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The Final thesis

The Results of Minimally Invasive Treatment of Morbid Obesity

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List of abbreviations

Abbreviation	Meaning
MGB	Mini-gastric banding
BPD/DS	Laparoscopic biliopancreatic diversion with duodenal switch
ESG	Endoscopic sleeve gastropasty
LAGB	Laparoscopic gastric banding
LRYGB	Laparoscopic Roux-en-Y gastric bypass
LSG	Laparoscopic sleeve gastrectomy

Definitions:

- BMI: weight in kilograms (kg) / square of height in meters (m²)
- Percent excess weight loss (%EWL): $((\text{initial weight} - \text{follow-up weight}) / (\text{initial weight} - \text{ideal weight})) * 100$.
- Total weight loss (%TWL): $((\text{pre-op weight} - \text{follow-up weight}) / \text{pre-op weight}) * 100$.
- Total body weight loss (%TBWL) = pre-op weight – post op body weight.
- weight regain (%WR) was regarded significant if $\geq 15\%$
- Ideal weight corresponds to a BMI of 25 kg/m².

1. SUMMARY

Obesity is a worldwide epidemic with dramatic increase in patients within the last decades. The best treatment for this condition is to undergo bariatric surgery which promotes both weight loss and resolution of co-morbidities. A major challenge to a successful outcome is to maintain long-term weight loss and minimizing weight-regain. This work evaluated the long-term results of the most common minimally invasive bariatric procedures in the morbidly obese.

2. KEY WORDS

Bariatric surgery, long-term, obesity, minimally invasive

3. INTRODUCTION

The prevalence of minimally invasive procedures is increasing globally (1). As the population grows, the rates of obesity are increasing (2) with the US having the highest BMI for men and women among high-income countries (3). Overweight and obesity are the fifth leading risk for global deaths (4) with at least 2.8 million adults dying annually as a result (5).

The multifaceted complexity of obesity (6) arises from an interplay of factors including behavior, environment, genetics, signaling pathways (7) and metabolism. This poses significant efforts by healthcare systems (8) to combat by implementing preventive measures, providing education and counseling, and offering medical and surgical interventions.

With significant growth in obesity in the last few years, the burden of obesity has increased substantially resulting in healthcare budgets of OECD (Organization for Economic Co-operation and Development) countries allotting to an average of 8.4% on treating the consequences of overweight patients' disease outcomes over the next thirty years (9).

Due to generally ineffective long-term treatments of obesity using weight control (10), in recent years minimally invasive treatments has been on the rise (11). These treatments promote a large amount of sustained long-term weight loss (12).

While overweight and obese patients may face many considerable comorbidities, morbid obesity is associated with a greater and more severe range of comorbidities, including cardiovascular disease, diabetes, sleep apnea, and certain types of cancer (13).

An emerging class of patients in clinical settings in recent years was named 'super-obese' indicating an extremely high level of obesity with a BMI of ≥ 50 (14) which corresponds to a weight of around 179 kg at 175 cm tall, this puts the patient at an even greater risk of co-morbidities and burden to the healthcare system.

To combat obesity and the low efficacy of traditional weight loss practices patients may choose to undergo surgical procedures; the most performed minimally invasive bariatric procedure in recent years being sleeve gastrectomy (SG). SG accounts for around 60% of bariatric surgeries in the US (15) with adjustable gastric banding, biliopancreatic diversion with duodenal switch, Roux-en-Y gastric bypass (RYGB) being routinely practiced to varying degrees in major centers. SG and RYGB are the most effective therapies to induce persistent weight loss (16).

Newer techniques such as mini gastric bypass (MGP) and endoscopic sutured gastroplasty (ESG) have risen in popularity due to their innovative nature and improved cosmetic outcome. All of the mentioned minimally invasive procedures have demonstrated significant weight loss, improvement in comorbidities, and increased quality of life in comparison to the alternative of an open surgical approach. A prominent significance of minimally invasive technique is the reduced risk of wound infection and incisional hernia which is lowered by 79% and 89% (17), respectively.

Due to the nature of newer techniques in the medical field which take years to implement and research, long-term durability of over 5 years are difficult to acquire and may not provide as much clinical value due to the nature of weight regain in obese patients. For example, the first ESG was performed as recently as 2008 and no research was found that shows long term results over 5 years.

Some of the associated downside of bariatric surgery is the invasive and often irreversible nature of the procedure with weight regain continuing to be a major hurdle for patients, as regardless of the surgical approach many experience weight regain sometimes as soon as 3 years after undergoing the procedure, with many of them having to do revisions, sometimes within the first year.

With limited success of educating and motivating patients about diet and exercise to achieve long-term results, there is still great debate within the scientific community of the correct approach to eradicate obesity (18).

With the technological advancements of bariatric surgical techniques in recent years (19) and accumulation of experience by surgeons, we must re-evaluate the clinical significance of previous systematic reviews such as from Buchwald et al (20) that includes data from studies published before 2003 and additionally gather better data for the future during follow-up consultations in order to achieve greater statistical results. Recent clinical trials point out targeted data for the available surgical procedures but still raises a demand for which procedure may be the most efficacious, especially long-term. It is therefore crucial to review the current literature to provide present data.

While obesity has been a health concern for centuries, the societal perception of this condition has shifted considerably over time (21). In the past and even in some cultures in present day, obesity is viewed as a sign of wealth and affluence. In western society, despite obesity being viewed as serious public health issue there are individuals who rake popularity using social media to promote inclusion of obese people as a disguise of body positivity, a disturbing trend that justifies unhealthy behaviors and eating habits even in young children with latest research indicating that the more exposure to media the higher the risk of obesity (22).

In this paper we will discuss the current literature regarding long-term results of minimally invasive bariatric surgery in morbidly obese patients, highlighting the preferred method, risks and long-term outcome.

4. OVERVIEW

Bariatric surgery is currently the most effective treatment for morbid obesity as was stated by the World Health Organization (WHO) in 2000 (23), leading to significant weight loss and improvement in metabolic comorbidities. Minimally invasive bariatric surgery has gained popularity over the years due to its lower morbidity and mortality rates, faster recovery, and improved cosmetic outcomes. The most common types of minimally invasive bariatric surgery are laparoscopic sleeve gastrectomy (LSG), laparoscopic Roux-en-Y gastric bypass (LRYGB),

laparoscopic adjustable gastric banding (LAGB), and laparoscopic biliopancreatic diversion with duodenal switch (LDB/DS).

There are numerous challenges of morbidly obese patients (24). These patients are associated with greater morbidity than those with obesity in both metabolic diseases such as obstructive sleep apnea, hypoventilation syndrome, diabetes and operative cardiac risk factors as well as reduced mobility and ability to exercise which will delay weight loss post-operatively. Moreover, some of the patients are sarcopenic (25), a condition characterized by loss of strength, muscle mass, reduced stamina and function which is commonly found in a separate patient demographic of older adults which manifests in slow walk and difficulty performing daily activities.

Surgical technique is also more challenging as the patients obesity is more pronounced due to torque on the laparoscopic ports when establishing access and heavier abdominal wall which is requiring adjustment to the pressure in order to establish adequate ventilation of the pneumoperitoneum (26) required for bariatric procedures.

There are three types of bariatric surgery: restrictive, malabsorptive, and mixed. Restrictive surgery limits the amount of food intake by reducing the stomach's size, malabsorptive surgery alters the small intestine's length to reduce nutrient absorption and mixed surgery involves both restrictive and malabsorptive components, which combines the creation of a small stomach pouch with the rerouting of the small intestine, reducing the amount of food and nutrients absorbed.

This paper will highlight the following procedures currently practiced:

Laparoscopic sleeve gastrectomy involves the removal of approximately 75-85% of the stomach, leaving a narrow tube or sleeve-shaped pouch. This procedure reduces the stomach's capacity and alters the gut hormones' secretion, resulting in a feeling of satiety and reduced hunger.

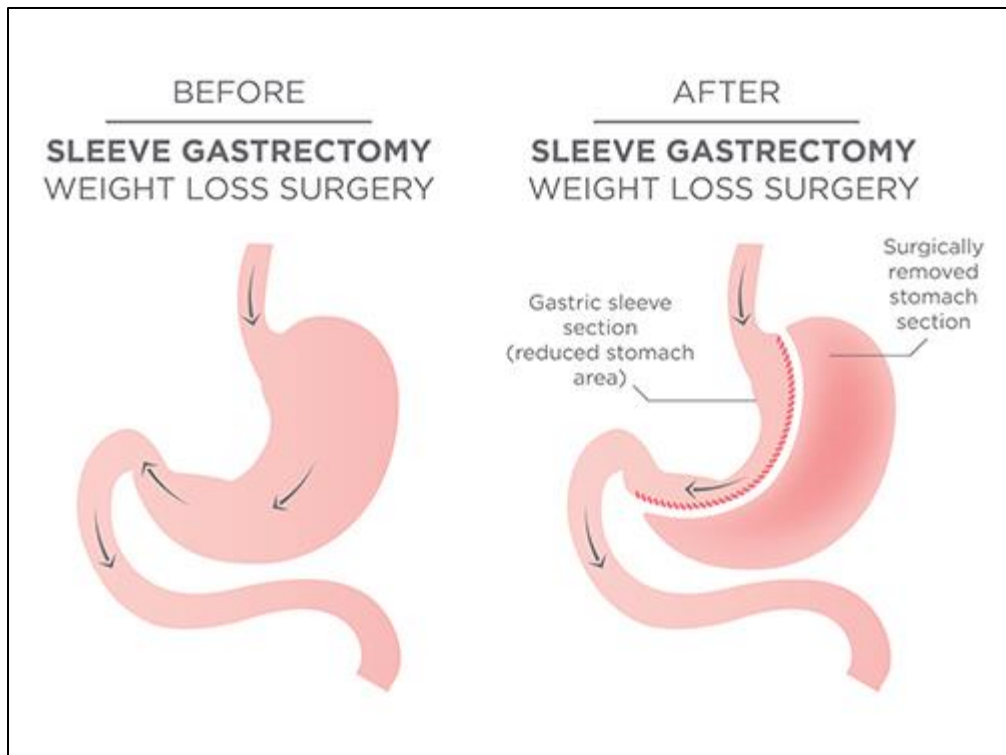


Figure 1: Sleeve gastrectomy

Laparoscopic Roux-en-Y gastric bypass involves creating a small pouch from the upper stomach and rerouting the small intestine to this pouch, bypassing the remaining stomach and duodenum. This procedure reduces the stomach's capacity, alters the gut hormones' secretion, and leads to malabsorption of nutrients, resulting in weight loss and improvement in metabolic comorbidities.

As stated in Aly(27): “RYGB remains an effective and safe procedure for the treatment of the super obese. The super obese may have more resistant obesity than the morbidly obese as reflected in weight loss outcomes when using %EWL as a measure although %TBW appears comparable. Attention should be paid to the length of the biliopancreatic limb and consideration given to making this longer in the super obese, keeping the total limb lengths to less than 300 cm. The safety and long term results compare favourably with other non-malabsorptive procedures making LRYGB an excellent option.”

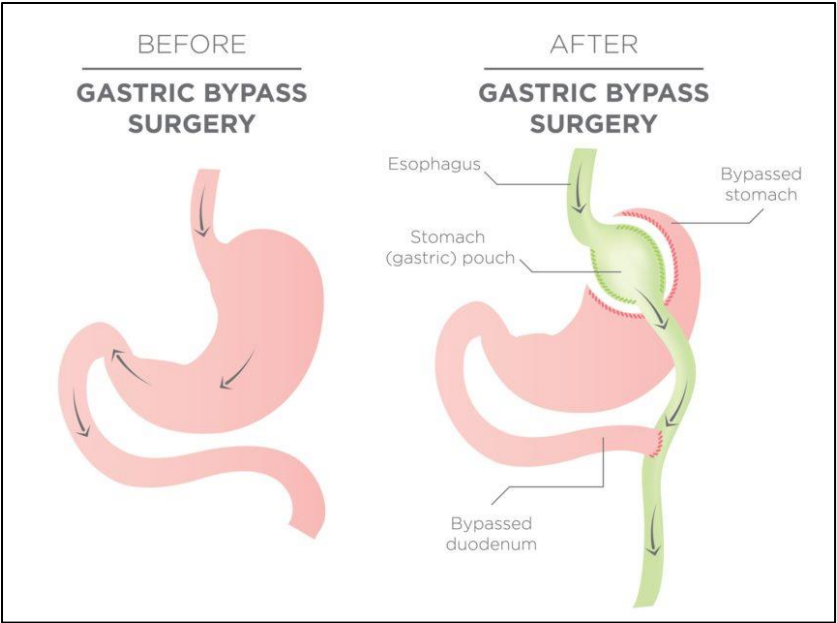


Figure 2: RYGB

Laparoscopic adjustable gastric banding involves placing a band around the upper stomach, creating a small pouch and limiting food intake. This procedure does not alter the gut hormones' secretion and leads to slower weight loss and fewer metabolic improvements than other bariatric surgeries.

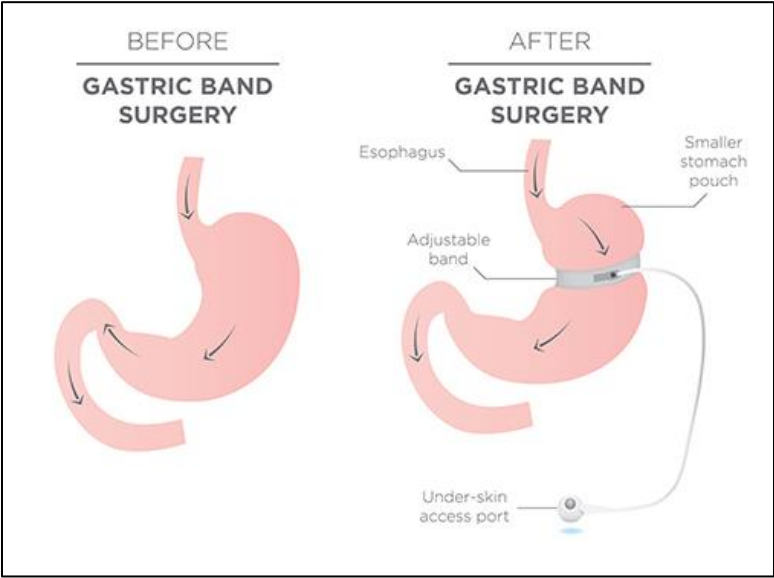


Figure 3: Gastric banding

Laparoscopic biliopancreatic diversion with duodenal switch involves a sleeve gastrectomy and rerouting the small intestine, leading to both malabsorption and reduced stomach capacity, resulting in significant weight loss and improvement in metabolic comorbidities.

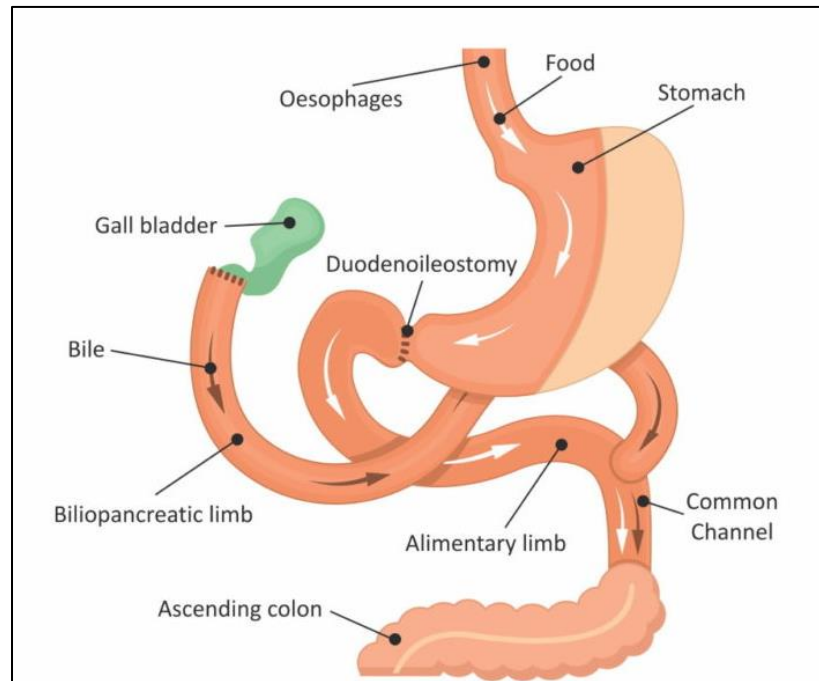


Figure 4: Biliopancreatic diversion

It is significant to mention Endoscopic Sleeve Gastroplasty as an innovative and relatively recent procedure that involves using an endoscope inserted orally without a need for laparoscopic ports which has a reversible and better cosmetic outcome in order to invaginate the stomach using a full-thickness endoscopic suturing device to create a fold which transforms the stomach into a tube-like structure that restricts the amount of food that can be consumed. No articles were found that met the inclusion criteria and it is therefore not critically valued in this work's results but both surgeons and patient should take this procedure into consideration for its great outcomes as mentioned in a four-year prospective cohort study in India by Bhandari (28) which showed that among 612 patients mean %TBWL was 18.19%, %EWL was 49.30% with 90% of patients maintain TWL of $\geq 5\%$ and resolution of comorbidities of diabetes, hypertension and dyslipidemia in majority of patients with a great safety profile with no patients requiring any emergency intervention and no mortality or significant morbidity. A second article by Sharaiha(29) followed 216 patients over a 5 year period a mean %TBWL of 15.9% with over 61% of patients maintaining

at least 10% of their %TBWL. With an overall rate of 1.3% of moderate adverse events without any fatalities.

The results of the weight loss are acceptable with being more effective than traditional weight loss regimens but less effective than LSG, although with a far superior safety profile when in comparison as was also mentioned in an efficacy and safety study made in Korea by Yoon and Arau (30), strengthens the notion that ESG is to be a considered safe and effective treatment for at least for up to 5 years post-op and a reliable surgical option.

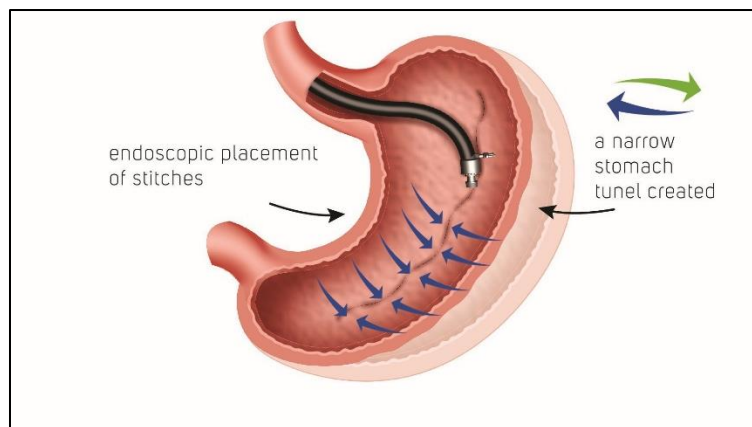


Figure 5: Endoscopic sleeve

Another bariatric procedure not included in the results is Mini-gastric bypass (MGP) which has been routinely performed since for over two decades and is similar to LRYGB but has only one anastomosis whereas in LRYGB there are two, although it possess a set of infamous risks and complications such GERD, severe malnutrition and increased long-term risk of gastric and esophageal cancers that voiced concerns between a large number of surgeons across the world. Despite these expressed fears, there are advantages such as ease of revision and reversal, technical simplicity, comparable weight loss and co-morbidity resolution results which encouraged some surgeons to advocate for this procedure (31). To demonstrate the results of this procedure, data on 1,000 patients by Noun(32) shows that over a 6 year period %EWL of 72.5% occurred at 18 months with weight regain occurring with a mean variation of -3.9% of EWL at 60 months and a 50% EWL achieved by 95% of patients with a short term complications of 2.7%. This shows MGB to be “an effective, relatively low-risk, and low-failure bariatric procedure” which can be easily revised, converted, or reversed.

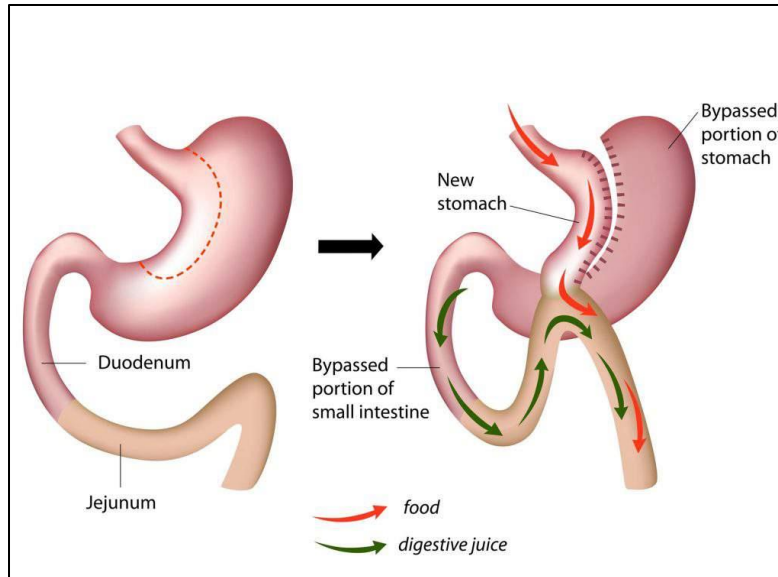


Figure 6: Mini-gastric bypass

Minimally invasive bariatric surgery is an effective treatment option for severe obesity, leading to significant weight loss and improvement in metabolic comorbidities. The choice of surgery depends on several factors, including the patient's comorbidities, preferences, and surgeon's expertise.

5. METHODOLOGY

To conduct this systemic literature review the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology was used. Inclusion criteria were articles that showed data about minimally invasive bariatric surgery, had a follow-up period of more than 10 years, reported the number of patients included over 50, had a patient retention rate of more than 70%, were only in the English language, and had free full text available, or all relevant data was presented clearly in the abstract.

A comprehensive search was conducted on relevant databases including PubMed which is maintained by the "National Center for Biotechnology and Information (NCBI)" at the "National Library of Medicine". The search terms included keywords related to bariatric surgery such as "gastric bypass", "sleeve gastrectomy" and "bariatric surgery," as well as keywords related to the inclusion criteria such as "long-term outcomes", "morbid obesity" and "follow-up rate." The search

was limited to articles published during the time period of 2017-2023 to ensure the most recent evidence was included. Additional articles were included by analysis of references from articles used. They were then screened for the same inclusion criteria and data was extracted from them. Finally, the selected articles were critically appraised, and results were extracted and synthesized the findings.

The results of this paper included data from 10 articles that met the inclusion criteria and provided insights into the long-term outcomes of different bariatric surgery methods.

The PRISMA flowchart of literature search is shown in Fig 6. The initial database search retrieved 41,531 articles. After inputting inclusion criteria of articles published between 2017-2023, free full text, age range above 19 years old the search showed 2,278 articles. These were further narrowed down with usage of relevant keywords to include 10 articles in analysis [22-31]. After serious consideration, all articles were of great research value and could provide strong evidence for this systemic literature review. Countries included were very representative and vast, including Austria, Spain, France, Israel, Switzerland, Norway, Poland from both big centers and private hospitals.

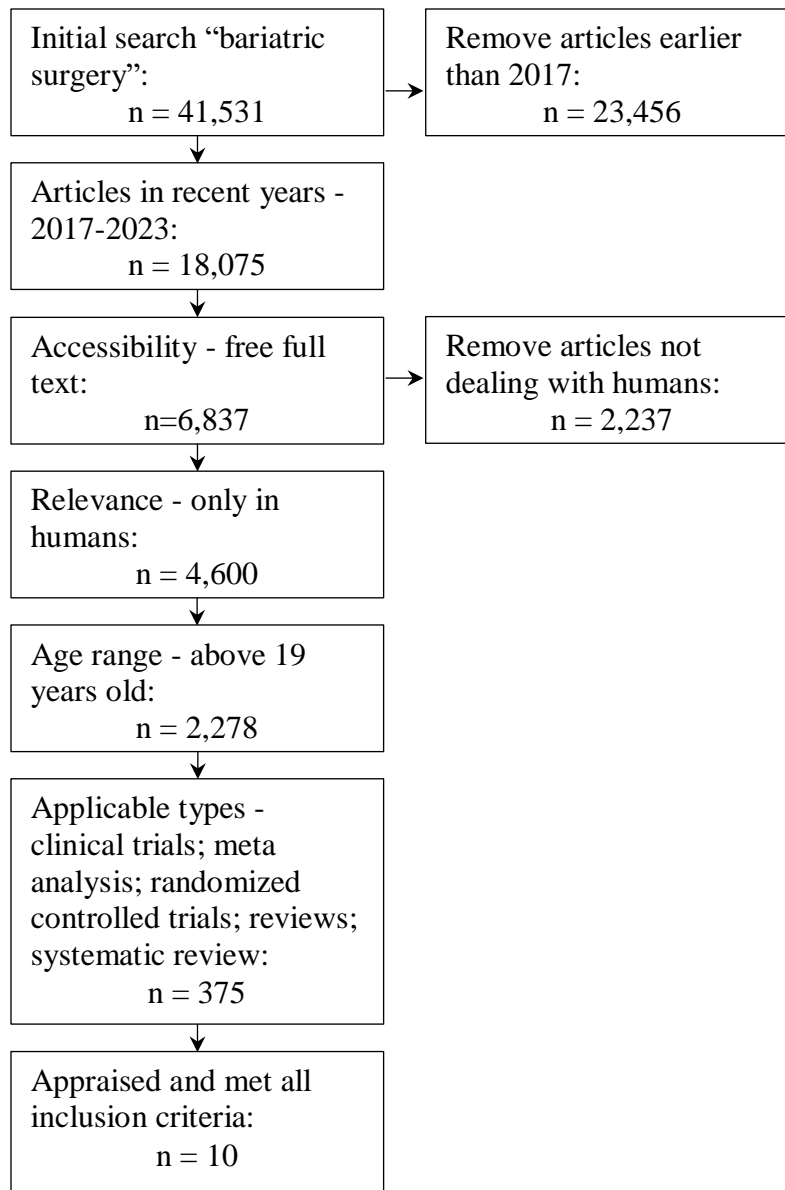


Figure 7: PRISMA diagram

6. RESULTS

Table 1: Results of minimal invasive surgery

#	Author	Operation	N of patients	Follow-up time	Mean %EWL	Mean %TWL	WR ($\geq 15\%$ maximum WL)	Re-operation	Mortality related to operation
1	Gissey (33)	LSG	182	10 years	52.5%	30.9%	10.4%	-	0%
2	Felsenreich (34)	LSG	53	10 years	53 \pm 25%	26.3 \pm 13.4%	13%	36%	-
3	Musella (35)	LSG	76	10 years	50.1 \pm 30.5	22.2 \pm 13	5.7%	15.8%	-
4	Kowaleswski (36)	LSG	84	8 years	51.1% \pm 22.3	23.5% \pm 11.67	-	16%	-
5	Chahal-Kummen (37)	LRYGB	203	10 years	53%	24.1%	63.3%	33.9%	-
6	Styliani (38)	LRYGB	764	10 years	61.3%	28.8%	-	17.7%	2.1%
7	Musella (35)	LAGB	76	10 years	47.3 \pm 35.2 %	21.2 \pm 16.1 %	16.1%	-	-
8	Vinzens (39)	LAGB	405	10 years	48 \pm 27%	-	25%	63%	
9	Froylich (40)	LAGB	74	10 years	47.8%	21.0 \pm 0.13%	-	30%	-
10	Topart (41)	LBD	80	10 years	73.4 \pm 26.7%	35.9% \pm 17.7%	-	11%	-

#	Author	Operation	N of patients	Follow-up time	Mean %EWL	Mean %TWL	WR ($\geq 15\%$ maximum WL)	Re-operation	Mortality related to operation
11	Sorribas (42)	LBD	224	10 years	67.4%	33.8%	-	12%	-

7. RESULTS INTERPRETATION

The results of the table reveal that different types of bariatric surgery show varying outcomes in terms of weight loss, weight regain, re-operation rates, and mortality related to surgery.

LSG was performed in three studies, with a follow-up time of 8-10 years, and demonstrated a mean percent excess weight loss (%EWL) ranging from 50.1% to 53%, and a mean percent total weight loss (%TWL) ranging from 22.2% to 26.3%. LSG also had a relatively low rate of weight regain (WR) of 5.7-13%, and no mortality related to the operation in the articles used. A literature review by Rebibo(43) that states that among 6227 who had undergone LSG there was a 0-0.08% mortality rate which we can use to justify the our result. However, re-operation rates ranged from 15.8% to 36%, indicating that some patients may require additional surgery after the initial LSG due to various factors including onset of GERD which is very prevalent among patients that undergone LSG.

Laparoscopic Roux-en-Y gastric bypass (LRYGB) was performed in two studies, both with a follow-up time of 10 years. LRYGB showed a higher mean %EWL of 53% to 61.3% and a mean %TWL of 24.1-28.8%. However, LRYGB also had a higher WR rate of 63.3%, indicating that weight regain may be more common in patients who undergo this type of surgery. Re-operation rates ranged from 17.7% to 33.9%, and no mortality related to the operation was reported.

Laparoscopic adjustable gastric banding (LAGB) was performed in three studies, all with a follow-up time of 10 years. LAGB showed a mean %EWL ranging from 47.3% to 48%, and a mean

%TWL ranging from 21.0% to 21.2%. LAGB had a relatively high WR rate of 16.1-25%, and re-operation rates up to 30%. No mortality related to the operation was reported.

Biliopancreatic diversion (BPD) with or without duodenal switch (BPD/DS) was performed in two studies with significant reduction in %EWL of 67.4% to 73.4% and a mean TWL of 35.9%-33.8%, suggesting that LSG may provide better weight loss outcomes with lower rates of weight regain, but may still pose risk of complications and re-operation such as mentioned in Sethi(44) that looked retrospectively at 100 patients and shows a %EWL of 67.9% at 10-15 years with improved co-morbidities, but 37% of patients developed long-term complications requiring revision surgery. A high satisfaction rate of 94% of patients from the surgery is encouraging, but with nutritional deficiencies in fat-soluble vitamins, anemia and secondary hyperparathyroidism being common with the unfortunate mortality of one patient from severe malnutrition it is necessary to have careful monitoring and postoperative management.

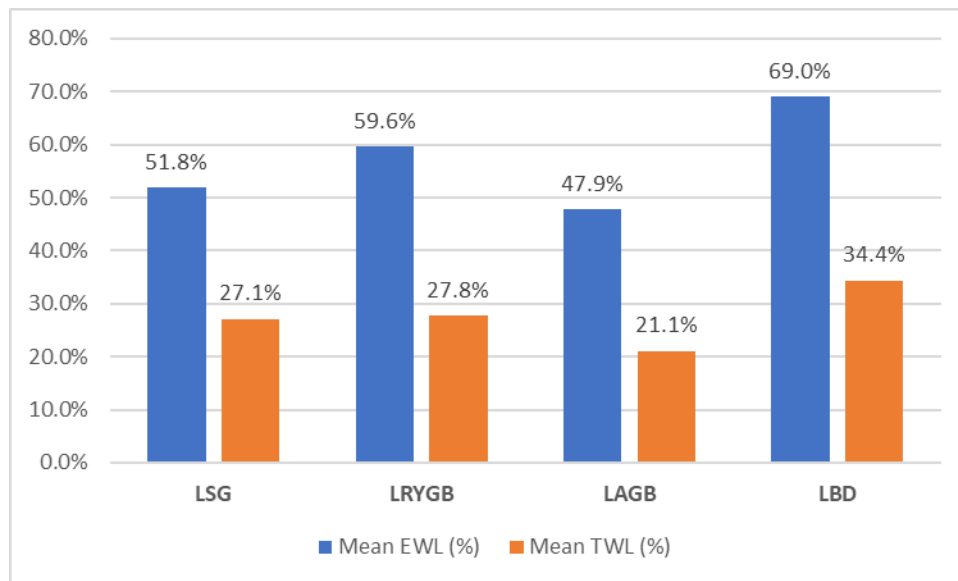


Figure 8: Mean EWL and mean TWL

Upon analyzing the selected articles, it was noticed some of them had data about resolution of metabolic disorders such as type 2 diabetes mellitus (T2DM) after undergoing bariatric procedures. An example of the efficacy can be seen in the study by Schauer et al.(45). The study involved a randomized clinical trial comparing intensive medical therapy with surgical therapy for T2DM in obese patients. The results showed that patients who underwent bariatric surgery had significantly greater reductions in HbA1c levels and were more likely to achieve a HbA1c level of less than

6.0% than those who received medical therapy alone. Furthermore, the study found that the surgical group had greater weight loss, improved lipid levels, and reduced medication use compared to the medical therapy group. This goes in line with another recent review article by Alquanai and Alrashid(46) which evaluated bariatric surgery for the management of T2DM showing the different metabolic surgical working mechanisms with their advantages and disadvantages, the indications for metabolic surgery for obese patients with T2DM and the key findings from over 8 studies showing the outcomes of metabolic surgery for T2DM patients. The articles that were reviewed showed similar results of resolution of metabolic disorders as the data from the articles used in the results of this systematic literature review with spontaneous resolution in 60-85% with variability depending on the type of surgery, BMI prior to operation, co-morbidities, follow-up time, insulin lowering drugs medicaments, physical activity levels and more.

The limited availability of articles reporting long-term outcomes of bariatric surgery over 5 years may be due to various factors. Firstly, bariatric surgery is a relatively new field of research, and studies reporting on long-term outcomes may have only recently reached the required follow-up time. Additionally, long-term studies can be challenging to conduct due to various factors such as patient dropout, incomplete data, and changes in the surgical technique or aftercare over time. Moreover, funding for long-term studies may be limited, and researchers may prioritize shorter-term studies due to practical and financial constraints.

As a result, most of the research available on bariatric surgery reports outcomes up to 5 years after the surgery. Therefore, more research is needed to understand the long-term durability of bariatric surgery, and efforts should be made to conduct larger, longer-term studies to address this gap in knowledge.

8. CONCLUSIONS

The results of the table indicate that all types of bariatric surgery are an effective method for weight loss in obese patients. However, the choice of surgery should be carefully considered based on individual patient characteristics, as different types of surgery may have varying outcomes in terms of weight loss, weight regain, and re-operation rates.

With advances in drug for the resolution of metabolic conditions, satiety controlling drugs, improved psychological techniques and new exercise routines it is important for surgeons to advise patients to continuously follow-up with outpatient care of family physician and endocrinologist to maximize long-term durability of weight loss which can in some cases experience significant weight regain over the 5-year post-op mark.

With the nature of morbid obesity becoming a life-long condition for many patients, physicians must keep in mind the longevity of bariatric surgery to not be a permanent fix and require a good aftercare even years after the operation and maximal weight loss.

Further research is needed to fully understand the long-term effects of bariatric surgery past the 10-year mark on weight loss durability and related health outcomes.

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