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The Metabolic Effects of Laparoscopic Sleeve Gastrectomy: A Review

Noah J. , Andrew Smith [2], Daniel Birch [3], Shahzeer Karmali [3,*]

[2] Department of Surgery, University of Calgary, Calgary, Alberta, Canada
[3] Department of Surgery, Center for the Advancement of Minimally Invasive Surgery (CAMIS), University of Alberta, Edmonton, Alberta, Canada

Corresponding author : Shahzeer Karmali, Center for the Advancement of Minimally Invasive Surgery (CAMIS), Department of Surgery, University of Alberta, Edmonton, Alberta, Canada. Tel: +1-7356650, Fax: +1-7356652, E-mail: shahzeer@ualberta.ca.

ABSTRACT

Bariatric surgery, as a whole, is the only proven modality to manage the severely obese. The laparoscopic sleeve gastrectomy (LSG) is the most recent tool in the armamentarium of bariatric surgery. Once used as the first-stage in a two-stage procedure for the super-obese patient, it is now used as a primary bariatric procedure. Involving the resection of the greater curvature of the stomach, it has been shown to achieve clinically significant excess weight loss and improvements in obesity-related co-morbidities. Its mechanism of action was originally classified as being a restrictive procedure, similar to laparoscopic gastric banding, but is now known to be far more complex. The pronounced effects of LSG on gut hormones such as ghrelin, PYY and incretins, allow this bariatric intervention to be adequately compared to the more historically classified malabsorptive procedures like the gastric bypass. In this review, we explore the metabolic effects and outcomes of LSG in producing significant weight loss and improving the factors associated with the metabolic syndrome.

Keywords: Bariatric Surgery; Gastrectomy; Metabolic syndrome; Diabetes Mellitus Type 2

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1. Context

The worldwide incidence of obesity is dramatically increasing; the World Health Organization has estimated that 1.7 billion adults are overweight (1). In the United States alone, approximately 1/3 of all adults are classified as obese (body mass index (BMI) > 30 kg/m2). Obesity, in addition with the associated factors of the metabolic syndrome (hypertension, dyslipidemia, and diabetes), put patients at increased risk of cardiovascular morbidity and mortality (2, 3). Bariatric surgery has been shown to be the most efficacious option for managing severe obesity (4). Not surprisingly, the field of bariatric surgery has grown remarkably over the past two decades with over 300, 000 procedures performed annually and is now the second most common abdominal operation (5, 6). As one would expect, the procedures themselves have evolved over the past 15 years. One procedure, in particular, has become increasingly popular; the Laparoscopic Sleeve Gastrectomy (LSG). Sleeve Gastrectomy (SG) did not begin as a stand-alone procedure. It was initially described by Marceau et al. as part of a larger bariatric operation- the biliopancreatic diversion with duodenal switch (BPD-DS) (7). Recognizing the less than consistent long-term weight loss results of a one-stage bariatric procedure in the super-obese patient, Regan et al. implemented LSG as part of a two-stage laparoscopic Roux-en-Y gastric bypass (RYGB) in this patient population (8). Building on this experience that LSG was both safe and effective, Baltasar et al. proposed LSG could employed as a primary bariatric procedure (9). As it is still a relatively new procedure, it continues to be evaluated by the medical community as more long-term information presents itself.

2. Evidence Acquisition

LSG has gained popularity as a primary bariatric procedure due to its comparative simplicity (10). It involves creating a “sleeve” of the stomach by resecting the majority of the greater curvature of the stomach, leaving a vertical tube of 60-80mL in capacity (11-13) compared to alternative bariatric procedures, LSG offers several advantages: 1) immediate restrictive weight loss; 2) maintained continuity of gastrointestinal anatomy; 3) avoidance of the dumping syndrome; 4) absence of an implantable foreign body; and 5) ease of operative technique with potential conversion to other bariatric procedures (14, 15). The disadvantages however, include: 1) irreversibility of the procedure; 2) possibility of a staple line leak and/or bleed; 3) higher operative risk compared to other restrictive procedures; 4) and paucity of long-term data on safety and efficacy (12, 14) .

2.1. Mechanism of Action

Historically, bariatric surgery has been classified as restrictive (Gastric Banding), malabsorptive (BPD-DS), or a combination of both (RYGB). Restrictive procedures rely on reducing caloric intake and mechanically delaying gastric emptying as a means of producing clinically significant weight loss (16). LSG was, at first, presumed to rely on a similar strategy. However, Melissas et al. contradicted this notion by demonstrating that with LSG there was actually an acceleration of gastric emptying of solids; a change that is maintained long-term (16, 17). It was also hypothesized that due to the removal of the gastric fundus, food boluses would cause distention of the antrum, leading to decreased hunger drive and early satiety (17). This research raised the idea that other mechanisms of energy intake reduction, such as gut hormones, may further explain the effectiveness of LSG in weight reduction.

2.2. Gut Hormones

2.2.1. Ghrelin

Ghrelin is a unique peptide with orexigenic, adipogenic and somatotrophic functions. Found in the pylorus of the stomach, it was originally identified by Kojima et al in 1999 (18). Ghrelin stimulation causes weight gain through hyperphagia, adiposity, and anabolic effects (19, 20). The physiological role of ghrelin in humans was further elicited by Cummings et al. who demonstrated a preprandial rise and postprandial fall in plasma ghrelin levels (21). Attributing the decline in ghrelin to the removal of the gastric fundus, Langer et al. showed a significant and maintained reduction in plasma ghrelin levels immediately after and 6 months post-LSG (22). Karamanakos et al. and Ramon et al. both prospectively evaluated the changes in fasting and postprandial ghrelin levels after RYGB and SG and found that only SG suppressed fasting and postprandial ghrelin levels significantly (23, 24).

2.2.2. Peptide Tyrosine-Tyrosine

Peptide tyrosine-tyrosine (PYY) is an anorectic hormone whose attenuated function, while fasting and after eating, is implicated in obesity (25). First identified by Tatemoto et al in 1980, this gut hormone is released into the circulation after meals (26). Batterham et al. showed that peripheral infusion of PYY in human subjects resulted in decreased caloric intake (27, 28). In respective prospective studies, both Karamanakos et al. and Ramon et al. found significantly increased levels of PYY post-LSG (23, 24). This clinically culminates in LSG patients having increased satiety and less hunger-drive after meals.

2.2.3. Incretins

Incretins are gut hormones that augment the release of insulin and promote pancreatic beta cell proliferation (29). Approximately 50% of insulin release following meals is due to the release of incretins, namely glucose-dependent insulin tropic polypeptide (GIP) and glucagon-like peptide 1 (GLP-1) (30). Despite being a purely gastric procedure, SG does in fact lead to an increased post-prandial release of distal gut hormones in a mechanism as yet to be determined (31).

2.3. Complications

There are several inherent risks associated with LSG. These risks include: 1) staple line disruption and subsequent leak; 2) bleeding requiring reoperation or transfusion; and 3) postoperative strictures requiring endoscopic or surgical intervention. In a systematic review of SG, Brethauer et al. identified 33 studies with detailed complication data. In these studies, there were 53 leaks (2.2%), 28 bleeding episodes (1.2%), and 15 postoperative strictures (0.6%), 15 Nonetheless, LSG is still considered a low morbidity procedure, with a mortality rate < 1% (32).

4. Results

4.1. Weight Loss

Bariatric surgery has consistently been shown to be more efficacious in managing severe obesity in comparison to pharmaceutical, diet or lifestyle regimens (33). Even so, the model of the Weight Wise Clinic in Edmonton, Alberta, has shown that a comprehensive medical, dietary and surgical approach can be effective and synergisitic (12). The average reduction in BMI for patients undergoing LSG is 8.75 kg/m2 at 6-months and 11.87 kg/m2 at 1-year. This is in comparison to laparoscopic gastric band and laparoscopic gastric bypass where the 6-month BMI reduction is 5.02kg/m2 and 10.82kg/m2 respectively and the 1-year BMI reduction is 7.05kg/m2 and 15.34kg/m2 respectively. As such, LSG is positioned between laparoscopic gastric band and laparoscopic gastric bypass for BMI reduction (34). A recent systematic review of sleeve gastrectomy reported an excess weight loss (%EWL) of 47% (35). However, there remains a wide range of reported weight loss in the literature; one review of 15 laparoscopic sleeve gastrectomy studies stated a %EWL between 33-90% (36). This high variability in reported weight loss could in part be due to the poor standardization of SG with differing inter-institutional agreement on operational technique (37). Nonetheless, this impressive weight loss has been shown to be sustainable in the long-term; Bohdjalian et al. demonstrated a mean %EWL of 55.0% at 5 years (38).

4.2. Type 2 Diabetes Mellitus

The effect of SG on Type 2 diabetes mellitus (T2DM) is quite impressive. In a recent systematic review, Gill et al. report a complete resolution of T2DM in 66.2% of patients undergoing SG (35). Resolution of diabetes is achieved with overall improvements in fasting glucose levels and HbA1c levels, leading to the cessation of all diabetic medications. The Stampede Trial at the Cleveland clinic, which compared SG and gastric bypass against medical management, showed that not only was there a significant reduction in overall oral hypoglycemic use, but at 1 year follow-up only 8% of SG patients required insulin (39). It is interesting that the resolution of T2DM does not significantly correlate with weight loss, lending strength to the argument that SG is not purely a restrictive procedure (40). Compared to duodenal switch and gastric bypass, Roslin et al. found that there was no significant difference in fasting glucose and insulin levels in those patients undergoing SG (41).

4.3. Hypertension

Hypertension is yet another component of the metabolic syndrome, affecting nearly half of patients presenting for bariatric surgery (42). In a recent review, 58% of patients reported resolutions of their hypertension at 1-year follow up, with 75% of patients experiencing at least some improvement. This is in keeping with other bariatric surgeries, as Buchwald et al. reported that 78.5% of all surgical patients had resolution or improvement in their hypertension (43).

4.4. Hyperlipidemia

A retrospective analysis by Zhang et al. showed that there is improvement in patients' lipid profiles post-SG (44). They found significant improvements in high-density lipoprotein cholesterol (HDL) and triglycerides (TRIG) but no change in low-density lipoprotein cholesterol (LDL) and total cholesterol (TC). Videl et al. found that the changes in HDL and TRIG seen after LSG were comparable to those seen after gastric bypass (40). In general however, bariatric procedures such as RYGB and BPD-DS tend to better improve all the variables in the lipid profile (TC, LDL, HDL and TRIG), and thus are more successful in treating hyperlipidemia (43, 44).

4.5. Other Co-morbidities

Chopra et al. showed that in addition to diabetes and hypertension, LSG significantly improve asthma, obstructive sleep apnea and gastro esophageal reflux disease (GERD), in 90%, 90.74% and 45.92% of patients respectively (45). However, there still remains to be a consensus as to the effect of SG on GERD as studies have found conflicting evidence about whether it is an aggravating or alleviating factor (46). It can be postulated that improvements in the metabolic syndrome after SG should be reflected in a reduction in overall mortality (39). There is evidence that there is a modest reduction in long-term mortality following bariatric surgery, however this relationship has yet to be conclusively shown for SG (47).

5. Conclusions

LSG has emerged as an effective stand-alone procedure in the thriving world of bariatric surgery. It continues to produce results that can be compared to the gold standard, RYGB. The literature has moved away from labeling LSG as a purely restrictive procedure, as its interactions with gut hormones (ghrelin, PYY, and incretins) are now recognized. As more long-term data becomes available, the true value of this bariatric procedure will be fully recognized.

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Authors' Contribution

Noah Switzer, Andrew Smith contributed to the inception and drafting of the manuscript. Daniel Birch and Shahzeer Karmali contributed in the inception, review and editing of the manuscript.

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