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Third bariatric procedure for insufficient weight loss or weight regain: how far should we go?

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Abstract

Background: Revisional procedures in bariatric surgery are increasing with several debated failure risk factors (super obesity, old age…). No study has yet evaluated the outcomes and risks of a third bariatric procedure indicated for weight loss failure or weight regain.

Objectives: To assess failure risks of a third bariatric procedure according to Reinhold's criteria (% Excess Weight Loss (%EWL) ≤50% and/or Body Mass Index (BMI) ≥ 35 kg/m²).

Settings: A university-affiliated tertiary care center.

Methods: From 2007 to 2019, clinical data and weight loss results of patients who benefited from 3 bariatric procedures for weight loss failure or weight regain were collected prospectively and analyzed using a binary logistic regression. Weight loss failure was defined according to Reinhold's criteria.

Results: Among 1401 bariatric procedures performed, 336 patients benefited from two or more procedures, and 45 had a third surgery. Eleven patients reoperated because of malnutrition or gastroesophageal reflux disease were excluded from the final analysis. Among 34 patients with 3 procedures because of weight loss failure or regain, mean BMI was 48.3 ±8.3 kg/m², and mean age was 30 ± 10.7 years old. Three out of 34 patients (9%) presented a severe complication (Dindo-Clavien IIIb) and two (6%) had a minor one. Achieving Reinhold's weight loss criteria after the 2nd bariatric procedure was a significant predictor of success of the 3rd procedure (β = 2.9 ±1.3 S.E.).

Conclusion: Not reaching Reinhold's criteria after a second bariatric procedure was identified as a significant risk factor of failure of a third procedure. A third surgery should be carefully discussed especially in case of primary failure of previous procedures.

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Keywords: Bariatric surgery, Revisional surgery, Third bariatric procedure, Weight loss failure, obesity

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Introduction

Obesity is a worldwide issue with an increased incidence through the years. In 2016, 13% of the worldwide population was obese[1], with 634,897 bariatric operations performed[2]. Weight loss efficiency of bariatric surgery has been proved to be superior to medical therapy, as well as its beneficial effect on comorbidities as Type 2 Diabetes mellitus (T2D), hypertension or hypercholesterolemia[3]. However, it has been reported that 5 to 35% of these procedures will not be successful, and will need a revisional surgery[4–6]. Redo surgeries are often required in case of complications of the first procedure such as gastro esophageal reflux disease (GERD), dysphagia or malnutrition, etc [4]. Weight loss failure which is often defined according to Reinhold's criteria (Excess Weight Loss (%EWL) ≤50% and/or Body Mass Index (BMI) ≥35 kg/m²), is also a main cause of revisional surgery[4,7].

Several factors of weight loss failure after a bariatric surgery have been identified in the literature. More consensual factors are advanced age and a higher initial BMI (especially if BMI before surgery is over 50 kg/m² [8,9]). Other failure risk factors have been described and are sometimes debated, as nutritional disorders, the type of bariatric surgery[10–12], low socio-economic status, lack of physical activities, somatic or psychiatric comorbidities[9,13].

Several studies also suggest that revisional procedures are less effective regarding weight loss outcomes and are at higher risk of morbidity than primary procedures[14–18].

Literature data regarding revisional surgery is growing but there are only a few studies with small cohorts which assessed weight loss outcomes after a third bariatric procedure[19]. Moreover, risk factors of weight loss failure after a third bariatric procedure are not clearly identified and it remains difficult for bariatric teams to manage obese patients with failure of bariatric surgery and to assess if they are good candidates for a revisional surgery.

The main aim of our study was to determine among patients who underwent three bariatric procedures, risk factors of insufficient weight loss or weight regain. We also aimed to assess the morbidity rate to determine the benefit to risk ratio of repeated bariatric procedures and to help selecting the best candidates.

Materials and Methods

Patient Selection and Preoperative Data

From 2009 to 2019, all patients who had underwent a bariatric surgery in our tertiary care center of Bariatric Surgery were registered in a prospective database (BARIASURG, NCT02857179). Data regarding all the patients who underwent three bariatric procedures were analyzed. Patients reoperated a third time for malnutrition and/or complications of a previous procedure were excluded. Were included in the final analysis only patients with insufficient weight loss (primary failure) after the second bariatric surgery or weight regain (secondary failure). Weight loss failure was defined according to Reinhold's criteria (%EWL ≤50% and/or BMI ≥35 kg/m²).

Most of these patients underwent their first and second bariatric surgery in other institutions and were treated in our center for revisional surgery and for the postoperative follow up. At the first medical visit, all demographic data were collected (age, gender, weight and BMI evolution, comorbidities). We recorded the bariatric history of each patient with the interval time between procedures and the type of previous bariatric procedures: the first one was identified as S1, the second one as S2 and the third one as S3 (Figure 1). Indications to propose a second revisional bariatric procedure were patients with a BMI ≥40 kg/m² and/or 35 kg/m² with comorbidities as recommended by the French health care authorities (Haute

Autorité de Santé). Each patient benefited from a multidisciplinary evaluation prior to revisional surgery. After failure of previous restrictive surgeries, we favored a revision to a malabsorptive procedure. In case of initial BMI ≥ 50kg/m², a conversion to BPD-DS or SADI-S was preferred.

Peroperative data and follow-up

The type of third revisional procedure (S3) and its duration were recorded. Intraoperative and postoperative complications were analyzed, by distinguishing early complications (up to 90 days) from late complications and using Dindo-Clavien's Classification. A postoperative visit was planned at 2 months with the surgeon and patients were followed at 3, 6, 9, 12 months and once a year by the bariatric team to assess weight loss evolution (BMI and %EWL), remission of comorbidities and nutritional deficiencies. The third surgery was considered as a success if Reinhold's criteria were fulfilled at the last medical visit.

Statistical analysis

Continuous data were expressed as means and standard deviations; categorical data were expressed as counts and percentages. Because most of the variables did not show a normal distribution or because of a sample size <5, comparisons between groups were made by the nonparametric Mann-Whitney U test and Fisher's exact test.

We performed a binary logistic regression to explore the predictors After regression assumptions' verifications (including co-linearity) and model optimization (based on Wald test and Akaike Information Criterion), we chose to use Reinhold's criteria at each nadir endpoint after each procedure and maximum BMI as potential predictors of success in the regression model.

All statistical analyses were performed with SPSS version 26 (IBM Corporation, Armonk, NY). Each figure was realized using the Seaborn 0.10.0 python data visualization library. All reported p-values are two-sided; a p-value of < 0.05 was considered statistically significant.

Results

Demographic data of the studied population

From 2007 to 2019, 1401 bariatric procedures were performed. Among these procedures, 336 patients benefited from two or more surgeries, and 45 had three surgeries. Among these patients operated three times, 11 patients were excluded from the final analysis because of a procedure performed for malnutrition or GERD. Among the 34 patients included in the study, all benefited from a restrictive procedure as a first bariatric surgery (S1). A second restrictive surgery was performed for 26 of them (76%) and 8 (24%) benefited from a gastric bypass as a second bariatric procedure (S2). The third bariatric procedure (S3) was either restrictive (n=4) or corresponded to a gastric bypass (n=25) or to a Single Anastomosis Duodeno-Ileal bypass/BilioPancreatic Diversion with Duodenal Switch (SADI/BPD-DS) (n=5) as shown in the flow chart (Figure 1).

Demographic data of the studied population are shown in Table 1. Of the 34 patients included in this study, 27 (79%) were female, and 11 (32%) were super obese. Mean age before the first surgery and the third procedure was 29.8 ± 10.7 and 42.9 ± 11.2 years old, respectively. Mean BMI at baseline was 51.2 ± 8.3 kg/m² and mean BMI before the first surgery was 48.3 ± 8.3 kg/m². Mean interval between the first and third procedures was 13.6 ± 5.6 years (minimum: 5 years, maximum:26 years). Mean follow-up after the third surgery (S3) was 30.59 months ±27.65 (around 2.5 years).

%EWL at nadir for the first, second and third surgery was 64.2 ± 31.6 %, 48.7 ± 53.4 % and 47.9 ± 32.1 % respectively. Regain in %EWL after the first, second and third surgery was 52.9 ±63.7 % 34.5 ± 40.7 % and 11.1 ± 20.5 % respectively (Table 1).

The change in BMI during successive bariatric procedures is represented in Figure 2 for the global population and in Figure 3 function of the type of the 3rd procedure performed (S3). The type of the third bariatric procedure performed (restrictive surgery versus gastric bypass versus SADI/BPD-DS) did not seem to impact weight loss results according to Reinhold's criteria (Figure 3).

Factors impacting weight loss success or failure, according to Reinhold's criteria

At the end of the follow-up, 65% (n=22) of the patients achieved Reinhold's criteria after the third bariatric procedure. The number of patients reaching Reinhold's criteria according to the duration of the follow-up after the third surgery (≥ 24 months or > 24 months) was not significantly different (n=10/16 versus n=12/18 respectively, p=0.8). Even if the success rate was higher in the group of patients who underwent a gastric bypass or a BPD-DS/SADI (72% and 60% respectively) compared to those who had a restrictive procedure (25%), this was not statistically significant (Table 1). As shown by the logistic regression (Table 2), achieving Reinhold's weight loss criteria after the 2nd bariatric procedure (S2) was a significant predictive factor of success of the 3rd procedure (p=0.021). In the univariate analysis, the type of third surgery was not a significant predictor of weight loss; the adjunction of this variable in the different models of logistic regression was not significant as well (results not shown). Figure 4 represents weight loss evolution during successive bariatric procedures in both groups: patients achieving Reinhold's criteria after the 2nd procedure and those who did not.

Resolution of co-morbidities overtime

Comorbidities before the third bariatric procedure were represented by T2D (n=3, 9%), high blood pressure (n=12, 35%), obstructive sleep apnea (n=12, 35%) and dyslipidemia (n=4, 12%) (Table 1). After the third procedure (S3), the rate of comorbidities remained similar: 3 patients still had T2D (9%), 11 had high blood pressure (32%), 9 had Obstructive Sleep Apnea (OSA) (26%) and 3 had dyslipidemia (12%).

Complications of the third bariatric procedure

33 procedures (97%) were performed by laparoscopy and none were converted to open surgery. Mean operative time was 173 ± 103 min. Three out of 34 patients (9%) presented a severe complication (Dindo-Clavien ≥ III): 2 (5%) of them presented a leak of the duodeno ileal anastomosis after BPD-DS, but only one needed to be reoperated and one presented a severe malnutrition after revisional sleeve gastrectomy and required a jejunostomy. Two patients (5%) had a minor complication: 1 pneumonia and 1 wound abscess treated medically with success.

Discussion

There is obviously a lack of data in the literature regarding the efficiency of a third bariatric procedure, even if the interest in revisional surgery is currently increasing [16,18–20]. With the exponential growth of bariatric surgery worldwide, bariatric teams have to face a proportional increase of complications and weight loss failures which can lead to a redo procedure. Revisional surgery is also reported to be at higher risk of complications and weight loss failure[18] and therefore it seems of major importance to assess the benefit to risk ratio before increasing the number of successive procedures; it remains difficult for bariatric teams to select good candidates for redo surgery. Most of studies regarding revisional surgery mix

the data of patients operated for complications with those operated for weight regain and this is thus difficult to draw conclusions on weight loss outcomes after redo surgery [18–20]. Our study is one of the first studying specifically the patients with weight loss failure after 2 bariatric procedures and their outcomes after a third one: this tricky situation is probably going to be more and more frequent in the bariatric population and data are needed to help practitioners to deal with it.

Many factors of failures have been identified in the literature and are still debated. Advanced age, female gender, high BMI before the bariatric procedure have been clearly associated to a higher risk of weight loss failure after bariatric surgery [4,21,22]. The impact of the type of bariatric procedure, postoperative eating disorders, low socioeconomic status and psychiatric or somatic comorbidities is still debated [9,10,12,13]. In this study, by analyzing the bariatric history of a series of patients reoperated 3 times for weight loss failure, we tried to identify the factors that could be responsible for insufficient weight loss or weight regain after revisional surgery.

Morbid obesity is now known as a chronic disease with an increasing incidence all around the world [1]. It requires a lifelong multidisciplinary management with a strong coordination and support from medical specialists and bariatric surgeons because of its high risk of recurrence. In our study, the mean interval time between the first and the third bariatric procedure was around 13 years which illustrates the chronicity of the obesity disease. At baseline, mean BMI was 51.2 ± 8.3 kg/m² which also illustrates the severity of obesity in our population; 32% of our population requiring several bariatric procedures were super obese initially. The patients who underwent a SADI or BPD-DS as a third bariatric procedure (n=5) were still super obese despite previous surgeries, with a mean BMI of 51.2 ± 7.4 kg/m² before S3. The high prevalence of super obesity in our cohort could explain the failure of successive bariatric procedures even if we were not able to demonstrate here that superobesity was a risk factor of weight loss failure. Indeed, many authors had previously reported the negative impact of superobesity on weight loss outcomes [4,22]; the small sample size in our study could be one of the limits. Another interpretation could be that many of these patients have been managed initially in other institutions and had benefited from various bariatric programs, some being less well prepared. Moreover, we actually know that BPD-DS is a safe and efficient procedure for superobese, but most of our patients began their medical program in the 90's, which was a period when this procedure was not commonly performed in France [16,23].

What is also striking is that all our patients benefited from a restrictive surgery as a first bariatric procedure and most of them (n=30/34) had a gastric bypass or malabsorptive surgery as a third procedure. Indeed, restrictive procedures as gastric banding or sleeve gastrectomy seem interesting options as a first step for young patients with a severe obesity, giving way to more aggressive strategies if necessary. Even if gastric bypass and especially SADI and BPD-DS are considered by many bariatric teams to be more effective on weight loss in the long term [11,24], the type of the third procedure did not significantly impact weight loss outcomes in our study. Three factors could explain this finding: firstly, the patients who underwent a SADI or a BPD-DS had a higher initial BMI what makes it more difficult to reach Reinhold's criteria. Secondly, the small sample size of our population could lead to a lack of statistical power. Finally, there is probably a selection bias as we studied here patients who were already in failure of 2 previous bariatric procedures and who were therefore at high risk of failure of a new procedure.

In our study, we observed a decrease of efficiency of successive bariatric procedures over time as illustrated in Figure 2, with a decrease of %EWL obtained after each new procedure. This is in accordance with the findings of others authors in the scarce literature [18]. Radtka et

al found a significantly inferior weight loss after a revisional bariatric procedure than after a primary one.

Even if mean BMI at the end of the follow up was still superior to 35 kg/m² (36.8 ± 8 kg/m²) in the global population, 22 (65%) of our patients fulfilled Reinhold's criteria after the third procedure. This illustrates that patient selection has been carefully assessed by an expert bariatric team, so as to optimize the results. It also seems to confirm that obesity is a chronic and lifelong disease and that maintaining weight loss overtime is a challenge.

One of the main findings of our study was that not achieving Reinhold's criteria after the second bariatric procedure was a predictive factor of failure of the third procedure. As example, if a patient has failed to achieve weight loss after a Laparoscopic Adjusted Gastric Banding (LAGB) as a first procedure, and fail again after a revision to sleeve gastrectomy and never achieves Reinhold's criteria, the risk of failure of a third bariatric procedure is significant. Primary failure of the second bariatric procedure was a predictive factor of failure of a third procedure whatever the type of surgery, and this must be deeply discussed after multidisciplinary evaluation before validating a third step. Indeed, weight loss is one of the aims of bariatric surgery but not the only one: the improvement of metabolic comorbidities is also a strong argument that must be included in the final decision of revisional surgery. It has been previously reported that bariatric surgery has a protective effect on metabolic comorbidities [25] which seems to be illustrated by our study: at the time of the third bariatric procedure, our population did not present as many comorbidities as those candidate to a first procedure as usually described in the literature [20,26,27]. This suggests that patients could have been protected from metabolic disorders because they underwent their first surgery rather young (29.8 ± 10.7 years old).

Regarding the risk of revisional surgery, it is common surgical knowledge that it is technically demanding compare to primary procedures, with longer operative time and a higher morbidity [24]. The higher risk of revisional surgery is probably due to the previous procedures often responsible for severe adhesions especially if the patients were previously operated by laparotomy; the higher rate of superobesity probably contributes to this higher operative risk. In our study, mean operative time was 173 ± 103 min which is long and illustrates the technical difficulty of these surgeries. The complication rate of revisional surgery is also reported to be higher than primary surgery in the literature [20], nevertheless we had a low rate of surgical complications mainly represented by 2 leaks after BPD-DS, and only one requiring a surgical management. 97% of the third revisional procedures were performed by laparoscopy and there was no conversion. The benefit to risk ratio of revisional surgery seems safe when performed by trained and experienced surgeons, in a bariatric center where endoscopists, radiologists, physicians and surgeons collaborate.

Our study has some limits: our population is heterogenous with most of the patients refered to our center after failure of two bariatric procedures, with different kind of surgeries, and no standardized preoperative care program. Finally, even if we report one of the largest populations operated for the third time because of weight loss failure, it is still a quite small cohort.

Conclusion

In this study, not reaching Reinhold's criteria after a second bariatric procedure was identified as a significant risk factor of failure of a third procedure. A third surgery should be carefully discussed after multidisciplinary assessment, especially in case of insufficient weight loss and primary failure of the previous procedures. More studies are needed with a larger population to assess the failure risk of successive bariatric surgeries and to help the decision making of bariatric teams

Disclosures

The authors have no disclosures and no commercial interest in the subject of study.

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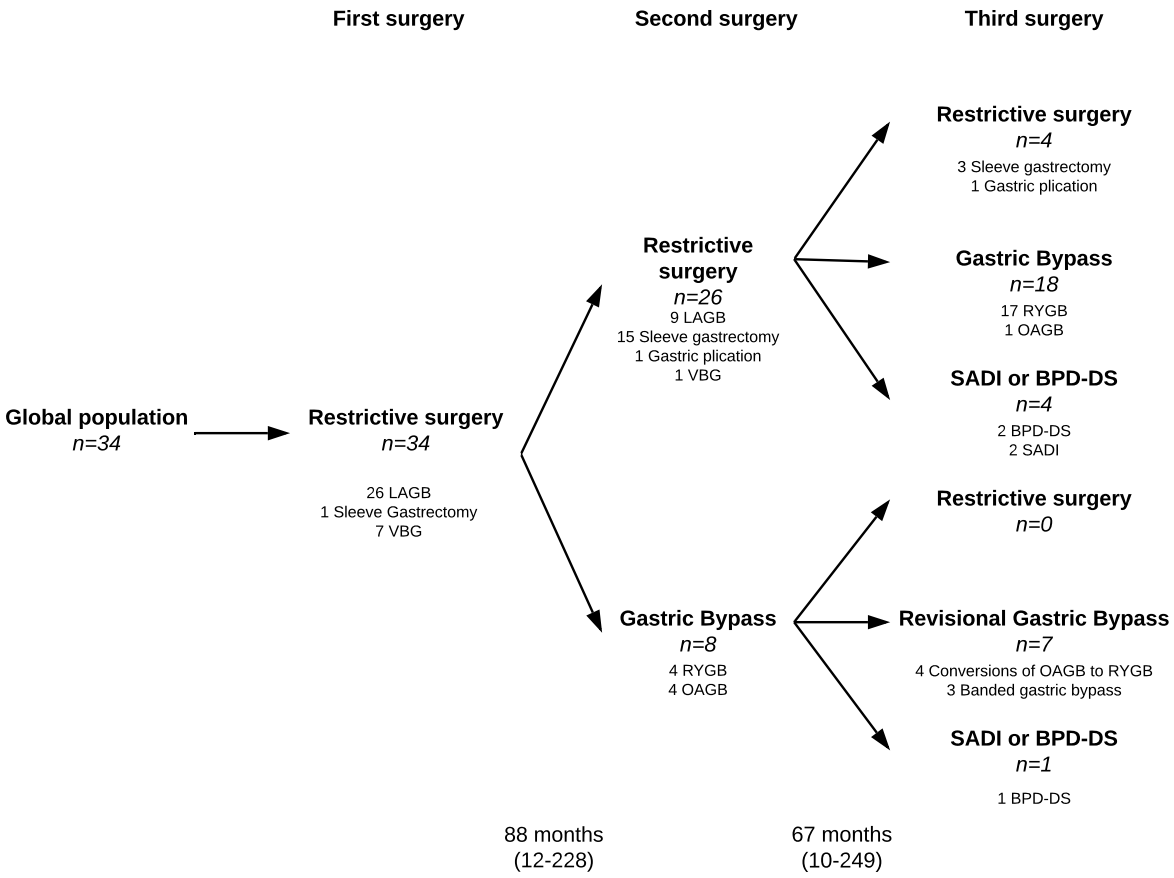
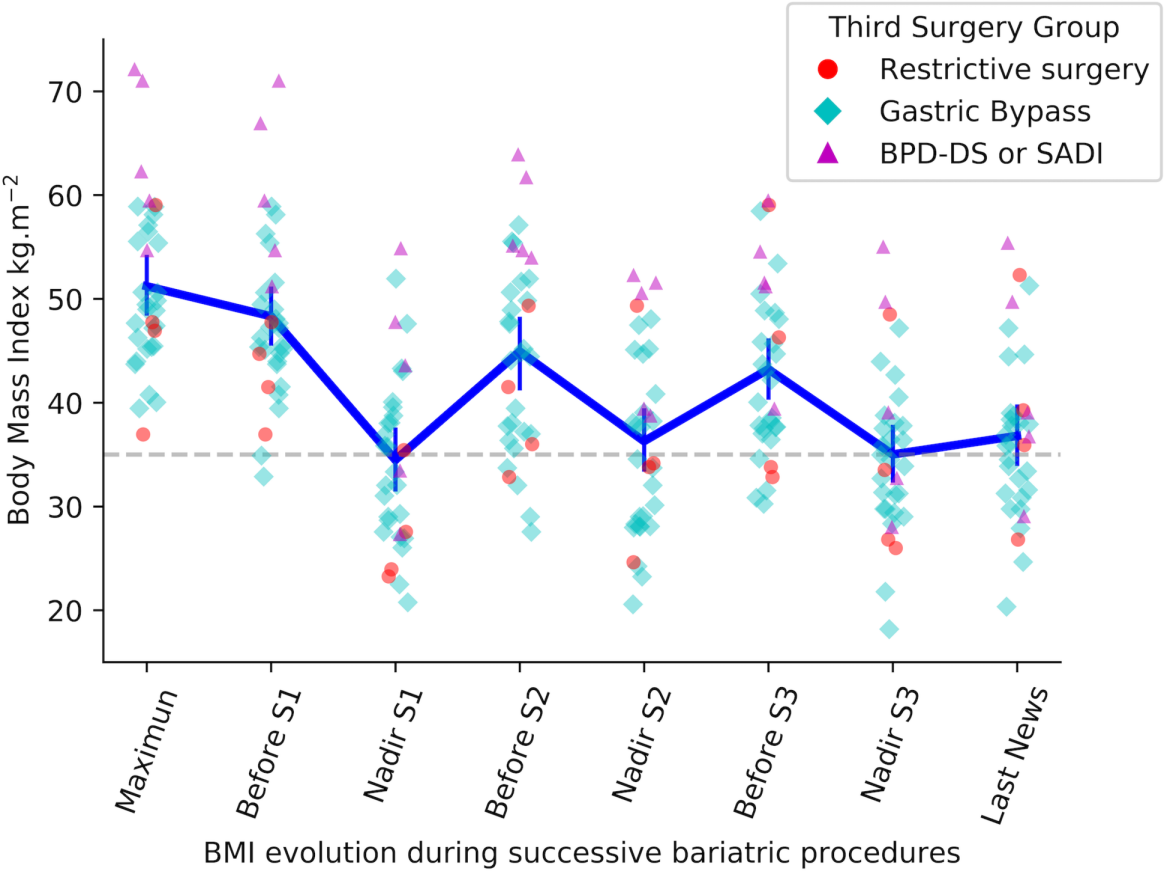
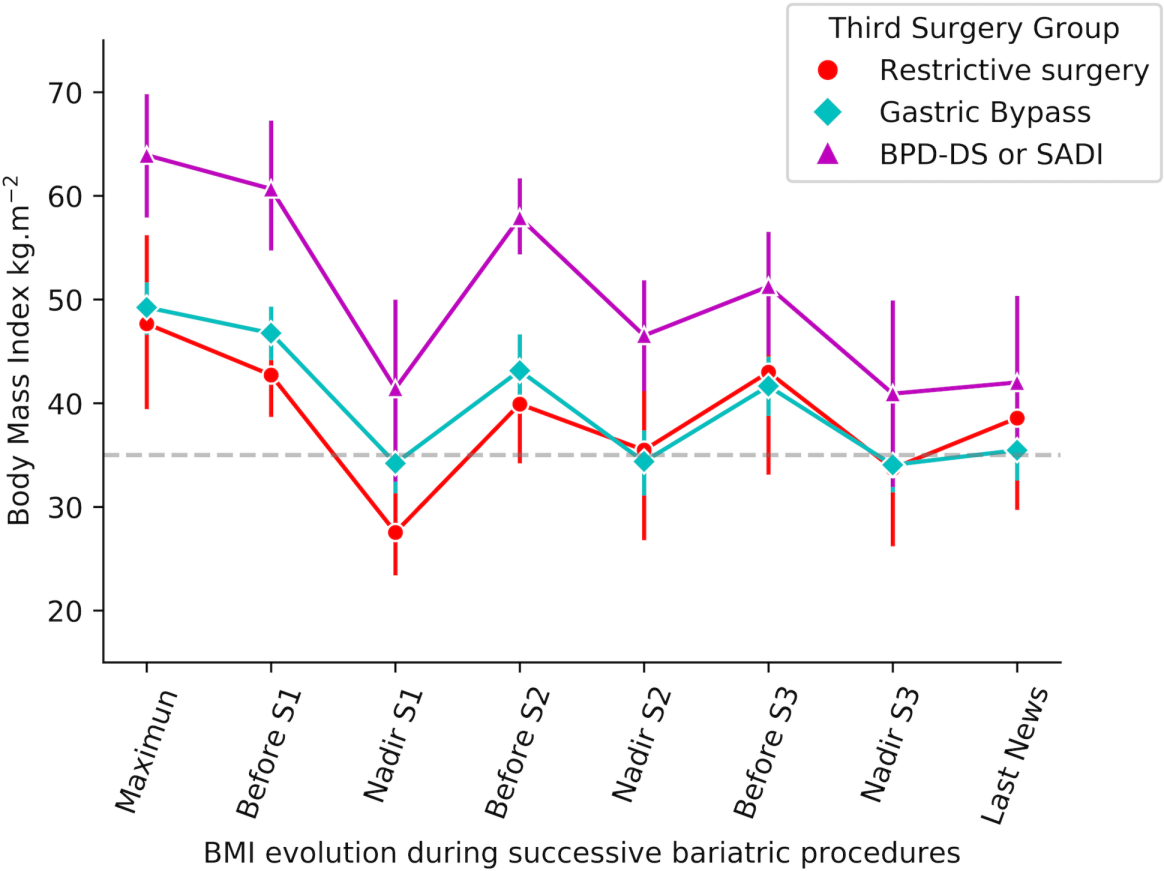

First surgery
Second surgery
Third surgery
Global population
n=34
Restrictive surgery
n=34
26 LAGB
1 Sleeve Gastrectomy
7 VBG
Restrictive surgery
n=26
9 LAGB
15 Sleeve gastrectomy
1 Gastric plication
1 VBG
Gastric Bypass
n=8
4 RYGB
4 OAGB
Restrictive surgery
n=4
3 Sleeve gastrectomy
1 Gastric plication
Gastric Bypass
n=18
17 RYGB
1 OAGB
SADI or BPD-DS
n=4
2 BPD-DS
2 SADI
Restrictive surgery
n=0
Revisional Gastric Bypass
n=7
4 Conversions of OAGB to RYGB
3 Banded gastric bypass
SADI or BPD-DS
n=1
1 BPD-DS
88 months
(12-228)
67 months
(10-249)


Third Surgery Group
Restrictive surgery
Gastric Bypass
BPD-DS or SADI
Body Mass Index kg.m^{-2}
70
60
50
40
30
20
Maximun
Before S1
Nadir S1
Before S2
Nadir S2
Before S3
Nadir S3
Last News
BMI evolution during successive bariatric procedures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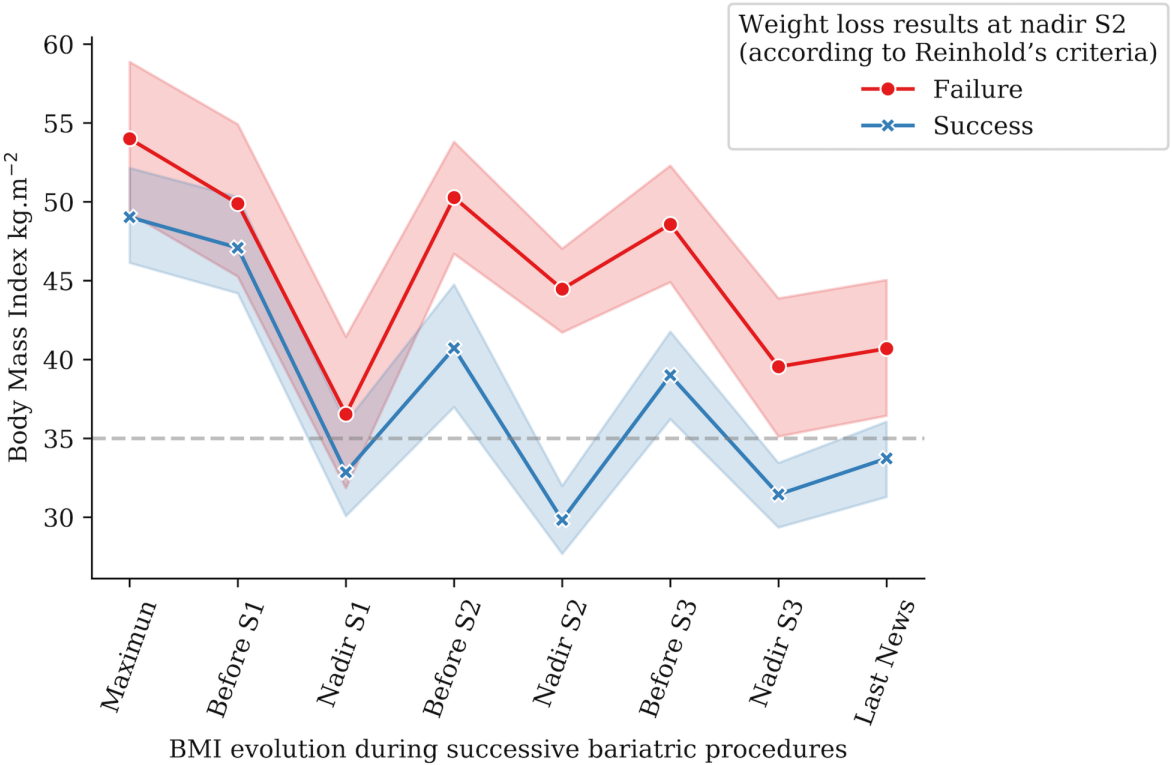
Weight loss results at nadir S2
(according to Reinhold's criteria)
Failure
Success
Body Mass Index kg.m^{-2}
60
55
50
45
40
35
30
Maximun
Before S1
Nadir S1
Before S2
Nadir S2
Before S3
Nadir S3
Last News
BMI evolution during successive bariatric procedures

		GLOBAL POPULATION		THIRD SURGERY PERFORMED							
				Restrictive		Gastric Bypass		SADI or BPD-DS			
		n = 34		n = 4		n = 25		n = 5			
		mean or *n*	SD or %	mean or *n*	SD or %	mean or *n*	SD or %	mean or *n*	SD or %		p value
BASELINE	Maximum BMI	51.21	± 8.28	47.66	± 9.04	49.24	± 5.90	63.92	± 7.51		0.007
	Female gender	27	(79%)	4	(100%)	21	(84%)	2	(40%)		0.069
	Patient with BMI > 50	11	(32%)	0	(0%)	6	(24%)	5	(100%)		0.001
FIRST SURGERY	Type of surgery										
	Gastric banding	26	(76%)	2	(50%)	19	(76%)	5	(100%)		
	Sleeve	1	(3%)	0	(0%)	1	(4%)	0	(0%)		
	VBG	7	(21%)	2	(50%)	5	(20%)	0	(0%)		
	Age at surgery	29.85	± 10.75	24.50	± 6.56	30.80	± 11.51	29.40	± 9.61		0.563
	BMI Before S1	48.32	± 8.28	42.72	± 4.63	46.75	± 6.37	60.66	± 8.26		0.004
	Reinhold's criteria at nadir S1 *(% success)*	22	(65%)	3	(75%)	17	(68%)	2	(40%)		0.502
	Mean %EWL at nadir S1	64.22	± 31.58	89.24	± 30.09	62.26	± 31.34	53.99	± 29.59		0.194
	%EWL Regain (%EWL nadir S1 - %EWL before S2)	52.93	± 63,69	71.19	± 32.85	50.99	± 72,21	48.01	± 31,26		0.247
SECOND SURGERY	Type of surgery										
	Gastric banding	9	*(26%)*	*3*	*(75%)*	*6*	*(24%)*	*0*	*(0%)*		
	Sleeve	15	*(44%)*	1	*(25%)*	10	*(40%)*	4	*(80%)*		
	Roux-en-Y Bypass	4	*(12%)*	0	*(0%)*	3	*(12%)*	1	*(20%)*		
	One Anastomosis Gastric Bypass	4	*(12%)*	0	*(0%)*	4	*(16%)*	0	*(0%)*		
	Others (gastric plication, revisional VBG)	2	*(6%)*	0	*(0%)*	2	*(8%)*	0	*(0%)*		
	Age at surgery	37.69	± 11.17	33.74	± 13.96	38.54	± 11.35	36.59	± 9.45		0.614
	BMI before S2	44.93	± 9.53	39.92	± 7.23	43.14	± 8.50	57.89	± 4.59		0.006
	Interval S1 - S2 *(months)*	88.71	± 53.17	105.50	± 91.49	87.72	± 51.53	80.20	± 27.18		0.982
	Reinholds at nadir S2 *(% success)*	19	(56%)	3	(75%)	15	(60%)	1	(20%)		0.239
	Mean %EWL at nadir S2										
	Between Before S1 and Nadir S2	50.32	± 45.16	46.37	± 52.73	53.18	± 48.65	39.18	± 17.70		0.596
	Between Before S2 and Nadir S2	48.75	± 53.41	37.33	± 49.64	53.31	± 58.99	35.08	± 17.66		0,800
	%EWL Regain (%EWL nadir S2 - %EWL before S3)	34.52	± 40.72	47.89	± 33.61	36.34	± 44.21	14.74	± 20.30		0.299

THIRD SURGERY	Age at surgery	42.91	±	11.27	36.5	±	13.53	44.32	±	11.31	41	±	9.19	0.385
	BMI before S3	43.22	±	8.32	42.98	±	12.33	41.65	±	7.15	51.25	±	7.39	0.055
	Interval S2 - S3 *(months)*	67.32	±	56.24	32.75	±	26.35	74.48	±	60.00	59.20	±	48.80	
	Reinhold's criteria at nadir S3 *(% success)*	25		(74%)	3		(75%)	19		(76%)	3		(60%)	0.817
	Mean %EWL at nadir S3													
	Between Before S1 and Nadir S3	54.06	±	45.17	53.21	±	52.49	53.27	±	48.56	58.66	±	24.24	0.913
	Between Before S3 and Nadir S3	47.89	±	32.13	64.42	±	25.08	46.37	±	33.65	42.23	±	30.42	0.275
	Comorbidities													
	Type 2 Diabete mellitus	3		*(9%)*	0		*(0%)*	2		*(8%)*	1		*(20%)*	
	High Blood Pressure	12		*(35%)*	1		*(25%)*	9		*(36%)*	2		*(40%)*	
	Obstructive Sleep Apnea	12		*(35%)*	1		*(25%)*	8		*(32%)*	3		*(60%)*	
	Dyslipidemia	4		*(12%)*	0		*(0%)*	3		*(12%)*	1		*(20%)*	
LAST NEWS	Age	45.41	±	11.25	41.25	±	13.18	46.72	±	11.37	42.20	±	9.88	0.385
	BMI	36.79	±	8.00	38.57	±	10.55	35.47	±	6.90	42.00	±	10.52	0.345
	Interval S3 - Last news *(in months)*	30.59	±	27.65	62.00	±	33.83	29.04	±	25.47	13.20	±	13.33	0.061
	Reinhold's criteria at Last News *(% success)*	22		(65%)	1		(25%)	18		(72%)	3		(60%)	0.157
	%EWL Regain (%EWL nadir S3 - %EWL last news)	11.12	±	20.52	34.30	±	35.51	9.01	±	17.59	3.12	±	5.06	0.222
	Comorbidities													
	Type 2 Diabete mellitus	3		*(9%)*	0		*(0%)*	2		*(8%)*	1		*(20%)*	
	High Blood Pressure	11		*(32%)*	1		*(25%)*	8		*(32%)*	2		*(40%)*	
	Obstructive Sleep Apnea	9		*(26%)*	1		*(25%)*	5		*(20%)*	3		*(60%)*	
	Dyslipidemia	3		*(9%)*	1		*(25%)*	2		*(8%)*	0		*(0%)*	

SD : Standard Deviation ; BMI : Body Mass Index in $kg.m^{-2}$; %EWL : percentage excess weight loss ; SADI : Single Anastomosis Duodeno–Ileal bypass ; BPD-DS : BilioPancreatic Diversion with Duodenal Switch ; VBG : Vertical Banded Gastroplasty ; S1 : first surgery ; S2 : second surgery ; S3 : third surgery.

Table 1: Demographic data and weight loss outcomes of the patients benefiting from a third bariatric surgery during their successive bariatric procedures

Potential predictors of weight loss success	β	S.E. β	Wald χ^2	*df*	*p*	e^{β} (odds ratio)	95% C.I. for e^{β} Lower	Upper
Constant	3,856	3,787	1,037	1	0,309	*na*	*na*	
Maximun BMI	-0,092	0,07	1,74	1	0,187	0,912	0,795	1,046
Reinhold's criteria at Nadir S1 (1 = success, 0 = failure)	1,716	1,084	2,507	1	0,113	5,564	0,665	46,571
Reinhold's criteria at Nadir S2 (1 = success, 0 = failure)	2,914	1,267	5,295	1	0,021*	18,435	1.540	220,654

β = regression coefficient in log-odds units ; S.E. = standard error ; df : degrees of freedom ; na : not applicable ; C.I. : Confidence Interval ; BMI : Body Mass Index in kg.m-2 ; S1 : First Surgery ; S2 : Second Surgery.

Table 2: Logistic regression searching for predictive factors of weight loss outcomes according to Reinhold’s criteria