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Original Research

Laparoscopic sleeve gastrectomy versus laparoscopic gastric bypass: A retrospective cohort study

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ABSTRACT

Background: There are many reports on short-term outcomes following sleeve gastrectomy, which demonstrate that it has comparable efficacy to gastric bypass. However, there are very few long-term comparative reports. This study compared the outcomes from laparoscopic sleeve gastrectomy (LSG) and laparoscopic gastric bypass (LGB) in a cohort of patients who had surgery in 2011 with a six-year follow up.

Materials and methods: Data on patients who had either LSG or LGB at a single centre in Mohak Bariatric and Robotic Surgery Centre, Indore, M.P. India in 2011 were identified from a database of routinely collected data. This retrospective cohort was analysed for weight loss, resolution of comorbidities and nutritional status over six years. Patients who had revision operations or for whom six-year follow-up data were not available were excluded from the analysis.

Results: 154 patients had LGB and 152 had LSG. The six-year follow up rate was 61.7% (n = 95) and 64.5% (n = 98) respectively for LGB and LSG. Percentage of excess bodyweight loss (%EWL) peaked at approximately 70% after two years in the LSG group and after three years in the LGB group. However, after six years %EWL was 61% for LGB and 50% for LSG (p = 0.001). Resolution of type-2 diabetes was more common in the LGB group compared to the LSG group (79% vs 62%, p = 0.126). Resolution of hypertension and dyslipidaemia was similar in both groups at approximately half of patients in each group for each condition. Nutrient deficiencies were found in both groups but were generally more pronounced in the LGB group.

Conclusion: LGB is a better operation for weight loss, weight loss maintenance, and resolution of type-2 diabetes than LSG. This is at the expense of an increased incidence of nutrient deficiencies. LSG appears to have greater treatment failure by six years follow up and this should be further investigated.

1. Introduction

Obesity is a health problem in both developed and developing countries. Severe obesity leads to complications affecting nearly every organ system and also reduces life expectancy [1,2]. Surgical therapy provides the only long-term viable treatment for severe obesity with durable excess weight loss (EWL), resolution or amelioration of co-morbidities, improvement in quality of life and lengthened lifespan [3,4]. Surgical treatment has evolved and surgeons have various surgical options for treating severe obesity. These operations range from simple to complex operations that alter gastrointestinal tract structure and function [5]. Laparoscopic sleeve gastrectomy (LSG) and laparoscopic gastric bypass (LGB) are the two most common operations performed in the world to treat severe obesity [6].

LGB is a safe technique that has been used for many years due to its mal-absorptive effect in addition to its restrictive effect [6,7]. LSG became accepted as a standalone operation in 2008 following publication of comparative outcome reports with gastric bypass [7]. Since LSG is easy to learn, has a lower complication rate, and has fewer nutritional effects, it is being increasingly used in the surgical treatment of obesity [8,9]. The most important disadvantage of these surgical techniques is postoperative nutritional deficiencies that require long-term follow-up [10].

Evidence from a systematic review has revealed that %EWL after sleeve gastrectomy was not significantly different from %EWL after gastric bypass 24 months following surgery [11]. However, there are few studies published with comparisons of long-term outcomes of LSG versus LGB head to head, most of which were vulnerable because of low patient numbers, short follow-up, or both [12].

We conducted a retrospective study on a cohort of patients who had

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surgery in 2011. Our aim was to determine how the outcome from LSG compares to LGB over a long-term period of follow-up. The comparisons of interest were in terms of weight loss and weight loss maintenance, and also in terms of resolution of comorbidities and nutritional deficits. We hypothesized that there would be a trend for LGB to have greater persisting weight loss than LSG across a longer six-year follow-up.

2. Methods

We conducted a retrospective review using a database of routinely collected information on a cohort of patients who underwent LSG and LGB in 2011 with follow up from 2010 through 2017 at the [LOCATION REDACTED FOR BLIND REVIEW] (a high volume tertiary bariatric medical centre). Patients were offered both procedures. The decision to undergo a particular procedure was taken by the patient after detailed understanding of the procedure, its risks and follow up course in one-on–one consultation with the operating surgeon and/or a member of the medical team. Preoperatively, all patients provided written informed consent for their operation and to have de-identified data analysed. The institutional review board approved this study Patients who were lost to follow up or were re-operated on for inadequate weight loss or weight regain were excluded from this study. The work has been reported in line with the STROCSS criteria [13]. A single senior consultant surgeon with extensive bariatric surgery experience had performed all surgeries.

Collected data included patient demographics, body weight, body mass index (BMI), nutritional deficiencies, and the existence of any comorbid conditions. Data for patients undergoing the two surgical procedures was compared for weight loss outcomes and resolution of comorbidities. Remission of type-2 diabetes (T2DM) was defined as attaining a fasting plasma glucose level below 126 mg/dl and HbA1c below 6.5%, with cessation of all diabetes medications [14,15]. Hypertension resolution was defined as normal blood pressure (systolic < 140 mm Hg and diastolic < 80 mm Hg), without the use of antihypertensive medications [16]. For dyslipidemia, a level of < 130 mg/dL for low-density lipoprotein (LDL), > 35 mg/dL for high-density lipoprotein (HDL), and < 150 mg/dL for triglycerides, off all lipid-lowering medications, was considered as remission [17].

2.1. Operative technique

2.1.1. Laparoscopic gastric bypass

All operations had been performed laparoscopically. Access to the abdomen was gained by veress needle. A 10 mm port was placed and used as an optical port and two 12 mm ports were placed in line with the optical port in the mid clavicular line. Two 5 mm ports were placed in the subcostal region in the mid clavicular line on both sides. A Nathanson retractor was used to retract the liver. A vertical gastric pouch of length 6–7 cm and volume 20–30 cc was created using 38 Fr. bougie in situ. A roux-en-y was created with biliopancreatic limb of 80 cm and alimentary limb of 120 cm in all procedures and a gastrojejunostomy (GJ) of 2 cm–2.5 cm was created with a linear cutter stapler. The gastro-enterotomy was closed with Endo Stitch from Covidien. Bleeding if present was tackled with clips. Internal hernia spaces i.e. Petersen's space and mesenteric defect were closed with non-absorbable suture material.

2.1.2. Laparoscopic sleeve gastrectomy

Access to the abdomen was gained by veress needle and a 10 mm port was placed and used as an optical port. Two 12 mm ports were placed in line with the optical port in the mid clavicular line and two 5 mm ports in the subcostal region in the mid clavicular line on both sides. A Nathanson retractor was used to retract the liver. The procedure began with dissection of the omentum from the greater curvature using a harmonic scalpel from Ethicon. This dissection continued to Belsey's fat pad upwards and until the pylorus downwards. Next, with a 38 Fr. bougie in situ, stapling was started 5 cm from the pylorus using an Ethicon stapler with green reload. A distance of at least 2.5 cm was maintained away from the lesser curvature. Stapling was continued upwards with an Ethicon stapler using blue reload maintaining a width of around 2.5 cm until 1–2 cm from the gastroesophageal junction. A sleeve of 90–120 cc was created. Any bleeding if present was tackled with clips. No leak test was done. All patients had pneumatic compression devices applied and all received prophylactic enoxaparin 0.4 ml 12 h after surgery to prevent thromboembolism.

2.2. Statistical analysis

Chi-square tests for categorical variables and t-tests for continuous variables were used to compare the differences in means between groups. Six-year changes over time in continuous variables were tested by one-way analysis of the variance test (ANOVA). Continuous variables were reported as means with standard deviation. All 2-sided p values of < 0.05 were considered statistically significant.

3. Results

3.1. Patient characteristics

During the baseline year (2011), 154 patients underwent LGB and 152 underwent LSG with a six-year follow up rate of 64.1% and 64.4% respectively. Nineteen LSG patients (12.5%) had gone on to have revision surgery and were excluded. There were 2 cases of bleeding requiring transfusion post-operatively in the LSG group and none in the LGB group. Patient demographics are displayed in Table 1. LSG patients were slightly younger (40 years vs 45 years, $p = 0.007$) but in other respects the groups were comparable. Mean pre-operative BMI in the LGB and LSG groups were 45.25 ± 6.04 and 45.39 ± 8.44 respectively and mean pre-operative weight was 123.07 kg ± 16.12 and 120.71 kg ± 23.52 respectively (Table 1).

3.2. Follow-up and revision surgery

Of the 152 patients who had LSG in 2011, 54 were not included at the six-year follow-up mark either because they were lost to follow-up (n = 35) or because they underwent revision surgery (n = 19). Of the 19 LSG patients who went on to have further surgery for inadequate weight loss, three patients underwent revision within two years of their initial surgery and 16 additional patients within three years of their initial surgery. Eleven revisions were sleeve to banded gastric bypass, six patients underwent sleeve to mini gastric bypass one anastomosis gastric bypass, and 2 patients underwent re-sleeve.

Table 1
Baseline demographics of patients followed for six years.

	LGB (n = 95)	LSG (n = 98)	*p*-value
Age	45.40 ± 12.57	40.21 ± 13.78	0.007
Sex	Female: 51 (53.7%) Male: 44 (46.3%)	51 (52.1%) 47 (47.9%)	0.466
Height	1.65 ± 0.10	1.64 ± 0.10	0.675
Body Mass Index	45.25 ± 6.04	45.39 ± 8.44	0.897
Weight (kg)	123.07 ± 16.12	120.71 ± 23.52	0.419
Diabetes	29 (30.5%)	21 (21.4%)	0.101
Hypertension	46 (48.4%)	47 (47.9%)	0.532
LDL (mg/dL)	140.31 ± 29.0	139.67 ± 28.35	0.879
HDL (mg/dL)	44.11 ± 11.79	41.94 ± 8.89	0.150
Triglycerides (mg/dL)	152.14 ± 52.55	147.66 ± 48.82	0.542
Total Cholesterol (mg/dL)	190.56 ± 30.17	189.77 ± 29.49	0.854

Mean and standard deviation displayed unless otherwise stated; HDL: high-density lipoprotein; LDL: low-density lipoprotein; LGB: laparoscopic gastric bypass; LSG: laparoscopic sleeve gastrectomy.

Table 2
Weight loss and BMI over time for laparoscopic gastric bypass versus laparoscopic sleeve gastrectomy.

	Baseline	6M	12M	24M	36M	48M	60M	72M
Weight (kg)								
LGB	123.07 ± 16.12	94.68 ± 11.08	90.01 ± 10.66	85.60 ± 10.44	84.44 ± 10.23	85.59 ± 10.44	87.92 ± 10.98	88.15 ± 10.93
LSG	120.71 ± 23.52	90.87 ± 13.36	82.84 ± 12.27	83.26 ± 13.04	85.53 ± 14.05	90.17 ± 14.61	93.23 ± 15.57	95.23 ± 15.85
p	0.419	0.33	0.001	0.170	0.540	0.013	0.007	0.001
%TWL								
LGB	–	22.76 ± 5.02	26.52 ± 5.49	30.06 ± 6.24	30.94 ± 6.78	29.99 ± 7.0	28.14 ± 7.02	27.94 ± 7.09
LSG	–	23.97 ± 5.54	30.59 ± 6.42	30.16 ± 8.30	28.19 ± 9.70	24.45 ± 8.4	22.01 ± 8.16	20.30 ± 8.51
p	–	0.112	0.001	0.926	0.024	0.001	0.001	0.001
%EWL								
LGB	–	51.74 ± 6.72	60.35 ± 6.54	68.33 ± 7.07	70.38 ± 9.20	68.13 ± 10.67	63.74 ± 12.21	61.05 ± 16.25
LSG	–	56.98 ± 5.16	73.43 ± 9.96	72.45 ± 16.36	67.63 ± 20.16	58.56 ± 17.03	52.98 ± 16.59	50.25 ± 18.92
p	–	0.001	0.001	0.025	0.001	0.001	0.001	0.001
BMI								
LGB	43.5 ± 7.1	33.7 ± 3.4	32.1 ± 2.9	30.7 ± 2.3	30.5 ± 2.5	31.2 ± 2.5	32.2 ± 2.9	33.2 ± 2.9
LSG	44.9 ± 8.3	33.1 ± 3.8	30.2 ± 3.3	30.4 ± 4.3	31.2 ± 5.1	33.1 ± 5.1	34.3 ± 5.6	35.5 ± 5.6
p	0.897	0.26	0.001	0.311	0.203	0.001	0.001	0.001
%BMI Loss								
LGB		22.52	26.20	29.42	29.88	28.27	25.97	23.67
LSG		26.28	32.73	32.29	30.51	26.28	23.60	20.93
p		0.557	0.013	0.992	0.133	0.003	0.001	0.001

BMI: body mass index; EWL: excess weight loss; LGB: laparoscopic gastric bypass; LSG: laparoscopic sleeve gastrectomy; M: months; TWL: total weight loss.

3.3. wt loss and BMI

Outcomes including patient weight, weight loss, percentage total weight loss (%TWL), percentage excess weight loss (%EWL) and BMI across 6 years are shown in Table 2.

Results indicate that TWL is initially higher in the LSG group. However, there is crossover in this outcome around the two-year mark, and thereafter TWL is greater in those patients who underwent LGB (Fig. 1).

After two years (LSG group) and three years (LGB group), both groups began to gain weight again. Total weight loss as a percentage of bodyweight is shown in Fig. 2 and excess bodyweight loss is shown in Fig. 3. The failure rate for the procedure as measured by a < 50% EWL was 46.9% with LSG and 11.5% with LGB at six years (Table 3).

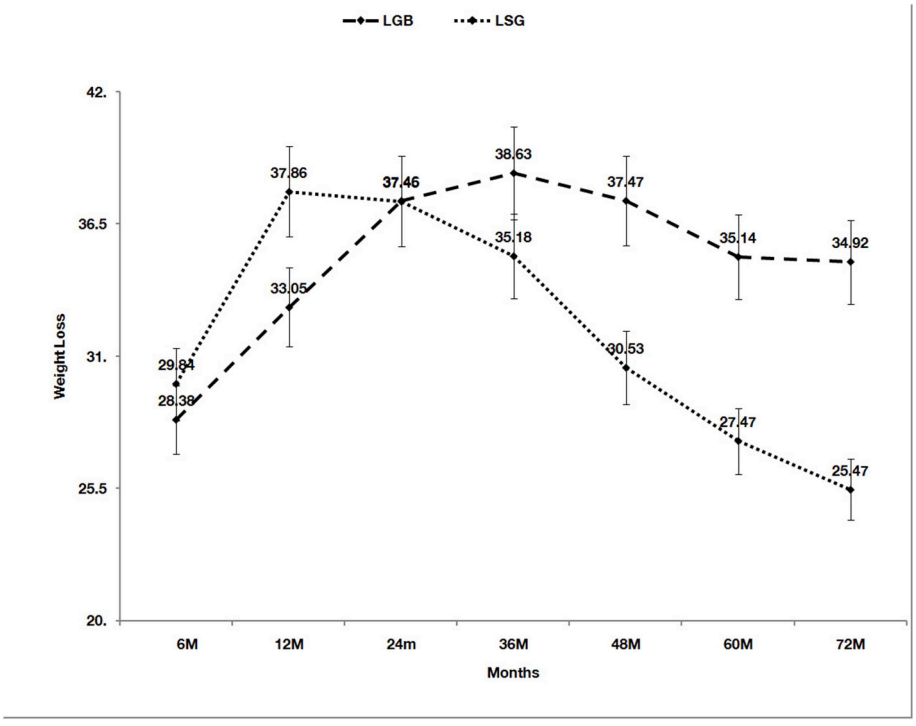

Fig. 1. Total weight loss (kg) across six years - laparoscopic sleeve gastrectomy (LSG) versus laparoscopic gastric bypass (LGB).

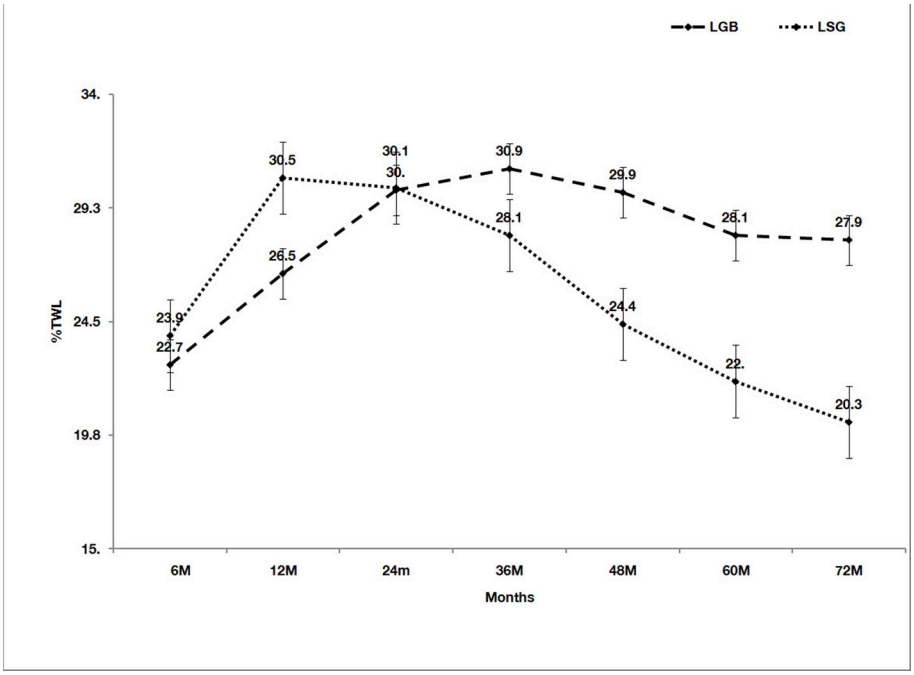

Fig. 2. Percentage total weight loss (%TWL) after laparoscopic gastric bypass (LGB) and laparoscopic sleeve gastrectomy (LSG) across six years.

3.4. Comorbid conditions

Before surgery, 21 patients (21.4%) in the LSG group had T2DM compared with 29 (30.5%) in the LGB group (p = 0.101). Resolution of diabetes, defined by fasting glucose, haemoglobin A1c level, and the cessation of medication, was more common after LGB than after LSG. Results show that diabetes resolved in 79.3% the LGB group and 61.9% of previously diabetic patients in the LSG group (p = 0.126). Resolution of hypertension was seen in 52.1% in the LGB group, and similarly, 48.9% in the LSG group. Similarly, although all patients had dyslipidaemia at baseline, approximately half of patients in both groups had resolution of dyslipidaemia. The resolution of co-morbidities is summarised in Table 4.

3.5. Nutritional deficiencies

Table 5 summarizes the nutritional status of study participants over time.

4. Discussion

This study evaluated the long-term outcomes in weight loss, resolution of comorbidities and nutritional deficiencies in a cohort of patients undergoing LSG or LGB for obesity. Results show that greatest weight loss for both procedures occurs in the first year and weight loss and BMI loss is greater in the LSG group compared to LGB group in the first two years following surgery. After two years, weight regain started

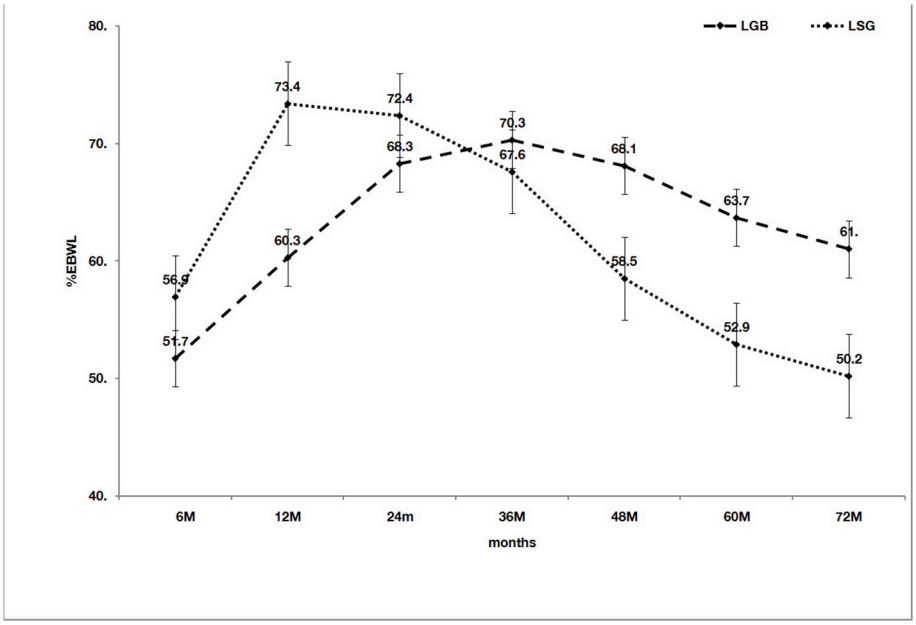

Fig. 3. Percentage excess bodyweight loss (%EWL) following laparoscopic gastric bypass (LGB) and laparoscopic sleeve gastrectomy (LSG) across six years.

Table 3
Failure rate of procedures at 3 years and 6 years LGB versus LSG.

	3 years			6 years		
%EWL	< 50%	50–75%	> 75%	< 50%	50–75%	> 75%
LGB	(2) 1.5%	(71) 55%	(56) 43%	(11) 11.5%	(74) 77.8%	(13) 13.6%
LSG	(15) 11.1%	(66) 47.4%	(53) 39.5%	(46) 46.9%	(46) 46.9%	(9) 9.1%

EWL: excess weight loss; LGB: laparoscopic gastric bypass; LSG: laparoscopic sleeve gastrectomy.

Table 4
Resolution of co-morbid conditions and lipid levels following laparoscopic gastric bypass versus laparoscopic sleeve gastrectomy.

	LGB	LSG	*p* value
T2DM	23/29 (79.3%)	13/21 (61.9%)	0.126
HTN	24/46 (52.1%)	23/47 (48.9%)	0.583
DL	49/95 (51.0%)	50/98 (51.5%)	0.526

DL: dyslipidemia; HTN: hypertension; T2DM: type-2 diabetes mellitus; percentages indicate percentage of patients for whom the comorbid condition resolved.

Table 5
Nutritional status of patients before and after laparoscopic gastric bypass and laparoscopic sleeve gastrectomy.

	LGB		LSG	
	Baseline (% ND)	72 months (%ND)	Baseline (% ND)	72 months (% ND)
Hb < 11 gm/dL	3/95 (3.1%)	15/95 (15.78%)	16/98 (16.32%)	10/98 (10.20%)
Albumin < 3 g/dL	1/95 (1.05%)	28/95 (29.47%)	0/98 (0%)	1/98 (1.02%)
Protein < 6 g/dL	9/95 (9.47%)	64/95 (67.36%)	17/98 (17.34%)	46/98 (46.93%)
Vitamin D3 < 20 ng/mL	2/95 (2.10%)	0/95 (0%)	4/98 (0%)	5/98 (5.10%)
Vitamin B12 < 200 ng/mL	37/95 (38.94%)	13/95 (13.68%)	35/98 (35.71%)	3/98 (3.06%)
Calcium < 8 mg/dL	0/95 (0%)	31/95 (32.63%)	0/98 (0%)	4/98 (4.08%)

Mean and standard deviation reported unless otherwise indicated; %ND: Percentage of patients with nutritional deficiencies; LGB: laparoscopic gastric bypass; LSG: laparoscopic sleeve gastrectomy.

in the LSG group whereas weight loss continues in the LGB group until three years, after which both groups regained weight. At the end of six years both LSG and LGB appeared to be effective weight loss procedures.

Importantly, however, weight regain in the LSG group was significantly higher than in the LGB group. A previous six-year follow up study of LSG alone, showed EWL% of 77.5% and 53.3% at three years and six years respectively [18]. Taken together this study and our study confirm there is a significant regain of lost weight following LSG over the long-term. This is in comparison to studies that have found similar weight loss for both procedures in the shorter term.

However, the failure rate of LSG at six years approaches 50% in comparison to 11.5% for LGB. This suggests that even longer-term follow-up studies are warranted to explore whether there is a trajectory of diminishing effectiveness for LSG that is steeper and quicker than for LGB and also to determine whether re-emergence of comorbidities is seen at a greater rate with LSG in the long-term.

For patients with type-2 diabetes (T2DM), our results show good resolution with both procedures (79% of patients having LGB showed resolution at six years, as did 62% of patients having LSG, with no statistically significant difference between groups). LGB has previously been shown to achieve a remission rate as high as 88% in obese class I patients for as long as 6 years [19]. Although LSG also appears safe and effective for improving diabetes, many studies have reported the remission of T2DM to be much better in the LGB group than in the LSG group [20–23].

With respect to nutritional deficiencies, these are well known following gastric bypass and we found a higher prevalence of nutritional deficiency with LGB than LSG after six years. For example, although anaemia increased from 3% of patients to 15% of patients after LGB, it reduced following LSG (Table 5). Similarly, Hypoalbuminaemia levels increased from 1% of patients to nearly 30% of patients in LGB, whereas with LSG they remained largely unchanged. Calcium deficit and serum vitamin B12 deficiency were also more common after LGB, although not as pronounced as in some studies [24].

Previous studies indicate that these nutritional deficiencies may be promoted by abnormal gastric emptying following surgery [25,26]. In addition, LSG removes the greater curvature and fundus of the stomach, thereby reducing the levels of gastric acid and intrinsic factor, which affect the absorption of some nutrients (e.g., folate, vitamin B12, and iron) [2]. Importantly, we found preoperative nutritional deficiencies, which indicate that bariatric surgery was not the only reason for postoperative nutritional deficits in our patient population, and this is consentient with other studies [27–29].

Preoperative nutrient deficiency may be a very important predictive risk factor for postoperative nutritional deficiency. This coupled with the low bioavailability and relatively limited efficacy of oral treatment after surgery, underscores the importance of evaluating and correcting nutritional deficiencies preoperatively [30].

Overall, there are few data in the literature directly comparing results between LGB and LSG [31,32]. The present data confirm similar initial improvement rates with both surgical techniques and good resolution rates for comorbidities but suggest divergence in effectiveness over time.

These results also need to be put in the wider context of LSG versus LGB where considerations such as operative time and technical challenge must be addressed. There is also still a need for further prospective studies evaluating the long-term impact of LSG on other comorbidities such as gastroesophageal reflux disease and evaluating quality of life outcomes between these two procedures.

4.1. Study strengths and limitations

This study has some key strengths. It is one of few studies to evaluate the long-term (greater than 3–5 years) outcomes following LSG and LGB. The analysis evaluated a larger patient cohort with a more equal sex distribution of participants than a recently published comparison of LGB versus LSG [12]. The study also exclusively reports on laparoscopic procedures and presents long-term data for a new patient population and context [LOCATION REDACTED FOR BLIND REVIEW]. Another strength of the study is that it reports on real world data and outcomes outside of the stringent context of controlled trials.

However, this study also has limitations, which include the study design. Although all data were prospectively collected, the level of evidence provided by a retrospective analysis is not as strong as that from a well-designed prospective randomized control study. Another important limitation of this study is that the procedures were all performed by a single surgeon and at a single surgical centre. These features may introduce bias such as practitioner skill or specific

characteristics of the patient population, and may limit the ability of the findings to be generalised to other settings. Additionally, there was a relatively low six-year follow-up rate in both groups 64.1% and 64.4% after LGB and LSG respectively. This is in line with other long-term follow-up studies, however, a greater retention rate would be preferable. This study also did not objectively report on, gastrointestinal complaints, neo-GERD after LSG, and marginal ulcers after LGB with post-operative endoscopic surveillance. These would all be relevant for a full comparison of LSG versus LGB.

5. Conclusion

At long-term follow-up of six years, both LSG and LGB appear to be safe and effective procedures resulting in good weight loss outcomes and resolution of co-morbidities including diabetes and hypertension. Weight loss persisted for longer a longer time in patients having LGB, but this came at the cost of greater nutritional deficiencies. The treatment failure rate was higher with LSG after six years and this should be explored further.

Ethical approval

Sri Aurobindo Institute of Medical Sciences Institutional Ethics Committee approved this retrospective study. No consent from the patients was necessary for this retrospective study. Patients signed a consent form when they had the operation to allow redacted data from their care to be used for research, presentations and publications.

Sources of funding

No funding was necessary.

Author contribution

Bhandari, Mohit: Guarantor, study design, data collection and data analysis.
Reddy, Manoj: Data collection and writing.
Kosta, Susmit: Writing and data analysis.
Mathur, Winni: Data collection and writing.
Fobi, Mathias: Guarantor, study design, data analysis and writing.

Conflicts of interest

Dr. Mohit Bhandari Consultant to: Johnson and Johnson, Stryker, Bariatric Solution, Medtronic, Apollo Endo-surgery, Karl Storz, Applied Materials.
Reddy, Manoj: No conflicting interest.
Kosta, Susmit: No conflicting interest.
Mathur, Winni: No conflicting interest.
Fobi, Mathias Consultant to: Bariatec Corporation.

Research registration number

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Additional Guarantor: Dr. Mathias Fobi.

Provenance and peer review

Not commissioned, externally peer reviewed.

CRediT authorship contribution statement

Mohit Bhandari: Conceptualization, Writing - review & editing, Funding acquisition, Investigation. **Manoj Reddy:** Methodology, Formal analysis, Resources. **Susmit Kosta:** Writing - original draft, Formal analysis, Software, Validation, Visualization. **Winni Mathur:** Data curation, Project administration. **Mathias Fobi:** Conceptualization, Writing - original draft, Supervision, Writing - review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.05.004.

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