VILNIUS UNIVERSITY
FACULTY OF MEDICINE

Integrated Studies of Medicine

Institute of Clinical Medicine, Clinic of Gastroenterology, Nepro-Urology and Surgery

Johannes Lothar Kolb, Year 6, Group 1

INTEGRATED STUDY MASTER'S THESIS

Long Term Results (10 and More Years) After Sleeve Gastrectomy Operation for the Treatment of Obesity

Supervisor: **Dr. Žygimantas Juodeikis**

Head of the department: **Prof. Dr. Habil. Kestutis Strupas**

Vilnius, 2025

Email of the student: Johannes.kolb@mf.stud.vu.lt

1 Outline

1.1 Table of content

1.2 Abbreviations

BMI = Body mass index

WHR = Weight-to-hip ratio

EOSS = Edmonton Obesity Staging System

WHO = World Health Organization

BS = Bariatric surgery

LSG = Laparoscopic sleeve gastrectomy

SG = Sleeve gastrectomy

RYGB = Roux-en-Y gastric bypass

LRYGB = Laparoscopic Roux-en-Y gastric bypass

BPD-DS = biliopancreatic diversion with duodenal switch

T2DM = Type 2 diabetes mellitus

DLP = Dyslipidemia

GERD = Gastroesophageal reflux disease

HTN = Hypertension

OSA = Obstructive sleep apnea

QOL = Quality of life

Reop = Reoperation

EBMIL = Excess body mass index loss

EWL = Excess weight loss

TWL = Total weight loss

WL = Weight loss

F/U = Follow-up

N/A = Not available

1.3 Summary

In this systematic literature review, the long-term results 10 years or more after LSG for the treatment of obesity will be discussed regarding its effectiveness for long-term weight loss, complications, and general satisfaction compared to other bariatric surgery methods and conservative weight loss methods, including multimodal lifestyle changes.

1.4 Aim of the paper

This study aims to evaluate the long-term efficacy of LSG, to determine whether the procedure is superior to other bariatric procedures, and what can be recommended to physicians. For this goal, the average weight loss after 10 years is recorded, the effect on the quality of life is analyzed, the complications that occur during this period, the total EWL, the need for reoperation, and a direct comparison with LRYGB are included.

At the end of the analysis, a conclusion should be drawn as to whether the advantages of the operation outweigh the disadvantages in the long term and in which context it makes sense to recommend gastric sleeve surgery over other methods of weight loss.

1.5 Literature selection strategy:

Medline (PubMed) was queried for human studies published until August 2024, analyzing patients who had undergone sleeve gastrectomy. The search was conducted on August 01, 2024, using the search terms (long-term results of sleeve gastrectomy for obesity) AND (10 years[title]).

Only the articles with a 10-year timeframe in the title were included since the rest included patients with more recent sleeve gastrectomy. Articles were only included in a 10-year timeframe, starting in August 2014.

The result of this search showed a total of 10 articles. Of these, articles that did not compare sleeve gastrectomy with no treatment, other forms of obesity treatment, or other bariatric surgery methods were excluded, and studies that included patients less than 10 years after their sleeve gastrectomy were excluded.

With these exclusion criteria, eight articles were included in the literature selection.

2 Introduction

Obesity is one of the biggest problems facing society today. In 2020, 46.6% of women and 60.5% of men in Germany were overweight, and almost one-fifth of adults were obese. [1]

Obesity is a global problem, in every country of the world, obesity rates are increasing, even in the poorest countries of the world, there is a rising population of overweight persons. [2]

About 8% of all deaths worldwide are related to obesity, and it is associated with several comorbidities that lead to reduced life expectancy and physical functioning. [3]

Obesity is mainly related to an overconsumption of processed, readily available food sources. Many Obese patients have difficulties integrating a healthy lifestyle of a balanced diet and sufficient exercise into their daily lives. While obesity is always caused by an excess of calories, the tendency to overeat can be associated with metabolic, hormonal, or psychiatric disorders. For this reason, losing weight on their own can be a near-impossible challenge for many people struggling with obesity, as they are used to a particular lifestyle and trapped in a cycle of overconsumption.

There are many strategies to help patients lose excess weight by stopping dietary overconsumption. Many conservative weight loss strategies exist, such as multimodal lifestyle changes or weight loss medication, therefore different surgical approaches to reduce food consumption should always be considered a reserve treatment for extreme cases. One of the most popular surgeries in the bariatric

field is the LSG, a surgical technique that involves removing a significant portion of the stomach to help suppress appetite. In recent years, there has been an increase in bariatric operations. [4]

This is why the question arises: How does the outcome of the sleeve gastrectomy perform in comparison to other bariatric surgeries and conservative methods from a long-term perspective?

3 Obesity

3.1 Definition

Obesity is defined as the excessive accumulation of fat tissue within the organism. It is a chronic condition in which body weight is significantly increased due to excess fat in relation to body size. Obesity is not only an aesthetic problem, it is also associated with an increased susceptibility to various health problems and a reduced life expectancy.

3.2 Pathophysiology

Obesity results from a long-term energy imbalance, with excess calories consumed compared to calorie expenditure, which is composed of calories burned during daily activities through basal metabolic rate and thermogenesis.

While neuroendocrine dysfunctions, genetic predisposition, and hormonal dysregulation can affect appetite, the most significant contributors to obesity are the environmental factors that create eating habits, levels of physical activity, and general lifestyles. Multiple factors form this environment.

A lower education level is often connected to poor nutritional knowledge. Poor parental food and lifestyle choices are often copied by the children, leading to an inheritance of obesity. Also, limited financial resources can lead to a diet of cheap, processed, and calorie-dense ingredients. Modern society creates an environment with easy access to unlimited fast food sources, sugary beverages, and desserts.

In addition, urbanization reduces natural opportunities for physical activities. Desk jobs are more common than ever, and elevators, escalators, and e-scooters are more comfortable choices for many.

3.3 Classification

3.3.1 Body mass index (BMI)

Although BMI is not an accurate way to determine a person's overall fitness and body fat percentage, it is an easy, convenient, safe, and cheap way to determine quickly whether someone is statistically overweight for their height.

The WHO uses the BMI classification to determine the degree of obesity quickly:

Fig. 1:

Body mass index (kg/m^2)	Class	Body mass index (kg/m^2)	Class
25–29.9	Overweight	25–29.9	Overweight
30–34.9	Class I obesity	≥30	Obese
35–39.9	Class II obesity	35–39.9	Severe obesity
≥40	Class III obesity	40–49.9	Morbid obesity
		≥50	Super obesity

[5]

According to the WHO, individuals with a BMI over 30 are classified as obese. A man of average European height of 180 cm and a BMI of 30 weighs about 100 kg. [6]

While this may be a healthy weight for some professional athletes with a certain amount of muscle, for the average person, this weight is associated with a lot of excess fat and many diseases. As skeletal muscle weighs more than adipose tissue for a specific group of people, the BMI is an oversimplified method to use the weight/height ratio to determine the degree of pathology in all patients. [7]

This criticism leads to many attempts to replace the BMI method with another, more precise staging system.

3.3.2 Waist-to-hip ratio (WHR) and Body fat Percentage

The diagnosis of obesity is also supported with the factors waist-to-hip ratio and the fat distribution in the body by some physicians.

The WHR measures fat distribution by dividing waist circumference by hip circumference. Since a higher waist-to-hip ratio indicates central obesity, which is linked to a higher risk of metabolic diseases, this method demarcates unhealthy obesity more accurately than BMI. A similar method is

the Waist-to-Height Ratio (WHtR), which compares waist circumference to height. This method considers a ratio above 0.5 a risk factor for obesity-related conditions.

Fat distribution can be measured using a combination of different methods. Skinfold thickness can be measured using skinfold calipers, and the DEXA scan directly assesses fat content. Bioelectrical impedance analysis (BIA) estimates the body fat percentage by measuring electrical conductivity through the body using the specific impedance of fat tissue.

3.3.3 Edmonton Obesity Staging System (EOSS)

Some physicians use the EOSS to evaluate the associated health risks and the need for obesity treatment. The EOSS classifies patients on a scale of 0 to 4 according to the degree of orthopedic, psychological, and medical comorbidities associated with their elevated BMI.

Stage 0 represents the absence of obesity-related risk factors, physical symptoms, psychopathology, functional impairment, and/or impaired well-being. Counseling to prevent further weight gain is recommended.

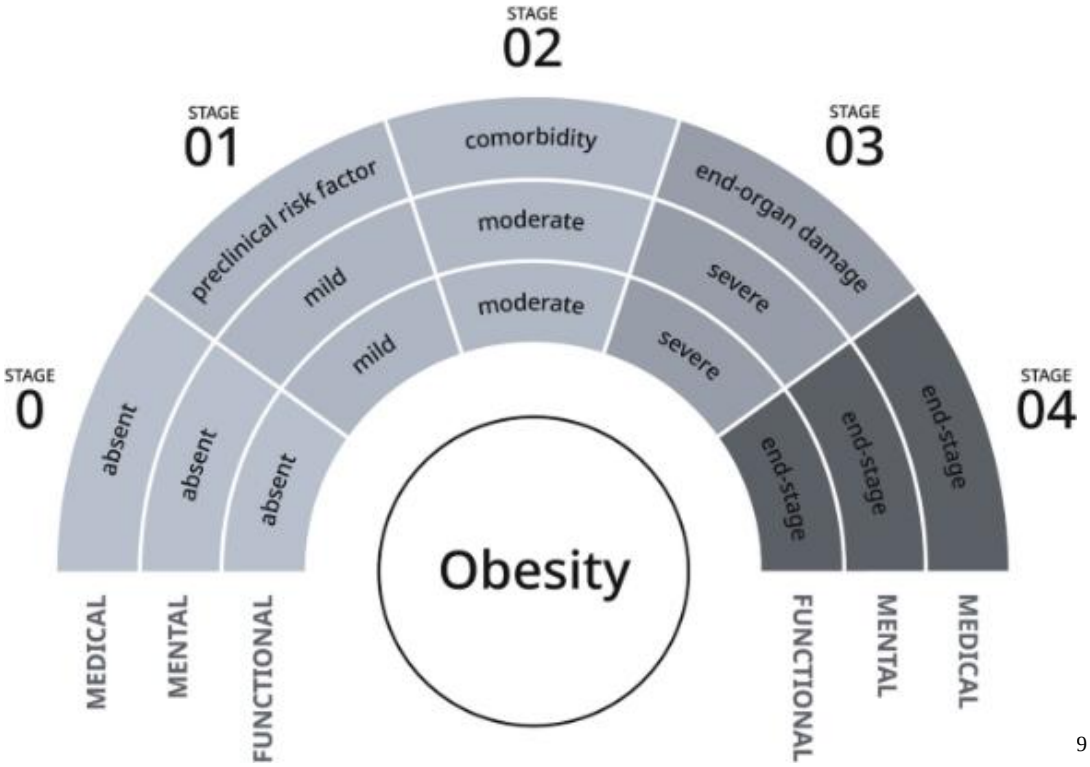
Stage 1 represents obesity-related subclinical risk factors, mild symptoms, limitations, and/or impaired well-being. Intensive diet and exercise, along with patient health monitoring, are recommended.

Stage 2 represents established obesity-related chronic diseases and moderate limitations. Treatment of obesity with pharmacological and behavioral therapies to support lifestyle changes is recommended, and management of underlying comorbidities is advised. Bariatric surgery is also recommended, depending on the patient's BMI.

Stage 3 represents end-organ damage, dysfunction requiring endoprosthesis surgery, or significant obesity-related psychopathology. Intensive treatment of obesity with all behavioral, pharmacological, and surgical options is recommended, as well as aggressive management of comorbidities.

Stage 4 represents significant disability, immobility, and severe chronic disease caused by obesity. Aggressive management of obesity is recommended if possible, palliative management may be necessary. [8]

Fig. 2:



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A combination of the EOSS and the BMI classification is a more precise method for identifying the most optimal management option by evaluating the effect that obesity has on the patient's health. [10]

3.3.4 Conclusion

Although these alternative methods appear promising, the BMI remains the primary criterion for determining eligibility for bariatric surgery due to its simplicity. In most cases where bariatric surgery is considered, the BMI is relatively meaningful, as such a high BMI can never be achieved by someone who is healthy and athletic. However, since the surgeries always carry certain risks, they should be carefully considered; therefore, a more accurate method should be used to make the decision.

4 Complications of obesity

In Germany, over half of all adults are affected by overweight, and worldwide, 32% of adults suffer from a nonalcoholic fatty liver. [11]

The complications of obesity have a massive impact on our healthcare system and our quality of life. In the following, the most significant complications of obesity are presented.

4.1 Osteoarthritis

Obesity leads to excess body weight without increasing the required strength of the muscles to support the joints. This increases joint and surrounding cartilage stress, especially at the hip and knee. Overuse causes the cartilage tissue to wear off.

Through hormonal and inflammatory mechanisms, obesity can also impair tissue metabolism and aggravate cartilage damage.

This can lead to osteoarthritis in the knee and hip joints and degeneration of the spine, which can cause herniation of the vertebral discs and arthritis of the vertebral joints. This is connected to constant pain and restriction of physical ability.

4.2 Metabolic syndrome

A chronic overconsumption of calories also plays a central role in the development of the metabolic syndrome, a cluster of conditions including abdominal obesity, high blood pressure, elevated blood sugar, high triglycerides, and low HDL cholesterol, that increase the risk of cardiovascular disease and type 2 diabetes. The high-caloric diet leads to an accumulation of adipose tissue, in combination with insulin resistance, this leads to an increased release of free fatty acids into the bloodstream. The liver then reacts with an overproduction of very low-density lipoproteins, resulting in dyslipidemia, characterised by high triglyceride levels, low high-density lipoprotein cholesterol, and small, dense low-density lipoprotein particles. This causes the secretion of pro-inflammatory cytokines and alteration of adipokine levels, promoting chronic low-grade inflammation. The increased lipid deposition in blood vessels increases atherosclerosis and therefore the risk for cardiovascular events such as myocardial infarction.

4.3 Diabetes mellitus type 2

A carbohydrate-rich diet combined with excess body fat, resulting in impaired glucose metabolism, can lead to Type 2 diabetes mellitus, a compound of metabolic dysfunctions that can cause episodes of hyperglycemia or even a constant blood sugar increase. If not treated properly, this can cause severe vascular and neuropathic complications. [12]

4.4 Liver cirrhosis

Obesity leads to an accumulation of visceral adipose tissue around and inside the internal organs, especially inside the liver, the amount of this visceral fat can be seen as an accurate marker of cardiometabolic risk. There is a direct association between obesity and the development and

progression of nonalcoholic fatty liver disease, which can develop into liver cirrhosis and finally into hepatocellular carcinoma (HCC). [13]

4.5 Sleep apnoea

Through an accumulation of fat tissue around the neck and throat area, through an enlargement of soft tissue leading to an increase in tongue and soft palate size, and through chronic inflammation caused by obesity, the airways can constrict during sleep, decreasing the air circulation and leading to long pauses between respiration. Obstructive sleep apnoea is characterized by snoring, concentration deficiency during the day, and chronic exhaustion, which can decrease the quality of life and increase the risk of accidents, as well as lead to an increase in cardiovascular diseases such as atrial fibrillation.

4.6 Cardiovascular diseases

An increase in body weight also leads to a higher demand for blood volume; the increased volume inside the vascular system leads to a higher blood pressure, which puts much stress on the heart, resulting in cardiac insufficiency, arrhythmia, renal insufficiency, aneurysms and more frequent events of ischemic stroke and heart attacks. Obesity also leads to fat deposits inside the blood vessels, which leads to vessel constrictions and decreased blood flow. Signs include angina pectoris from decreased blood flow to the coronary arteries, claudication, and leg pain during physical activity. The decreased peripheral blood flow can cause ulcers and infections and can even require amputation. Being overweight can also lead to an increase in the size of the heart, which can cause disturbances in the transmission of electrical impulses. The resulting arrhythmia, such as atrial fibrillation, increases the risk for strokes significantly, especially together with dyslipidemia and the other complications connected to obesity and metabolic syndrome.

4.7 Psychosocial disorders

A Meta-analysis confirmed that depression and obesity are interrelated, with each influencing the development of the other. The analysis not only showed that obesity increases the risk of depression, but also that depression is a predictive factor for the development of obesity. This can be explained by behavioural factors, such as a lack of physical activity, emotional or stress eating, or a poor diet in general, that can be a cause of both depression and obesity, but also biological mechanisms influencing both diseases could be a possible cause. [14]

4.8 Oncology

Obesity is connected to chronic inflammation that can lead to cell damage; increased insulin levels can promote cell proliferation and reduce apoptosis, which all promote cancer growth and reduce a sufficient immune response. Obesity is strongly linked to a higher risk of developing several types of cancer, including uterine, kidney, breast, pancreatic, esophageal and colorectal cancer. It is also associated with greater chances of cancer recurrence and increased mortality across many cancer types.

5 Conservative treatment

To manage or prevent these complications, obesity must be treated by significantly reducing the accumulated body fat.

A long-term daily caloric surplus causes obesity, so treatment always involves reducing intake and sometimes increasing expenditure.

The conservative treatment consists of lifestyle counseling, diet planning, exercise, and medication therapy.

5.1 Multimodal lifestyle changes

Lifestyle modifications are unavoidable in all treatment methods for obesity. Even if the patient takes weight loss medications to reduce their appetite or if their stomach capacity is decreased through surgery, when a patient continues to overconsume high-calorie food and drinks throughout the day, the excess body weight will not decrease.

The first step in making a change is realizing that the current state is unhealthy.

Very commonly seen in severely obese individuals who have the motivation to lose weight is the attempt at extreme crash diets that consist of eating in a significant caloric deficit for a short period, which often leads to a rebound effect because the diet is not sustainable. It causes severe calorie withdrawal symptoms, leading to resignation and a return to the original habits of overeating calorie-dense food.

A better approach is to change to a diet rich in protein and fiber, with enough unsaturated fats, and avoid sugar and saturated fats. This diet should be supported by foods with high volume to reach the feeling of satiety. Many patients lack knowledge of what defines healthy food and what helps them lose weight, and many dieticians fail to give that knowledge to those patients appropriately.

Another problem is the modern food industry; products make more profit if they are highly processed, often because it increases shelf life, if they contain more sugar than recommended because it improves the taste, if they contain cheaper ingredients such as saturated fats, all leading to a more calorie-dense end product. The patients must resist the influence of junk food advertisements and know how to prepare essential ingredients enjoyably.

Dietitians are the primary professionals responsible for implementing dietary interventions aimed at preventing and managing obesity in our society. However, even though the patients attend dietary seminars, it is not ensured that they can apply the given knowledge to their daily lives; the difference in the quality of the dietary consultation, along with how well the patient understands the advice, can determine the outcome of the obesity treatment. Evidence shows that an individualized consultation with a dietitian can significantly affect weight control, and the average weight loss is only slight. [15]

A physician cannot ensure that the patient follows their dietary recommendations in daily life; it is always up to the patient to implement lifestyle changes.

To lose enough weight, these lifestyle changes must be maintained daily for several years. Therefore, discipline alone is often not enough to achieve weight loss goals; a routine must be created.

Losing weight is even more challenging for insulin-resistant individuals since excess glucose is stored as additional adipose tissue. 85% of patients with severe obesity suffer from insulin resistance.

Since the prevalence of insulin resistance among individuals with severe obesity is so high, an important aspect of obesity treatment is the reduction of carbohydrate intake.

Next to a reduction of caloric intake, the other central aspect of losing weight is increasing energy expenditure. The most significant modifiable impact on daily energy expenditure is the increase in muscle mass, which is practical in daily tasks and can increase the patient's participation in social activities and prevent frailty and complications of elderly sarcopenia, such as osteoporosis. Increasing muscle mass can be achieved by weight and resistance training a minimum of three times per week for 30 minutes or more per session. This should be supported by a coach or a physiotherapist in the beginning to prevent injuries due to incorrect exercise execution. This should be supported by a high-protein diet of at least one gram per kilogram of body weight, enough good-quality sleep, and adequate hydration to ensure a healthy increase in strength.

The metabolic syndrome is a reversible state. Lifestyle changes can treat insulin resistance, reduce hypertension, decrease cholesterol levels, and improve the patient's mental health.

It takes dedication, consistency, and knowledge to change a lifestyle effectively in the long term. It is not enough for obese patients to force themselves through a few weeks of crash dieting to lose enough excess body fat.

New research shows that even with a professional sports program and supported by a dietitian, only 20% of patients manage to sustainably reduce their excess weight in the long term. If once overweight, the body always tries to return to its maximum weight. One possible explanation is that during weight gain, more adipose cells are produced; when losing weight, these cells only shrink but do not disappear. Studies suggest that an "obesogenic memory" exists, lasting epigenetic changes and obesity-promoting conditions cause the persistent "yo-yo" effect often seen with dieting. [16]

5.2 Medication therapy

GLP-1 agonists are possibly the most promising weight-loss medications currently available for the general population due to generally mild side effects and promising weight loss outcomes. The drug was initially marketed as a treatment option for type 2 diabetes. However, mainly due to celebrities who used it to get a leaner body, the drugs Semaglutide (Ozempic), Tirzepatide (Mounjaro), and Liraglutide (Victoza) gained much popularity through social media to the point where it was no longer available for patients with T2DM who required the medication for medical purposes. Now that the pharma companies have started mass producing the products, doctors have started prescribing them not only for T2DM but also for patients suffering from obesity.

GLP-1 agonists effectively reduce glucagon and protect insulin-producing cells in the pancreas; they also help the muscles absorb more glucose and decrease glucose production in the liver, which is the basic mechanism of action beneficial in the treatment of T2DM. The drugs offer multiple benefits, such as reducing the risk of cardiovascular events by lowering cholesterol levels and blood pressure. On top of that, the drugs are very effective in initiating weight loss by slowing stomach emptying and increasing feelings of fullness. As a result, patients with T2DM using GLP-1 agonists can achieve better blood sugar management, as well as significant weight loss and reduced mortality. [17]

The medications show a significant but less dramatic weight loss than bariatric surgery. However, even though the medications have some side effects, they are less significant compared to the risk

of surgical complications. Possibly, with the uprising trend of the GLP-1 agonists, the demand for bariatric surgery may be reduced, and perhaps, together with a more health-oriented young generation, they are a tool to reverse the obesity pandemic in the future.

The greatest challenge regarding GLP-1 agonists is the price. In Germany, the monthly cost of the treatment with Ozempic or Wegovy ranges between 300 and 400€; in America, the costs are around three times higher. Since most patients experience an immediate rebound from weight gain to the initial state of excess weight, the medication needs to be taken lifelong. [18]

Because such a high price would overload any health insurance, the treatment of obesity with GLP-1 agonists is not covered or is only covered for a short period in some cases. [19]

The average person can't afford such a high price out of their own pocket, so a one-time payment for weight loss surgery, covered by insurance, is the only affordable option for most patients.

5.3 Conclusion of conservative management

Various interventions support patients in adopting lifestyle changes to significantly lose excess body weight. However, sustained success ultimately depends on the ability of the patient to cooperate with the presented treatment and to maintain habits consistently, thereby preventing the regain of excess body weight. Epigenetic changes combined with an obesity-promoting environment make it highly challenging for obese patients to achieve weight loss sustainably.

Obesity medications such as GLP-1 agonists are a promising solution in treating the obesity epidemic. However, the high price and the need for lifelong treatment make them unavailable to many. Also, a few patients experience side effects, and the medication is not practical in reducing appetite for some patients.

6 Bariatric surgery

In many cases, life, lifestyle modifications, and conservative treatment fail to reduce excess body weight in severely obese patients. To minimize the complications of obese patients and to reduce their morbidity, the last resort management is to surgically interfere with the gastrointestinal tract to reduce the total calories consumed. Since the rate of obesity has increased over the last decade, the number of weight-loss surgeries is also increasing. [20]

The total number of bariatric procedures performed worldwide in 2020 was around 500,000, reaching nearly 600,000 in 2021. [21]

For some patients, bariatric surgery presents as a last resort since the obesity has progressed to a point where exercising or even performing daily tasks is not possible anymore. For these patients, lifestyle modification is no longer applicable; for them, a surgery for weight reduction is seen as necessary for survival.

Bariatric surgery is a tool to help patient with losing excess body weight, to prevent more comorbidities and to lead to a healthier body. This is achieved by altering the digestive tract, which decreases hunger, normalizes saturation, and changes hormones, leading to improved metabolism.

6.1 Indication

A BMI of over 35 is a clear indication for bariatric surgery, even if the patient does not experience any comorbidities. Patients with a BMI of between 30 and 34.9, that are not able to achieve significant and persisting excess weight loss, or that fail to improve metabolic disorders such as type 2 diabetes through a diet change, should be considered for surgery as well. [22]

In general, an intensive weight loss program must be attempted prior to the surgical interventions, and the obesity must be evaluated as treatment-resistant with conservative means by a medical practitioner.

If a patient with a BMI between 35 and 40 fails to lose 15% or with a BMI greater than 40 fails to lose 20% of their weight over 6 months to 2 years, if the patient regains the excess fat, or if another comorbidity develops, surgery is recommended as well. [23]

A common criticism is that physicians' motivation to support patients with conservative measures has decreased in recent years since surgery is seen as more profitable. Helping patients make changes in their lifestyle is not financially encouraged enough.

Most sources state that patients should see surgery as a last resort to manage their obesity.

On the other hand, some evidence is presented that may suggest, that it might be beneficial to not only reserve bariatric surgery for patients with a progressed stage of type 2 diabetes mellitus but that it should also be applied in an early phase, because it carries a higher risk to perform surgery on patients with a high frailty due to comorbidities, that would be exposed to a possibly dangerously fast loss of body weight. [24]

For patients with severe obesity, achieving sustainable weight loss presents a challenging task since it requires year-long dedication to sticking to a permanent change in lifestyle consisting of diet and

physical activity. Psychological and metabolic disorders make it even more challenging to fulfill the requirements to lose weight.

Bariatric surgery allows the patient to set a strong impulse to apply those lifestyle changes. Most patients will start losing significant weight within a few months after the surgery, even without dietary adjustments, because they cannot eat as much as before.

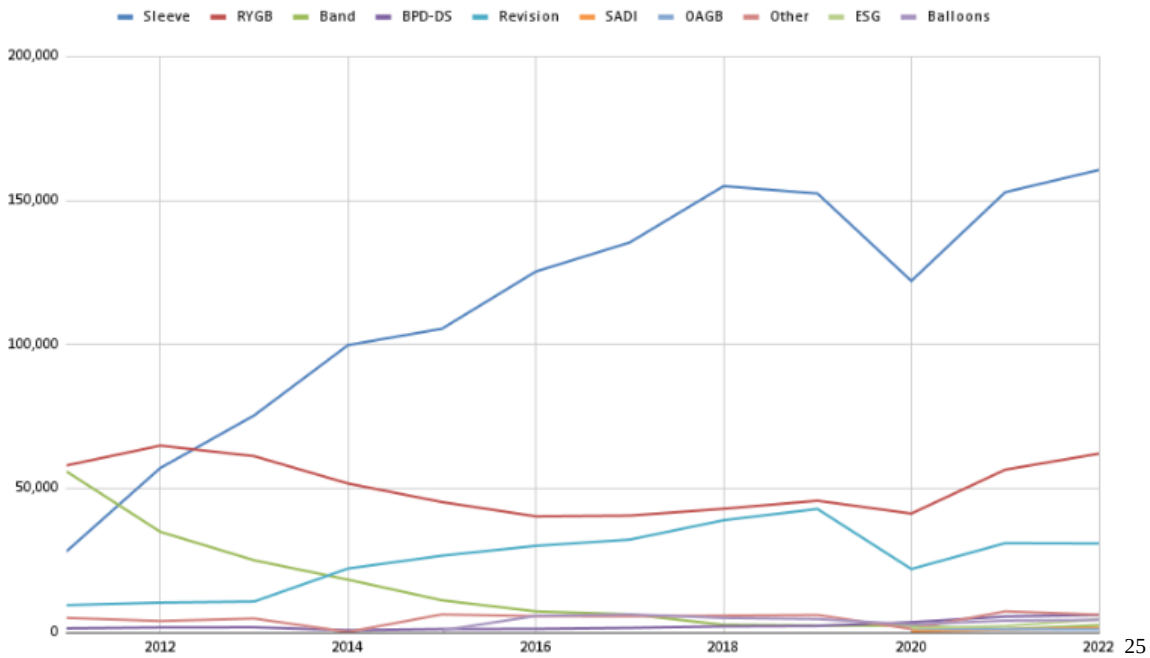
Undergoing bariatric surgery can improve health, increase mobility, and increase the ability to engage in physical activity. The most important task is to establish a structured routine in the months following the surgery and maintain it for the following years. Returning to excessive consumption of calorie-dense foods results in a regain of weight over time.

Bariatric surgery reduces the sensation of appetite while enhancing sensations of satiety and contentment after a meal. A considerable proportion of obese individuals do not engage in overeating only due to physiological hunger. Instead, their eating behaviors often originate from emotional factors such as sadness or boredom. Therefore, the long-term effect of the surgery will diminish if the patient loses dedication to their newly obtained healthy lifestyle and returns to the lifestyle before the surgery.

6.2 Comparison of different methods

Worldwide, the trend towards LSG increased in the last decade, but in some countries other methods are used more frequently. In the following, the alternatives to LSG are presented.

Fig. 3:



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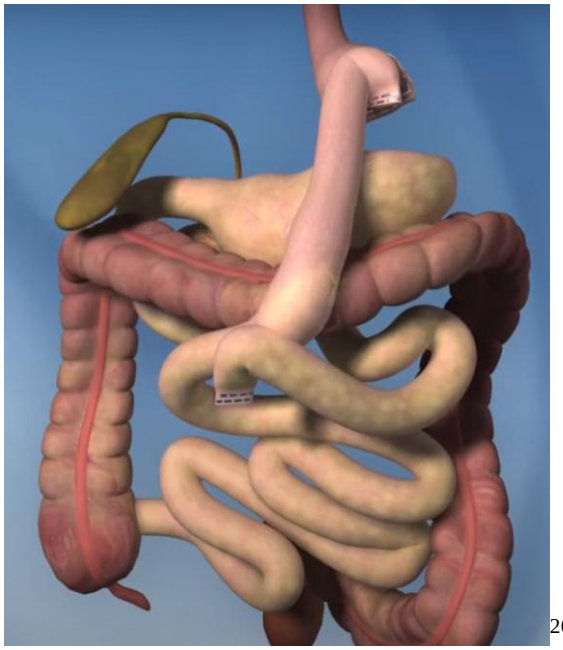
6.2.1 Roux-en-Y Gastric Bypass (RYGB)

Most often the LSG is compared to the LRYGB, since they share a similar efficacy in estimating weight loss. The LRYGB ranks as the second most frequently performed bariatric procedure and is especially popular in America and Western Europe.

During this surgery, a small pouch of the cardia is preserved, and the rest of the stomach is detached from the esophagus. The jejunum is cut short from the duodenum and connected to the created pouch. The stomach is left in place to produce digestive juices, and the proximal part of the jejunum is rerouted to join a more distal section of the draining jejunum. As a result, the food travels to the preserved stomach pouch and then, without the need for a stomach or duodenum, the food directly reaches the jejunum. The digestive fluids from the stomach, bile, and pancreatic fluid reach the small intestines through the jejuno-jejunal anastomosis. With this procedure, not only is the amount of food that can be consumed at once reduced, but the absorption of nutrition is also decreased.

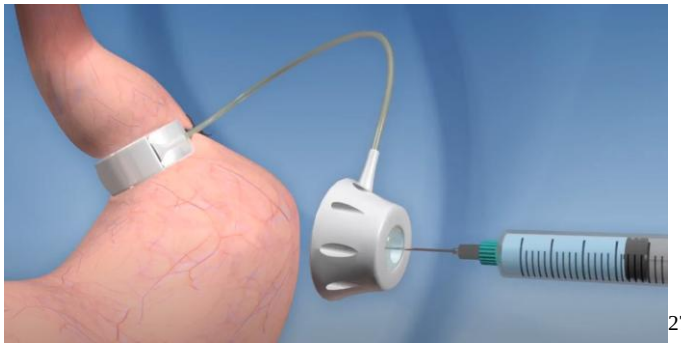
 [26]

6.2.2 Adjustable Gastric Band (AGB)

Before 2010, the gastric band was the most frequently used bariatric procedure. However, it lost much relevance after being replaced by more effective and sustainable alternatives like LSG and LRYGB.

During the procedure, the surgeon places a balloon around the stomach at the upper part, so above the band a small pouch is created, that is connected to the rest of the stomach with a small opening. Then, the surgeon places a port to allow inflation or deflation to adjust the opening width. After the

procedure less amount of food is needed to cause a feeling of satiety, but the amount of calories or nutrients absorbed is not reduced.

 [27]

6.2.3 Biliopancreatic Diversion with Duodenal Switch (BPD/DS)

The BPD/DS can be performed as a standalone surgery, but can also be an extension of a sleeve gastrectomy. It adds the factor of a decreased absorption of nutrients to the LSG and is therefore used primarily in patients with a BMI >50, severe T2DM, or treatment-resistant Hyperlipidaemia.

First, a LSG is performed, then the distal part of the duodenum containing the papilla vateri is disconnected, and an anastomosis is created between the proximal duodenum and the lower part of the small intestine. The disconnected part is then connected to the last part of the ileum to allow bile and pancreatic fluid to join the digestive tract before the colon. This results in a decreased absorption of calories and nutrients on top of the restricted stomach volume created by the sleeve gastrectomy.

 [28]

6.3 Benefits of bariatric surgery

Performing bariatric surgery, on average, increases life expectancy significantly by reducing the risk for cardiovascular diseases, osteoarthritis, cancer, liver cirrhosis, and psychiatric disorders.

6.3.1 Reduction of cancer risk

Even a modest reduction of excess body fat can help lower the risk of multiple cancer types by reducing inflammation, balancing hormone levels, such as insulin, which can promote cancer growth when increased, and enhancing the function of the immune system. By achieving significant excess weight loss, bariatric surgery can cause to a decrease in cancer and mortality that is associated to obesity. [29]

6.3.2 Reduction of obesity induced liver diseases

A nonalcoholic fatty liver also occurs in people who are not overweight and who have a healthy diet, and this can lead to cirrhosis of the liver and liver cancer. Therefore, a stomach reduction only makes sense if a high-sugar diet is also avoided. However, it helps to extend the fasting periods as it reduces the feeling of hunger. Avoiding food for an extended period gives the liver time to recover and, therefore, has a preventative effect against a nonalcoholic fatty liver.

6.4 Challenges regarding weight-loss surgery

Patient cooperation is an essential aspect of the Aftercare of bariatric surgery. The surgeries reduce hunger by creating a smaller stomach volume and/or reducing the nutrients and calories that are absorbed by the digestive organs. However, the surgeries success always depends on the discipline of the patients to apply lifestyle changes in addition to the surgery. The patient has to avoid eating for reasons other than hunger. Also, the patient must take care of adequate nutritional supplementation of essential micro- and macronutrients to prevent deficiencies.

6.4.1 Postoperative care

Patients with a high risk for venous thromboembolism must receive thromboprophylaxis for an extended period because 80% of these events happen after discharge, and they are associated with a 28 times higher mortality. The usual recommendation for thromboprophylaxis is between 7 and 10 days, in high risk patients the American Society for Metabolic and Bariatric Surgery recommends up to 28 days. 10 variables are included in the risk-assessment model to decide who should receive extended thromboprophylaxis:

“congestive heart failure, paraplegia, reoperation, dyspnea at rest, nongastric band surgery, age ≥60 years, male sex, BMI ≥50 kg/m^2, postoperative hospital stay ≥3 days, and operative time ≥3 hours“ [30]

6.4.2 Aftercare and substitution

In the first four weeks after surgery, food must be introduced following a strict step-by-step plan to avoid overwhelming the digestive tract.

Because the surgery alters digestion, food intake, and eating behavior, a high-protein diet with high-fiber foods (vegetables, low-sugar fruit, complex carbohydrates) and unsaturated fats is recommended to prevent malnutrition and reduce the consumption of saturated fats and sugar.

However, nutritional deficiencies are not only caused by the surgical procedure; they commonly exist before surgery due to unbalanced diets; deficiencies of at least two micronutrients were found in 28.5% of obese patients before surgery. [31]

Nutrient deficiencies are most relevant for sleeve gastrectomy and should be substituted or consumed with a carefully balanced diet.

Widespread is a postoperative protein deficiency that can lead to muscle loss, hair loss, brittle nails, and edema. At least 1.5 g of high-quality protein per kilogram of lean body mass should be consumed, which can be achieved with a combination of soy, wheat, and pea protein, dairy products containing a high protein content, lean meat like chicken breast, and lean fish such as tuna. It can be supported with whey protein powder supplementation.

Reduced stomach acid can affect iron absorption, and menstruating women have an increased susceptibility to low iron. Therefore, a supplementation of 45-60 mg/day (50-100 mg for menstruating women) is recommended.

LSG reduces stomach acid and intrinsic factors, leading to poor Vitamin B12 absorption. Therefore, oral supplementation with 1000 µg per day or an injection of 1000 to 3000 µg on a 3- to 6-month basis is recommended.

The reduced absorption of Calcium and D Vitamin increases the osteoporosis risk; therefore it is advised to supplement 3000 units per day of D3 Vitamin and 1000 to 2000 mg per day of calcium citrate.

Folic acid, vitamin B1, magnesium, zinc, copper, selenium, and fat-soluble vitamins (A, E, K) are less common deficiencies after LSG. However, they may still occur and require monitoring and supplementation if necessary. [32]

7 Sleeve gastrectomy

Of all weight-loss surgeries, LSG is the most frequently performed worldwide, with over 50%, additionally it had the highest increase rate in the previous years. [33]

It became so popular because the surgery is technically relatively easy to perform, and it is associated with less morbidity compared to other bariatric surgeries. The operation's principle is forming a sleeve stomach by resecting the large gastric curvature and the entire gastric fundus. At the same time, the physical anatomy of the digestive tract is preserved. Mainly the procedure restricts the amount of food that can be consumed, through removal of a large part of the stomach. This leads to a reduced stomach volume and influences the hormonal processes inside the body. The affected hormones include Ghrelin, widely known as the "hunger hormone," and the Glucagon-like Peptide 1, whose analogs are commonly used in antidiabetic medications and contribute significantly to appetite regulation and blood sugar levels. [34]

The LSG is not only suitable as an standalone surgary, but also as a first-step procedure because it can easily be converted into a RYGB, a BPD-DS, or a post-pyloric bypass. [35]

7.1 History of sleeve gastrectomy

The SG was first performed in 1990 by Dr. Picard Marceau in Canada as the beginning part of a two-phase approach for BPD-DS. This method was initially aimed at helping patients with extreme obesity with a BMI over 60 to achieve sufficient weight loss so that the second part of the operation could be performed safely. [36]

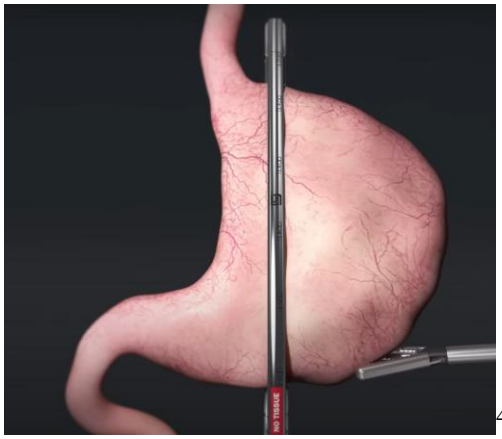
The first standalone LSG was performed in 1999 by Dr. Michel Gagner, who was based in New York at the time. During the follow-up, impressive success was achieved in reducing excess weight. [37]

This led to the indications for LSG being officially defined in 2008. [38]

7.2 Procedure

During the LSG, a significant part of the stomach is removed. After the laparoscopic environment is established, the gastro-omental arteries supplying the removed portion of the stomach are disconnected. A sizing tube, also called a bougie, is inserted orally into the stomach to help evaluate the appropriate size of the stomach part that will remain in place. The stomach is then divided and sealed using a stapler, and the disconnected portion is extracted.

The stomach capacity is limited to around 100 to 150 ml of food, before the surgery the stomach capacity of an obese patient can reach close to 2 liters. Due to the distension satiety-simulating sensation appeares in obese patients after an average of 850 ml compared to 540 ml in a person with average weight. [39]


[40]

7.3 Complications

7.3.1 Early postoperative risk

Staple line leaking and bleeding are the predominant acute complications of the LSG procedure, reaching a rate of around 3% without reinforcement. With staple line reinforcement with bovine pericardium, the rate can be decreased to 1.3%. [41]

In case of postsurgical gastrointestinal or peritoneal bleeding recognizable by hematemesis, melena, or signs of shock, blood transfusion and even reoperations may be indicated. Gastric leakage can be a life-threatening complication that happens more often after revision procedures and is connected to a BMI over 50. The staple line complication can be treated by endoscopic clipping; reoperation and peritoneal drainage are required in an unstable patient. [42]

Due to pancreatic manipulation during surgery or impaired microcirculation, in over 1% of patients, acute pancreatitis develops after the operation. [43]

The leading cause of early mortality after LSG is Postoperative Porto-mesenteric vein thrombosis, observed in 0.37 to 1% and resulting in mortality in around 3% of patients. [44]

7.3.2 Gastroesophageal reflux disease

The leading long-term complication of LSG is GERD. An analysis between 2018 and 2021, including 669 patients, showed that 57.8% of the patients were suffering from GERD after an LSG, with the rate increasing to 64.3% in a follow-up five years later. 38.9% of the patients have been

developing a de novo GERD. During the follow-up, endoscopy showed that erosive esophagitis developed in 60% of the patients; of that, up to 8.3% developed a Barett's esophagus. These results show how important an endoscopic follow-up after LSG is and how common GERD is after the procedure. [45]

In another study with 213 participants that underwent LSG, 47.06% de novo heartburn was reported. [46]

The high incidence of GERD is connected to the ordinary intraoperative disruption of the gastroesophageal sphincter, together with a higher pressure buildup inside the reduced stomach.

7.3.3 Gastric stenosis

Gastric stenosis happens in approximately 1% of patients receiving LSG, about 10% after revision surgery. The symptoms ranged from food intolerance and dysphagia to nausea and vomiting,

The intervention to reverse the stenosis is either endoscopic dilatation or surgery. In this study published in 2018, the dilatation showed a higher success rate of 90% compared to only 33% success in the surgical group, with 47 patients with gastric stenosis. [47]

7.3.4 Nutritional deficiency and anaemia

The most significant risk factors for anemia after LSG include an age below 40, anemia during the operation, as well as inadequate iron supplementation. Sufficient iron supplementation can help reduce the incidence of anemia, but current guideline-recommended dosages are not optimal for everyone. A stricter monitoring and improved supplementation strategy should be applied for an early detection and management. [48]

A critical thought is that patients who lack the discipline to stick to a healthy diet might also experience more difficulties regularly taking the necessary supplements after bariatric surgery.

Another common issue is dehydration, as reduced stomach capacity can make it challenging to consume enough fluids.

7.3.5 Dumping Syndrome

Dumping Syndrome is a frequent complication of LRYGB surgery; studies indicated that also up to 40% of patients getting an LSG experience symptoms suggestive of dumping syndrome in the year after surgery. [49]

Dumping syndrome occurs when chyme enters the small intestine faster than usual, resulting in a disruption of normal digestion. Symptoms such as diarrhea, nausea and meteorism, appearing 10 to

30 minutes after eating, are called early dumping. Late dumping manifests 1 to 3 hours after eating, and it usually happens after a high-carb meal. It can lead to hypoglycemia from an exaggerated insulin response. Both types are linked to hormonal imbalances and changes in gastric function. [50]

Not only for this complication but also in general, patients undergoing sleeve gastrectomy must adopt new eating habits rather than relying solely on the procedure's effectiveness. Simple sugars and dairy products should be avoided, while consuming proteins and healthy fats should be increased. Fiber-rich foods are recommended, as they have been shown to extend intestinal transit time. In most cases of mild to moderate dumping syndrome, these adjustments are enough to manage the symptoms. For more severe cases, medication or even reoperation might be necessary.

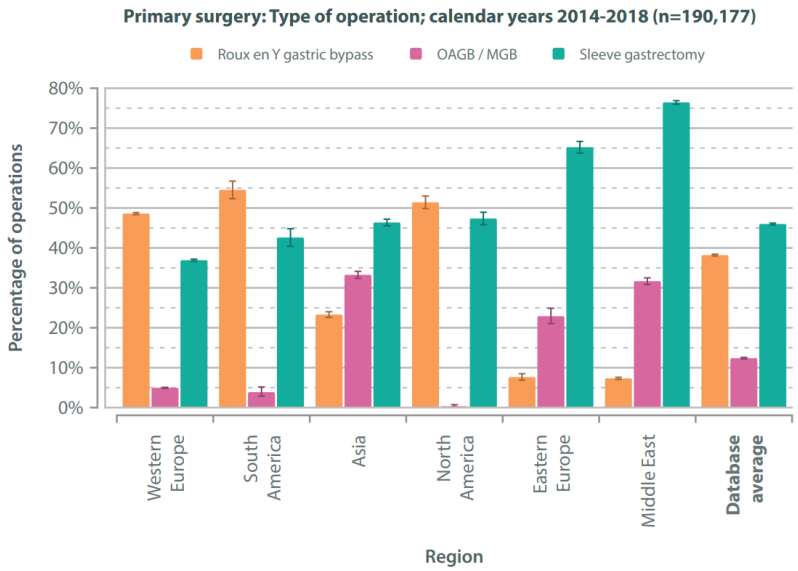
7.3.6 Gallstone disease

Bariatric surgery is associated with an elevated risk of developing symptomatic gallstone disease, often requiring cholecystectomy, particularly within the first few years after the procedure. This increased risk is caused by rapid weight loss, which alters bile composition and promotes gallstone formation. [51]

7.4 Comparison to LRYGB

LSG and LRYGB represent the predominant surgical approaches in bariatric treatment. LSG is the leading procedure worldwide, but especially in Western industrial civilizations, LRYGB is more popular. In Eastern Europe and the Middle East, LRYGB plays a minor role compared to LSG. It is a more simplistic approach with a shorter surgery duration and lower acute complication risk.

Fig. 4:



[52]

Five-year studies did not find a significant difference in weight loss between LSG and LRYGB. In both procedures a gradual regain of excess body weight was noted over the follow-up period.

After LRYGB, protein digestion is impaired by reduced hydrochloric acid secretion.

Some studies showed a significantly decreased perioperative complication risk with LSG compared to LRYGB and a shorter hospitalization period. The lethality for both surgeries is far below 1%, so LSG is generally regarded as a surgery with a low risk of complications. [53]

Even though both procedures have comparable costs, estimated loss of excess weight, as well as rate of complication, the LSG is performed more frequently because of its shorter surgery time, more simplistic approach, lower risk for acute complications, and fewer nutritional deficits because of the preservation of the physiological digestion tract. The LRYGB is more effective for T2DM patients with a BMI over 50 and is used in patients suffering from GERD since it does not worsen the symptoms as severely as the LSG.

8 Literature analysis of studies with outcomes after 10 years

After giving a detailed introduction to the topic, including the primary indications, alternative treatments, and procedures, as well as an overview of the LSG, in the following, the long-term efficacy of this surgery is evaluated to determine what recommendations can be made to physicians. In order to achieve this, the effect on the quality of life after 10 years is analyzed, as well as the complications that occur during this period and the total excess weight loss, the need for reoperation, and a direct comparison with LRYGB is included.

For this purpose, a Medline (PubMed) search was conducted, including human studies published between August 1, 2014, and August 1, 2024, referring to a 10-year period.

Eight articles in the literature selection, met the inclusion and exclusion criteria.

8.1 Change in quality of life

In addition to weight reduction and the improvement of concomitant diseases, improving QOL is one of the main goals of weight-loss surgery. A successful operation improves the patient's physical and mental health in the long term, which is why QOL is a vital element in determining the overall success of bariatric surgery.

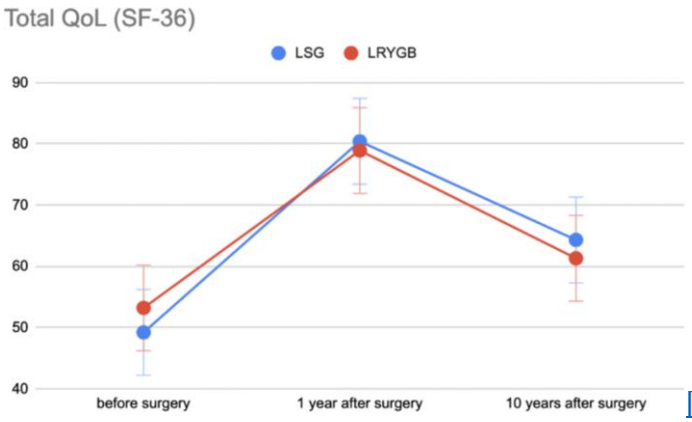
Reducing physical complaints related to obesity, having a positive effect on self-esteem, and increasing social participation can improve QOL. However, complications, especially GERD, have

significant adverse impact on the patient's QOL, especially since they are difficult to manage in patients who received a LSG.

The QOL is mainly assessed via questionnaires given to the patients before and at a specific time after the surgery. The following two studies, which are included, concern the 10-year follow-up after the LSG.

The lack of studies with more participants shows again how rare a sufficient follow-up of patients receiving bariatric surgeries is. From the result of this study, it is unclear whether LSG is more sustainable in the long term compared with patients who undergo LRYGB since there was a higher number of patients who were lost to follow-up in the LRYGB group. Even though the study supervisors concluded a significantly higher increase in QOL in patients of the LSG group.

Fig. 5:



[S2]

The study showed that GERD caused the patients to have a lower score in all quality of life questionnaire categories, while patients with decreased excess weight loss after the 10-year period had significantly lower scores in some of the categories.

The central part of the study directly assesses the QOL with a questionnaire called SF36, which consists of 36 parts of the general QOL of the patients. The data is divided into eight categories, with each category having a score ranging from 0 to 100 assigned:

“physical functioning, social functioning, physical problems, emotional problems, mental health, energy and vitality, pain, and general perception of health“

An addition to this questionnaire was the BQL questionnaire, which generally focuses on the QOL after BS. The most significant conclusion of the study was that both a regain of weight and an EWL of below 50%, as well as reflux complications, correlate with lower scores in the SF36 and BQL questionnaires. Thus, both can be used to assess the QOL of patients who received BS and,

hopefully, increase the sample size to improve the long-term data surrounding sleeve gastrectomy. [54] [S3]

8.2 Complications

Now that it has been made clear that the complications, especially Gastroesophageal reflux disease, significantly impact the quality of life of the patients, it is important to assess the general prevalence of these complications in the patients who received an LSG.

The second part of the second QOL study was separately published and focuses on the long-term complications of Reflux, Sleeve Dilation, and Barrett's Oesophagus in the follow-up of 10 years by performing 24-h pH meter, manometries, gastroscopies, and questionnaires focusing on reflux of patients that did not suffer from either of that symptoms before the surgery. This study also has significant limitations due to its small sample size. However, the study shows a high incidence of gastrointestinal complications, even though 14% were excluded because they had already treated the reflux with a LRYGB reoperation; still, in 45% of the patients, the gastroscopy revealed de novo hiatal hernias, and in 15% of Barett's metaplasia. As the questionnaire suggested, patients who experienced reflux-related complications had a significantly lower QOL. [55]

The treatment of de novo GERD after LSG can be very challenging and can involve the need for a combination of lifestyle changes, medications, and, in some cases, additional surgical interventions to be successful. Additional medication and surgery also come with more complications and adverse effects, possibly compromising the patient's health.

More than 10 years after LSG, the authors reported a 33% conversion rate, a mean %EWL of 50% among non-converted patients, GERD in 57%, and Barrett’s metaplasia in 14% of those who had not undergone conversion. Gastroscopic findings showed a significantly higher incidence of de-novo hiatal hernia in patients with GERD. Patients with GERD generally demonstrated a significantly lower QOL, as measured by GIQLI and BAROS scores. [S4]

The conversion to RYGB has proven to be effective for resolving GERD in patients following sleeve gastrectomy. However, while it offers substantial relief from reflux symptoms, its efficacy in addressing significant weight regain is comparatively limited, and outcomes may vary depending on individual patient factors and adherence to postoperative guidelines. [S4]

8.3 Excess weight loss

The other significant value influencing the patients' QOL is the regain of weight within 10 years of the surgery, which is assessed by the value of excess weight loss (EWL).

At the 10-year follow-up, patients who underwent primary LSG achieved a mean percentage of EBMIL of 53.6 ± 24.6%. While this shows a moderate long-term EWL, the wide standard deviation indicates a large variability among individuals, highlighting the importance of patient selection and follow-up care. [S5]

Inadequate weight loss was defined as achieving less than 50% EWL or requiring revisional bariatric surgery in this study, which can be considered quite strict, as it may classify patients with modest but clinically meaningful improvements as having inadequate outcomes. Despite this stringent definition, the incidence of inadequate weight loss remained high, with up to 80% of patients meeting these criteria ten years after LSG. This shows up potential limitations of LSG in achieving sustained long-term weight loss and underscores the importance of long-term follow-up and patient support. [S6]

8.4 Need for a reoperation

In some cases, the long-term complications or the regain of weight require a reoperation.

The revision rate in the first 10 years after LSG is around 12.2%. Most commonly, the sleeve is converted to a gastric bypass, accounting for 75.2% of the revisions, followed by a re-sleeve operation, accounting for 18.7%.

In some cases, either weight regains or complications led to the patients receiving revision surgery because the result of the primary LSG was not satisfactory.

The main reason is the persistence of obesity in 87.0% of the revisions, which can be made by a re-sleeve or an extension into gastric bypass or duodenal switch. The second reason is GERD, the most frequent complication of LSG, with 5.2% of revisions.

Revision surgery can have an increased complication risk because of adhesions or instabilities; in 5.1%, gastric leak is reported, bleeding in 18%, and the need for another reoperation in 6.4% of all cases of revision surgery. [S1]

In other statistics 19.2% [S5] or even as many as 23.5% [S6] of patients required a revisional bariatric procedure with conversion to different anatomy, either due to insufficient weight loss or de novo reflux.

In this study, the LSG was seen as successful in only 41% of patients, de novo GERD appeared in 41% (6/14) and persisted in 80% (16/20) of patients, 18% were converted to RYGB after regaining weight. [56] Another study also showed a 10-year success rate of 41%, with a 65% incidence of

GERD. [57] Sleeve gastrectomy generates sustained weight loss and comorbidity resolution up to 10 years postoperatively, with mean weight loss exceeding 30%. [58]

8.5 Comparison to LRYGB

LSG demonstrates satisfactory 10-year outcomes, with TWL exceeding 20% and a notable remission rate of hypertension. However, the long-term impact of LSG on T2DM requires additional study through prospective trials. Although approximately one-third of patients may experience de novo GERD, the need for revisional surgery remains relatively low, affecting fewer than 20% of individuals within a decade following the procedure.

The overall mean TWL was 24.4%, with remission rates of 45.6% to TD2M and 41.4% to hypertension. De novo GERD was reported in 32.3% of patients, and five cases of Barrett's esophagus, accounting for 0,5% of cases, were identified. Revisional surgery was necessary in 19.2% of cases, primarily managed through conversion to RYGB. [S7]

Another comparison between LSG and LRYGB showed a more significant estimated weight loss with LRYGB and a more significant number of oesophageal complications after LSG. The median estimated weight loss was at 43.5% ranging from 2.1% to 109.2% in the LSG group and at 50.7% with a range from 1.7% to 111.7% after the LRYGB. There was no statistically significant difference in type 2 diabetes remission or obstructive sleep apnoea, but hypertension remission was superior after LRYGB, and esophagitis was more common after LSG. The overall reoperation rate was 15.7% for LSG and 18.5% for LRYGB. The high rate of reoperations for LRYGB can be explained by the greater complexity and therefore increased possibility of acute complications such as dumping syndrome, adhesive bowel obstructions, and stenosis or leak of anastomosis. The number of participants included into this comparison was quite small with 240 patients. [S8]

When comparing the two most common bariatric surgeries, long-term weight loss outcomes appear similar, but studies show that QOL reduces long-term complications such as GERD and is more prevalent in LSG. More QOL studies are required to directly compare the two surgeries' long-term outcomes to give a well-founded recommendation.

8.6 Summary of the results

In order to allow a direct comparison of the long-term results of the included studies, a summary table was created that contains important key figures such as number of patients (N pts), follow-up duration (F/U Time), percentage of total or excess weight loss (TWL/EWL), rate of weight gain or insufficient weight loss (Insuff. WL), incidence of gastroesophageal reflux disease (GERD Rate),

complication profiles and revision surgery rates. This allows for a direct visual comparison of long-term effectiveness and safety issues across different study designs and patient populations.

Table 1:

ID	Study Title	N (pts)	F/U Time	TWL / EWL	Insuff. WL	GERD Rate	Complications	Revision Rate	Notes/ conclusions
S1	Rev surgery: 10y nationwide study (France)	224,718	10y: 12.2 %	N/R	In 87% reason for revision	N/R In 5.2% reason for revision	After revision: Leak: 5.1%, Bleed: 18%, Reop: 6.4%	@10y: 12.2%	75.2% of revisions were to bypass, 18.7% were resleeves
S2	QoL 10y after BS (LSG vs LRYGB)	65	10y	25.2 ± 9.6 TWL, 45.4 ± 17.9 EWL	N/R	N/R	N/R	N/R	QoL ↑ 10y after LSG, no QoL ↑ after LRYGB
S3	QoL 10y after SG – Multicenter (Austria)	48	10y	<50% EWL: ↓QoL	Cause of ↓QoL	Reflux → ↓QoL	N/R	N/R	GERD & poor EWL → ↓QoL
S4	Update: 10y of SG – First 103 pts (Austria)	103	10y+	50.0 ± 22.5 EWL (non-converted)	Yes	57% GERD, 14% Barett		33% (conversion)	RYGB conv. treats GERD well, but not weight regain
S5	Long term effects of LSG: beyond 10y	307	5–15y	5y:62.8% 10y:53.6% 13y:51.2%	7.8% reop due to insuff. WL	32.4% de novo	N/R	19.2%	Common insuff WL & de novo reflux
S6	10y LSG outcomes – Single center	149	10y	35.9% EWL (revisions excluded)	80.5% inadequate WL	N/R	N/R	23.5%	Low WL linked to higher revision
S7	Review of 10y+ LSG outcomes (meta)	1020	10y+	24.4% TWL	N/R	32.3% GERD, 0.5% Barett	N/R	19.2%	67.2% of revisions to RYGB, 19.7% to DS
S8	SLEEVEPASS RCT: LSG vs LRYGB	240	10y	EWL: LSG 43.5%, LRYGB 50.7%	N/R	Esophagitis: 31% (LSG), 7% (RYGB)	N/R	LSG: 15.7%, RYGB: 18.5%	WL better with RYGB, reflux higher with LSG

To compare the key outcomes from the studies included in this review clearly, a comprehensive summary table was created. The data shows that between 12.2% and 33% (weighted average: 12.3%) of LSG patients needed revision surgery, either due to insufficient weight loss in 87% or due to GERD in 5.2% of patients. In total the weighted average of excess weight loss was 47.4% and the incidence of GERD was 33.9% in total. Some studies reported alarmingly high rates of inadequate weight loss, such as S6, where over 80% of patients failed to achieve satisfactory weight reduction at 10 years.

While some studies showed durable weight loss and remission of comorbidities, others reported high rates of GERD and the need for revision surgery. This variability underscores the importance of individualized patient selection and long-term follow-up in bariatric treatment.

8.7 Critical evaluation

There is a lack of robust and comprehensive data surrounding the 10-year follow-up after sleeve gastrectomy. It is concerning that the most common bariatric procedure lacks strong evidence of durability. [59]

It is important to figure out the cause of the clinician's lack of motivation to sufficiently follow up with the patients who have been operated on.

Long-term follow-up care is not part of the surgeons' scope of treatment. Since it is not adequately remunerated, there is a lack of interest in continuing to care for patients for a decade after the operation.

8.8 Conclusion

Even though the sleeve gastrectomy has significantly improved the lives of many patients, it should be seen as a last resort option.

Notably, since many studies suggest inferior long-term outcomes for LSG compared to RYGB, LSG should not automatically be considered the first-line surgical option for all patients. Especially patients with GERD benefit more from RYGB, as it is associated with a significantly lower prevalence of GERD exacerbation. Many patients experience a decrease in quality of life due to GERD after LSG and eventually require reoperation. Similarly, patients with a very high BMI or those diagnosed with treatment-resistant T2DM tend to experience better outcomes with RYGB.

In order to promote sustainable lifestyle changes, effective incentives should be provided through appropriate compensation for physicians who are able to sustainably improve lifestyles by educating their patients about healthy and adaptable habits.

The patients need to understand that the long-term improvement in quality of life is often compromised by the regain of weight and long-term complications such as GERD. Also, patients are required to undergo a lifelong daily supplementation to compensate for the decreased micronutrition uptake. To prevent weight regain, a lifestyle change is still required. Without compliance, patients are at risk of returning to a state of obesity similar to their pre-surgery

condition, now compounded by complications such as GERD and with a lifelong requirement of daily supplementation.

Effective and individual patient education should include realistic expectations about potential weight regain, the need for lifelong supplementation, and possible long-term complications, and it should contain strategies for sustainable lifestyle changes. The positive outcomes of LSG are not guaranteed and are directly linked to patients adopting and maintaining healthy lifestyle habits.

9 Sources

9.1 Studies included in the literature analysis

[S1] Lazzati A, Bechet S, Jouma S, Paolino L, Jung C. Revision surgery after sleeve gastrectomy: a nationwide study with 10 years of follow-up. Surg Obes Relat Dis. 2020 Oct;16(10):1497-1504. doi: 10.1016/j.soard.2020.05.021. Epub 2020 May 29. PMID: 32636173. https://pubmed.ncbi.nlm.nih.gov/32636173/

[S2] Major P, Stefura T, Dziurowicz B, Radwan J, Wysocki M, Małczak P, Pędziwiatr M. Quality of Life 10 Years After Bariatric Surgery. Obes Surg. 2020 Oct;30(10):3675-3684. doi: 10.1007/s11695-020-04726-7. Epub 2020 Jun 13. PMID: 32535784; PMCID: PMC7467960. https://pubmed.ncbi.nlm.nih.gov/32535784/

[S3] Felsenreich DM, Prager G, Kefurt R, Eilenberg M, Jedamzik J, Beckerhinn P, Bichler C, Sperker C, Krebs M, Langer FB. Quality of Life 10 Years after Sleeve Gastrectomy: A Multicenter Study. Obes Facts. 2019;12(2):157-166. doi: 10.1159/000496296. Epub 2019 Mar 15. PMID: 30879011; PMCID: PMC6547272. https://pubmed.ncbi.nlm.nih.gov/30879011/

[S4] Felsenreich DM, Ladinig LM, Beckerhinn P, Sperker C, Schwameis K, Krebs M, Jedamzik J, Eilenberg M, Bichler C, Prager G, Langer FB. Update: 10 Years of Sleeve Gastrectomy-the First 103 Patients. Obes Surg. 2018 Nov;28(11):3586-3594. doi: 10.1007/s11695-018-3399-1. PMID: 30047101. https://pubmed.ncbi.nlm.nih.gov/30047101/

[S5] Kraljević M, Cordasco V, Schneider R, Peters T, Slawik M, Wölnerhanssen B, Peterli R. Long-term Effects of Laparoscopic Sleeve Gastrectomy: What Are the Results Beyond 10 Years? Obes Surg. 2021 Aug;31(8):3427-3433. doi: 10.1007/s11695-021-05437-3. Epub 2021 Apr 22. Erratum in: Obes Surg. 2021 Aug;31(8):3434-3435. doi: 10.1007/s11695-021-05460-4. PMID: 33890225. https://pubmed.ncbi.nlm.nih.gov/33890225/

[S6] Vital R, Navez J, Gunes S, Tonneau C, Mehdi A, Moussaoui IE, Closset J. Long-Term Outcomes 10 Years after Laparoscopic Sleeve Gastrectomy: a Single Center Retrospective Analysis. Obes Surg. 2023 Aug;33(8):2356-2360. doi: 10.1007/s11695-023-06709-w. Epub 2023 Jun 29. PMID: 37382873. https://pubmed.ncbi.nlm.nih.gov/37382873/

[S7] Vitiello A, Abu-Abeid A, Dayan D, Berardi G, Musella M. Long-Term Results of Laparoscopic Sleeve Gastrectomy: a Review of Studies Reporting 10+ Years Outcomes. Obes Surg. 2023 Nov;33(11):3565-3570. doi: 10.1007/s11695-023-06824-8. Epub 2023 Sep 25. PMID: 37743393; PMCID: PMC10603075. https://pubmed.ncbi.nlm.nih.gov/37743393/

[S8] Salminen P, Grönroos S, Helmiö M, Hurme S, Juuti A, Juusela R, Peromaa-Haavisto P, Leivonen M, Nuutila P, Ovaska J. Effect of Laparoscopic Sleeve Gastrectomy vs Roux-en-Y Gastric Bypass on Weight Loss, Comorbidities, and Reflux at 10 Years in Adult Patients With Obesity: The SLEEVEPASS Randomized Clinical Trial. JAMA Surg. 2022 Aug 1;157(8):656-666. doi: 10.1001/jamasurg.2022.2229. PMID: 35731535; PMCID: PMC9218929. https://pubmed.ncbi.nlm.nih.gov/35731535/

9.2 General Sources

[1]Robert Koch-Institut. Abteilung für Epidemiologie und Gesund-heits-monitoring. Rki.de. 2024 July 03; Available from: https://www.rki.de/DE/Content/Gesundheitsmonitoring/Themen/Uebergewicht_Adipositas/Uebergewicht_Adipositas_node.html#:~:text=Nach%20Selbstangaben%20aus%20den%20Jahren,steigen%20%C3%9Cbergewichts%2D%20und%20Adipositaspr%C3%A4valenzen%20an

[2] Katapult Magazin. Übergewichtig und unterernährt [Internet]. Katapult Magazin. 2020 July 27. Available from: https://katapult-magazin.de/de/artikel/uebergewichtig-und-unternaehrt#in-kenia-beispielsweise-leiden-rund-dreissig-prozent-der-bevoelkerung-an-unterernaehrung

[3] The World Counts. Statistics about obesity [Internet]. The World Counts. [date unknown] [cited 2025 Mar 13]. Available from: https://www.theworldcounts.com/challenges/people-and-poverty/hunger-and-obesity/statistics-about-obesity

[4] American Society for Metabolic and Bariatric Surgery (ASMBS). Estimate of bariatric surgery numbers [Internet]. ASMBS. 2022. Available from: https://asmbs.org/resources/estimate-of-bariatric-surgery-numbers/

[5] ResearchGate. Classification of obesity: World Health Organization 2019 definitions [Internet]. ResearchGate. 2019 June. Available from: https://www.researchgate.net/figure/Classification-of-obesity-World-Health-Organization-2019-definitions-Surgical_tbl1_333695508

[6] De Lorenzo A, Soldati L, Sarlo F, Calvani M, Di Lorenzo N, Di Renzo L. New obesity classification criteria as a tool for bariatric surgery indication. World J Gastroenterol. 2016 Jan 14;22(2):681-703. doi: 10.3748/wjg.v22.i2.681. PMID: 26811617; PMCID: PMC4716069. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4716069/

[7] Humphreys S. The unethical use of BMI in contemporary general practice. Br J Gen Pract. 2010 Sep;60(578):696-7. doi: 10.3399/bjgp10X515548. PMID: 20849708; PMCID: PMC2930234. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2930234/

Humphreys S. The unethical use of BMI in contemporary general practice. Br J Gen Pract. 2010 Sep;60(578):696-7. doi: 10.3399/bjgp10X515548. PMID: 20849708; PMCID: PMC2930234. https://pubmed.ncbi.nlm.nih.gov/20849708/

[8]Swaleh R, McGuckin T, Myroniuk TW, Manca D, Lee K, Sharma AM, Campbell-Scherer D, Yeung RO. Using the Edmonton Obesity Staging System in the real world: a feasibility study based on cross-sectional data. CMAJ Open. 2021 Dec 7;9(4):E1141-E1148. doi: 10.9778/cmajo.20200231. PMID: 34876416; PMCID: PMC8673483. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8673483/#:~:text=The%20EOSS%20includes%20stages%20from,a%20higher%20risk%20of%20death

Swaleh R, McGuckin T, Myroniuk TW, Manca D, Lee K, Sharma AM, Campbell-Scherer D, Yeung RO. Using the Edmonton Obesity Staging System in the real world: a feasibility study based on cross-sectional data. CMAJ Open. 2021 Dec 7;9(4):E1141-E1148. doi: 10.9778/cmajo.20200231. PMID: 34876416; PMCID: PMC8673483. https://pubmed.ncbi.nlm.nih.gov/34876416/

[9] Pajecki, D., Dantas, A.C.B., Santo, M.A. et al. Beyond the BMI: a Critical Analysis of the Edmonton Obesity Staging System and the New Guidelines for Indications for Metabolic and Bariatric Surgery. OBES SURG 33, 1276–1278 (2023). https://doi.org/10.1007/s11695-023-06516-3

[10] Sharma AM. Edmonton obesity staging system [Internet]. Dr. Sharma's Obesity Notes. 2009 February 11. Available from: https://www.drsharma.ca/edmonton-obesity-staging-system

[11] Teng ML, Ng CH, Huang DQ, Chan KE, Tan DJ, Lim WH, Yang JD, Tan E, Muthiah MD. Global incidence and prevalence of nonalcoholic fatty liver disease. Clin Mol Hepatol. 2023 Feb;29(Suppl):S32-S42. doi: 10.3350/cmh.2022.0365. Epub 2022 Dec 14. PMID: 36517002; PMCID: PMC10029957. https://pmc.ncbi.nlm.nih.gov/articles/PMC10029957/

[12] Sturm R. Obesity overview [Internet]. Medscape. 2023. Available from: https://emedicine.medscape.com/article/117853-overview#showall?form=fpf

[13] Starley BQ, Calcagno CJ, Harrison SA. Nonalcoholic fatty liver disease and hepatocellular carcinoma: a weighty connection. Hepatology. 2010 May;51(5):1820-32. doi: 10.1002/hep.23594. PMID: 20432259. https://pubmed.ncbi.nlm.nih.gov/20432259/

[14] Luppino FS, de Wit LM, Bouvy PF, Stijnen T, Cuijpers P, Penninx BW, Zitman FG. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry. 2010 Mar;67(3):220-9. doi: 10.1001/archgenpsychiatry.2010.2. PMID: 20194822. https://pubmed.ncbi.nlm.nih.gov/20194822/

[15] Williams LT, Barnes K, Ball L, Ross LJ, Sladdin I, Mitchell LJ. How Effective Are Dietitians in Weight Management? A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Healthcare (Basel). 2019 Feb 1;7(1):20. doi: 10.3390/healthcare7010020. PMID: 30717197; PMCID: PMC6473916. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6473916/

[16] Hinte, L.C., Castellano-Castillo, D., Ghosh, A. et al. Adipose tissue retains an epigenetic memory of obesity after weight loss. Nature 636, 457–465 (2024). https://doi.org/10.1038/s41586-024-08165-7 https://www.nature.com/articles/s41586-024-08165-7

[17] Collins L, Costello RA. Glucagon-Like Peptide-1 Receptor Agonists. 2024 Feb 29. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan–. PMID: 31855395. https://www.ncbi.nlm.nih.gov/books/NBK551568/

[18] Bayerischer Rundfunk. Abnehmspritze: Nach dem Absetzen kommen die Kilos zurück [Internet]. BR24. 2024 Feb 8. Available from: https://www.br.de/nachrichten/wissen/abnehmspritze-nach-dem-absetzen-kommen-die-kilos-zurueck,TyDhHmz

[19] Krankenkassen.de. Abnehmespritzen: Neue Leistungen der gesetzlichen Krankenkassen [Internet]. Krankenkassen.de. Available from: https://www.krankenkassen.de/gesetzliche-krankenkassen/leistungen-gesetzliche-krankenkassen/gesetzlich-vorgeschriebene-leistungen/neue-leistungen/abnehmespritzen/

[20] Felsenreich DM, Bichler C, Langer FB, Gachabayov M, Prager G. Sleeve Gastrectomy: Surgical Technique, Outcomes, and Complications. Surg Technol Int. 2020 May 28;36:63-69. PMID: 32359172. https://pubmed.ncbi.nlm.nih.gov/32359172/

[21] Angrisani L, Santonicola A, Iovino P, Palma R, Kow L, Prager G, Ramos A, Shikora S; Collaborative Study Group for the IFSO Worldwide Survey. IFSO Worldwide Survey 2020-2021: Current Trends for Bariatric and Metabolic Procedures. Obes Surg. 2024 Apr;34(4):1075-1085. doi: 10.1007/s11695-024-07118-3. Epub 2024 Mar 4. PMID: 38438667; PMCID: PMC11026210. https://pmc.ncbi.nlm.nih.gov/articles/PMC11026210/#:~:text=The%20total%20number%20of%20surgical,the%20most%20performed%20bariatric%20procedure.

[22] Eisenberg D, Shikora SA, Aarts E, Aminian A, Angrisani L, Cohen RV, De Luca M, Faria SL, Goodpaster KPS, Haddad A, Himpens JM, Kow L, Kurian M, Loi K, Mahawar K, Nimeri A, O'Kane M, Papasavas PK, Ponce J, Pratt JSA, Rogers AM, Steele KE, Suter M, Kothari SN. 2022 American Society for Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO): Indications for Metabolic and Bariatric Surgery. Surg Obes Relat Dis. 2022 Dec;18(12):1345-1356. doi: 10.1016/j.soard.2022.08.013. Epub 2022 Oct 21. PMID: 36280539. https://pubmed.ncbi.nlm.nih.gov/36280539/

[23] Busetto L. Timing of bariatric surgery in people with obesity and diabetes. Ann Transl Med. 2015 May;3(7):94. doi: 10.3978/j.issn.2305-5839.2015.03.62. PMID: 26015936; PMCID: PMC4430740. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4430740/

[24] Busetto L. Timing of bariatric surgery in people with obesity and diabetes. Ann Transl Med. 2015 May;3(7):94. doi: 10.3978/j.issn.2305-5839.2015.03.62. PMID: 26015936; PMCID: PMC4430740. https://pubmed.ncbi.nlm.nih.gov/26015936/

[25] American Society for Metabolic and Bariatric Surgery (ASMBS). Estimate of bariatric surgery numbers [Internet]. ASMBS. 2022, June. Available from: https://asmbs.org/resources/estimate-of-bariatric-surgery-numbers/

[26] Mayo Clinic Health System. Roux-en-Y Gastric Bypass [Internet]. YouTube; 2011 Oct 29. Available from: https://www.youtube.com/watch?v=z8Ajg53fpkA

[27] Mayo Clinic Health System, Drugs.com. Laparoscopic adjustable gastric banding [Internet]. YouTube; 2018 March 28. Available from: https://www.youtube.com/watch?v=v0aHr5GuG7Y

[28] Mayo Clinic Health System, Drugs.com. Biliopancreatic diversion with duodenal switch [Internet]. YouTube; 2018 March 28. Available from: https://www.youtube.com/watch?v=EX68RG6faUo

[29] Aminian A, Wilson R, Al-Kurd A, Tu C, Milinovich A, Kroh M, Rosenthal RJ, Brethauer SA, Schauer PR, Kattan MW, Brown JC, Berger NA, Abraham J, Nissen SE. Association of Bariatric Surgery With Cancer Risk and Mortality in Adults With Obesity. JAMA. 2022 Jun 28;327(24):2423-2433. doi: 10.1001/jama.2022.9009. PMID: 35657620; PMCID: PMC9166218. https://pubmed.ncbi.nlm.nih.gov/35657620/

[30] Aminian A, Andalib A, Khorgami Z, Cetin D, Burguera B, Bartholomew J, Brethauer SA, Schauer PR. Who Should Get Extended Thromboprophylaxis After Bariatric Surgery?: A Risk Assessment Tool to Guide Indications for Post-discharge Pharmacoprophylaxis. Ann Surg. 2017 Jan;265(1):143-150. doi: 10.1097/SLA.0000000000001686. PMID: 28009739. https://pubmed.ncbi.nlm.nih.gov/28009739/

[31] Lefebvre P, Letois F, Sultan A, Nocca D, Mura T, Galtier F. Nutrient deficiencies in patients with obesity considering bariatric surgery: a cross-sectional study. Surg Obes Relat Dis. 2014 May-Jun;10(3):540-6. doi: 10.1016/j.soard.2013.10.003. Epub 2013 Oct 14. PMID: 24630922. https://pubmed.ncbi.nlm.nih.gov/24630922/

[32] Mechanick JI, Youdim A, Jones DB, Garvey WT, Hurley DL, McMahon MM, Heinberg LJ, Kushner R, Adams TD, Shikora S, Dixon JB, Brethauer S; American Association of Clinical Endocrinologists; Obesity Society; American Society for Metabolic & Bariatric Surgery. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient--2013 update: cosponsored by American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic & Bariatric Surgery. Obesity (Silver Spring). 2013 Mar;21 Suppl 1(0 1):S1-27. doi: 10.1002/oby.20461. PMID: 23529939; PMCID: PMC4142593. https://pmc.ncbi.nlm.nih.gov/articles/PMC4142593/

[33] Ozsoy Z, Demir E. Which Bariatric Procedure Is the Most Popular in the World? A Bibliometric Comparison. Obes Surg. 2018 Aug;28(8):2339-2352. doi: 10.1007/s11695-018-3163-6. Erratum in: Obes Surg. 2018 Aug;28(8):2353. doi: 10.1007/s11695-018-3202-3. PMID: 29512038. https://pubmed.ncbi.nlm.nih.gov/29512038/

[34] Felsenreich DM, Bichler C, Langer FB, Gachabayov M, Prager G. Sleeve Gastrectomy: Surgical Technique, Outcomes, and Complications. Surg Technol Int. 2020 May 28;36:63-69. PMID: 32359172. https://pubmed.ncbi.nlm.nih.gov/32359172/

[35] Regan JP, Inabnet WB, Gagner M, Pomp A. Early experience with two-stage laparoscopic Roux-en-Y gastric bypass as an alternative in the super-super obese patient. Obes Surg. 2003 Dec;13(6):861-4. doi: 10.1381/096089203322618669. PMID: 14738671. https://pubmed.ncbi.nlm.nih.gov/14738671/

[36] A Brief History of the Duodenal Switch [Internet]. ResearchGate; 2023 April. Available from: https://www.researchgate.net/publication/370314727_A_Brief_History_of_the_Duodenal_Switch

[37] International Federation for the Surgery of Obesity and Metabolic Disorders. Biliopancreatic Diversion with Duodenal Switch [Internet]. IFSO; [cited 2025 May 8]. Available from: https://www.ifso.com/bilio-pancreatic-diversion-with-duodenal-switch/

[38] Seeras K, Sankararaman S, Lopez PP. Sleeve Gastrectomy. [Updated 2023 Jan 23]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. https://www.ncbi.nlm.nih.gov/books/NBK519035/

[39] Granström L, Backman L. Stomach distension in extremely obese and in normal subjects. Acta Chir Scand. 1985;151(4):367-70. PMID: 4036492. https://pubmed.ncbi.nlm.nih.gov/4036492/

[40] Standard Bariatrics @standardbariatrics114. Animation of Sleeve Gastrectomy with Titan SGS™ [Internet]. YouTube; 2021-07-15. Available from: https://www.youtube.com/watch?v=vu2pV8JPqmg

[41] Shikora SA, Mahoney CB. Clinical Benefit of Gastric Staple Line Reinforcement (SLR) in Gastrointestinal Surgery: a Meta-analysis. Obes Surg. 2015 Jul;25(7):1133-41. doi: 10.1007/s11695-015-1703-x. PMID: 25968078; PMCID: PMC4460272. https://pubmed.ncbi.nlm.nih.gov/25968078/

[42] Woźniewska P, Diemieszczyk I, Hady HR. Complications associated with laparoscopic sleeve gastrectomy - a review. Prz Gastroenterol. 2021;16(1):5-9. doi: 10.5114/pg.2021.104733. Epub 2021 Mar 26. PMID: 33986881; PMCID: PMC8112272. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8112272/

[43] Kumaravel A, Zelisko A, Schauer P, Lopez R, Kroh M, Stevens T. Acute pancreatitis in patients after bariatric surgery: incidence, outcomes, and risk factors. Obes Surg. 2014 Dec;24(12):2025-30. doi: 10.1007/s11695-014-1337-4. PMID: 24972683. https://pubmed.ncbi.nlm.nih.gov/24972683/

[44] Shaheen O, Siejka J, Thatigotla B, Pham DT. A systematic review of portomesenteric vein thrombosis after sleeve gastrectomy. Surg Obes Relat Dis. 2017 Aug;13(8):1422-1431. doi: 10.1016/j.soard.2017.03.015. Epub 2017 Mar 27. PMID: 28526434. https://pubmed.ncbi.nlm.nih.gov/28526434/

[45] Znamirowski P, Kołomańska M, Mazurkiewicz R, Tymchyshyn O, Nawacki Ł. GERD as a Complication of Laparoscopic Sleeve Gastrectomy for the Treatment of Obesity: A Systematic Review and Meta-Analysis. J Pers Med. 2023 Aug 10;13(8):1243. doi: 10.3390/jpm13081243. PMID: 37623493; PMCID: PMC10455448. https://www.mdpi.com/2075-4426/13/8/1243

[46] Althuwaini S, Bamehriz F, Aldohayan A, Alshammari W, Alhaidar S, Alotaibi M, Alanazi A, Alsahabi H, Almadi MA. Prevalence and Predictors of Gastroesophageal Reflux Disease After Laparoscopic Sleeve Gastrectomy. Obes Surg. 2018 Apr;28(4):916-922. doi: 10.1007/s11695-017-2971-4. PMID: 29043549. https://pubmed.ncbi.nlm.nih.gov/29043549/

[47] Turcu F, Balahura C, Doras I, Constantin A, Copaescu C. Symptomatic Stenosis after Laparoscopic Sleeve Gastrectomy - Incidence and Management in a High-Volume Bariatric Surgery Center. Chirurgia (Bucur). 2018 Nov-Dec;113(6):826-836. doi: 10.21614/chirurgia.113.6.826. PMID: 30596370. https://revistachirurgia.ro/pdfs/2018-6-826.pdf

[48] Nie Y, Tian Z, Wang P, Liu B, Zhang N, Zhou B, Wang S, Hei X, Meng H. Prevalence of anemia and related nutrient deficiencies after sleeve gastrectomy: A systematic review and meta-analysis. Obes Rev. 2023 Jan;24(1):e13516. doi: 10.1111/obr.13516. Epub 2022 Nov 2. PMID: 36323610. https://pubmed.ncbi.nlm.nih.gov/36323610/

[49] Tzovaras G, Papamargaritis D, Sioka E, Zachari E, Baloyiannis I, Zacharoulis D, Koukoulis G. Symptoms suggestive of dumping syndrome after provocation in patients after laparoscopic sleeve gastrectomy. Obes Surg. 2012 Jan;22(1):23-8. doi: 10.1007/s11695-011-0461-7. PMID: 21647622. https://pubmed.ncbi.nlm.nih.gov/21647622/

[50] Hui C, Dhakal A, Bauza GJ. Dumping Syndrome. 2023 Jun 26. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan–. PMID: 29261889. https://www.ncbi.nlm.nih.gov/books/NBK470542/

[51] Anveden Å, Peltonen M, Näslund I, Torgerson J, Carlsson LMS. Long-term incidence of gallstone disease after bariatric surgery: results from the nonrandomized controlled Swedish Obese Subjects study. Surg Obes Relat Dis. 2020 Oct;16(10):1474-1482. doi: 10.1016/j.soard.2020.05.025. Epub 2020 Jun 1. PMID: 32654897. https://pubmed.ncbi.nlm.nih.gov/32654897/

[52] Himpens J, Ramos A, Welbourn R, Dixon J, Kinsman R, Walton P (2018) Fourth IFSO global registry report 2018. https://www.ifso.com/pdf/4th-ifso-global-registry-report-last-2018.pdf.

[53] Colquitt JL, Pickett K, Loveman E, Frampton GK. Surgery for weight loss in adults. Cochrane Database Syst Rev. 2014 Aug 8;2014(8):CD003641. doi: 10.1002/14651858.CD003641.pub4. PMID: 25105982; PMCID: PMC9028049. https://pubmed.ncbi.nlm.nih.gov/25105982/

[54] Jenkinson C, Coulter A, Wright L. Short form 36 (SF36) health survey questionnaire: normative data for adults of working age. BMJ. 1993 May 29;306(6890):1437-40. doi: 10.1136/bmj.306.6890.1437. PMID: 8518639; PMCID: PMC1677870. https://pmc.ncbi.nlm.nih.gov/articles/PMC1677870/

[55] Felsenreich DM, Kefurt R, Schermann M, Beckerhinn P, Kristo I, Krebs M, Prager G, Langer FB. Reflux, Sleeve Dilation, and Barrett's Esophagus after Laparoscopic Sleeve Gastrectomy: Long-Term Follow-Up. Obes Surg. 2017 Dec;27(12):3092-3101. doi: 10.1007/s11695-017-2748-9. PMID: 28593484. https://pubmed.ncbi.nlm.nih.gov/28593484/

[56] Jiménez A, Ibarzabal A, Moizé V, Pané A, Andreu A, Molero J, de Hollanda A, Flores L, Ortega E, Lacy A, Vidal J. Ten-year outcomes after Roux-en-Y gastric bypass and sleeve gastrectomy: an observational nonrandomized cohort

study. Surg Obes Relat Dis. 2019 Mar;15(3):382-388. doi: 10.1016/j.soard.2019.01.020. Epub 2019 Jan 29. PMID: 30772254. https://pubmed.ncbi.nlm.nih.gov/30772254/

[57] Hauters P, Dubart JW, Desmet J, Degolla R, Roumain M, Malvaux P. Ten-year outcomes after primary vertical sleeve gastrectomy for morbid obesity: a monocentric cohort study. Surg Endosc. 2021 Dec;35(12):6466-6471. doi: 10.1007/s00464-020-08137-8. Epub 2020 Nov 2. PMID: 33140154. https://pubmed.ncbi.nlm.nih.gov/33140154/

[58] Castagneto Gissey L, Casella Mariolo JR, Genco A, Troisi A, Basso N, Casella G. 10-year follow-up after laparoscopic sleeve gastrectomy: Outcomes in a monocentric series. Surg Obes Relat Dis. 2018 Oct;14(10):1480-1487. doi: 10.1016/j.soard.2018.06.021. Epub 2018 Jul 2. PMID: 30093311. https://pubmed.ncbi.nlm.nih.gov/30093311/

[59] O'Brien PE, Hindle A, Brennan L, Skinner S, Burton P, Smith A, Crosthwaite G, Brown W. Long-Term Outcomes After Bariatric Surgery: a Systematic Review and Meta-analysis of Weight Loss at 10 or More Years for All Bariatric Procedures and a Single-Centre Review of 20-Year Outcomes After Adjustable Gastric Banding. Obes Surg. 2019 Jan;29(1):3-14. doi: 10.1007/s11695-018-3525-0. PMID: 30293134; PMCID: PMC6320354. https://pubmed.ncbi.nlm.nih.gov/30293134/