worse %EWL ≥ 50. Conversely, the LAGB group's %EWL ≥ 50 was dependent on BMI before operation (p = 0.049). The best results were achieved in patients with BMI < 40, but only in 36% of them. Significantly higher percentages of patients who achieved %EWL ≥ 50 after SG compared with LAGB were found in the BMI 40–44.9 and BMI 45–49.9 groups (p = 0.0001 and p = 0.02, respectively). There were no significant differences between the two operations in the group with BMI ≥ 50, but the number of patients after LAGB was very low: only 8 patients underwent LAGB, and only 1 of them achieved %EWL ≥ 50. Multivariate analysis found that LSG, smoking and diabetes were independent predictors of %EWL ≥ 50%. SG increased the chance for achievement %EWL ≥ 50% by 2.5 times, but associated DM decreased the chance for achievement %EWL ≥ 50% by almost half (Table IV).

There are no postoperative complications after LAGB. A total of 221 patients in the SG group and 6 (2.7%) had postoperative surgical complications within 30 days after surgery. Two patients had leakage in stapler line 2 (0.9%). Postoperative bleeding requiring ≥ 2 j of packed blood was observed in 3 patients (1.3%). Three patients underwent reoperation (1.3%). The frequency of all postoperative complications was higher after SG, but there were no differences between the groups in the reoperation rate (Table V).

Postoperative complications and reoperation in the long term were significantly higher for LAGB than for LSG (p = 0.0062, Table V). Reoperation was performed in 16 (7%) patients after LAGB compared to 2 (0.9%) patients after LSG. Patients after SG were reoperated because of weight gain; in both cases, LRYGB was performed. Among 16 patients after LAGB, 8 (3.5%) underwent reoperation because of restriction intolerance, 3 (1.3%) underwent band erosion, and 2 (0.9%) underwent surgery because of stomal obstruction. In 3 (1.3%) patients, a reoperation was performed for reasons of port problems.

## Discussion

Weight loss surgery has become the most popular method to treat morbid obesity because it has substantial beneficial associations with weight loss and several

**Table V. Postoperative early and late complications in both groups of patients**

| | LAGB (n = 228) | SG (n = 221) | P-value |
|---|---|---|---|
| Complications < 30 days after surgery | | | |
| Leakage (%) | 0.0 | 2 (0.9) | 0.464 |
| Bleeding (%) | 0.0 | 3 (1.3) | 0.462 |
| Others requiring reoperation (%) | 0.0 | 1 (0.5) | 0.987 |
| Total complications (%) | 0.0 | 6 (2.7) | 0.036 |
| Reoperation (%) | 0.0 | 3 (1.3) | 0.253 |
| Late complication | | | |
| Band erosion (%) | 3 (1.3) | – | |
| Port/tubing malfunction (%) | 3 (1.3) | – | |
| Stomal obstruction (%) | 2 (0.9) | – | |
| Band slippage (%) | 8 (3.5) | – | |
| Others requiring reoperation (%) | 0.0 | 2 (0.9) | 0.464 |
| Total complication (%) | 16 (7.01) | 2 (0.9) | 0.0062 |
| Reoperation (%) | 16 (7.01) | 2 (0.9) | 0.0062 |

clinical outcomes [16]. Bariatric surgery leads to not only a significant reduction in excess weight but also a significant resolution or improvement of obesity-related comorbidities, especially type 2 diabetes mellitus (T2D), hypertension, and dyslipidaemia [17, 18]. The IFSO Global Registry Report [19] and data from the American Society for Metabolic and Bariatric Surgery [20] have shown increasing use of metabolic and bariatric procedures. Both documents have demonstrated that the most performed bariatric procedures include LRYGB, SG and LAGB. The sleeve gastrectomy trend is increasing, and it continues to be the most common procedure.

Since 1993, from the first laparoscopic implantation of adjustable gastric banding, LAGB has become the second most performed bariatric procedure worldwide after gastric bypass [21]. During the last few years, the prevalence of LAGB has declined due to the literature showing weight regain and high late complication and reintervention rates. SG has become the most popular bariatric procedure worldwide, but there are differences according to region and country [19]. LSG is a well-tolerated surgical procedure, with a relatively low rate of late complications, reintervention rate and efficiency regarding weight loss, which is comparable to RYGB [22].

The results of the present analysis showed significant differences in % BMI and %EWL reduction between SG and LAGB. SG was superior to LAGB, and %EWL and %BMIL were significantly higher after SG during all postoperative follow-up months. A similar trend was obtained for %EWL ≥ 50%, defined as good operation results. The impact of SG on %EWL ≥ 50 was independent of preoperative BMI. Conversely, the LAGB group %EWL ≥ 50% was dependent on BMI before the operation, and the best results were obtained in patients with BMI < 40. The results of the multivariate regression revealed that SG increased the likelihood of achieving good results after the operation, expressed as %EWL ≥ 50, by 2.5 times, whereas obesity-associated T2D decreased it by approximately half.

Our results were generally similar to those of previous studies that compared comprehensive evidence of weight loss surgery procedures, which showed that SG appeared to be more effective for weight loss than LAGB [22–24]. A recent literature review concerning the estimated effectiveness of LAGB versus SG indicated that SG was a more effective procedure than LAGB for morbidly obese patients, contributing to higher %EWL and greater improvement in T2D at the 3-year follow-up [25]. Authors have shown that patients who underwent SG have significantly higher lost excess weight by 6, 12, 24 and 36 months, however, there was no differences et 3 months follow-up. Only one prospective randomized study that directly compared the effectiveness of LAGB and SG confirmed the data from a retrospective and prospective non-random study [26]. The results showed that the median weight loss, BMI reduction and %EWL were significantly greater after SG than after LAGB at the 1- and 3-year follow-ups. On the other hand, the available literature shows that LAGB is a safe procedure with acceptable weight loss and a low complication rate [27]. Long-term weight loss results vary between an EWL of 30% and 41%, but there are reports of mean EWL of approximately 50% [13, 23–25]. In the present study, the %EWL was lower, but patients with BMI < 40 had 37% EWL.

The present study indicated that LAGB was a safe surgical procedure. There were no surgical complications or reoperations in the early postoperative period within 30 days after surgery. In the early postoperative period, 2.7% of patients after SG had complications, and 1.3% of patients required reoperation. The most common outcomes after the SG procedure were bleeding and leakage, but their rates were low (1.3% and 0.9%, respectively), which is in accordance with the observations of other authors [12]. SG was associated with a higher rate of complications, and the reoperation differences were statistically insignificant. Conversely, long-term complications and reoperation rates were significantly higher after LAGB than after SG. Only 2 (0.9%) patients who underwent SG were reoperated on because of weight regain. Conversely, 7% of patients after LAGB had complications related to surgery, and all required reoperations. The most common complications were band slippage, band migration and port or tubing malfunction, but their rates were relatively low (3.5%, 1.3% and 1.3%, respectively). These findings are similar to the results of a study regarding complications of LAGB, although in the present study, the rate of late complications at the 4-year follow-up was slightly lower than that presented in the literature, whether the total complication rate [28] or the reoperation rate [24].

## Conclusions

LSG is a more effective procedure than LAGB, contributing to greater improvement of weight loss in the short and long term. Both are safe procedures with acceptable postoperative complication rates. LAGB is associated with lower surgery-related complications in the early postoperative period compared to SG, but long-term outcomes contributing to a higher late complication rate led to a higher reoperation rate than SG procedure.

### Author disclosures

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