

DOI:10.2478/jbcr-2020-0003
Review

WEIGHT LOSS TEN YEARS AFTER BARIATRIC SURGERY: A REVIEW OF THE LITERATURE

**Toni I. Stoyanov,
Pedro Cascales-Sanchez,
Kaloyan T. Ivanov¹,
Agustina Martinez-Moreno,
Servando Usero-Rebollo,
Pencho T. Tonchev²,
Emilio Garcia - Blazquez**

*Department of General Surgery,
Unit of Bariatric, Metabolic & Endocrine
Surgery,
University Hospital Center Albacete,
Spain*

¹*Department of General & Plastic
Surgery,*

*Medika University Hospital,
Ruse, Bulgaria*

²*Department of Surgery,
Medical University, Pleven, Bulgaria*

Corresponding Author:

Toni I. Stoyanov,
Department of General Surgery,
Unit of Bariatric, Metabolic & Endocrine
Surgery,
University Hospital Center Albacete, Spain.
e-mail: dr_stoyanov@yahoo.com

Received: May 08, 2020

Revision received: June 09, 2020

Accepted: September 08, 2020

Summary

Introduction: Bariatric surgery has amply demonstrated its benefit in the treatment of morbidly obese patients. After surgery, there is a progressive and significant decrease in weight in a high percentage of patients. Most comorbidities resolve, improving quality of life and increasing life expectancy.

Methods and Objective: The literature review is based on a 10-year or longer follow-up of patients who underwent various bariatric surgery procedures. The long-term weight loss results and the clinical impact were evaluated.

Results: The applied surgical techniques, including Roux-en-Y gastric Bypass (RYBG), Biliopancreatic Diversion, Scopinaro type (BPD), and Duodenal Switch (DS), have contributed to achieving very satisfactory long-term and sustainable weight loss results. According to the reviewed literature, the percentage of excessive BMI Loss (%EBMIL) for the various techniques was 67.9%, 70.7%, and 71.5% for RYGB, BPD, and DS, respectively. Patients undergoing BGYR have lost much more weight than non-surgical patients and can maintain long-term weight loss, reaching a Percentage of Excessive Weight Loss (%EWL) as high as 56.4% in 10 years. Patients who underwent Adjustable Gastric Band (AGB) presented with a %EWL of 45.9% in 10 years, but with very high re-operation rate range (8-78%). There are few studies in the literature on Laparoscopic Sleeve Gastrectomy, reporting weight loss results over ten years. According to the study carried out by Arman G. A., Himpens J., et al. isolated Laparoscopic Sleeve Gastrectomy (LGS) produced a satisfactory weight loss over ten years, reaching EBMIL of 62.5%. Amending LSG with a new surgical design with malabsorptive component (in 25% of patients) increased the weight loss, achieving %EBMIL of 81.7%. The Vertical Band Gastroplasty technique resulted in EWL of $38.1 \pm 28.8\%$, as shown by a mean follow-up of 17.3 years, with a high rate of re-operations and conversions.

Keywords: long term weight loss, bariatric surgery, morbid obesity

Introduction

Morbid obesity is a disorder impossible to cured through diet and medication. Clinical studies and meta-analyzes with high-degree evidence suggest that surgical treatment leads to significant weight loss, which remains stable over time. Besides, this treatment reduces mortality and improves the quality of life

in these patients [1,2,3]. Bariatric surgery is considered to have an acceptable complication rate, and patients who undergo this type of surgery lose approximately 30% -40% of their initial weight and up to 67% of excessive weight. The indices of weight loss vary and depend on the bariatric surgical technique. These indices, however, change over time [2,4,5]. Recent studies have reported weight gain five years after the operation in 50% of the patients and therapeutic failure between 7 and 20% eight years after the operation [6,7].

The most commonly used methods for assessing weight loss after bariatric surgery today are the following indexes: Percentage Excessive Weight Loss (% EWL), Percentage of Excess BMI Loss (% EBML); Percentage of Total Weight Loss in Kilograms (%TWL), Percentage of Expected BMI after bariatric surgery (%EBMI) described by Balthazar.

Knowing the long-term weight results in patients undergoing bariatric surgery is essential because obesity is a chronic and long-lasting disease. Good weight loss results are directly related to the resolution rate or improvement of comorbidities associated with obesity and ensure an improved quality of life for patients [8].

Results

The most commonly used surgical techniques are Laparoscopic Sleeve Gastrectomy (LSG) and Roux-Y Gastric Bypass (RYGB). Adjustable Gastric Band (AGB) is a technique that has had a high rise in the first decade of the twenty-first century. However, because of insufficient results and postoperative complications (high revision and conversion rate), this latter technique is currently in decline. The Scopinaro-type Biliopancreatic Diversion (BPD) with or without Duodenal Switch (DS) is a surgical technique with excellent metabolic and weight-loss results,

though it is less used today [9,10]. It requires close monitoring and adequate nutritional education.

Matthew L. Maciejewski et al. present a retrospective cohort study of 1787 patients who underwent RYGB from January 1, 2000, to September 30, 2011 (573 of 700 eligible, 81.9%), with a follow-up of 10 years after surgery. Weight loss was evaluated in the second cohort of 5305 (1274 of 1889 eligible, 67.4%) severely obese patients who had not undergone bariatric surgery.

The patients undergoing RYGB and the non-surgical cohort were predominantly Caucasian (1503, 84.1%, and 4452, 83.9%, respectively). Of these, 981 (54.9%) and 2927 (55.2%), respectively, had diabetes mellitus (DM). Also, 595 (33.3%) and 1742 (32.8%) were super-obese (BMI \geq 50) at the start of the study. The cohort of patients who underwent RYGB had a median BMI of 47.7 \pm 7.8. The men in this study were 1306 (73.1%), whereas the non-surgical cohort had a median BMI of 47.1, and 3911 (73.7%) were men. Associated comorbidities like high blood pressure, hypercholesterolemia, metabolic syndrome, and depression were common in both cohorts [11].

Patients undergoing RYGB lost an estimated 31.0% (CI 95%) of their initial weight per year. Therefore, patients undergoing RYGB lost 29.9% (CI 95%) more initial weight after one year than non-surgical patients. This difference remained clinically significant in 26.9% (CI 95%) at year 3, 24.0% at year 5, and 22.2% at year 7. At year 10, the RYGB patients had a remarkably higher weight loss - 21.3% (CI 95%), than the non-surgical cohort. Patients undergoing RYGB lost 28.6% of their initial weight at ten years, while non-surgical patients lost 7.3% for the same period. Among patients undergoing RYGB with a weight followed up for ten years (n = 564), the weight loss from

Table 1. Results after ten years of follow-up(Matthew L. Maciejewski et al.)

Variable	% initial weight loss	%EWL	Total weight loss kg	>20% initial weight loss	>30% initial weight loss	<5% initial weight loss
RYGB N = 564	28.6%	56.4%	41.3 kg	71.8%	39,7%	3.4%
Non Surgical Cohorte	7.3%	7.7%	6.3 kg	0%	0%	55.5%

the baseline was 41.3 kg on the average, and the %EWL from the baseline was 56.4%. Weight loss for the non-surgical group with a weight followed up for ten years (n = 1247) was 6.3 kg, and the %EWL was 7.7%. At ten years, 405 of 564 RYGB patients (71.8%) maintained a weight loss of more than 20% of their base weight, and 224 of 564 (39.7%) maintained a weight loss of more than 30%. These results are comparable to 41% of the patients in the Adams study. These patients maintained a weight loss of more than 30% for six years [12]. Only 19 of 564 RYGB patients (3.4%) had less than 5% of their initial weight at ten years versus 692 of 1247 non-surgical patients (55.5%). The weight loss results are presented in Table 1.

The authors also compared weight loss at four years after surgery between patients who underwent RYGB, AGB, and laparoscopic sleeve gastrectomy (LSG). Patients undergoing RYGB lost 27.5% (CI 95%) of their initial weight, whereas patients undergoing AGB lost 10.6% (CI 95%), and patients undergoing LSG lost 17.8% (CI 95%). Patients undergoing RYGB lost 16.9% (CI 95% IC) more than their initial weight than patients undergoing AGB and 9.7% (CI 95%), more than patients undergoing LGS [11].

In another clinical research on patients who underwent RYGB with a high follow-up rate (96%), Adams and colleagues reported that 76% of them achieved a weight loss of 20 % or more at six years [12]. They reported that only 19 of the 564 RYGB patients (3.4%) had regained up to 5% of their original initial weight at ten years, thus providing evidence that the low rate of unsatisfactory weight loss after RYGB is quite uncommon. These findings prove that patients undergoing RYGB have well-maintained long-term weight loss. The authors conclude that patients with RYGB lose significantly more

weight than the non-surgical cohort, and can maintain weight loss in time. Furthermore, they proved that RYGB resulted in remarkably more significant weight loss in the fourth postoperative year, as compared to LSG or Adjustable Gastric Band techniques.

Another retrospective study with more than ten years of follow-up was carried out by Mantziari S., Daye A. et al. on patients undergoing RYGB. Their series consisted of 820 patients, who underwent primary RYGB between 1999 and 2007 with a 10-year follow-up (80.6%). According to their age at the start of the study, they were divided into three groups: A (<40 years old), B (40-54 years old), and C (≥55 years old).

In the tenth year after surgery, the mean BMI of the patients was 32.7 kg/m², 32.6 kg/m², and 32.1 kg/m² for groups A, B, and C, respectively. The vast majority of patients achieved their lowest median BMI in the second postoperative year: 29.0 kg/m², 30.2 kg/m², and 30.7 kg/m² for groups A, B, and C, respectively. Following the second postoperative year, the % TWL was 36.8% for group A, 33.6% for group B, and 33.1% for group C (p <0.001), whereas %EBMIL at the same time was 83.3% (group A), 77.1% (group B) and 71.1% (group C). The results were better in the first seven years in younger patients, but no difference was maintained after the 8th postoperative year. Ten years after the operation, the %TWL was 28.7% in group A, 28.1% in group B, and 29.6% in group C, whereas %EBMIL were 65.8%, 64.6%, and 67.9% respectively in groups A, B, and C. The %TWL did not correlate with the patients' age, BMI, or blood glucose levels before surgery. The %TWL was significantly higher in women than in men (29 vs. 26.7%, p = 0.02), but no difference was found between patients with or without diabetes mellitus at the start of the study.

Table 2. RYGB, 10 years follow up. (Mantziari S. et al)

Groups	Gr. A N 396	Gr. A N 396	Gr. A N 396	Gr. B N 337	Gr. B N 337	Gr. B N 337	Gr. C N 87	Gr. C N 87	Gr. C N 87
Variable	BMI/ weight	%TWL	%EBMIL	BMI/weight	%TWL	%EBMIL	BMI/weight	%TWL	%EBMIL
Initial	45.8±5.9/ 128 ± 21	NA	NA	45.6±6.2 / 125.8±22	NA	NA	45.9±5.6 / 121.6±19.7	NA	NA
2 year	29.0 / -	36.8%	83.3%	30.2 / -	33.6%	77.1%	30.7 / -	33.1%	71.1 %
10 year	32.7 / -	28.7%	65.8%	32.6 / -	28.1%	64.6%	32.1 / -	29.6%	67.9%

Over ten years, resolution or improvement of associated comorbidities was seen: arterial hypertension (AH) in 91.7%, 84.1%, and 80% of patients in groups A, B, and C, respectively. Deterioration or relapse of AH was seen in 6.7%, 3.4%, and 8% in groups A, B, and C. Nevertheless, the figures were more encouraging for DM, representing resolution or partial remission in 95.7%, 93.7%, and 91.7% for patients in groups A, B, and C ten years after surgery. Deterioration or relapse of DM was found in 2.5%, 2.15%, and 4.5% for groups A, B, and C, respectively. No correlation was found between postoperative DM results and preoperative weight, age, or gender. In this study, no difference was detected in general morbidity (9.3 vs. 8.3%, $p=0.37$), or mortality (0.3 vs. 0%, $p=1$) for the patients approximately 55 years old.

All patients faced a similar and significant amelioration in quality of life (QoL), as compared to the time of surgery. The Moorehead-ArdeIdt 10-year score was 1.67, 1.66, and 1.64, for groups A, B, and C ($p = 0.99$). No correlation was found between preoperative weight, age, gender, or the existence of DM at the time of surgery and improvement in QoL.

The authors concluded that the long term results after RYGB were similar for patients \geq 55 years old, in contrast to younger ones. The comparative benefit could be surprisingly more significant for older patients, considering their higher comorbidity at the start of the study [13].

Gustavo A. Arman, Jacques Himpens, et al. carried out one of the few studies on weight loss after Laparoscopic Sleeve Gastrectomy. The authors presented 118 patients who underwent LSG and were operated between November 2001 and June 2003. In 2015, the follow-up was completed for 63 pts, with a follow-up rate of 59.1%. The mean follow-up was 11.7 years (range 11.1-12.8). Twenty of the 63 patients (31.7%) underwent 21 re-interventions.

Seventeen re-operations were done mainly because of unsatisfactory postoperative weight loss and included new sleeve gastrectomy in 3 patients, and 14 were converted to another bariatric surgical technique: Duodenal Switch (DS), $n = 10$; RYGB, $n = 4$. Four re-interventions were done mainly for gastroesophageal reflux (GERD), and included: hiatoplasty post LSG, $n = 1$, hiatoplasty post DS, $n = 1$, and conversion in RYGB, $n = 2$.

The authors distinguished two groups of patients: group A, formed by the 47 persons (74.6%) who had not been converted to another bariatric technique (this group adds included the three patients who needed a new sleeve procedure), therefore keeping the sleeve design; and group B, consisting of the 16 patients (25.4%) converted to a different anatomical design (RYGB, $n = 6$; DS, $n = 10$).

In group A (anatomy of the sleeve, $n = 47$), the mean% EBMIL was 82.4%, 75.9% and 62.5% and the average% TWL was 28.2%, 25.8% and 21%, respectively at 3, 6 and 11 years or afterwards. For the three patients who underwent a new resection, the %EBMIL was 14.7%, and the %TWL was 4.4% for a period longer than 11 years.

In group B (converted to new anatomical design, $n = 16$), the mean time between LGS and re-operation was two years, seven months. The median %EBMIL was 73.6%, 70.7%, and 81.7%, the median %TWL was 27.5%, 25.7%, and 30.9% at 3, 6, and over 11 years, accordingly. The difference in weight loss results between Duodenal Switch and Roux en Y Gastric Bypass patients in group B was insignificant.

Across both groups (A + B), the median %EBMIL was 80.2%, 74.6%, and 67.4%, at 3, 6, and 11 years or more. As far as chronology of weight loss is concerned, no statistically appreciable variation was found between the two groups at 3 and 6 years of follow-up. However,

Table 3. Laparoscopic Sleeve Gastrectomy, 11.7 years follow-up

Groups	Gr. A; n=47	Gr. A n = 47	Gr. A n=47	Gr. B n= 16	Gr. B n = 16	Gr. B n= 16	Gr.A+B n = 63	Gr. A+B n = 63	Gr.A+B N= 63
Variables	BMI	%EBMIL	%TWL	BMI	%EBMIL	%TWL	BMI	%EBMIL	%TWL
Before surgery	38.6	NA	NA	41.5	NA	NA	38.8	NA	NA
3 rd yr	28.1	82.4%	28.2%	30.0	73.6%	27.5%	28.6	80.2%	28.0%
6 th yr	29.1	75.9%	25.8%	30.9	70.7%	25.7%	28.3	74.6%	25.8%
11 th +yrs	29.7	62.5%	21.0%	28.4	81.7%	30.9%	28.7	67.4%	23.6%

%EBMIL ($p = 0.015$) and %TWL ($p = 0.006$) became statistically significant between the two groups after more than 11 years. The results of weight loss in the three groups are presented in Table 3.

In group A, 17 patients (36.2%) did not achieve 50% %EBMIL versus one in group B (6.3%) ($p = 0.023$) at 11 years or later. In general, 18 of the 63 patients (28.6%) did not meet the 50% of %EBMIL goal. On the other hand, only 13 patients gained 50% EBMIL after conversion from the primary surgery to DS or RYGB. Thus, the weight loss “failure” rate was 31 of 63 patients (49.2%).

At 11 years or more after surgery, 30 patients needed medicine for comorbidities while did not 28 at the time of surgery. None of the seven patients presenting symptomatic GERD before the operation were relieved of the symptoms after the sleeve procedure. Other patients experienced de novo GERD. The total patient satisfaction rate was eight on a scale of 0-10.

The authors concluded that isolated LSG gives a long-term %EBMIL of 62.5%. Conversion to a different bariatric technique, necessary in 25% of the patients, ensures %EBMIL of 81.7%. The patients’ satisfaction scores remained good, despite the disadvantageous results for GERD [14].

Paul E. O’Brien, Annemarie Hindle et al. performed a systematic review with meta-analysis on all references containing ten or more years of follow-up data on weight loss after bariatric surgery.

The review covered the period from November 2011 to December 2017, with 18,304 references. Finally, 10,853 references in the title and abstract were selected, and 323 were reviewed in full text.

There were 18 gastric bypass references, 16 of which were for RYGB and two -for One Anastomosis Gastric Bypass (OAGB). All the types of Gastric Bypass presented a median %EWL of 56.7% at ≥ 10 years, with a median %EWL of 55.4% for RYGB, and 80.9% of %EWL for OAGB. The median %EWL for the 17 references of Adjustable Gastric Band (AGB) was 45.9%. In a single-center study, 8378 patients with AGB had a postoperative assessment of up to 20 years, with an average follow-up of 54%. Weight loss at 20 years ($N = 35$) was 30.1 kg, 48.9% of %EWL, and 22.2% of %TWL [3]. The re-intervention rate was high initially but was pointedly reduced with changing the band, better surgical experience, and postoperative care. Eleven references of Biliopancreatic Derivation \pm Duodenal Switch (BPD \pm DS) showed a 74.1% of %EWL. BPD studies (4 references) showed a median %EWL of 71.5%, while for a duodenal switch (7 references), it reached 75.2%. Two references for LSG, including 79 patients, presented an average %EWL of 57.0%. Weight loss is shown in Table 4.

A meta-analysis of published long-term results shows that major bariatric techniques provide essential and lasting weight loss. Excellent results were achieved with BPD or DS with figures of 71.0% EWL, better than with RYGB (60% EWL), and AGB (with 49% EWL [3]).

The study carried out by Stoyanov T., Cascales-Sanchez P. et al. presented 141 patients with morbid obesity, treated using the Duodenal Switch surgical technique. The patients underwent surgery from January 2003 to June 2012 at the Albacete University Hospital Center. The patients studied were divided into groups according to four variables: age, sex,

Table 4. Long term results, more than 10 years of follow up in different bariatric procedures

Bariatric Surgical Procedure	Number of references	Mean %EWL	%EWL Range	Range of reoperations
RYGB	16	55.4%	27 – 69%	8 - 64%
OAGB	2	80.9%	70 – 84%	2 – 14%
BGAL	17	45.9%	27 – 66%	8 – 78%
BPD	4	71.5%	64 – 73%	NA
DS	7	75.2%	61–94%	3–37%
LGS	2	57.0%	53–62%	32–36%
Gastroplasty	7	50.9%	10 – 62%	10 – 40%

initial BMI, and length of the typical loop. The main characteristics of the studied group are demonstrated in Table 5.

The weight loss results are shown in Table 6.

The most considerable weight loss was seen in the second year: EWL was 78.9%, and EBMI was 85.6%. These indices decreased with time, but always remained over 50%, and on the 9th year reached 64.4% and 70.7%, respectively. The patients' weight and mean BMI were also lowest in the second year: 77.5 kg/m² and 28.8 kg/m², respectively. Then, they increased slightly, reaching 89.4 kg/m² and 29 kg/m² in the ninth year. The expected BMI stayed more than 100% until the 4th year, with the highest result also in the 2nd postoperative year, i.e., 110.1%. In the ninth postoperative year, the expected BMI was still 90.4%. No significant differences in weight loss were found neither between the groups of patients with different standard loop lengths nor concerning their age and sex.

DM, HA, syndrome of obstructive sleep

apnea (SOSA), hypercholesterolemia, and hypertriglyceridemia was found in respectively 19.1%, 66.7%, 78%, 35.5%, and 38% of the patients preoperatively. Resolution or remission of the disorders on the 6th postoperative years was as follows: DM - 81.2%, AH - 71.9%, SOSA - 96.9%, hypercholesterolemia - 100%, hypertriglyceridemia - 93.6% [15]. One of the main criticisms of BPD-DS is the long-term risk of nutritional deficiencies [9,16]. Protein caloric malnutrition (PCM) was observed in 7 patients (4.96%). Four were from the 75 cm common channel (CC) group and three patients from the 100 cm CC group. Six patients (4.26%) required surgical enlargement of the CC. In five of them, an extension of the CC at the expense of the biliopancreatic loop was performed. In one patient, a 100cm CC revision of CC was done initially, but later a reversal of the gastrointestinal tract was carried out. However, no PCM was seen in patients with 50 cm CC, which is in disagreement with the literature

Table 5. Main characteristics of the studied group

Variables	N	mean	range
Sex:			
Male	40 (28.4%)		
Female	101 (71.6)		
Age groups:	141	41.8	21-60
<25y	6		
26-45y	82		
45-65y	53		
Weight		139.13	100-193kg
Height		163.2	141-192cm
BMI			
40-60 kg/m ²	98 (69.5%)	51.91kg/m ²	41.6 - 75.1kg/m ²
>60 kg/m ²	43 (30.5%)		
Length of the common channel:		BMI	BMI
50cm common channel	34 (24.1%)	53 kg/m ²	41.6 - 75.1 kg/m ²
75cm common channel	51 (36.2%)	53.9 kg/m ²	43.6 - 70.5 kg/m ²
100cm common channel	56 (39.7%)	50 kg/m ²	42.1 - 62.2 kg/m ²

Table 6. Weight loss results after DS

Time -years	Initial	1 yr	2 yrs	4 yrs	6 yrs	7 yrs	9 yrs
Bodyweight	139.1	82.6	77.6	81.9	85.3	86.2	89.4
%EWL	NA	72.8%	78.9%	72%	67.6%	66.8%	64.4%
BMI	51.9	30.7		30.7	32.1	32.5	29.0
% EBMI	NA	79.1%	85.6%	78.1%	73%	71.9%	70.7%
%Expected BMI	NA	101.7%	110.1%	100.6%	94.5%	93.5%	90.4%

results. The authors concluded that Duodenal Switch is a bariatric surgery technique that provides significant weight loss that is sustained over time.

Topart P., Becouarn G. reported 80 consecutive patients, aged 42 ± 10.9 years, who underwent Biliopancreatic Diversion with Duodenal Switch between February 2002 and June 2006. The 64 operated patients had a mean follow-up of 141 ± 16 months for at least ten years after surgery. The patients had a BMI of 48.9 ± 7.3 kg/m² at the time of surgery and afterward reduced their BMI to 31.2 ± 6.2 kg/m². The figure of % Excessive Weight Loss and % Total weight Loss were $73.4 \pm 26.7\%$ and $35.9\% \pm 17.7\%$, respectively. Despite the recovery of more than 10% of the lowest weight in 61% of the individuals, 78% of the patients maintained a BMI less than 35 kg/m² in ten years [17].

Froylic D. et al. carried out a study on patients undergoing Vertical Gastrectomy with a Silastic Ring (SRVG) based on a 13-year follow-up. The authors presented 92 patients undergoing SRVG, and 89 met the inclusion criteria between 1996 and 2001. The patients' median age was 52.4 ± 10.6 years, and their BMI was 46.1 ± 6.5 kg/m². The mean duration of follow-up was 208.5 ± 16.8 months. One year after surgery, weight loss was satisfactory, reaching up to 70% of % EWL, while in the fifth and tenth years, this index decreased remarkably. The %EWL was $50.8 \pm 21.9\%$ in the first year and progressively decreased to $38.1 \pm 28.8\%$, while the median BMI was 46.1 ± 6.5 kg/m² and decreased to 34.2 ± 9.8 kg/m² with a mean follow-up of 17.3 years. Only one surgical intervention was reported in 42.6% of patients, and a revision was carried out in 26.9%, mainly to those undergoing RYGB (39%). Band removal was performed on 38 patients (42.6%) for unsatisfactory weight loss results (42.1%), poor tolerance (28.9%), band slippage (15.7%), erosion of the gastric wall (10.5%), and excessive esophageal dilatation (2.6%). The band was removed 5.3 ± 3.6 years after surgery. In the group of patients who needed their band removed, 23 (60.5%) were involved in conversion to a different surgical technique. Mainly They were converted to RYGB (n = 9, 39.1%), to DS (n = 4, 17.3%), to LSG (n=1, 4.3%), OAGB (n=1, 4.3%), to AGB (n = 1, 4.3%), and to BPD (n = 1, 4.3%).

No resolution or remission of comorbidities

was found. The rate of arthropathy and gastroesophageal reflux disease aggravated with time. The authors concluded that SRVG was associated with high re-operation and conversion rates and that the majority of patients showed poor resolution of comorbidities, even worsening of some of these. The authors concluded that SRVG is not an adequate bariatric procedure [18].

Summary of evidence found

Obesity has shown to be a risk factor for health. It plays a role in the development of various diseases and pathological conditions. It reduces average life expectancy and deteriorates the quality of life in the affected population, substantially limits physical activity and mobility of people, all giving rise to problems in social, professional, and sexual relationships.

The higher the obesity rate, the longer it is maintained. Furthermore, the older the patient is, the more elevated is the risk of developing associated diseases, such as type 2 diabetes, high blood pressure, obstructive sleep apnea, metabolic syndrome, and other comorbidities related to obesity. Four out of five obese patients suffer from at least one associated pathology. There is a direct link between BMI and the risk of morbidity and mortality in overweight people [19].

It is estimated that there is a reduction in life expectancy between 5 and 7 years in patients with a BMI between 30 and 40 kg/m². This reduction is ten years when the BMI is higher than 40 kg/m². Finally, mortality is 12 times higher in men aged 25 to 34 years with morbid obesity compared to healthy men of the same age [20]. The risk of premature death increases in obese patients and is directly related to weight gain [21]. That is why bariatric surgery is critical to maintaining a stable weight loss in time. In this way, quality of life is improved, recurrence of obesity-associated comorbidities is avoided, and the mortality rate is decreased.

The literature review of 10-years-follow-up weight loss, related to the different bariatric techniques applied, found that:

- The surgical technique with the best %EWL loss and more than ten years of follow-up according to O'Brian's meta-analysis is OAGB with %EWL of 80.9%, followed by

DS - 75.2%, BPD - 71.5%, Laparoscopic Sleeve Gastrectomy - 57%, RYGB - 55.4%, Gastroplasty- 50.9%, and Adjustable Gastric Band - 45.9%. AGB was found to have the highest re-operation rate (range 8-78%), followed by RYGB (8-64%) and LSG (32-36%) [3]

- RYBG, BPD, and DS techniques have very satisfactory long-term and sustainable weight loss. According to the reviewed literature, the %EBMIL for these techniques was 67.9% for RYGB, 70.7% for DS, and 71.5% for DBP [15,5]. Patients undergoing RYBG lose much more weight than non-surgical patients and can maintain weight loss in the long run, reaching %EWL 56.4% in 10 years. Loss of their initial weight of more than 20% and more than 30% is achieved in 71.8% and 39.7% of the patients, respectively [11]. The long-term weight loss results after RYGB are similar in patients \geq 55 years old if compared to younger ones. The comparative benefit could be more significant for older patients, considering their common comorbidities at the start of the study [13].
- Patients undergoing DS present with well-maintained long-term postoperative weight loss with a mean %EWL of 73.4%, and mean %TWL of 35.9% in >10 years, and %EBMIL 70.7% in 9 years. At ten years, weight loss recovery rate of more than 10% was observed in 61% of the operated patients. Most patients (78%) maintained a BMI of less than 35 kg/m² [15,17].
- There are few studies on Laparoscopic Sleeve Gastrectomy with weight loss results over ten years. According to the study by Arman G. A., Himpens J., et al., the isolated LGS provides a long-term %EBMIL of 62.5%. Conversion to another surgical technique was made in 25% of cases and provided a %EBMIL of 81.7% [14].
- The Vertical Band Gastroplasty technique leads to %EWL $38.1 \pm 28.8\%$ in a mean follow-up of 17.3 years, with a high rate of re-operations [17]. No improvement was found in any of the comorbidities.

Conclusions

1. Well-maintained over time, weight loss is

an essential factor for resolving associated comorbidities and ensures a better quality of life for patients.

2. Patients undergoing RYGB have well-maintained long-term weight loss with a significant difference from those not undergoing bariatric surgery.

3. In the tenth year, the rate of unsatisfactory weight loss in patients undergoing RYGB is very low.

4. RYGB induces significantly higher weight loss than LGS or AGB in 4 years. Also, the weight loss results after ten years in RYGB patients remain satisfactory compared to AGB, but comparable to those achieved through LSG.

5. Isolated LSG provides a well-maintained and satisfactory long-term weight loss, but has a high rate of conversion to another bariatric surgical technique (RYBG or DS), required in 25% of cases according to the literature reviewed. Patients converted to another surgical technique have better long-term weight loss when compared to those without a conversion.

6. BPD and DS provide well-maintained long-term weight loss but need close monitoring, nutritional education, and life-long supplemental treatment.

7. One Anastomosis Gastric Bypass (OAGB) is a relatively new bariatric technique, providing well-maintained long-term weight loss, as comparable to BPD with or without DS, and is superior to RYGB. More clinical data is needed for its correct evaluation.

Acknowledgements

The authors declare no financial support or other sponsorship.

References

1. Buchwald H, Avidor Y, Braunwald E, Jensen MD, Pories W, Fahrbach K, et al. Bariatric surgery: A systematic review and meta-analysis. Vol. 292, *Journal of the American Medical Association*. 2004. p. 1724–37.
2. Puzifferri N, Roshek TB, Mayo HG, Gallagher R, Belle SH, Livingston EH. Long-term follow-up after bariatric surgery: A systematic review. Vol. 312, *JAMA - Journal of the American Medical Association*. American Medical Association; 2014. p. 934–42.

3. O'Brien PE, Hindle A, Brennan L, Skinner S, Burton P, Smith A, et al. Long-Term Outcomes After Bariatric Surgery: a Systematic Review and Meta-analysis of Weight Loss at 10 or More Years for All Bariatric Procedures and a Single-Centre Review of 20-Year Outcomes After Adjustable Gastric Banding. *Obes Surg.* 2019;29(1):3–14.
4. Wood GC, Benotti PN, Lee CJ, Mirshahi T, Still CD, Gerhard GS, et al. Evaluation of the association between preoperative clinical factors and long-term weight loss after Roux-en-Y gastric bypass. *JAMA Surg.* 2016;151(11):1056–62.
5. Coleman KJ, Huang YC, Hendee F, Watson HL, Casillas RA, Brookey J. Three-year weight outcomes from a bariatric surgery registry in a large integrated healthcare system. *Surg Obes Relat Dis* [Internet]. 2014 [cited 2020 May 5];10(3):396–403. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/24951065>
6. Neto RML, Herbella FAM, Tauil RM, Silva FS, De Lima SE. Comorbidities remission after roux-en-y gastric bypass for morbid obesity is sustained in a long-term follow-up and correlates with weight regain. *Obes Surg.* 2012 Oct;22(10):1580–5.
7. Valezi AC, Junior JM, De Menezes MA, De Brito EME, De Souza SAF. Weight loss outcome after silastic ring Roux-en-Y gastric bypass: 8 years of follow-up. *Obes Surg.* 2010 Nov;20(11):1491–5.
8. Sjöström L, Lindroos AK, Peltonen M, Torgerson J, Bouchard C, Carlsson B, et al. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *N Engl J Med.* 2004 Dec 23;351(26):2683–93.
9. Marceau P, Biron S, Hould FS, Lebel S, Marceau S, Lescelleur O, et al. Duodenal switch: Long-term results. *Obes Surg.* 2007 Nov;17(11):1421–30.
10. Scopinaro N. Thirty-five years of biliopancreatic diversion: Notes on gastrointestinal physiology to complete the published information useful for a better understanding and clinical use of the operation. Vol. 22, *Obesity Surgery*. 2012. p. 427–32.
11. Maciejewski ML, Arterburn DE, Van Scoyoc L, Smith VA, Yancy WS, Weidenbacher HJ, et al. Bariatric Surgery and Long-term Durability of Weight Loss. *JAMA Surg* [Internet]. 2016 Nov 1 [cited 2020 Apr 15];151(11):1046. Available from: <http://archsurg.jamanetwork.com/article.aspx?doi=10.1001/jamasurg.2016.2317>
12. Adams TD, Davidson LE, Litwin SE, Kolotkin RL, LaMonte MJ, Pendleton RC, et al. Health benefits of gastric bypass surgery after 6 years. *JAMA - J Am Med Assoc.* 2012 Sep 12;308(11):1122–31.
13. Mantziari S, Dayer A, Duvoisin C, Demartines N, Allemann P, Calmes JM, et al. Long-Term Weight Loss, Metabolic Outcomes, and Quality of Life at 10 Years After Roux-en-Y Gastric Bypass Are Independent of Patients' Age at Baseline. *Obes Surg.* 2020;30(4):1181–8.
14. Arman GA, Himpens J, Dhaenens J, Ballet T, Vilallonga R, Leman G. Long-term (11+years) outcomes in weight, patient satisfaction, comorbidities, and gastroesophageal reflux treatment after laparoscopic sleeve gastrectomy. *Surg Obes Relat Dis.* 2016 Dec 1;12(10):1778–86.
15. Ivanov Stoyanov T., Cascales Sanchez P., Prat Calero A., Martinez Moreno A., Garcia Blazquez E., Usero Rebollo S., Tonchev P., Ivanov K., Stoikov D. CSP. Resultados de pérdida de peso a largo plazo , en pacientes obesos mórbidos sometidos a derivación biliopancreática con cruce duode. *BMI Bariatrica Metab Ibero Lat.* 2016;2(3):1219–27.
16. Biertho L, Biron S, Hould FS, Lebel S, Marceau S, Marceau P. Is biliopancreatic diversion with duodenal switch indicated for patients with body mass index <50 kg/m²? *Surg Obes Relat Dis.* 2010 Sep;6(5):508–14.
17. Topart P, Becouarn G, Delarue J. Weight Loss and Nutritional Outcomes 10 Years after Biliopancreatic Diversion with Duodenal Switch. *Obes Surg.* 2017 Jul 1;27(7):1645–50.
18. Froylich D, Abramovich TS, Fuchs S, Zippel D, Hazzan D. Long-Term (over 13 Years) Follow-Up of Vertical Band Gastroplasty. *Obes Surg.* 2020;1808–13.
19. Noria S, Grantcharov T. Biological effects of bariatric surgery on obesity-related comorbidities. *Can J Surg* [Internet]. 2013 Feb;56(1):47–57. Available from: <https://doi.org/10.1503%2Fcjs.036111>
20. Duce Martín A. *Cirugía de la Obesidad Mórbida*. Ediciones A, editor. Madrid 2007. Ediciones. Madrid; 2007.
21. Chang J, Wittert G. Effects of bariatric surgery on morbidity and mortality in severe obesity. Vol. 7, *International Journal of Evidence-Based Healthcare*. Lippincott Williams and Wilkins; 2009. p. 43–8.