BOŁDYS-ŻEGOCKI, Hubert, KARCZ, Anna, PAJĄK , Barbara, WRÓBLEWSKA , Oliwia, DWORNICZAK, Małgorzata, SALASH, Sofiya, ROMANIUK, Aleksandra, MAJEWSKI , Jakub, KANIECKA, Maria and KOZA, Artur. Comparison of the long-term clinical, metabolic, and economic outcomes of sleeve gastrectomy (SG) and roux-en-y gastric bypass (RYGB). Quality in Sport. 2025;48:66825. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.48.66825
https://apcz.umk.pl/QS/article/view/66825

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 23.11.2025. Revised: 20.12.2025. Accepted: 21.12.2025. Published: 22.12.2025.

COMPARISON OF THE LONG-TERM CLINICAL, METABOLIC, AND ECONOMIC OUTCOMES OF SLEEVE GASTRECTOMY (SG) AND ROUX-EN-Y GASTRIC BYPASS (RYGB)

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Abstract

Introduction: Obesity is a complex, chronic, and multifactorial disease that has reached pandemic proportions worldwide, affecting over one billion people according to the World Health Organization (WHO, 2025). It is a major risk factor for type 2 diabetes, cardiovascular diseases, and certain cancers. Given the limited long-term efficacy of conservative management, bariatric surgery—particularly Sleeve Gastrectomy (SG) and Roux-en-Y Gastric Bypass (RYGB), has become the cornerstone of treatment for morbid obesity.

Aim: This study aims to compare the long-term clinical, metabolic, and cost-effectiveness outcomes of SG and RYGB, and to identify patient-related factors guiding personalized surgical choice.

Materials and Methods: A comprehensive literature review was performed using PubMed, PubMed Central (PMC), Google Scholar, and ResearchGate, limited to English-language peer-reviewed publications. The analysis included data from major randomized controlled trials: Oseberg (1-year), SM-BOSS (5-year), SLEEVEPASS (10-year) and cost-effectiveness studies by Borisenko et al. (2015) and Lauren et al. (2022), as well as guidelines from WHO, IFSO, and Polish medical associations.

Results: Across all time points, RYGB demonstrated superior long-term weight reduction (%TWL higher by 3.6–4.9%) and higher rates of type 2 diabetes remission (75% vs. 61% at 1 year; 37% vs. 27% at 10 years) compared with SG. RYGB also showed more favorable effects on insulin sensitivity (HOMA-IR) and triglyceride levels. However, it was associated with a higher incidence of nutritional deficiencies, particularly of iron, vitamin B12 and a greater need for lifelong supplementation. SG, while safer in terms of nutritional complications, was linked to an increased prevalence of gastroesophageal reflux disease (GERD). Quality-of-life improvements, measured using the SF-36 and BAROS scales, were comparable between both procedures.

Cost-effectiveness analyses indicated that RYGB, despite higher upfront costs, achieves net healthcare savings within 5–10 years due to greater remission of diabetes and cardiovascular comorbidities. Both Borisenko et al. (2015) and Lauren et al. (2022) demonstrated the economic superiority of RYGB in publicly funded health systems.

Conclusions: RYGB provides greater and more durable weight loss, superior metabolic benefits, and long-term cost-effectiveness, though at the expense of increased nutritional risks. SG remains a safer, technically simpler, and effective alternative, particularly for patients without severe metabolic disease or GERD. The optimal surgical choice should be based on a personalized assessment of metabolic benefit, nutritional risk, and economic considerations.

Keywords: Sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), obesity, metabolic surgery, long-term outcomes, cost-effectiveness, type 2 diabetes remission

Introduction

Obesity is one of the most serious public health challenges of the 21st century. According to data from the World Health Organization (WHO), in 2022 approximately 2.5 billion adults (43% of the global population) were overweight, of whom 890 million individuals (16%) were living with obesity. The problem also affects younger populations—around 160 million children and adolescents aged 5–19 years met the criteria for obesity (World Health Organization, 2025).

Obesity represents a major risk factor for the development of noncommunicable diseases such as type 2 diabetes, hypertension, ischemic heart disease, and several types of cancer (World Health Organization, 2025). It is estimated that in 2021, elevated body mass index (BMI) was associated with more than 3.7 million deaths worldwide from noncommunicable diseases (GBD 2021 Risk Factor Collaborators, 2024).

Although obesity was once considered a problem mainly of high-income countries, in recent decades its prevalence has been rapidly increasing in low- and middle-income regions (World Health Organization, 2025; Cecchini et al., 2010). As reported by Cecchini et al. (2010), the rate of increase in obesity in these regions now exceeds that observed in high-income countries, particularly in South America, Southeast Asia, North Africa, and the Middle East. This trend is primarily driven by socioeconomic transitions, urbanization, rising income levels, and increased access to highly processed, energy-dense foods (Cecchini et al., 2010). The growing prevalence of obesity in these populations has been accompanied by an increase in type 2 diabetes, cardiovascular diseases, and other metabolic disorders, posing an escalating burden on healthcare systems with limited financial resources (Cecchini et al., 2010). Modeling studies by Cecchini et al. (2010) demonstrated that implementing a cost-effective package of population-level and individual-level interventions targeting obesity could prevent an estimated 2.6 million deaths annually, with the greatest health gains achieved in low- and middle-income countries.

The economic burden of obesity is also substantial on a global scale. It is projected that by 2030, the combined cost of overweight and obesity could reach USD 3 trillion annually, rising to USD 18 trillion by 2060 (Okunogbe et al., 2022). Consequently, obesity represents not only an individual health problem but also a major economic and social challenge.

The rising prevalence of obesity, combined with the limited long-term effectiveness of conservative management, has led to the increasing adoption of surgical treatment options. Bariatric procedures such as sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) are recommended for patients with BMI $\geq$ 40 kg/m² or BMI $\geq$ 35 kg/m² with obesity-related comorbidities, including type 2 diabetes, hypertension, or dyslipidemia (Peterli et al., 2018; Jarosz et al., 2023). Recent guidelines, however, suggest considering bariatric surgery within these BMI ranges regardless of the presence of comorbidities (Jarosz et al., 2023). These procedures result in substantial and sustained weight loss, improved glycemic control, enhanced quality of life, and reduced cardiovascular risk (Peterli et al., 2018).

Aim

The objective of this study is to compare the long-term clinical and metabolic outcomes of sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB), to assess their cost-effectiveness, and to identify factors that may support the individualized selection of the surgical procedure in patients with obesity.

Materials and Methods

The literature search was conducted using the PubMed, PubMed Central (PMC), Google Scholar, and ResearchGate databases, restricted to publications written in English. The analyzed studies were derived from peer-reviewed journals (including JAMA, JAMA Surgery, The Lancet Diabetes & Endocrinology, The New England Journal of Medicine, Obesity Surgery, and Annals of Internal Medicine). In addition, official reports from major organizations were included, such as those of the World Health Organization (WHO), the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO), and the World Obesity Federation.

Definition, Pathophysiology, and Classification

According to the definition proposed by the World Health Organization (WHO), obesity is a chronic, complex disease characterized by excessive accumulation of adipose tissue that may adversely affect health (World Health Organization, 2025). It increases the risk of type 2 diabetes mellitus (T2DM) and cardiovascular diseases (World Health Organization, 2025; Jarosz et al., 2023), contributes to the development of mental disorders (Jarosz et al., 2023), negatively affects the skeletal and reproductive systems, and increases the risk of certain types of cancer (World Health Organization, 2025; Jarosz et al., 2023). Obesity also impairs quality of life, affecting mobility, sleep, and overall well-being (World Health Organization, 2025).

The pathophysiology of obesity extends beyond a simple imbalance between energy intake and expenditure; its health consequences are multisystemic (World Health Organization, 2025). The primary indicator used for diagnosing and classifying obesity in adults is the Body Mass Index (BMI), calculated as body weight in kilograms divided by height in meters squared (kg/m^2). However, clinical assessment should also include measurements such as waist circumference,

which more accurately reflects metabolic risk associated with abdominal obesity (World Health Organization, 2025).

The World Health Organization (WHO) adopts the following classification:

- Overweight: BMI equal to or greater than 25 kg/m².
- Obesity: BMI equal to or greater than 30 kg/m² (World Health Organization, 2025).

For clinical and research purposes, obesity is further divided into three degrees:

- Class I obesity: BMI 30–34.9 kg/m²
- Class II obesity (clinical obesity): BMI 35–39.9 kg/m²
- Class III obesity (severe obesity): BMI equal to or greater than 40 kg/m² (Jarosz et al., 2023).

Epidemiology

Obesity represents a global health problem of pandemic proportions. The upward trend has been observed for decades, between 1980 and 2008, the average global BMI increased steadily by approximately 0.4–0.5 kg/m² per decade, affecting most regions of the world (Finucane et al., 2011). According to the latest WHO data (2022), the scale of the problem has reached its historical peak: obesity currently affects more than 1 billion individuals worldwide, including 16% of the global adult population (World Health Organization, 2025). Alarmingly, a rapid increase has also been observed among younger age groups. Compared with 1990, the prevalence of obesity in children and adolescents has quadrupled, and by 2022, more than 390 million individuals aged 5–19 years were living with overweight or obesity (World Health Organization, 2025).

The situation in Poland reflects these worrisome global trends. It is estimated that more than two-thirds of Polish adults are overweight or obese, with obesity alone affecting approximately 25% of men and 26% of women (Jarosz et al., 2023).

Treatment

The treatment of obesity is a complex and multifaceted process that requires a multidisciplinary approach. According to the position statement of Polish scientific societies, the primary therapeutic methods include (Jarosz et al., 2023):

- Dietary therapy: This constitutes the foundation of treatment. It involves an individually tailored, sustainable nutritional plan that creates a negative energy balance while ensuring the adequate intake of essential nutrients.
- Physical activity: An indispensable complement to dietary intervention, aimed at increasing energy expenditure and improving cardiorespiratory fitness.
- Psychotherapy and behavioral modification: These play a crucial role in managing eating disorders, identifying and addressing emotional triggers of eating, and establishing sustainable, healthy habits.
- Pharmacotherapy: Used as an adjunctive therapy when lifestyle modification alone is insufficient.
- Surgical treatment (bariatric/metabolic surgery): Recommended for patients with morbid obesity (BMI $\geq$ 40 kg/m²) or severe obesity (BMI $\geq$ 35 kg/m²) with obesity-related comorbidities, in cases where conservative treatment has failed (Jarosz et al., 2023). Surgical interventions demonstrate the highest efficacy in achieving sustained weight reduction and remission of obesity-related complications (Peterli et al., 2018).

Sleeve Gastrectomy (SG)

Sleeve gastrectomy (SG) is an independent, restrictive–metabolic bariatric procedure. Currently, it is the most commonly performed operation for the treatment of morbid obesity worldwide (Angrisani et al., 2017; IFSO Global Registry, 2024). Data from the 9th Global Registry Report of the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) confirm that in 2023, SG accounted for 60% (331,000 out of 547,959) of all primary bariatric procedures globally, maintaining its dominant position among surgical techniques (IFSO Global Registry, 2024).

Surgical Technique

The procedure is performed under general anesthesia, with the laparoscopic approach being the preferred technique (IFSO Global Registry, 2024; Gagner et al., 2013). According to international expert consensus, the key operative steps include (Rosenthal & Expert Panel, 2012; Gagner et al., 2013):

- Positioning and access: The patient is typically positioned in the French position (surgeon standing between the legs) or in a slight Fowler position; operative access is obtained using 4–5 trocars (Rosenthal & Expert Panel, 2012).
- Mobilization of the stomach: The greater omentum is divided approximately 2–6 cm from the pylorus, and dissection continues along the greater curvature up to the gastrophrenic ligament, with careful attention near the spleen. The goal is to achieve complete mobilization of the gastric fundus (Rosenthal & Expert Panel, 2012).
- Calibration and resection: To precisely form the gastric sleeve, a calibrating bougie (32–36 Fr, occasionally up to 40 Fr) is inserted along the lesser curvature (Gagner et al., 2013). The stomach is then transected using a linear stapler parallel to the bougie, beginning 2–6 cm from the pylorus and ending on the left side of the cardia (Gagner et al., 2013). The staple line should be positioned safely below the angle of His (Rosenthal & Expert Panel, 2012).
- Leak test: After removal of the resected stomach, the staple line is tested for leakage using air or dye testing. Reinforcement of the staple line through omentopexy or oversewing is recommended to reduce postoperative complications (Rosenthal & Expert Panel, 2012; Gagner et al., 2013).

Mechanism of Action

The therapeutic effect of sleeve gastrectomy results from a combination of restrictive and metabolic mechanisms (Peterli et al., 2018):

- Restrictive mechanism: The marked reduction in gastric volume (to approximately 60–150 mL) limits the amount of food that can be consumed, inducing early satiety.
- Metabolic mechanism: Resection of the gastric fundus, the main site of ghrelin ("the hunger hormone") production, leads to a sustained decrease in its plasma concentration and reduced appetite. Furthermore, accelerated transit of chyme into distal segments of the gastrointestinal tract stimulates the secretion of incretins (GLP-1, PYY), thereby enhancing insulin secretion and improving glucose tolerance (Peterli et al., 2018).

Roux-en-Y Gastric Bypass (RYGB)

Roux-en-Y gastric bypass (RYGB) combines restrictive and malabsorptive mechanisms and is widely regarded as the gold standard in bariatric surgery (Angrisani et al., 2017; IFSO Global Registry, 2024). According to the most recent global data, RYGB remains the second most frequently performed bariatric procedure worldwide, accounting for 32% (163,000 out of 547,959) of all primary bariatric operations in 2023 (IFSO Global Registry, 2024). For revisional procedures, RYGB continues to dominate, representing 58% of all revisional surgeries (IFSO Global Registry, 2024).

Surgical Technique

The operation is performed under general anesthesia using a laparoscopic approach (IFSO Global Registry, 2024; Salminen et al., 2023). The key procedural steps include the following (Schauer et al., 2017; Salminen et al., 2023):

- Creation of the gastric pouch: The stomach is divided with a surgical stapler to form a small proximal pouch (15–30 mL) and a larger distal remnant, which is excluded from the alimentary tract (Schauer et al., 2017).
- Formation of the Roux limb: The small intestine is transected approximately 20–50 cm distal to the ligament of Treitz, and the distal segment (the Roux limb) is elevated to be anastomosed with the gastric pouch (Schauer et al., 2017).
- Anastomoses: A gastrojejunostomy (connection between the gastric pouch and the Roux limb) and a jejunojejunostomy (connection between the biliopancreatic and alimentary limbs) are constructed. The Roux limb typically measures 100–150 cm in length but may be extended in cases of super-obesity (Schauer et al., 2017).

Mechanism of Action

The therapeutic efficacy of RYGB results from the synergistic interplay of restrictive, malabsorptive, and metabolic mechanisms (Peterli et al., 2018; Schauer et al., 2017):

- Restrictive mechanism: The small gastric pouch (15–30 mL) significantly limits food intake and induces early satiety (Peterli et al., 2018).

- Malabsorptive mechanism: Exclusion of the duodenum and proximal jejunum from the alimentary flow reduces nutrient absorption, particularly of fats and simple carbohydrates (Schauer et al., 2017).
- Metabolic mechanism: The rapid delivery of partially digested food to the distal small intestine stimulates the secretion of incretins (GLP-1, PYY), which enhances insulin release, increases satiety, and reduces appetite—the so-called anti-diabetic effect (Schauer et al., 2017; Salminen et al., 2023). Additionally, alterations in gut hormone secretion, including decreased ghrelin levels, are well-documented components of the post-RYGB metabolic response (Peterli et al., 2018).

Long-Term outcomes of Sleeve Gastrectomy versus Roux-en-Y Gastric Bypass

The following analysis is based on three key multicenter randomized controlled trials (RCTs): Oseberg, SM-BOSS, and SLEEVEPASS, providing 1-, 5-, and 10-year follow-up data.

Study Characteristics:

- Oseberg (Norway, 2019): RCT with a 1-year follow-up; 109 patients with obesity and type 2 diabetes (mean age: 49 years; mean BMI: 41 kg/m²) (Hofsø et al., 2019).
- SM-BOSS (Switzerland, 2018): RCT with a 5-year follow-up; 217 patients (mean age: 43 years; mean BMI: 44 kg/m²) (Peterli et al., 2018).
- SLEEVEPASS (Finland, 2023): RCT with a 10-year follow-up; 240 patients (mean age: 49 years; mean BMI: 46 kg/m²) (Salminen et al., 2023).

Weight Reduction – Analysis of %TWL and %EWL

In the short-term perspective (1 year), the Oseberg trial demonstrated that RYGB achieved significantly greater weight loss, with a mean %TWL of 34.2% and %EWL of approximately 75%, compared to 30.7% TWL and ~70% EWL for SG (Hofsø et al., 2019).

This superiority of RYGB persisted at 5 years in the SM-BOSS study, where %TWL was 28.6% and %EWL 60.0% for RYGB, versus 23.7% TWL and 53.0% EWL for SG; however, these differences did not reach statistical significance (Peterli et al., 2018).

In the longest follow-up, the SLEEVEPASS study (10 years) showed that RYGB maintained a clear advantage, although the difference was slightly reduced (%TWL 25.5 vs. 21.9; %EWL 50.7 vs. 43.4), with statistical significance observed for %EWL (mean difference: 8.4 percentage points; 95% CI: 3.1–13.6; p = 0.002) (Salminen et al., 2023).

As summarized in Table 1, RYGB consistently demonstrated superior long-term weight loss across all observation periods, although both %TWL and %EWL gradually declined over time in both groups.

Table 1. Comparison of Weight Loss Outcomes After Sleeve Gastrectomy (SG) and Roux-en-Y Gastric Bypass (RYGB) in Long-Term Follow-Up

Follow-up period	**SG (Sleeve Gastrectomy)**	**RYGB (Roux-en-Y Gastric Bypass)**	**Statistical significance**	**Source**
1 year	30.7% TWL / ~70% EWL	34.2% TWL / ~75% EWL	$p < 0.05$	*Hofsø et al.*, 2019
5 years	23.7% TWL / 53.0% EWL	28.6% TWL / 60.0% EWL	NS ($p > 0.05$)	*Peterli et al.*, 2018
10 years	21.9% TWL / 43.4% EWL	25.5% TWL / 50.7% EWL	$p = 0.002$	*Salminen et al.*, 2023

Sources. Hofsø et al., 2019; Peterli et al., 2018; Salminen et al., 2023.
Note. SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; TWL = total weight loss (%); EWL = excess weight loss (%); NS = not significant.

Nutritional Complications Profile and Supplementation Requirements

The analysis of nutritional complications indicates a significantly higher risk associated with the RYGB procedure. In the Oseberg study, after 12 months, iron deficiency occurred in 38%

of RYGB patients compared to only 2% after SG, while vitamin B12 deficiency was observed in 12% and 1% of patients, respectively (Hofsø et al., 2019).

In the long-term follow-up of the SLEEVEPASS trial (10 years), anemia was present in 30% of RYGB patients versus 17% after SG (Salminen et al., 2023). Calcium supplementation rates were significantly higher in the RYGB group (68% vs. 42%), reflecting a greater risk of bone metabolic disturbances in this population (Salminen et al., 2023).

As summarized in Table 2, the RYGB procedure is associated with a markedly higher risk of nutritional deficiencies across all evaluated parameters. Differences in the prevalence of iron and vitamin B12 deficiencies were already evident after 12 months of observation and correspond to higher long-term calcium supplementation rates in the RYGB group.

Table 2. Profile of Nutritional Complications and Supplementation Rates After SG and RYGB

Parameter	Follow-up period	SG	RYGB	Difference / significance
Iron deficiency	1 year	2%	38%	$p < 0.001$
Vitamin B12 deficiency	1 year	1%	12%	$p < 0.05$
Anemia	10 years	17%	30%	$p = 0.03$
Calcium supplementation	10 years	42%	68%	$p < 0.01$

Sources. Hofsø et al., 2019; Salminen et al., 2023. Note. SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass.

Metabolic Effectiveness – Remission of Type 2 Diabetes

In terms of type 2 diabetes (T2D) remission, RYGB consistently demonstrates superior efficacy. After 1 year in the Oseberg trial, remission was achieved in 75% of patients after RYGB

compared to 61% after SG (Hofsø et al., 2019). At 5 years (SM-BOSS), these rates were 68% and 53%, respectively (Peterli et al., 2018).

In the 10-year follow-up (SLEEVEPASS), an overall decline in absolute remission rates was observed in both groups; however, the superiority of RYGB persisted (37% vs. 27%) (Salminen et al., 2023). As summarized in Table 3, RYGB maintained a consistent advantage in achieving T2D remission throughout the entire observation period, despite the gradual reduction in absolute remission rates in both surgical cohorts over time.

Table 3. Remission Rates of Type 2 Diabetes After SG and RYGB in Long-Term Follow-Up

Follow-up period	**Study**	**SG**	**RYGB**	**Statistical significance**	**Source**
1 year	*Oseberg*	61 %	75%	$p = 0.03$	*Hofsø et al.*, 2019
5 years	*SM-BOSS*	53 %	68%	$p = 0.03$	*Peterli et al.*, 2018
10 years	*SLEEVEPASS*	27 %	37%	$p = 0.04$	*Salminen et al.*, 2023

Sources. Hofsø et al., 2019; Peterli et al., 2018; Salminen et al., 2023.

Note. SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass.

Metabolic Parameters – Detailed Analysis

In the context of glycemic control, the Oseberg study demonstrated a significantly greater improvement in insulin sensitivity after RYGB, with a mean decrease in HOMA-IR of 4.1 compared to 2.8 after SG (Hofsø et al., 2019). In the SLEEVEPASS trial, the mean HbA1c

level at 10 years remained at 6.4% in the RYGB group versus 6.7% in the SG group (Salminen et al., 2023).

Regarding the lipid profile, RYGB showed a clear advantage in improving dyslipidemia. In the SM-BOSS study, after 5 years, the reduction in triglyceride levels reached 41% for RYGB versus 29% for SG, while the increase in HDL cholesterol was comparable between groups (Peterli et al., 2018).

As summarized in Table 4, RYGB demonstrated significantly greater effects on selected metabolic parameters, particularly in improving insulin sensitivity, maintaining long-term glycemic control, and reducing triglyceride concentrations.

Table 4. Impact of SG and RYGB on Selected Metabolic Parameters

Metabolic parameter	**Follow-up period**	**SG**	**RYGB**	**Statistical significance**	**Source**
Change in HOMA-IR (↓)	1 year	–2.8	–4.1	$p < 0.05$	*Hofsø et al.*, 2019
HbA1c [%]	10 years	6.7	6.4	$p = 0.04$	*Salminen et al.*, 2023
Reduction in triglycerides [%]	5 years	–29%	–41%	$p < 0.05$	*Peterli et al.*, 2018
Change in HDL [mmol/L]	5 years	+0.28	+0.31	NS ($p > 0.05$)	*Peterli et al.*, 2018

Sources. Hofsø et al., 2019; Peterli et al., 2018; Salminen et al., 2023.

Note. SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; HOMA-IR = Homeostasis Model Assessment of Insulin Resistance; HDL = high-density lipoprotein; NS = not significant.

General Complications Profile and Quality of Life

The SLEEVEPASS study showed no significant difference in hospitalization rates between the two groups after 10 years (32% for SG vs. 35% for RYGB) (Salminen et al., 2023). Regarding gastrointestinal complications, heartburn occurred significantly more often after SG (46% vs.

28%), whereas dumping syndrome was almost exclusively observed after RYGB (19% vs. 1%) (Salminen et al., 2023).

In the SM-BOSS study, after 5 years, reoperation rates were 16% for SG and 23% for RYGB (Peterli et al., 2018). Similarly, in SLEEVEPASS (10-year follow-up), the rates were 25% for SG and 30% for RYGB (Salminen et al., 2023).

Remission rates of obstructive sleep apnea (OSA) were comparable between procedures in SM-BOSS (75% for SG vs. 78% for RYGB) (Peterli et al., 2018), while hypertension remission reached 50–55% in both groups, without statistically significant differences in either SM-BOSS or SLEEVEPASS (Peterli et al., 2018; Salminen et al., 2023).

No significant differences were observed between SG and RYGB in terms of quality of life improvement, as measured by standardized questionnaires SF-36 (Short Form Health Survey) and BAROS (Bariatric Analysis and Reporting Outcome System) (Salminen et al., 2023; Peterli et al., 2018).

As summarized in Table 5, complication profiles differ substantially between the two procedures, SG is associated with a higher risk of reflux, while RYGB is characterized by typical dumping syndrome-related symptoms. Despite these differences, both procedures lead to comparable improvements in comorbidity remission and overall quality of life.

Table 5. General Complications and Quality of Life After SG and RYGB in Long-Term Follow-Up

Parameter	**Follow-up period**	**SG**	**RYGB**	**Statistical significance**	**Source**
Hospitalizations	10 years	32%	35%	NS	*Salminen et al.*, 2023
Heartburn / reflux	10 years	46%	28%	$p < 0.01$	*Salminen et al.*, 2023

Dumping syndrome	10 years	1%	19%	$p < 0.001$	*Salminen et al.*, 2023
Reoperations	5 years	16%	23%	NS	*Peterli et al.*, 2018
Reoperations	10 years	25%	30%	NS	*Salminen et al.*, 2023
OSA remission	5 years	75%	78%	NS	*Peterli et al.*, 2018
Hypertension remission	5–10 years	50–55%	50–55%	NS	*Peterli et al.*, 2018; *Salminen et al.*, 2023
Quality of life improvement (SF-36, BAROS)	5–10 years	↑ significant	↑ significant	no difference	*Peterli et al.*, 2018; *Salminen et al.*, 2023

Sources. Peterli et al., 2018; Salminen et al., 2023. Note. SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; NS = not significant.

- SF-36 (Short Form Health Survey) – a 36-item standardized questionnaire for assessing health-related quality of life across eight domains: physical functioning, role limitations due to physical and emotional health, pain, general health, vitality, social functioning, and mental health.
- BAROS (Bariatric Analysis and Reporting Outcome System) – a composite system evaluating bariatric surgery outcomes across five domains: excess weight loss,

comorbidity improvement, complications, reoperations, and patient-reported quality of life.

Selection Criteria Between Sleeve Gastrectomy and Roux-en-Y Gastric Bypass

The choice between Sleeve Gastrectomy (SG) and Roux-en-Y Gastric Bypass (RYGB) represents a complex clinical decision that largely depends on individual patient characteristics, including body mass index (BMI), comorbidities, and demographic factors.

Body Mass Index (BMI) and Weight-Loss Efficacy

In patients with high BMI values, SG is considered an appropriate standalone option for individuals with BMI ≥ 50 kg/m² (Mahawar et al., 2021). However, in the long-term perspective, RYGB is associated with a greater percentage of total and excess weight loss at 1, 3, and 5 years postoperatively (Arterburn et al., 2023), suggesting superior long-term weight maintenance.

Gastroesophageal Reflux Disease (GERD) and Barrett's Esophagus (BE)

Gastrointestinal disorders represent a key differentiating factor in surgical selection. According to expert consensus, SG is strongly discouraged as a standalone option for patients with Barrett's esophagus, regardless of dysplasia status (Mahawar et al., 2021). In patients with symptomatic, treatment-resistant GERD, conversion to RYGB is the recommended corrective approach (Mahawar et al., 2021). Data from the PCORnet study confirm that RYGB is associated with a lower long-term risk of GERD treatment and related complications compared with SG (Arterburn et al., 2023).

Type 2 Diabetes Mellitus and Personalized Procedure Selection

For patients with type 2 diabetes mellitus (T2DM), consensus statements consider SG an acceptable option for individuals with non–insulin-dependent diabetes and BMI > 35 kg/m² (Mahawar et al., 2021). However, the lack of consensus regarding SG in long-standing diabetes suggests that RYGB, due to its stronger metabolic effects, may be a more suitable option in such cases.

Cohort data reinforce this view. In a four-year observational study of 1,837 patients, Guerreiro et al. (2019) demonstrated that RYGB consistently achieved higher remission rates for

metabolic syndrome and its components, including T2DM—than SG. The superiority of RYGB in metabolic control is particularly evident in patients with advanced diabetic complications.

Impact of Age and Sex on Treatment Outcomes

The effectiveness of both procedures is influenced by demographic modifiers, as highlighted by Gonzalez-Heredia et al. (2015) age acts as a key outcome determinant, patients under 40–45 years achieve significantly greater weight loss following either procedure than older adults, although individuals aged ≥ 60 years still derive meaningful benefit. Regarding sex, women tend to achieve more sustained long-term weight reduction, while men experience a faster initial weight loss phase.

Economic Considerations

Economic evaluations of bariatric surgery clearly demonstrate its long-term systemic benefits. In a multi-country decision model involving data from eight European nations (Belgium, Finland, France, Germany, Italy, the Netherlands, Sweden, and the United Kingdom), Borisenko et al. (2017) found that both SG and RYGB generate net savings for national healthcare systems within 5–10 years in adults with BMI ≥ 35 kg/m². Notably, RYGB consistently yielded greater cost savings across all countries. The key economic mechanism, responsible for approximately 54–85% of savings, was the reduced cost of treating T2DM and cardiovascular disease.

A more recent U.S. cost-effectiveness microsimulation analysis by Lauren et al. (2023) supported this advantage, estimating a cost of $71,824 per QALY for RYGB versus $98,852 per QALY for SG. Over five years, RYGB provided both better health outcomes and lower overall costs. This difference was primarily driven by RYGB's superior metabolic efficacy, yielding 15–20% higher diabetes remission rates and approximately $29,000 per patient in reduced diabetes-related treatment costs over a 10-year period (Lauren et al., 2023).

Together, these data form a consistent picture: while RYGB entails higher initial operative and supplementation costs, these are fully offset over time by its superior clinical and economic effectiveness. Consequently, both Borisenko et al. (2017) and Lauren et al. (2023) provide strong arguments for RYGB as the cost-effective procedure of choice in patients with obesity complicated by type 2 diabetes.

Table 6. Clinical and Demographic Criteria Guiding Selection Between SG and RYGB

Clinical / Demographic Criterion	**Preferred Procedure**	**Clinical Justification / Commentary**	**Source**
BMI < 50 kg/m²	SG or RYGB (individualized)	Both procedures effective; choice depends on comorbidities and desired weight loss.	*Mahawar et al.*, 2021
BMI ≥ 50 kg/m² (super-obesity)	RYGB (or staged SG → RYGB)	Greater and more durable weight reduction; superior metabolic control.	*Arterburn et al.*, 2023
Symptomatic GERD	RYGB	Reduces reflux; SG may exacerbate GERD and lead to BE.	*Mahawar et al.*, 2021; *Arterburn et al.*, 2023
Barrett's esophagus (BE)	RYGB	SG contraindicated; risk of disease progression.	*Mahawar et al.*, 2021

Type 2 diabetes (short duration, non–insulin-dependent)	SG or RYGB	Both effective; RYGB has a stronger incretin effect.	*Guerreiro et al.*, 2019
Type 2 diabetes (long-standing with complications)	RYGB	Higher remission and better glycemic control; stronger metabolic effect.	*Schauer et al.*, 2017; *Guerreiro et al.*, 2019
Age < 40–45 years	SG or RYGB	Greater weight loss regardless of procedure.	*Gonzalez-Heredia et al., 2015*
Age ≥ 60 years	SG	Shorter operative time, lower complication risk; adequate metabolic improvement.	*Gonzalez-Heredia et al., 2015*
Male sex	RYGB	Faster early weight loss phase.	*Gonzalez-Heredia*

			et al., 2015
Female sex	SG or RYGB	More durable long-term weight reduction.	*Gonzalez-Heredia et al., 2015*
Patients at risk of nutritional deficiencies	SG	Lower risk of iron and vitamin B12 deficiency.	*Salminen et al.*, 2023
Patients requiring maximal metabolic benefit	RYGB	Stronger incretin response (GLP-1, PYY); higher diabetes remission rates.	*Peterli et al.*, 2018; *Schauer et al.*, 2017

Sources.; Mahawar et al., 2021; Arterburn et al., 2023; Guerreiro et al., 2019; Schauer et al., 2017; Gonzalez-Heredia et al., 2015; Peterli et al., 2018; Salminen et al., 2023.

Abbreviations: SG – Sleeve Gastrectomy; RYGB – Roux-en-Y Gastric Bypass; BE – Barrett's Esophagus; GERD – Gastroesophageal Reflux Disease.

Discussion

This comparative analysis of sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) confirms that both procedures provide substantial and durable benefits in weight reduction and metabolic improvement in patients with obesity. However, the long-term outcomes demonstrate

distinct physiological, clinical, and economic profiles that should guide individualized surgical decision-making.

Consistent with previous randomized controlled trials, including SLEEVEPASS (Salminen et al., 2023) and SM-BOSS (Peterli et al., 2018), RYGB achieved superior total weight loss (TWL%) and excess weight loss (EWL%) at 5- and 10-year follow-up compared with SG. Although both procedures demonstrated gradual weight regain over time, RYGB maintained a statistically significant advantage in percentage of excess weight loss ($\Delta EWL \approx 8\%$) at 10 years. This long-term superiority is likely attributed to the combined restrictive and malabsorptive mechanisms of RYGB and its enhanced incretin response.

Metabolic outcomes mirrored these findings. RYGB produced higher remission rates of type 2 diabetes (T2DM) across all observation periods — 75% vs. 61% at 1 year (Oseberg, Hofsø et al., 2019) and 37% vs. 27% at 10 years (SLEEVEPASS). This enhanced metabolic effect corresponds to the greater stimulation of GLP-1 and PYY secretion following rapid nutrient transit to the distal small intestine. Improvements in lipid metabolism, including greater reductions in triglycerides and sustained increases in HDL levels, further support the metabolic advantage of RYGB over SG.

Nevertheless, these clinical benefits come at the expense of higher nutritional risks. Both short- and long-term analyses identified RYGB as significantly associated with iron and vitamin B12 deficiencies (Hofsø et al., 2019; Salminen et al., 2023), necessitating lifelong supplementation and laboratory monitoring. In contrast, SG carries a markedly lower risk of malabsorption-related complications but presents an increased incidence of gastroesophageal reflux disease (GERD) and Barrett's esophagus, particularly in predisposed patients (Mahawar et al., 2021; Arterburn et al., 2023).

From an economic perspective, cost-effectiveness models by Borisenko et al. (2015) and Lauren et al. (2022) support the long-term financial sustainability of RYGB. Despite higher upfront costs and postoperative supplementation expenses, RYGB demonstrates greater cost savings over 5–10 years, primarily driven by improved T2DM remission and reduced cardiovascular disease burden. These findings suggest that RYGB should be prioritized in patients with severe metabolic comorbidities or long-standing diabetes, while SG remains a viable and safer alternative for patients without advanced metabolic disease.

Patient characteristics further influence surgical outcomes. Data from Guerreiro et al. (2019) and Gonzalez-Heredia et al. (2015), indicate that younger age and female sex are associated

with more durable weight reduction, while men experience faster early weight loss. Therefore, demographic and clinical personalization remains essential in determining the optimal surgical approach.

Overall, the evidence indicates that RYGB provides superior long-term metabolic and economic benefits but requires a higher level of postoperative nutritional management. SG offers a simpler, safer, and metabolically beneficial alternative for selected patients, particularly those without GERD or extensive nutritional risk. Surgical choice should balance expected metabolic gains, nutritional risks, and healthcare cost implications within the context of individualized patient assessment.

Conclusions

Roux-en-Y gastric bypass (RYGB) provides significantly better long-term weight control (TWL% higher by 3.6–4.9%) and a clear metabolic advantage, manifested by higher rates of diabetes remission and improved lipid control (Salminen et al., 2023; Peterli et al., 2018; Hofsø et al., 2019). This advantage, however, comes at the cost of a higher risk of nutritional deficiencies requiring intensive, supervised supplementation (Hofsø et al., 2019; Salminen et al., 2023). Sleeve gastrectomy (SG) remains a safer alternative in terms of metabolic and nutritional complications, though it is associated with a higher risk of gastroesophageal reflux disease (Salminen et al., 2023; Peterli et al., 2018). The selection of procedure should therefore be guided by an individualized assessment balancing metabolic benefits against nutritional risks.

Cost-effectiveness analyses indicate that, despite higher initial costs, RYGB may be more economically advantageous in the long term, primarily due to its greater impact on diabetes remission and the reduction of metabolic complications requiring pharmacological treatment. In publicly funded healthcare systems, RYGB is considered more cost-effective in patients with obesity and type 2 diabetes, whereas SG represents a financially rational alternative for individuals without advanced metabolic disturbances.

From an economic perspective, the analysis by Borisenko et al. (2018) demonstrated that, despite higher upfront costs, RYGB can be more cost-effective over the long term, particularly in populations with type 2 diabetes, by reducing the expenses associated with managing metabolic complications and by improving quality-adjusted life years (QALYs). Similarly, data from Lauren et al. (2020) confirm that the maintenance of metabolic outcomes and patient

satisfaction is comparable between procedures, with RYGB providing greater long-term weight stability and improvements in quality-of-life outcomes.

Findings from Guerreiro et al. (2019) and Gonzalez-Heredia et al. (2015) emphasize the importance of personalized procedural selection. RYGB demonstrates superior outcomes among patients with long-standing diabetes, metabolic syndrome, and high BMI, while SG may be preferred in younger patients with lower BMI and without gastroesophageal reflux disease. Furthermore, treatment outcomes are modulated by demographic factors: younger patients and women tend to achieve more durable weight loss, whereas men experience a faster, early-phase reduction in body weight (Guerreiro et al., 2019; Gonzalez-Heredia et al. 2015).

Ultimately, the choice of bariatric procedure should be based on an individualized evaluation of the relationship between:

- Metabolic benefits (remission of diabetes and dyslipidemia),
- Risk of nutritional and reflux-related complications, and
- Long-term cost-effectiveness within the clinical context.

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All authors have read and agreed to the published version of the manuscript.

Funding Statement

This study did not receive special funding.

Disclosure

The authors declare no conflict of interest.

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