

Laparoscopic sleeve gastrectomy: perioperative outcomes, weight loss and impact on type 2 diabetes mellitus over 2 years

Marius Hoogerboord, MD
Shannon Wiebe, MD
Dennis Klassen, MD
Tom Ransom, MD
Diana Lawlor, NP
James Ellsmere, MD

From the Department of Surgery,
Dalhousie University, Halifax, NS

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Correspondence to:

J. Ellsmere
Department of Surgery
Dalhousie University
1276 South Park St., Vic 818
Halifax NS B3H 2Y9
james.ellsmere@dal.ca

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Background: Laparoscopic sleeve gastrectomy (LSG) is an increasingly performed operation for morbid obesity worldwide. To date there has been limited experience in Canada. We report our intermediate results, assessing whether LSG can be safely performed at a Canadian academic teaching hospital and whether it is effective as a bariatric procedure and as metabolic therapy for type 2 diabetes mellitus.

Methods: We performed a retrospective review of all patients who underwent LSG at our institution from Sept. 1, 2007, to June 30, 2011.

Results: We included 166 patients (mean age 44 yr, 82% female) in our study. The mean preoperative body mass index was 49.61. At baseline, 87 (52%) patients had type 2 diabetes. For this subgroup, mean preoperative HbA1c and AC glucose were 7.6% and 8.3 mmol/L, respectively. The mean duration of surgery was 93 minutes. Major complications included 1 staple line leak (0.6%), and 2 patients required reoperation for bleeding (1.2%). The mean hospital stay was 2.6 days. Two patients required readmission (1.2%). Seven minor complications occurred (4%). Postoperative excess weight loss was 49.3% at 6 months, 54.2% at 12 months and 64.4% at 24 months. In the type 2 diabetes subgroup, resolution occurred in 78% and improvement in 7% of patients at 12 months.

Conclusion: Laparoscopic sleeve gastrectomy can be safely performed at Canadian teaching hospitals. It is effective both as a bariatric procedure and as a therapeutic intervention for type 2 diabetes mellitus.

Contexte : La gastrectomie verticale par laparoscopie (GVL) est une intervention de plus en plus utilisée pour traiter l'obésité morbide partout dans le monde. À ce jour, au Canada, l'expérience en a été limitée. Nous faisons état de nos résultats intérimaires et nous évaluons si la GVL peut être effectuée de manière sécuritaire dans un hôpital d'enseignement universitaire canadien et si elle est efficace en tant qu'intervention bariatrique et comme traitement métabolique du diabète de type 2.

Méthodes : Nous avons procédé à une revue rétrospective des dossiers de tous les patients qui ont subi une GVL dans notre établissement entre le 1er septembre 2007 et le 30 juin 2011.

Résultats : Nous avons ainsi inclus 166 patients (âge moyen 44 ans, 82 % de femmes) dans notre étude. L'indice de masse corporelle préopératoire moyen était de 49,61. Au départ, 87 patients (52 %) souffraient de diabète de type 2. Pour ce sous-groupe, l'HbA1c et la glycémie à jeun préopératoires moyennes étaient respectivement de 7,6 % et de 8,3 mmol/L. La durée moyenne de la chirurgie a été de 93 minutes. Les complications majeures ont inclus une fuite au niveau de la ligne d'agrafage (0,6 %) et on a dû réopérer chez 2 patients en raison de saignements (1,2 %). Le séjour hospitalier moyen a été de 2,6 jours. Deux patients ont dû être réadmis (1,2 %). Sept complications mineures sont survenues (4 %). La perte de poids excédentaire postopératoire a été de 49,3 % à 6 mois, de 54,2 % à 12 mois et de 64,4 % à 24 mois. Dans le sous-groupe atteint de diabète de type 2, la résolution est survenue chez 78 % des patients et une amélioration, chez 7 % des patients à 12 mois.

Conclusion : La gastrectomie verticale par laparoscopie peut être effectuée de façon sécuritaire dans les hôpitaux universitaires canadiens. Il s'agit à la fois d'une intervention bariatrique et d'un traitement pour le diabète de type 2.

Sleeve gastrectomy was initially performed as the first part of a 2-step approach in superobese (body mass index [BMI] > 50) patients. Weight loss incurred from this procedure would facilitate a subsequent duodenal switch.¹ Several groups, however, reported adequate, sustained weight loss following the sleeve.^{2,3} The ability to perform this procedure laparoscopically contributed to the enthusiasm for the sleeve gastrectomy as a final procedure for the treatment of morbid obesity.⁴

Being a fairly novel procedure, laparoscopic sleeve gastrectomy (LSG) lacks long-term data, but short-term and intermediate results confirm its effectiveness at inducing and maintaining weight loss and addressing obesity-related comorbidities.^{5,6} Although infrequent, complications related to LSG — especially staple line leak — remain a concern.

In this paper we review our experience with LSG in terms of perioperative outcomes, weight loss and impact on type 2 diabetes mellitus over 24 months of postoperative follow-up.

METHODS

We retrospectively reviewed prospectively recorded data for all patients who underwent LSG at our academic teaching hospital between Sept. 1, 2007, and June 30, 2011. Patient age and sex, preoperative weight and BMI, fasting serum glucose and HbA1c, history of type 2 diabetes and previous abdominal surgeries were recorded. Perioperative data included duration of surgery, conversion to laparotomy, duration of hospital admission, early (within 30 d postoperatively) complications and readmission within 30 days. Postoperative percentage excess weight loss (%EWL) was recorded at 6, 12 and 24 months; %EWL was calculated as follows:

$$(\text{weight loss} \div \text{baseline excess weight}) \times 100$$

Baseline excess weight = baseline weight – maximum ideal weight (X).

X was calculated using a BMI of 25, thus $X = 25 \times \text{m}^2$.

For the subgroup of patients who had a diagnosis of type 2 diabetes at baseline, we recorded AC glucose, HbA1c and resolution or improvement of diabetes at follow-up. Resolution was defined as AC glucose below 5.6 mmol/L and HbA1c less than 6.5% with discontinuation of all hypoglycemic drugs, whereas improvement implied a decrease in the dose or number of hypoglycemic drugs required to control serum glucose.

Preoperative care

Patients underwent a standardized preoperative assessment, including complete history, physical examination and psychological evaluation. Further workup based on medical conditions or other risk factors for surgery and/

or anesthesia was done appropriately. Selection criteria for weight loss surgery were based on guidelines provided by the American Association of Clinical Endocrinologists, The Obesity Society and the American Society for Metabolic and Bariatric Surgery.⁷ Patients with a BMI greater than 40 or a BMI greater than 35 with at least 1 obesity-related comorbidity were considered potential candidates. A large number of patients are waiting to be seen in our program, and all consultations were triaged. We selected patients such that 80% of incoming patients had type 2 diabetes. It was expected that all candidates would follow a supervised weight loss program, including moderate exercise and a high-protein, low-carbohydrate and low-fat diet, and that commitment to the program would be demonstrated by actual weight loss. Smokers were required to quit. Exclusion criteria were obesity related to a reversible endocrine disorder; drug or alcohol abuse; uncontrolled psychiatric illness; and lack of comprehension of risks, benefits, outcomes, alternatives and lifestyle changes required with bariatric surgery.

Operative technique

Surgery was performed by 1 of 2 surgeons (J.E. and D.K.), both experienced in bariatric surgery. The patient was positioned supine on the operating table with both arms abducted 90°. General anesthesia was induced and an endotracheal tube placed. An orogastric tube was inserted and appropriate prophylactic antibiotics administered. Sterile prep and draping of the abdomen was then done.

A standard 6-port technique was used. A pneumoperitoneum was established to a pressure of 15 mm Hg using CO₂ gas. After port placement the patient was placed in a reverse Trendelenburg position. A 10 mm 30° laparoscopic camera was used. A liver retractor was placed to elevate the left lobe of the liver. Starting approximately 5 cm proximal to the pylorus, the greater curvature of the stomach was mobilized by division of the gastrocolic and gastrosplenic ligaments using an ultrasonic dissector. This dissection was completed to the angle of His.

The orogastric tube was then exchanged for a 42-Fr bougie that was positioned along the lesser curvature of the stomach. Using the bougie as a guide, a gastric sleeve was constructed with sequential firings of a 60 mm laparoscopic stapler (Ethicon Endo-Surgery). The staple line commenced approximately 5 cm proximal to the pylorus and ended 1 cm lateral to the esophagogastric junction. Next, the bougie was removed and an esophagogastroduodenoscopy (EGD) performed. Obstruction was excluded and the staple line was inspected for bleeding and/or leaking. After EGD, the transected gastric specimen was retrieved

via a port site. This port site was closed at the sheath with an absorbable multifilament suture. Skin incisions were closed.

Postoperative care

Early ambulation was encouraged. Patients were allowed sips of water on postoperative day 1, and intravenous fluid was administered at a rate appropriate for weight. Opioid analgesia was kept to a minimum. Low molecular weight heparin was administered as deep vein thrombosis prophylaxis. All patients underwent a water soluble contrast study on postoperative day 1. With a leak ruled out, diet was advanced to clear fluids followed by soft food. Patients were discharged when oral intake was adequate, pain was well controlled and when independent mobilization reached the preoperative level. All patients attended a follow-up visit with the operating surgeon at 4–6 weeks postoperatively. Subsequent follow-up was done by a multidisciplinary team, including a nurse practitioner, dietician and psychologist, in the obesity clinic.

RESULTS

During the study period, 166 patients underwent LSG and completed 6-week follow-up; mean age was 44 ± 10 years, and 136 (82%) patients were female. Mean preoperative BMI was 49.61 ± 7 . A total of 87 (52%) patients had a diagnosis of type 2 diabetes at baseline. For this subgroup, mean preoperative HbA1c and AC glucose were $7.6 \pm 1.7\%$ and 8.3 ± 2.9 mmol/L, respectively. In all, 105 (63%) patients had a history of abdominal surgery. Mean duration of surgery was 93 ± 33 minutes. One (0.6%) patient required conversion to laparotomy owing to intra-abdominal adhesions. Mean length of stay in hospital was 2.6 ± 0.8 days.

A total of 12 (7%) complications occurred within the first 30 postoperative days (Table 1). Minor complications included 3 (1.8%) superficial surgical site infections that all resolved with conservative management, 1 (0.6%) urinary tract infection that was managed with appropriate antibiotics, 2 (1.2%) cases of gluteal nerve neuropraxia that resolved spontaneously

and 1 (0.6%) extrahepatic biliary obstruction that resolved after endoscopic retrograde cholangiopancreatography (ERCP) and sphincterotomy. The patient who was converted to laparotomy experienced superficial wound dehiscence that was managed conservatively. One (0.6%) patient required readmission for dehydration and electrolyte disturbances caused by intractable nausea and vomiting. Gastrointestinal obstruction was ruled out, and her symptoms subsided with conservative management.

All 166 patients completed the 6-week follow-up. Ninety-nine of 140 eligible patients attended 6-month postoperative follow-up (29% attrition rate). At 12 months the attrition rate was 47% (50 of 109), and at 24 months it was 73% (32 of 44). Eligibility refers to patients who were 2, 12 and 24 months postsurgery at the time of our study. Excess weight loss was $49.3 \pm 13\%$ at 6 months, $54.24 \pm 19\%$ at 12 months and $64.4 \pm 31\%$ at 24 months (Fig. 1). The type 2 diabetes subgroup consisted of 87 patients. Attrition rates were 23% (16 of 66) at 6 months, 48% (25 of 52) at 12 months and 89% (17 of 19) at 24 months. Mean HbA1c was $6.3 \pm 1\%$ at 6 months, $6.5 \pm 1.2\%$ at 12 months and $6.2 \pm 0.5\%$ at 24 months (Fig. 2). Mean AC

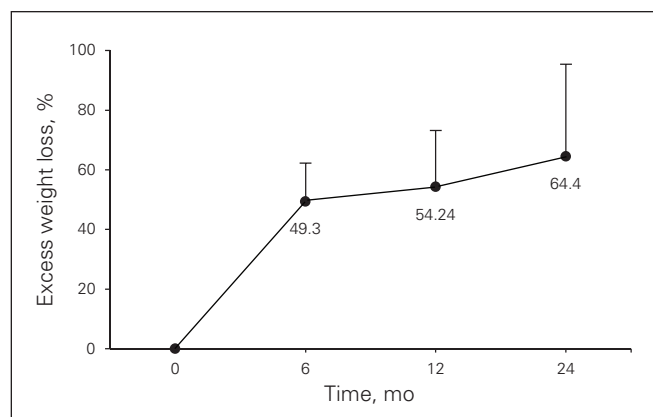


Fig. 1. Percentage of excess weight loss over 24 months of postoperative follow-up.

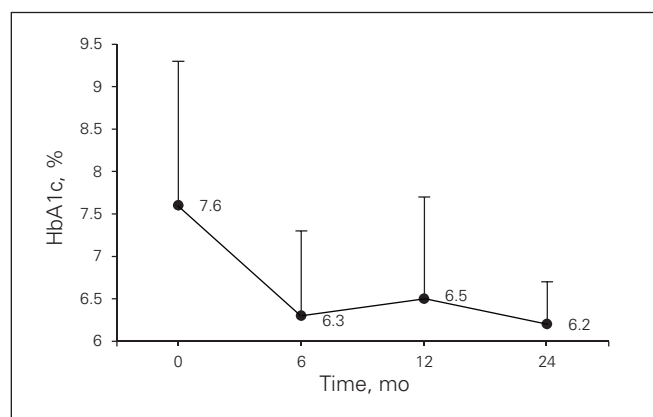


Fig. 2. Decrease in HbA1c levels in patients with diabetes over 24 months of postoperative follow-up.

Table 1. Complications within the first 30 postoperative days after laparoscopic sleeve gastrectomy

Complication	No. (%)
Staple line leak	1 (0.6)
Bleeding	2 (1.2)
Sleeve stenosis	0
Death	0
Minor complications	9 (5)
Total	12 (7)

glucose was 6.4 ± 2.2 mmol/L at 6 months, 6.9 ± 2.3 mmol/L at 12 months and 5.6 ± 0.7 mmol/L at 24 months (Fig. 3).

At 12-month follow-up, 21 (78%) patients with diabetes experienced resolution and 2 (7%) showed significant improvement of the disease.

DISCUSSION

Major bariatric-specific complications of LSG include staple line leak (2%), bleeding (1.2%), sleeve stenosis (0.6%) and death (0.19%).⁸ We had no sleeve stenosis or death in our series. Three (1.8%) patients underwent surgical reintervention. One (0.6%) patient presented with a staple line leak on postoperative day 7. She required laparoscopic drainage of an abscess and placement of a percutaneous drain. This resulted in a gastrocutaneous fistula that healed with conservative management. Two (1.2%) patients required reintervention for bleeding; 1 was returned to the operating room on the day of surgery owing to a staple line bleed, which was managed laparoscopically, while the other underwent a hand-assisted splenectomy on postoperative day 1 for an iatrogenic capsular tear. All patients attended 6-week follow-up, so we are confident that we captured all perioperative complications. Several technical aspects are key to limiting complications. These include careful, complete division of the gastrocolic and gastrosplenic ligaments as well as all peritoneal adhesions to the posterior gastric wall. Careful retraction of omental fat and the greater curvature of the stomach is essential to optimize visualization, especially when dividing the short gastric vessels. The risk for staple line bleeding can be reduced with the use of the optimal staple length relative to tissue thickness.⁹ We use green loads (4.1 mm staple height) to divide the thicker antral tissue and switch to blue loads (3.5 mm staple height) for the corpus and fundus. We selectively clip or oversew staple line bleeds. Some authors have advocated the use of but-

tress material to decrease the risk of staple line bleeding.¹⁰ This technique would add considerably to the cost of the procedure and has not been our practice.

Several studies have confirmed the efficacy of LSG in inducing EWL and improving obesity-related comorbidities.⁸ We are aware of concerns with reporting weight loss as EWL using a BMI of 25 as maximum ideal weight, but our study population was a fairly homogeneous group.^{11,12} Excess weight loss is also commonly used, and we were therefore better able to compare our results with those in the published literature.

We recorded a mean EWL of 54.24% and 64.4% at 12 and 24 months postoperative follow-up, respectively. Weight loss started soon after surgery with a mean EWL of 49.3% at 6 months. The weight loss achieved by patients in this study is consistent with that reported in the literature.^{5,6,8} Laparoscopic sleeve gastrectomy induces weight loss by several mechanisms. As a restrictive procedure, it limits food intake and leads to early satiety.¹³ There is compelling evidence of accelerated gastric emptying and increased small bowel transit time, leading to decreased nutrient absorption.¹⁴ Metabolic effects are attributed primarily to reduced production of ghrelin.¹⁵ This hormone is mainly secreted by X/A-like cells in the oxyntic glands in the gastric fundus, which is resected during an LSG. Ghrelin is orexigenic. It induces preprandial hunger and meal initiation and also contributes to long-term body weight regulation.¹⁶

Selection criteria for weight loss surgery were based on guidelines provided by the American Association of Clinical Endocrinologists, The Obesity Society and the American Society for Metabolic and Bariatric Surgery.⁷ We do, however, have a large number of patients waiting to be seen in our program, and we triaged according to the severity of comorbidities and the probability of benefit. Eighty percent of the patients enrolled into the preoperative assessment phase had type 2 diabetes mellitus.

Diabetes resolved in 21 of 27 (78%) patients, and 2 (7%) showed significant improvement of their disease at 12-month postoperative follow-up. Leonetti and colleagues¹⁷ reported similar outcomes. Schauer and colleagues¹⁸ reported 37% resolution at 12-month follow-up in 18 patients with type 2 diabetes who underwent LSG. Resolution was defined as an HbA1c level of 6.0%, compared with 6.5% in our study. Improvement in type 2 diabetes often precedes any significant weight loss, and currently the specific mechanisms mediating the metabolic effects of LSG are still poorly understood. Several hypotheses have been presented, none of which is mutually exclusive. These include compromised secretion of ghrelin and stimulated levels of hindgut hormones.¹⁹ Ghrelin blocks insulin secretion, stimulates secretion of insulin antagonists growth hormone and adrenocorticotropic hormone, suppresses production of the insulin sensitizing hormone adiponectin and blocks hepatic

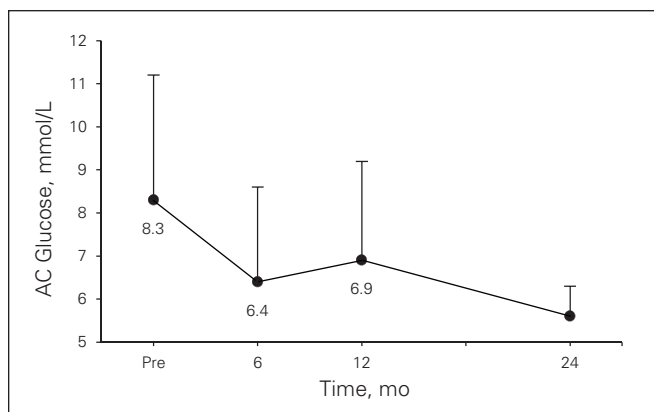


Fig. 3. Decrease in fasting serum glucose levels in patients with diabetes over 24 months of postoperative follow-up.

insulin signalling. Reduction in s-ghrelin levels, as seen post-LSG, would therefore have an antidiabetic effect. The hindgut theory states that stimulation of L cells by higher concentrations of undigested nutrients in the terminal ileum causes increased levels of glucagon-like peptide-1 and peptide YY. These incretins exert an antidiabetic effect by enhancing glucose dependent insulin secretion, suppressing glucagon secretion and increasing insulin sensitivity.²⁰

Limitations

The high attrition rates at 12- and 24-month follow-up are an important limitation to our study. Also, the retrospective study design does not allow for assessment of individual patients' rationale for leaving the program, but many find travel to Halifax to attend the 1 regional clinic too arduous and choose alternative means for follow-up, including email and telephone. Only patients who returned to clinic and for whom objective BMI measurements and laboratory results were available were included in our study. Several measures aimed at improving follow-up rates have been instituted, including involving family physicians with an interest in bariatric medicine. Although still at an early stage, this seems to be a viable alternative for most patients.

In a multicentre observational study, younger age, higher expected BMI loss and lower goal BMI were identified as independent predictors of attrition for patients entering a weight management program.²¹ It is important to set realistic weight goals at an early stage and to be even more diligent in the follow-up of younger patients.

CONCLUSION

Laparoscopic sleeve gastrectomy can be performed safely at Canadian academic teaching hospitals with acceptable complication rates. While the attrition rate has to be borne in mind, our intermediate data suggest that LSG is an effective stand-alone bariatric procedure and that it has an important role as metabolic therapy for type 2 diabetes mellitus. Long-term data remain limited.

Competing interests: D. Klassen is a paid consultant and a hernia product advisory panel member at Ethicon Endo-Surgery Inc. and has received speaker fees for cadaveric laboratory sessions on hernia repair. J. Ellsmere is a consultant for Ethicon Endo-Surgery Inc. No other competing interests declared.

Contributors: M. Hoogerboord, S. Wiebe, T. Ransom and J. Ellsmere designed the study. M. Hoogerboord, S. Wiebe, D. Klassen, D. Lawlor and J. Ellsmere acquired the data, which M Hoogerboord, S. Wiebe and J. Ellsmere analyzed. M. Hoogerboord and J. Ellsmere wrote the article, which all authors reviewed and approved for publication.

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