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Long Term Results after Sleeve Resection in Morbid Obese Patients. Literature Review

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Summary

Bariatric surgery has been around for many years and is increasing as the number of morbidly obese people is continuously rising. Over time, sleeve resection has established itself as the most frequently performed bariatric operation and could become the gold standard in the following years. Sleeve resection is particularly popular because it is considered a technically simple surgery and makes fewer changes to the patient's gastrointestinal tract. However, long term data lasting 10 or more years that examine the effectiveness and outcomes of sleeve resection in terms of weight loss, enhancement of co-morbidities and quality of life are still rare.

This literature review examined 7 studies with 480 patients and a follow-up rate of at least 10 years. Weight reduction counts as one of the key factors in the favorable outcome of bariatric surgery. In general, this occurs very successfully in the first years after the surgery but decreases as the post-surgery time progresses. In cases of failure of weight loss, conversion to a different procedure is an option.

Patients with extreme obesity are more likely to suffer from gastro-esophageal reflux disease. Some studies have examined how sleeve resection may affect reflux. Most studies tend to recommend a bariatric procedure other than the sleeve for patients with preexisting reflux.

In addition to other co-morbidities, quality of life after gastric sleeve was examined as well, as this provides important information about the success rate of sleeve resection, too. There are several assessment tools for that, including the Bariatric Quality of Life Index and Medical Outcome Study Short Form-36. In general, patient satisfaction was better when reflux symptoms were reduced, and sufficient weight loss was achieved.

To sum up, surgical weight loss methods remain the best option for morbidly obese patients even after 10 or more years, but more studies with a larger sample size are important to be able to make even better conclusions in the future.

Keywords: Bariatric surgery; GERD; Long term outcomes; Obesity; Sleeve resection

Introduction

Throughout the years, many different bariatric surgical methods have been developed. For now, all professional societies agree on 4 main procedures: adjustable gastric banding (AGB), sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB) and biliopancreatic diversion (BPD). (1) SG was introduced in 1988 as the restrictive component in BPD with duodenal switch (DS) procedure. (2) In the beginning of the year 2000, SG was performed by Regan et al. (3) in superobese patients or those with high surgical risk to increase the performance status of the patient before RYGB operation. The surgeons found a prominent weight loss and betterment in patients' co-morbidities with the first step alone, the SG, which seemed to not need having the second step of the operation. Today, SG is the leading operation in the bariatric surgical field worldwide, followed by RYGB, which still remains the standard procedure. (1) In the report of the American Society for Metabolic and Bariatric Surgery is written, that 228.000 total cases were undertaken in the United States (US) in 2017 and about 60% of them were SG, followed by RYGB with 17.8%. Therefore, SG may become the gold standard for bariatric surgeries (BS) in the future. The popularity of SG may lie in the technical simplicity of the procedure which creates less anatomical and physiological changes to the gastrointestinal tract (GIT) of the patient. (4) The simplicity of SG in comparison with gastric bypass makes operative time shorter, which is a major advantage for high-risk surgical patients. Components like previous abdominal operations, large amounts of visceral fat, and abdominal wall compliance can all negatively influence the success of gastric bypass and therefore making SG a better option. (2) Follow-up after SG for 10+ years is rare and usually does not proceed more than 5 years. A previous systematic review about long term outcomes of SG by Juodeikis et al. (5) in 2016 focused on the 5 and more years results.

The objective of this work was to review the results after 10+ years following sleeve resection in morbid obese patients and evaluate weight loss, complications, the impact on co-morbidities and quality of life (QOL).

Sleeve resection, gastric sleeve, and SG are used synonymous in this literature review.

Methodology

Based on the recommendations from Chapter 9, Methods for Literature Review, from 2017 (6), a comprehensive literature search was run.

Medline (PubMed) was queried for studies on humans published until November 2023 which investigated patients with previous sleeve resection. The search was done on November 30,

2023, using the search terms “sleeve resection” or “sleeve gastrectomy” or “gastric sleeve” or “vertical sleeve” and “long term”. Exclusion criteria were publications including case reports, abstracts only, letters, comments, reviews, or meta-analyses, studies conducted on patients with a Body Mass Index (BMI) <35, studies on adolescents (younger than 18 years old), and studies with results < 10 years. Inclusion criteria incorporated studies presenting >10-year results on individuals who received sleeve resection as a primary procedure and held no less than one result of interest: weight reduction, co-morbidities, problems in the long-run, or QOL.

To include a study in this review, firstly the title and abstract of each article were scanned for relevance. In case of suitable abstracts, the full text was again scanned for appropriateness. Out of 171 articles found in the beginning, 164 studies were excluded according to the exclusion rules and 7 studies met the inclusion measures.

Weight loss was shown through percentage excess weight loss (%EWL) and percentage excess body mass index loss (%EBMIL). Since %EWL and %EBMIL give similar outcomes when a BMI of 25 kg/m2 is applied to create the excess weight threshold, they were classed as synonyms.

Sleeve resection

First performed openly, SG developed into a laparoscopic intervention with Ren et al. being the first one performing it as minimally invasive surgery. (2,7) Commonly, SG is considered as restrictive procedure inducing weight loss through mechanical or anatomical limitation of gastric capacity. (4) SG results in a lengthwise resection of the stomach along the major curvature with reduction of 75% to 80%. This technique leaves a banana-like gastric remnant which can hold about 50 to 100 mL volume. (4) A part of the antrum and greater curvature of the stomach are resected. Pylorus and duodenum are preserved. (8) This is how SG reduces the volume of the stomach and hence diminishes the volume for food ingestion (9), leading to a quick feeling of fullness after meals. (10) SG makes alterations in stomach volume and anatomy; thus, it is thought that gastric emptying could be a reason for early satiety and weight loss. The quicken gastrointestinal movements after SG might be the reason for a fast chyme delivery from the stomach to the distal gut, causing a rise in the secretion of anorexigenic hormones. (11) Plausible reasons for SG causing faster gastric emptying could be a rise in intragastric pressure, decreased compliance and contractility of the remaining stomach, and changes in neurohormonal signaling. (4) The complete mechanism how SG leads to weight loss is still not fully understood.

One other theory that could explain weight losing after SG is the reduction in the amount of ghrelin by resecting the gastric fundus. This is the place where oxyntic cells of the gastric fundus secret this orexigenic hormone mainly. (8,12) Ghrelin is commonly known as the 'hunger hormone', beyond that it has much more functions. This gut hormone stimulates and activates its receptor, growth hormone secretagogue receptor, resulting in 3 main functions: stimulatory effect with food intake, fat deposition and stimulation of growth hormone release. All of these can result in weight gaining. The level of ghrelin increases during fasting periods or starvation. In the contrary, the amount of ghrelin decreases after eating or during conditions like hyperglycemia. (13) Lower levels of ghrelin have been seen after SG. This could be associated with the resection of the fundus. Still, it is just a theory and cannot explain weight loss after the bariatric procedure alone. (12)

There is no united concurrence on the most efficient surgical method for SG and it various from surgeon to surgeon. Contrasting opinions persist with respect to the number of trocars, bougie size, starting width from the pylorus for transection, partial or total resection of the antrum, staple height, intraoperative testing, and the application of buttressing. (5,12) As an illustration, among the studies used for this literature review, the utilized bougie sizes differed from 33 French (Fr) to 48 Fr. Parikh et al. (14) provided a review with 93 participants after SG. They grouped patients into 3 groups based on bougie size: 40 Fr (n=30), 50 Fr (n=10), and 60 Fr (n=53). Remarkably, the 40 Fr group showed a significantly lower BMI in comparison to the 50 Fr group 6 months after surgery. Outcomes from several research papers proposed potential benefits by employing a smaller bougie (32-44 Fr) to increase weight loss. In a newer study by Elli et al. (15) with 409 patients, in which they compared laparoscopic to robotic SG, the researchers found out that a bougie size of 36 or 38 Fr were accompanied by a greater %EWL in comparison to a 40 Fr bougie 3 years after the BS. Nonetheless, a smaller bougie size, especially < 40 Fr, increases the risk of staple line leak. (16) Felsenreich et al. (17) reported that they could not identify any correlation between weight regain after SG and the bougie size of 42 or 48 Fr 10 years after the bariatric procedure. Nevertheless, further long-term follow-up with more participants is crucial to verify these findings.

Figure 2 in the appendix presents an illustration of the procedure.

Indications and contraindications for sleeve resection (respectively bariatric surgery)

The American Society for Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) published an update in 2022 of the guidelines for BS. (18) While only people with a BMI ≥ 40 or with a BMI ≥ 35 and

at least one co-morbidity related to obesity (e.g., hypertension, Diabetes Mellitus Type 2 (DMII), or severely limiting musculoskeletal issues) were operated before (19), a bariatric procedure is now suggested for people with a BMI ≥ 35, even without any co-morbidity linked to obesity. Moreover, BS is indicated for people with a BMI > 30-34.9 with uncontrollable DMII or metabolic syndrome, as well. (18)

Prior to surgery, patients should have tried several non-operative weight loss attempts. If they were unsuccessful, surgery can be considered as last option. It is important, that patients are mentally able to undergo BS, adhere to post-operative care and have no contraindication to surgery in general. Absolute contraindications involve intolerance of general anesthesia, unmanageable coagulopathy and cardiopulmonary diseases, and an alarming psychiatric disorder (including drug and alcohol abuse). (19)(20)

Patient selection

When the indications for BS descripted above are met, a patient must undergo the typical complete history and physical and surgical risk assessment. Additional elements for bariatric patients consist of estimation and optimization of coexisting medical conditions, psychological evaluation, discussion with a nutritionist, and in-depth education and informed consent concerning the different bariatric operations and postoperative outcomes. (2) There is an age limit for BS. The procedure is recommended for patients from 18 to 65 years of age. (21) Nevertheless, patients older than 70 years successfully underwent BS. The age alone should not be the only criteria to exclude a patient from BS. The surgical risk needs to be weighed against the risk for morbidity of adiposity-related complications. (18) Patients should quit smoking not less than 30 days prior to surgery. (21) Before surgery, all patients should undergo upper abdominal ultrasound, barium swallow or an esophagogastroduodenoscopy. With these medical imagines, mainly gallstones and any anatomical abnormality of the upper GIT, e.g., hiatal hernias and Barrett's esophagus (BE), should be excluded. (12) Considering the upraised occurrence of hiatal hernias and BE in the lengthy research of SG, preoperative sizeable hiatal hernias, gastro-esophageal reflux disease (GERD), and BE should be handled as (relative) contraindications to SG. (22)

Outcomes

In this literature review, 7 studies including 480 patients who underwent SG were analyzed for weight loss, health outcomes and QOL 10 or more years after their bariatric operation. Table 1 indicates the key features of the studies investigated.

When SG was performed, the average age of study participants was 40.5 years. Between the study population, 79% were female, while only 21% were male. The mean BMI measured before surgery set at 45.4 kg/m2. Follow-up time span lasted from 10 to 15 years, with a mean value 10-year follow-up rate of 67.0% (range, 37.7% - 93.0%). 4 studies yield outcomes at the 10-year mark, 2 studies provided results for the 11-year period, while one study presented findings for 15-year follow-up. Each of the studies analyzed alterations in the body mass, as shown in Table 2, and indicated them as %EWL. The outlier here was the study by Arman et al. (24), where %EBMIL was described alternatively. 4 studies, including 283 patients, revealed 10-year data. The average %EWL in these studies was 51.8%. The 2 studies exhibiting 11-year results indicated an average %EWL of 57.5%. One only study described weight loss outcomes at 15 years, the mean %EWL was 57.7%. In respect of study composition, there were different kind of studies present: 2 cohort studies, 2 retrospective studies, one prospective study, one cross-sectional study, one randomized clinical trial.

All studies assessed the influence of SG on coexisting conditions over a 10-year period, shown in Table 3. 2 studies investigated the result on DMII, 3 on dyslipidemia, 3 on arterial hypertension (AHT), 3 on obstructive sleep apnea (OSAS), and 4 on GERD. Among these, 5 of the 7 studies defined the criteria for improvement and resolution. The prevalent measures for resolution were described as ordinary clinical variables without the need for medication, while improvement was shown by a cutback in medical treatment. After a 10-year time frame following sleeve resection, the resolution or improvement of DMII was seen in 57.1% of participants. Moreover, high blood pressure, GERD, dyslipidemia, and OSAS depictured improvements or resolutions in 29.9%, 34.0%, 35.2% and 41.6%, respectively. Shifts, that can be seen after a long-time concerning GERD-associated features, were registered in 4 studies. Within these studies, one study demonstrated ameliorated GERD-related symptoms, whilst 6 studies underlined the appearance of newly occurring GERD symptoms. The frequency of turning SG into a different BS because of significant GERD or insufficient weight loss differed between 31.7% and 36.6%. Moreover, 3 studies described the frequency of incisional hernias and BE. In addition, nutrient status after SG was gauged in only 2 studies.

A total of 4 studies provided results on the QOL after SG. Among them, one study (25) particularly yielded assessments of the QOL before and after surgery. Noteworthy, the research done by Felsenreich et al. (10,22) employed the Gastrointestinal Quality of Life Index (GIQLI) to judge surgical results. The mean GIQLI scores for these studies were 105.3 out of 144 possible points in patients with symptomatic reflux, and 122.9 out of 144 points in patients without reflux symptoms, indicating better QOL without reflux. In their evaluation, Salminen

et al. (25) employed the Moorehead-Ardelt questionnaire, offering a mean score of 0.64, suggesting of a 'very good' outcome. In the study of Arman et al. (24) the satisfaction levels were assessed through responses to a Likert questionnaire with a final analyses of 8 for the entire cohort, indicating a 'pleased' result. A different study by Felsenreich et al. (26) applied the Medical Outcome Study Short Form-36 questionnaire (SF36), disclose a remarkable increase in bodily and societal role acting, common health, liveliness and lessen body pain.

Interestingly, the proportion of male patients opting for any kind of BS over the past 10 years remains outstandingly lower in comparison to the amount of female patients. (27) This phenomenon was noticed in this present literature review as well. Men who encounter BS frequently show a severer degree of disease, developing into higher risk-adjusted rates of serious morbidity and mortality. (27) Scientists think that women tend to have an increased awareness of health issues linked to obesity. They are more likely to consider surgery as a weight loss option, while men prefer to delay the decision until more serious co-morbidities have already developed. (28)

Table 1. Features of the included studies

Author	Patients (n)	Mean BMI (kg/m2) prior to surgery	Follow-up months	Patients who reached ≥ 10-year follow-up	Mean 10-year follow-up rate (%)	Patients who dropped out before 10-year point
Arman et al. (24)	110	38.5	> 132	63	59.1	43
Felsenreich et al. (22)	53	49.5	129	41	77.4	12
Castagneto et al. (16)	148	46.6	> 120	114	77.0	34
Csendes et al. (29)	104	38.6	126	97	93.0	7
Salminen et al. (25)	121	44.6	120	98	84.5	23
Felsenreich et al. (10)	53	48.7	180	20	37.7	33
Verras et al. (30)	116	51.1	120	47	40.5	69

Long term weight loss and maintenance

Although SG is considered the most popular technique for BS, follow-up for 10+ years is rare and usually does not proceed for more than 5 years. (16) One reason could be that the official recognition as a primary procedure only happened in 2009. (31) In a 2016 systematic review, in which Juodeikis et al. (5) reported about the long-term outcomes (≥ 5 years) of 2713 patients followed in 20 studies, the %EWL was found to be 58.4%, 59.5%, 56.6%, 56.4%, and 62.5% at 5, 6, 7, 8, and 11 years, respectively. Diamantis et al. (32) recorded about 16 studies, including 492 patients, for at least 5-year follow-up with %EWL of 62.3%, 53.8%, 43%, and 54.8% at 5, 6, 7, and 8 years, respectively, following gastric sleeve. As a general picture, it is noteworthy that majority of series depict a substantial weight loss in the initial one to 2 years after the bariatric procedure, followed by a gradual regain in weight afterwards. (16) In this literature review, among other things, weight loss in the long term was analyzed and results of %EWL after different time intervals can be found in Table 2.

The weight loss is described as %EWL and determined by the following equation: (weight before surgery – weight at end point of the study) / (weight before surgery – ideal weight for BMI 25) x 100. (25)

The results in this literature review show a mean %EWL 10 years after SG of 51,8% (range, 33.7% - 75.7%).

In the study of Castagneto et al. (16) from 2018, 114 patients were followed-up with a satisfactory mean 10-year follow-up rate of 77%. According to the authors, SG is successful in creating and keeping significant %EWL with a success rate of 50.9% of individuals in the very long term as well, with a mean %EWL of 52.5. At 10-year follow-up, mean BMI stood at 32.7 kg/m2. Reinhold (33) and Christou et al. (34) describe weight loss after BS as ‘good’ result when BMI is <35 kg/m2 and ‘excellent’ result when BMI is <30 kg/m2. Consequently, in the study of Castagneto et al. (16), patients presented with good to excellent results in 78.1% of the cases 10 years after SG.

In the study directed by Arman et al. (24) in 2016, the researchers found out that SG allows for an %EWL of 62.5% at 11 or more years of follow-up. In this analyses, 2 separate groups were formed: group A composed of 47 patients (74.6%) not requiring a conversion to a different procedure and group B with 16 converted patients (25.4%). In group A, the following %EWL was observed at 3, 6, and 11+ years, respectively: 82.4%, 75.9%, and 62.5%. 17 patients out of the 47 patients, that kept the sleeve, experienced favorable short-term outcomes, achieving a weight loss of more than 80% of %EBMIL. After 2 years postoperatively the smallest (nadir) BMI was reached (25.4 kg/m2). However, this group exhibited continuous weight regain, which

was statistically significant at nearly all analyzed time points. Consequently, the failure rate (≤50% EBMIL) reached 17 out of 47 (36.2%) at 11 or more years. Additionally, interpreting reoperation for weight loss as an indicator for bariatric operation failure, the cumulative failure rate is 49.2%, a rather unsatisfactory result in comparison to published data. (32)

Salminen et al. (25) performed a multicenter equivalence randomized clinical trial with 121 patients and a mean BMI of 44.6 kg/m2, a follow-up of 120 months and a rather high mean 10-year follow-up rate of 84.5%, in which they compared laparoscopic SG to RYGB. They concluded that SG showed a significant and constant weight loss in the long-term follow-up.

Felsenreich et al. (22) described a %EWL of 53.0% in their study with 53 individuals undergoing SG. During the study process of 10 years, 16 patients (37%) needed a second operation (RYGB) because of weight regain in 10 patients (23%) and severe reflux in 6 patients (14%).

Table 2. Excess weight loss (in percentage) at differing time periods

Author	3 yr (n)	5 yr (n)	6 yr (n)	7 yr (n)	10 yr (n)	11 yr (n)	15 yr (n)
Arman et al. (24)	82.4 (47)	-	75.9 (47)	-	-	62.5 (47)	-
Felsenreich et al. (22)	-	-	-	-	53.0	-	-
Castagneto et al. (16)	73.9	-	67.3	-	52.5	52.5	-
Csendes et al. (29)	-	-	-	-	75.7	-	-
Salminen et al. (25)	-	49.0 (38)	-	47.0 (39)	43.5 (98)	-	-
Felsenreich et al. (10)	-	-	-	-	52.5	-	57.7
Verras et al. (30)	-	-	-	-	33.7	-	-

Obesity and its co-morbidities

Patients undergoing BS suffer from extreme obesity. The World Health Organization describes obesity as an unusual or unrestricted fat buildup in the body, that reduces the general health of an individual. The reasons for this excessive fat accumulation lie in the disparity of caloric consumption and caloric expenditure. (35) To recognize a person as obese, the BMI is used. The BMI is estimated by dividing weight (in kilograms) by height (in meters squared). The definition of overweight is a BMI of 25.0 to 29.9 kg/m2 for adults. A BMI of 30 kg/m2 or more

is interpretated as obese. (36) Morbid obesity is classified as a BMI of 40.0 or more. (37) In 2014, approximately 10.8% of men and 14.9% of women worldwide were considerate as obese. If this course continues to develop at the same speed, by 2025, 21% of the female population and 18% of men will become obese. (38) Obesity is a multicomponent disease. Consequently, it can result in various complications, including cardiovascular and cerebrovascular issues, liver, kidney, and pulmonary disorders, and DMII along with others. (9) People with obesity have a more than 10 times increased risk of getting DMII and 3 times increased risk of getting coronary heart disease. Mortality increases subsequently; the risk of death for morbidly obese people is double that among people with healthy weight. (37) The aforementioned diseases are all co-morbidities seen in patients before and after SG and therefore it is essential to evaluate these conditions in the long-term follow-up after SG.

For every 5-unit growth in BMI over 25 kg/m2, the general mortality rises by 29%, the vascular mortality increases by 41%, and diabetes-related mortality turns up to even 210%. (36) Consequently, weight loss is an extreme important parameter for improving overall health of an individual.

Weight change demonstrates one of the key aspects of interest in bariatric procedures. Various analyses have exhibited that weight loss following BS can provide betterment of co-occurring conditions like GERD, DMII, OSAS and cardiovascular diseases, e.g., AHT and dyslipidemia. (39)

Among principal treatment strategies for obesity with enough evidence-based foundation are lifestyle changes, pharmacological approaches, and BS. Only if lifestyle and pharmacological interventions fail, BS may be considerate as a good option.

Pharmacological treatment is only recommended as a supportive method together with a reduced-calorie diet and a rise in physical activity. Weight-regulating medications can be given to adults with a BMI of 30 or more or to patients with a BMI between 27 and 29 with at least one co-morbidity related to obesity. (40) However, drug interventions have limited effectiveness. Therefore, the greatest outcomes are seen with BS. (36) Researchers could show that pharmacological treatment with weight losing medications firstly induce substantial reductions in food intake followed by a progressively loss of efficacy with little reductions in energy intake. (40)

The treatment outcomes of obesity related co-morbidities after SG are discussed below and can be reviewed in Table 3.

Table 3. Remission and improvement of co-occurring conditions 10 years after SG

Author	DMII		Remission and improvement % (n)				
	R%	I%	Dyslipidemia	OSAS	GERD	AHT	DMII
Arman et al. (24)	-	-	40 (10)	66 (3)	0 (7)	28.6 (7)	-
Felsenreich et al. (22)	-	-	-	-	38.0 (16)	-	-
Castagneto et al. (16)	64.7	23.5	R% 36.4 I% 45.5	R% 72.2 I% 27.8	42.9	R% 44.2 I% 36.5	88.2
Csendes et al. (29)	-	-	-	-	-	-	-
Salminen et al. (25)	26	-	19 (4)	R% 16 (5) I% 26 (8)	-	R% 8 (6) I% 32 (23)	26 (11)
Felsenreich et al. (10)	-	-	-	-	55 (11)	-	-
Verras et al. (30)	-	-	-	-	-	-	-

Gastro-esophageal reflux disease

Increased adipose tissue results in higher intra-abdominal pressure. This can cause disorders of the esophagus, e.g., GERD and BE. (38) Constantly occurring reflux not only influences a person's QOL but requires permanent treatment with proton pump inhibitors (PPIs). Reflux over a long period of time can possibly lead to esophagitis, which sequentially can lead to the progress of BE – a viable cause of the pathogenesis of esophageal carcinoma. (41)

Research-based proof reinforces that, for individuals with critical GERD and morbid obesity, gastric bypass is the preferred procedure. Moreover, the elimination of the stomachs' greater curvature during SG removes a portion of the same that could possibly operate as a graft (interposition) in cases where esophagectomy, for example if severe GERD develops into BE, is required. (12)

The mechanism how SG can result in GERD after some time could be explained with the physiological mechanism of a gastric sleeve. From a physical point of view, the gastric sleeve, marked by the pylorus muscle operating as a biological obstruction at the sleeve's outlet, generates high-pressure environs. Sometimes, acidulous fluids that build up in the sleeve could simply be passed up into the esophagus, causing symptoms related to GERD. In the initial period after SG, the lessen intra-abdominal pressure can counterbalance this result through weight loss. Nevertheless, a small amount of studies have disclose that GERD develops as a notable long-term aftereffect reaction of SG in widen follow-ups. (10)

Indeed, GERD symptoms strongly rose to 42.9% after 10 years compared to 16.9% at 6-years follow-up in the analyses of Castagneto et al. (16) All these patients experienced symptom relief with PPIs. But it is noteworthy that the diagnosis of GERD in these cases was only made based on symptoms and PPI intake and might not be well grounded in evaluating such condition.

Various studies and meta-analysis show conflicting results concerning the development of de novo GERD after SG, but their limitations are a short duration of the study, a small number of participants followed up and lower than 80% follow-up rate. A divergence in results could be due to multiple reasons. Firstly, a subjective assessment of GERD symptoms, secondly, even if symptoms were under control there can be still a pathological reflux present causing damage to the esophagus, and thirdly, different follow-up times were present (sometimes quite short). (29) Therefore, Csendes et al. (29) performed a prospective study with 97 patients to find out subjective and objective assessment of GERD after SG. 2 groups were formed in accordance with symptoms and endoscopic findings before surgery. Group 1 had no GERD symptoms present and normal upper endoscopic findings before surgery and group 2 had GERD symptoms present or unusual upper endoscopic findings (e.g., hiatal hernia, dilated cardia, erosive esophagitis) before surgery. The researchers performed clinical evaluation using a modified Visick gradation, radiological evaluation 2 to 3 days after surgery, endoscopic evaluation to examine the esophageal mucosa and describing presence of erosive esophagitis using the Los Angeles classification, and histological analysis with biopsies from 2 main places (gastric antrum and juxtacardial biopsies). New onset symptoms of GERD showed up in 58.5% of patients in Group 1. They all required daily PPI medication. In group 2, 13.6% of patients resolved from GERD symptoms and the rest in this group needed daily PPI medications. Unusual endoscopic findings linked to GERD significantly increased in group 1 after surgery. 6 patients in total (3 from each group) had to undergo conversion to gastric bypass due to unmanageable reflux.

Many surgeons believed in the theory that a reduction of 80% of the parietal cell mass must cause a decrease of gastric acid secretion, consequently resulting in a drop of reflux after SG. (42) Nevertheless, this theory did not come true and Csendes et al. (29) found out that 58% of non-refluxers from group 1 ended up with de novo GERD. 86% of refluxers stayed with this condition. Because GERD and reflux can be a quite subjective disorder, it is useful to have some objective markers for it. For this Csendes et al. (43) suggest carditis as a perfect histological marker for the presence of chronic GERD. In the prementioned more recent study from 2019 by Csendes et al. (29) in either study group, carditis rose from 2% to 21% in the first group and from 9 to 45% in the second group. An almost identical way of acting was observed

when examining the fundus. Funditis was found in quite a few patients and is also a marker for ongoing reflux. The study team stated that 10.5 years after SG, there was a clear and continuing rise in de novo reflux cases (58%). This could be caused by an unfavorable influence of the sleeve on the purpose of the anti-reflux barrier, leading to a key cause for anomalous acid and duodenal reflux into the lower esophagus being an unsuccessful lower esophageal sphincter, instead of fluctuations in weight or raised intragastric pressure. The researchers suggest to all centers performing SG to do an upper endoscopy regularly to disclose complications linked to GERD early.

In another study with 63 patients who got to the 10-year follow-up point, out of the 7 GERD-positive patients before surgery, none showed improvement. 6 of them had to pursue with PPIs, and one patient underwent conversion predominantly due to GERD, resulting in a remission rate of 0%. 9 patients (21.4%) needed conversion to RYGB due to the development of new GERD. The high incidence for de novo GERD is a cause for alarm. (24)

In the aforementioned study by Salminen et al. (25) the prevalence of esophagitis was quite high after SG. It was present in 28 out of 91 patients (31%) postoperatively. 4 out of 91 patients (4%) presented with de novo BE after the procedure. This is consistent with the results of a current prospective cohort at 10.5 year follow-up where the incidence of BE was 4% as well. (29) The widespread presence of de novo BE was 4% after SG and therefore significantly lower than described in previous studies, where they reported about a frightening prevalence of up to 17% postoperatively. (44,45) Nevertheless, the high prevalence of esophagitis after SG should not be underestimated. (25) Therefore, endoscopic surveillance is recommended as part of follow-up care after SG surgery in all cases, regardless of the presence of GERD symptoms. (44) Because SG can lead to a GERD problematic with increased PPI use more than other BS, especially when compared with laparoscopic RYGB, a preoperative evaluation for GERD symptoms and careful patient selection are extremely important, according to Salminen et al. (25) They stated that the presence of esophagitis, heart burn symptoms, and the use of PPIs are significantly increased after SG, especially when compared to laparoscopic RYGB. Indeed, they found that 10 years after SG, 64% of patients were dependent on PPI intake. After SG, individuals with esophagitis showed noticeably more symptoms of GERD.

With the aim of giving a more precious conclusion on how SG can positively or negatively affect GERD, Felsenreich et al. (22) conducted a 24-hour pH observation, manometry analyses, gastroscopies, and inspections concentrated on reflux among 53 participants with a mean BMI prior to surgery of 49.5 kg/m2. All patients underwent SG and were followed up for over a decade. Individuals in this study did not encounter symptomatic reflux or hiatal hernia prior to

surgery. As a result of this study an elevated incidence of hiatal hernias (n=9; 45%) and BE (n=3; 15%) were observed at more than 10 years following SG in the non-converted group of patients. Consequently, pre-existing large hiatal hernia, GERD, and BE can be seen as relative contraindications for SG. However, it is important to note that this study has a small number of participants and was conducted when SG was still a newer surgical method. The increased occurrence of a new GERD set of problems after SG could be due to weight regain or caused by new hiatal hernias, which might arise from the pressure in the gastric sleeve over the years. In the study by Felsenreich et al. (22) gastroscopy was used to identify symptomatic reflux, BE, and hiatal hernias before surgery, because patients with these conditions were excluded from the study. Individuals with H. pylori infections were excluded from the study as well. In total, 53 individuals were operated and received SG in 3 different Austrian hospitals between 2003 and 2005. Out of the 53 patients, in 41 individuals SG was the primary bariatric operation. As mentioned before, during the study process of 10 years, 16 patients (37%) needed a second operation (RYGB) because of weight regain in 10 participants (23%) and critical reflux in 6 patients (14%). GERD was present in 38% of the patients (10 patients) who had no need for conversion to another bariatric procedure. Symptoms of reflux were identified by clinically interviewing participants about the presents of symptoms (e.g., heartburn, regurgitation, acidic taste in the mouth, a painful throat after a meal, increased coughing, augmented salivation, or pain in the chest). 70% (7 patients) of the non-converted group must take PPIs regularly now. The following results count only for the non-converted patients. These patients underwent gastroscopy to detect following conditions. 45% (9 patients) experienced new onset of hiatal hernias. Esophagitis was present in 30% (6 patients). BE could be identified in 15% (3 patients). H. pylori infection was seen in 15% (3 patients) 10 years after SG. GERD was present in 38% of the patients (16 patients) after 10 years follow-up. Knowing that hiatal hernias, BE, and GERD all represented contraindications for the surgery, this is quite a high number. Yet, it is still not clear if GERD can be improved, cured, or even develop due to SG. Depending on whether short-, mid- or long-term studies are analyzed, different results concerning GERD are seen. The development of de novo GERD takes time, hence is only detected by studies with long-term follow-up. In examinations with short-term follow-up, the initial weight loss usually leads to a drop in the intra-abdominal pressure, resulting in the improvement of GERD symptoms. (46) Therefore, researchers reasoned that SG could be performed in patients with preoperative GERD. (47) Others stated that the presents of hiatal hernias in bariatric patients may be quite underestimated. This was suggested by Boules et al. (48) who showed that a significant percentage of hiatal hernias are only diagnosed intraoperatively and not before the

surgery. Therefore, it is not always possible to differentiate between real new-onset hernias and small hernias, which were not seen before or during the surgery and developed into bigger hernias over the years. (22)

The participants in a 15-year-cross-sectional study by Felsenreich et al. (10) were operated before December 2005. After 15 years, 11 patients (55%) experienced GERD and depend on regular PPI intake. The operation technique was somewhat different back then. Today the resection of the antrum is commonly performed and might prevent the development of new onset GERD.

Diabetes mellitus Type 2

Especially DMII is confirmed to be more prevalent in obese people. (49) With an increased body weight, the risk of developing DMII rises. (50) A few years ago, a cohort with 2.9 million adults from the United Kingdom could show that individuals with a BMI from 30 to 35 kg/m2 have a 5 times increased risk of being ill with DMII. This risk even increases to 12 times higher in morbid obese people with a BMI of 40-45 kg/m2. (51) Scientists found out that one of the key factors linking obesity to diabetes is connected to a rise in liver and pancreatic visceral fat. Surplus hepatic triglycerides are carried in very low-density lipoproteins to every single tissue, therefore to the beta-cells of the pancreas. Over an extended period, this process leads to the gradual dedifferentiation of beta-cells, leading to the clinical onset of diabetes. (52) Interestingly, studies could prove, that, when individuals with DMII and obesity achieved a weight loss of 15 kg, the remission of DMII and reduction of liver and pancreatic fat was achieved. Therefore, remission of DMII is essentially dependent on weight loss with lowering in liver and pancreatic visceral fat. (38)

In a study with 114 patients following SG, 64.7% of participants fully recovered from DMII and could stop taking all glucose-lowering agents 10 years after the bariatric procedure. 23.5% of the patients improved their glucose levels from baseline. No patient went back to preoperative glycemic values. (16)

In a sizeable meta-analysis enclose matched cohort and controlled prospective studies from recent years, it was found out that metabolic surgery corresponded with noteworthy diminished all-cause mortality rates and lengthened life expectancy, especially in patients with preoperative DMII. (53) Moreover, investigators could prove that longer preoperative DMII duration results in lower remission rates after BS, calling attention to the significance of early surgical intervention in individuals with obesity and DMII. (54)

Salminen et al. (25) showed at 10 years follow-up, that remission of DMII was observed in 11 out of 42 patients (26%) after SG.

In a study with 110 consecutive patients, which analyzed DMII outcomes 11 and more years after SG surgery, effectiveness of the BS on preexisting DMII could not be gauged as all 3 patients with DMII received a transformation to a different surgical anatomy: RYGB (n=2) or DS (n=1). Moreover, one patient contracted a new non-insulin dependent DMII even with undergoing a re-sleeve procedure. About the effectiveness of SG on co-occurring conditions, the literature mainly records its impact on DMII in the short to mid-term. There is a scarcity of information available on the long-term benefit of this bariatric procedure. (24) Consequently, more long-term studies with a larger sample size are needed to properly investigate the outcomes of DMII after SG.

Arterial hypertension

Research shows an almost linear relationship between the BMI and the arterial blood pressure in adults. Moreover, weight reduction results in a decreased blood pressure in most hypertensive people. (50) Individuals having obesity and hypertension at the same time are at higher risk of developing cardiac events early in life that may lead to death. Adipose tissue is a source for neuroendocrine hormones. Therefore, weight reduction can reduce the adipose tissue-related reasons for AHT. (55)

Castagneto et al. (16) found out that SG can determine (44.2% of cases) or at least better (36.5% of cases) AHT in patients 10 years after SG. A different study series with 110 patients reported about only one patient in remission and one patient improved, hence improvement or remission rate was 28.6%. (24) Salminen et al. (25) reported about 6 out of 72 patients (8%) who could stop taking blood lowering medications 10 years after SG and 23 out of 72 individuals (32%) could reduce their antihypertensive drugs.

Dyslipidemia

Obesity is linked to a permanent state of low-level inflammation, triggered by metabolic cells responding to a spillover of nutrients. (50) Visceral adipose tissue acts as a massive source for proinflammatory cytokines, e.g., tumor necrosis factor alpha, interleukin (IL)-1 and IL-6, which open on to inflammation in the body and therefore are involved in the development of cardiometabolic diseases, malignancy, and infectious diseases in individuals with obesity. (38) The compromised production of adipokines and chronic inflammation within the adipose tissue give rise to the development of resistance to insulin. A notable association between obesity and

dyslipidemia look like the start of insulin resistance in peripheral tissues. This resistance proceeds in a raised hepatic flow of fatty acids gained from nutritive origins, endovascular lipolysis, and adipose tissue that is unsusceptible to the antilipolytic function of insulin. (56)
Results from a study 10 years after SG show that dyslipidemia resolved in 36.4% of cases and improved in 45.5% of cases. (16) In the study of Arman et al. (24) similar outcomes were seen. Out of 10 patients 2 participants were in remission, 2 patients improved, and 6 patients did not encounter any benefit from the procedure. Therefore, improvement or remission rate was 40%. Nevertheless, 3 participants in this study even developed de novo dyslipidemia.
In the initial assessment in the study by Salminen et al. (25), 39 out of 121 (32%) presented with dyslipidemia. Remission of the same, indicated by normal lipid values without the need for medication, was observed in 4 out of 21 patients (19%) 10 years after SG.

Obstructive sleep apnea

In a study with 4000 adults from the US, the prevalence of OSAS was found to be 12% in obese versus 3% in non-obese individuals. Obesity counts as a major pathogenic factor in the development of OSAS in adults. (50) OSAS results from the buildup of additional adipose tissue inside the confines of the upper respiratory tract and hypopharynx, which in turn makes ventilation difficult, and so secondary hypoxia and sometimes even hypercapnia can develop. (57)
SG can contribute to resolving OSAS in morbid obese patients. Castagneto et al. (16) found SG to resolve OSAS in even 72.2% of cases and better the condition in 27.8% of cases. In a different study with 110 patients, remission rate was found to be 66%. However, one participant developed de novo OSAS. (24)
In the initial assessment of Salminen et al. (25), 30 out of 121 (24.8%) of participants were diagnosed with OSAS. After 10 years, the evaluation revealed that 5 out of 31 patients (16%) had stopped using continuous positive airway pressure (CPAP). Additionally, 8 out of 31 patients (26%) had reduced CPAP settings, and 58% (18 out of 31 patients) had experienced no change in CPAP settings.

Complications and adverse events

Deciding on BS requires first weighing possible consequences as well as risks and benefits. The irreversible nature of SG should be kept in mind when opting for it. (12) About 4% of individuals who faced a bariatric operation encounter complications in less than a month postsurgical, with the main issues being potential stapling complications like bleeding, leakage,

or strictures. (58) In addition, surgical complications like abscess in the abdomen, delayed gastric emptying, infection of wounds, reoperation, splenic trauma and trocar site hernia may arise later in SG patients. (12) Promptly occurring as well as delayed surgical complications can be recognized and managed through either surgical or endoscopic methods. (58)

In the study by Arman et al. (24) a significant proportion of patients (16 patients=25.4%) needed conversion to an anatomy other than the sleeve primarily due to inadequate weight loss or gain of weight, and in a few cases, because of GERD. In this case, 6 participants underwent RYGB and 10 DS. The authors concluded that conversion to a different anatomy (approximately needed in 1 out of 4 patients) is a good strategy in case of weight loss failure and increases %EWL to 81.7%.

Verras et al. (30) gave an account of 28% of individuals who needed conversion to a different bariatric procedure due to persistent symptoms of refractory GERD, 51.7% due to inadequate weight reduction, and 20% due to continuing complaints of dysphagia and gastric stenosis.

Extreme GERD symptoms after SG account as one of the main indications for conversion to RYGB. (22) Felsenreich et al. (10) concluded from their multi-center study that approximately every third patient needs conversion after SG. Fortunately, there are multiple treatment options that could be tried out to receive improvement for these patients. In the study by Felsenreich et al. (22) 11.3% of the participants underwent conversion to RYGB within the 10-year follow-up period. Another option is the insertion of a LINX® ring device. This is a magnetic anti-reflux system, which is set around the gastro-jejunal junction. Desart et al. (59) documented the implantation of this device in their study and could show an improvement of GERD symptoms based on a GERD score after 2 to 4 weeks after the usage of LINX® ring device. Re-sleeve gastrectomy, cardiopexy, and constant administration of anti-reflux medication demonstrate another option for treating GERD. (22) For supplementary data, Crawford et al. (60) dispense a broad and new outline of probable methods to direct GERD following SG, e.g., radiofrequency ablation, reflux management arrangements, revisional surgery, protective methods. But it must be said that almost all these measures require another operation with the corresponding risks and side effects.

Quality of Life

Long-term follow-up suggests that essential weight regain, or critical reflux could certainly impact the QOL after SG. Whilst the continual increase in QOL along with loss of weight and the subsidence of comorbidities is a primary objective of BS, there is restricted long-term data on patient's QOL after BS. (26) In 2016, Juodeikis et al. (5) evaluated latest long-term studies

post-SG, and claimed that only a small number of studies exist on QOL following SG. Therefore, they suggest approaching the accessible data carefully.

The study by Felsenreich et al. (26) marks the initial presentation of data on QOL 10 or more years following SG. By applying 5 standardly used questionnaires, namely Bariatric Analysis and Reporting Outcome System (BAROS), Bariatric Quality of Life Index (BQL), GIQLI, Reflux Symptom Index (RSI) and the SF36, the researchers found diminished QOL in people experiencing notable gain in weight and symptomatic reflux. Raising QOL, together with attaining weight reduction and subsidence of co-morbidities, is a desired result in BS. Hence, it is relevant to explore the extent to which BS, especially SG as a free-standing and ultimate procedure, contribute to an improved QOL. In general, the participants in the presented study showed rather low scores, a contrast that becomes even stronger when these findings are compared with studies of shorter duration.

The BAROS focuses on the outcomes of BS and is a straightforward and justifiable tool. This score includes sub-scores from 5 segments: ‘loss of weight’, ‘enhancement of the medical state’, ‘QOL’, ‘complications’, and ‘repeated surgery’, giving an overall score of 9 points as a maximum value. Employing the scoring key, the outcome of BS for each person can be categorized as follows: ≤ 1 point for “failure”, 1-3 points for “fair”, 3-5 points for “good”, 5-7 points for “very good”, or 7-9 points for “excellent”. (61)

Felsenreich et al. (17) performed a study with 53 patients who underwent SG before 2006. The researchers applied the BAROS to assess QOL 10 years after SG. The mean BAROS of the patients who did not undergo conversion to a different bariatric procedure was 2.4 at 10 years, which is equate with “fairly efficient”. According to these results, SG is classified as “slightly effective” bariatric procedure.

The RSI and GIQLI are mainly reflux-related questionnaires. (26) The GIQLI, designed by Eypasch et al. (62), is a verified survey form holding 36 questions with 5 categories apiece. The answers of the participants are accumulated to create a numeric index ranging from 0 to 144 points. Contrastingly, the RSI, invented by Belafsky et al. (63), is a verified score produced to identify laryngopharyngeal reflux. It contains 9 modules, with a sum of 45 points, 5 for each question. 10 or more points are defined as abnormal, while scores surpassing 13 are suggestive of a pathologic condition.

In another long-term study by Felsenreich et al. (22), 20 (77%) of the non-converted patients filled out the 2 questionnaires that focuses on gastrointestinal QOL: RSI and GIQLI. In the GIQLI, individuals encountering symptomatic reflux showed notable lower scores in contrast to those unescorted by reflux. For the QOL, it did not matter if patients suffered from hiatal

hernia or BE. Participants with expanded sleeve or infection with H. pylori performed worse on GIQLI, but no crucial divergence was seen in comparison to patients without these factors. Overall, in the RSI 15% (n=3) exhibited a pathologic result greater than 13 points. Participants with symptomatic reflux attained higher results than those without reflux. Hence, the researchers concluded, that individuals feeling symptomatic reflux show significantly lower scores in the GIQLI, underscoring the substantial impact of GERD on a person's gastrointestinal QOL.

Felsenreich et al. (10) found out that GERD-patients achieved notably lower results in the GIQLI questionnaire than those lacking GERD symptoms. This leads to the conclusion, that GERD impact the QOL quite negatively.

SF36 and BQL assess the QOL after BS on a broader spectrum. (26) The SF36 is a verified survey form containing 36 components created to evaluate an individual's overall QOL. There are 8 distinct areas with questions, each featuring a differing number of elements: energy plus vitality, physical and social functioning, mental health, physical and emotional problems, pain, and general perception of health. Each sector allows for a score between 0 and 100. (64)

The BQL is created to evaluate a person's QOL before and after BS and containing 2 parts. One part requires collecting medical data, while the other part needs collecting information through 13 questions, giving a sum of 65 points that can be achieved. The authors outline its straightforwardness making it a useful tool for postoperative QOL assessment. They state enhanced responsiveness gives superiority over other survey forms. (65)

In the aforementioned multicenter study by Felsenreich et al. (26) the BQL showed significant differences in the perception of QOL when it came to GERD symptoms. Participants with actual reflux symptoms scored 45.7%, while individuals without reflux symptoms scored 52.1%. The difference between patients with > 50% EWL and patients < 50% EWL was not significant.

The SF36 survey form in the same study revealed that participants with > 50% EWL presented with an improved QOL than those with < 50% EWL and participants lacking reflux symptoms showed a notable increased QOL in each of the 8 categories. The study could prove that reflux is not just an excruciating symptom but negatively influences an individual's QOL, including but not limited to the mental well-being.

In the study of Arman et al. (24) satisfaction levels were judge through responses to a Likert questionnaire involving 5 definite outcome groups: 0-2, representing very dissatisfied; 3-4, indicating dissatisfied; 5-6, showing a neutral stance; 7-8, pleased; and 9-10, signifying extremely pleased. In the final analyses, the satisfaction score for the entire cohort was 8, and majority of participants (83%) scored ≥ 7, a rather satisfying result.

Salminen et al. (25) used for their randomized clinical trial the Moorehead-Ardelt QOL questionnaire to assess overall satisfaction levels after SG. Before SG, participants had a mean Moorehead-Ardelt QOL score of 0.10, which is equivalent to 'fair enough'. After 10 years, the mean QOL total score following SG increased to 0.64, which can be translated as 'very good'. The highest score possible in this system is 0.9. (66)

Follow-up Protocols and Recommendations

In line with the Clinical Guidelines for the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults published by the National Heart, Lung, and Blood Institute (NHLBI), people facing BS should get a comprehensive program that covers guidance on dietary habits, physical activity, and psychosocial thoughts pre- and post-surgery. Especially the postoperative period is the perfect time to incorporate lifestyle changes to improve outcomes and compliance for patients receiving bariatric procedures. (67)

If compared to bariatric techniques like laparoscopic AGB and RYGB/BPD-DS, SG only needs a minimum of follow-up after surgery. For example, there is no need for adjustments like in laparoscopic AGB and marginal ulcerations and malabsorption of micronutrients are not expected like in RYGB and BPD-DS. This makes SG a rather popular bariatric procedure. If needed, SG can be easily changed into a malabsorptive surgery, like BPD-DS and LRYGB when weight loss is not efficient enough or severe GERD occurs. (12)

Usually, patients receiving BS are followed up 2 weeks after surgery, then at 3, 6 and 12 months, and then once a year for regular check-ups. (12) With the aim to explore probable nutritional deficiencies following the resection of about four fifths of the stomach, Abu-Jaish et al. (12) ran a study involving 218 participants who received SG. These patients were observed at typical intervals at 3, 6, and 12 months, as well as annually afterwards. All participants were provided with standard postoperative oral multivitamin tablets. A lack of thiamine (B1) and folate (B9) were each observed in one patient (0.4%), while 13 participants (5.9%) experienced vitamin D deficiency. These findings were accidently since all patients were asymptomatic. The study came to the conclusion that even infrequent and seemingly inconspicuous deficiency symptoms can arise in morbidly obese people after SG. (12)(68)

A significant part of patients undergoing SG suffer from weight regain or failure to weight loss. In this case, the study team advises closer follow up, consultative and nutritional maintenance. Moreover, because SG allows for easy procedure to revisional BS, surgeons should think about a second stage surgery, e.g., RYGB, one anastomosis gastric bypass, re-sleeve resection or BPD-DS, in some cases of primary failure of SG. (16)

Different results in BE frequencies among the surveys can be linked to the deviating interpretations of BE, concerning both intestinal and gastric metaplasia, as well as the possible difference in endoscopic evaluation of BE. Nevertheless, the remarkable upraised incident of endoscopic esophagitis, symptoms of GERD, and the utilization of PPI following SG, in comparison to LRYGB, accentuate the critical demand for an in-depth evaluation of GERD prior to surgery and its connected endoscopic findings. For sick people suffering from clinical GERD, SG might not be the prime weight loss intervention. (25)

One imaginable cause for the significant variance between the statistics given out in different studies (e.g., the study by Braghetto et al. (69) reported about a BE incidence of 1.2% at 5 years vs. BE incidence of 14% at 10 years of follow-up identified by Felsenreich et al. (22)) is surely the certainty that the continuance to Barrett's metaplasia commonly needs some years to exhibit. However, it is critical to incorporate constant gastroscopies, especially of the gastroesophageal junction in the usual follow-up appointments for SG to immediately recognize any new event of Barrett's metaplasia as early as possible. (22)

Beyond that researchers suggest to use standardized questionnaires that assess the QOL after SG to evaluate long-term outcomes and in preparation of a possible conversion to another BS in case of weight regain or severe symptomatic reflux. (26)

Conclusions

There has been earlier exchange between experts concerning weight loss methods. It is now generally believed, that surgical procedures provide better results in the short- and mid-term follow-up in terms of weight loss compared to non-surgical weight loss strategies. (70)

Sleeve resection is appraised the most popular technique for bariatric surgery in the world, nevertheless follow-up for 10+ years is rare and usually does not proceed for more than 5 years. (16) The aim of this literature review was to analyzed results after sleeve resection more than 10 years following the procedure. However, very long-term outcomes (10+ years) after sleeve gastrectomy yield different results.

While looking at lengthen follow-up research after sleeve gastrectomy, 2 concerns have been mentioned by various scientists lately: reflux and regaining of weight. The frequency of reflux ranges based on the duration of follow-up. (26) Particularly gastro-esophageal reflux disease leads to a decreased quality of life. New onset hernias and enlarged sleeves were found rather frequently. (10)

The conclusion that can be drawn from an increase of gastro-esophageal reflux disease cases after sleeve resection is that postoperative observation might be recommended, even if there

are no reflux symptoms present. (16) Regular endoscopies are extremely important in all patients following sleeve gastrectomy, especially when Barrett's esophagus is present as well. (10) Nevertheless, despite concerning outcomes related to gastro-esophageal reflux disease, general patient satisfaction remains positive. (24)

Weight regain and gastro-esophageal reflux disease remain frequent causes for conversion to Roux-en-Y gastric bypass following sleeve resection. (22)

Optimal weight reduction and health augmentation occur when surgical intervention goes along with steady medical recording throughout one's life, with assistance in developing and maintaining healthy adjustments in diet and physical activity. (67)

Many studies included in this literature review provided only a relatively low follow-up rate (from 37.0% to 93.0%) and included a small sample size (from 53 to 148 patients). Drawing conclusions about the general population from these results should be treated with caution. In the future, more long-term data with a sizable number of participants are urgently needed to conclude more accurately about long-term results following sleeve gastrectomy.

In my opinion, the consequences of obesity are significant and stopping adiposity is always associated with a better result than if nothing is done. Therefore, I think sleeve resection is a good choice for obese patients who have not been able to cope with conventional measures such as dietary changes, increased physical activity or medication. Of course, careful patient selection is important and follow-up care for these patients must be ensured. Although the results 10 or more years after sleeve gastrectomy are not perfect, there are more advantages than disadvantages and the surgery is worth trying as a last resort to help morbid obese people become healthier.

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Appendix

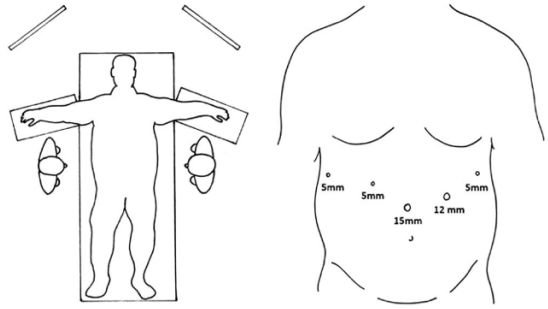

Figure 1 Position of patient (left) and positions and sizes of ports (right) (2)

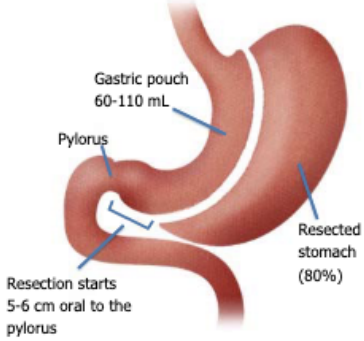

Figure 2 Sleeve gastrectomy (8)