

Perioperative Morbidity and Long-term Outcomes of Bariatric Surgery in Patients with Severe Obesity

Tamar Beck MD^{1,2}, Eyal Aviran MD^{1,2}, Shelly Cohn MD³, and David Goitein MD^{1,2}

¹Department of Surgery C, Sheba Medical Center, Tel Hashomer, Israel

²Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

³Azrieli Faculty of Medicine, Bar-Ilan University, Safed, Israel

ABSTRACT

Background: Long-term outcome data for bariatric surgery in patients with severe obesity (SO) (body mass index [BMI] ≥ 50 kg/m²) are scarce.

Objectives: To compare perioperative morbidity and long-term outcomes between patients with SO and non-SO (NSO).

Methods: Patients with SO who underwent primary bariatric surgery with a follow-up ≥ 5 years were age- and gender-matched with NSO patients in a retrospective, case-control study. Data included demographics, BMI, co-morbidities, early outcomes, current and nadir weight, co-morbidity status, and general satisfaction.

Results: Of 178 patients, 49.4% were male, mean age 44.5 ± 14 years. Mean preoperative BMI was 54.7 ± 3.6 and 41.8 ± 3.8 kg/m² in SO and NSO, respectively ($P = 0.02$). Groups were similar in preoperative characteristics. Depression/anxiety was more prevalent in NSO (12.4% vs. 3.4%, $P = 0.03$). Obstructive sleep apnea was higher in SO (21.3% vs. 10.1%, $P = 0.04$). Sleeve gastrectomy was performed most often (80.9%), with a tendency toward bypass in SO ($P = 0.05$). Early complication rates were: 13.5% in SO and 12.4% in NSO ($P = 0.82$). Mean follow-up was 80.4 ± 13.3 months. BMI reduction was higher in SO (31.8 ± 5.9 vs. 26.8 ± 4.2 kg/m², $P < 0.001$) and time to nadir weight was longer (22.1 ± 21.3 vs. 13.0 ± 12.0 months, $P = 0.001$). Co-morbidity improvement and satisfaction were similar.

Conclusions: Patients with SO benefited from bariatric surgery with reduced BMI and fewer co-morbidities. No added risk of operative complications was found compared to patients with NSO.

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KEY WORDS: bariatric surgery, co-morbidities, long-term outcomes, metabolic surgery, severe obesity

prevalence of co-morbidities associated with a higher BMI [3]. Studies have since shown adequate resolution of symptoms in short-term follow-up with no increased risk for complications [4,5]. Evidence regarding the long-term outcomes and adequate responsiveness to bariatric-metabolic surgery (compared with non-surgical treatment) has only recently started to accumulate and is still inconclusive [6]. The appropriate choice of bariatric procedure [7,8] and sufficiency of a single vs. a staged procedure [5,7] also should be discussed. Sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and one anastomosis gastric bypass (OAGB) are the most widely used bariatric procedures.

Our goal was to compare both perioperative characteristics and long-term (≥ 5 years) outcomes between patients with SO and patients with NSO operated in our center.

PATIENTS AND METHODS

All patients with SO who underwent a primary bariatric surgery at our center between June 2013 and January 2017 were randomly matched in a 1:1 ratio with NSO controls operated during the same period. The matching was conducted for gender and age (± 2 years).

Data were retrieved from electronic hospital medical records and supplemented by telephone interviews administered during December 2021. Preoperative data included demographics, weight, height, co-morbidities, type of bariatric procedure performed (with the possible addition of a cholecystectomy or hiatal hernia repair), length of hospital stay, complications at primary hospitalization, early (≤ 30 days) complications, and readmissions. Long-term data included current and nadir weight, time to nadir weight, co-morbidities, additional surgeries performed whether at our hospital or elsewhere (none, revisional bariatric, bariatrics-related, or bariatrics-unrelated), and general satisfaction with their long-term bariatric course (graded on a 1–10 scale).

Co-morbidities reviewed were hypertension, type 2 diabetes mellitus, dyslipidemia, gastro-esophageal reflux disease (GERD), depression/anxiety, obstructive sleep apnea (OSA) and degenerative joint disease (DJD). Long-term status of a co-morbidity was considered improved if there was a reduction in number and/or dosage of disease-specific medications.

The obesity pandemic is well described. As the prevalence of obesity increases worldwide, body mass index (BMI) values have also risen in the last few decades, with more patients having severe obesity (SO), BMI ≥ 50 kg/m² in contrast to non-severe obesity (NSO) [1,2].

Current literature focusing on this sub-population of patients is lacking. In the past, a unique profile of complications was hypothesized because of both technical difficulties (e.g., abundant visceral fat and obscuring fatty livers) and increased

Statistical analyses were performed using IBM Statistical Package for the Social Sciences statistics software, version 27 (SPSS, IBM Corp, Armonk, NY, USA). Differences for continuous variables were analyzed using independent sample *t*-tests. Differences for categorical variables were analyzed using chi-square or Fisher's exact test, as appropriate. Prediction of surgical outcomes was conducted by logistic regression analysis for continuous variables and chi-square test for categorical variables. Analysis of interaction between groups and BMI over time was done using 2-way mixed ANOVA. A *P*-value of 0.05 was considered statistically significant.

RESULTS

During the study period, 103 patients with SO were identified. Eight cases were excluded: 3 died and 5 had no age-appropriate

matching (all of them under 20 years of age). Six matched pairs were unavailable for long-term questioning (either case, control, or both), resulting in 89 case-control pairs (*n*=178) as our final cohort.

Table 1 describes demographic, preoperative, and perioperative patient characteristics, as well as early postoperative outcomes. In 88 patients, 49.4% were male. Mean age was 44.4 ± 14.2 years in SO and 44.5 ± 14.1 years in NSO (*P* = 0.98). Mean BMI was 54.7 ± 3.6 and 41.8 ± 3.8 kg/m² in patients with SO and NSO, respectively (*P* = 0.02). Distribution of co-morbidities was similar in both groups, hypertension being the most prevalent (38.2% and 34.8% in SO and NSO, respectively). Statistically significant differences were found for depression/anxiety and OSA present in 3 (3.4%) and 19 (21.3%) patients with SO, and in 11 (12.4%) and 9 (10.1%) patients with NSO (*P* = 0.03 and *P* = 0.04), respectively.

SG was performed on 67 (75.3%) and 77 (86.5%) of patients

Table 1. Demographic, preoperative, and perioperative characteristics and early postoperative outcomes

	SO (n=89)	NSO (n=89)	Total (n=178)	P-value
Age at surgery (years)	44.4 ± 14.2	44.5 ± 14.1	44.5 ± 14.1	0.98
BMI (kg/m ²)	54.7 ± 3.6	41.8 ± 3.8	48.2 ± 7.4	0.02
Height (cm)	166.4±10.6	170.2±10.9	168.3 ± 10.9	< 0.001
Weight (kg)	151.8 ± 20.3	121.7 ± 20	136.7 ± 25.1	< 0.001
Gender				N/A
Male	44 (49.4%)	44 (49.4%)	88 (49.4%)	
Female	45 (50.6%)	45 (50.6%)	90 (50.6%)	
Co-morbidities				
≥ 1 co-morbidity	63 (70.8%)	64 (71.9%)	127 (71.3%)	0.87
Hypertension	34 (38.2%)	31 (34.8%)	65 (36.5%)	0.64
Diabetes mellitus	26 (29.2%)	31 (34.8%)	57 (32.0%)	0.42
Dyslipidemia	30 (33.7%)	27 (30.3%)	57 (32.0%)	0.63
GERD	14 (15.7%)	12 (13.5%)	26 (14.6%)	0.67
Depression / anxiety	3 (3.4%)	11 (12.4%)	14 (7.9%)	0.03
OSA	19 (21.3%)	9 (10.1%)	28 (15.7%)	0.04
DJD	12 (13.5%)	6 (6.7%)	18 (10.1%)	0.14
Type of procedure				0.051
SG	67 (75.3%)	77 (86.5%)	144 (80.9%)	–
RYGB	18 (20.2%)	12 (13.5%)	30 (16.9%)	–
OAGB	4 (4.5%)	0 (0%)	4 (2.2%)	–
+ cholecystectomy	4 (4.5%)	1 (1.1%)	5 (2.8%)	0.37
+ hiatal hernia repair	11 (12.4%)	11 (12.4%)	22 (12.4%)	1.00
Length of hospital stay (days)	2.48 ± 1.52	2.51 ± 1.34	2.49 ± 1.43	0.92
Primary hospitalization complication	9 (10.1%)	10 (11.2%)	19 (10.7%)	0.81
Early (< 30 days) complications	12 (13.5%)	11 (12.4%)	23 (12.9%)	0.82
Early (≤ 30 days) readmissions	7 (7.9%)	4 (4.5%)	11 (6.2%)	0.35

Continuous variables are expressed as mean ± standard deviation

Categorical variables are expressed as n (%)

BMI = body mass index, DJD = degenerative joint disease, GERD = gastro-esophageal reflux disease, NSO = non-severe obesity, OAGB = one anastomosis gastric bypass, OSA = obstructive sleep apnea, RYGB = Roux-en-Y gastric bypass, SG = sleeve gastrectomy, SO = severe obesity

Table 2. Long-term characteristics and outcomes, including weight progress preoperatively at nadir weight

	SO (n=89)	NSO (n=89)	Total (n=178)	P-value
Length of follow up (months)	78.8 ± 13	82 ± 13.5	80.4 ± 13.3	0.108
Time to nadir weight (months)*	22.1 ± 21.3	13 ± 12	17.5 ± 17.7\$	0.001
Additional surgeries				0.105
None	61 (68.5%)	54 (60.7%)	115 (64.6%)	
Revisional bariatric	0 (0%)	0 (0%)	0 (0%)	
Bariatrics-related	20 (22.5%)	17 (19.1%)	37 (20.8%)	
Bariatrics-unrelated	8 (9.0%)	18 (20.2%)	26 (14.6%)	
Improvement in co-morbidities**				
Hypertension	17 (50%)	18 (58.1%)	35 (53.8%)	0.51
Diabetes mellitus	24 (92.3%)	24 (77.4%)	48 (84.2%)	0.12
Dyslipidemia	20 (66.7%)	21 (77.8%)	41 (71.9%)	0.35
GERD	7 (50%)	5 (41.7%)	12 (46.2%)	0.67
Depression / anxiety	1 (33.3%)	4 (36.4%)	5 (35.7%)	0.92
OSA	15 (78.9%)	8 (88.9%)	23 (82.1%)	0.52
DJD	6 (50%)	2 (33.3%)	8 (44.4%)	0.50
BMI (kg/m²)				
Preoperative	54.7 ± 3.6	41.8 ± 3.8	48.2 ± 7.5	< 0.001
At nadir weight	31.8 ± 5.9	26.8 ± 4.2	29.3 ± 5.7	< 0.001
Long-term	37.4 ± 6.8	30.9 ± 5.2	34.2 ± 6.9	< 0.001
% EWL				
Preoperative	–	–	–	
At nadir weight	77.2 ± 19.4	91 ± 25.9	84.1 ± 23.9	< 0.001
Long-term	58.3 ± 21.6	65.7 ± 29	62 ± 25.8	0.057
% TBWL				
Preoperative	–	–	–	
At nadir weight	41.7 ± 10.5	35.7 ± 9.9	38.7 ± 10.6	< 0.001
Long-term	31.5 ± 11.7	25.8 ± 11.6	28.6 ± 11.9	0.001
General satisfaction (1–10)	8.33 ± 2.49	8.39 ± 2.68	8.36 ± 2.58	0.862

*Missing data for 4 patients with SO

**Number in parenthesis represents % of patients morbid pre-operatively

Continuous variables are expressed as mean ± standard deviation

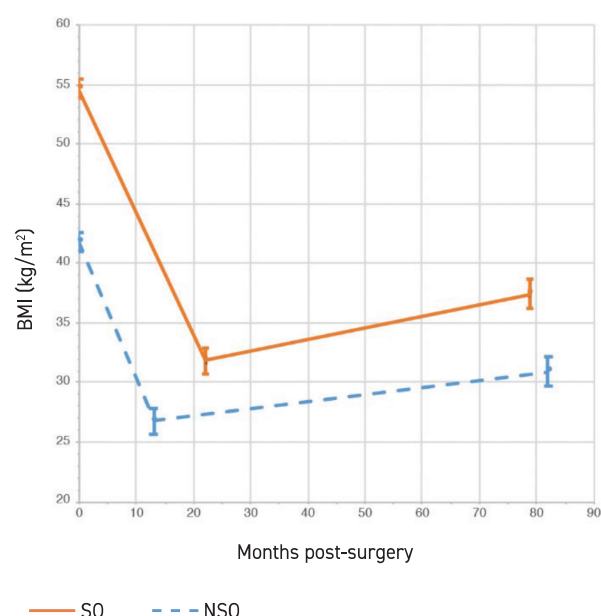
Categoric variables are expressed as n (%)

BMI = body mass index, DJD = degenerative joint disease, EWL = excess weight loss, GERD = gastro-esophageal reflux disease, NSO = non-severe obesity, OSA = obstructive sleep apnea, SO = severe obesity, TBWL = total body weight loss

with SO and NSO, respectively; RYGB on 18 (20.2%) and 12 (13.5%), respectively. The remaining four patients (all of whom with SO) underwent OAGB ($P = 0.051$). The primary bariatric procedure was supplemented with a cholecystectomy in 2.8%

Figure 1. Trends in body mass index over time (preoperatively, at nadir weight, and long-term)

BMI = body mass index, NSO = non-severe obesity, SO = severe obesity



and with a hiatal hernia repair in 12.4% of all patients, evenly distributed between the groups. All surgeries were conducted laparoscopically, except for one patient with SO who underwent conversion to open surgery due to a cholecystocolonic fistula necessitating colonic resection (unrelated to his BMI).

Overall mean length of hospital stay was 2.49 ± 1.43 days. A primary hospitalization complication occurred in 9 (10.1%) and 10 (11.2%) patients with SO and NSO, respectively ($P = 0.81$). An early complication occurred in 12 (13.5%) and 11 (12.4%) patients with SO and NSO, respectively ($P = 0.82$). Early complications in patients with SO comprised of 6 cases of hemorrhage, 2 dysphagia, 1 dehydration, 1 surgical site infection, 1 atrial fibrillation with deep vein thrombosis, and 1 case of missed enterotomy. Early complications in patients with NSO comprised of 7 cases of hemorrhage, 1 acute kidney injury, 1 pneumonia, 1 hypertensive crisis, and 1 case of repeated apneas.

Age was found to be a statistically significant predicting factor of early operative outcomes: for primary hospitalization complications (odds ratio [OR] = 1.06, 95% confidence interval [95%CI] 1.019–1.104, $P = 0.004$) and for early complications (OR=1.055, 95%CI 1.017–1.094, $P = 0.004$), although not for early readmissions ($P = 0.80$). Analyzing for co-morbidities, hypertension alone was found to be significantly correlated with primary hospitalization complications ($P = 0.041$) and early complications ($P = 0.002$), but not with early readmissions ($P = 0.525$). Results for hypertension were still significant when calculated

only for patients with SO ($P = 0.08$ for primary hospitalization complications and $P = 0.009$ for early complications).

Table 2 describes long-term outcomes including weight progress over time. In addition to BMI, weight progress is expressed as percentage of excess weight loss (%EWL) and percentage of total body weight loss (%TBWL).

Mean length of follow-up was 78.8 ± 13 and 82 ± 13.5 months for patients with SO and NSO, respectively ($P = 0.108$). No patient underwent a revisional bariatric operation, but 20 (22.5%) patients with SO and 17 (19.1%) patients with NSO underwent a bariatrics-related operation (most commonly cholecystectomy or abdominoplasty).

Change in co-morbidity status was comparable between SO and NSO, improvement most notable in diabetes 24 (92.3%) and 24 (77.4%), dyslipidemia 20 (66.7%) and 21 (77.8%), and OSA 15 (78.9%) and 8 (88.9%) for SO and NSO, respectively.

Time to nadir weight was 22.1 ± 21.3 and 13 ± 12 months in patients with SO and NSO, respectively ($P = 0.001$). BMI at nadir weight and long-term was 31.8 ± 5.9 and $37.4 \pm .8$ kg/m² for patients with SO, and 26.8 ± 4.2 and 30.9 ± 5.2 kg/m² for patients with NSO, respectively ($P < 0.001$ for both). Looking at BMI long-term, 77 (86.5%) patients with SO and 54 (60.7%) patients with NSO had BMI ≥ 30 kg/m² ($P < 0.001$). Analysis for interaction between BMI and group over time was also performed, and a statistically significant interaction was found ($F(2,274) = 58.129$, $P < 0.001$, partial $\eta^2 = 0.248$) [Figure 1]. Long-term %TBWL was 31.5 ± 11.7 percent and 25.8 ± 11.6 percent for patients with SO and NSO, respectively ($P = 0.001$). Long-term %EWL showed a similar trend ($P = 0.057$).

General satisfaction was 8.33 ± 2.49 and 8.39 ± 2.68 for patients with SO and NSO, respectively ($P = 0.862$).

DISCUSSION

Results of our study support bariatric surgery as a viable option for patients with SO. Our data suggest there is no significant difference in postoperative course between this sub-population and patients with NSO, and that patients with SO are satisfied with their operative outcomes despite long-term significant weight excess.

Preoperatively, the two groups were similar, and except for OSA being more common in SO and depression/anxiety more common in NSO, no significant difference in co-morbidity prevalence was found. Remarkably, we found no difference regarding early operative complications. The most common complication was hemorrhage, occurring in 6.7% patients overall, and was usually treated by tranexamic acid and/or blood products. Overall, only 3 patients (all SO) presented with a serious complication (Clavien-Dindo classification [9] class \geq III): 2 surgical explorations and 1 percutaneous hematoma drainage. Rate of overall early complications was 12.3%, which is somewhat higher than reported [10-13]. This discrepancy may be because in Israel, any surgical complication of a bariatric procedure must be reported to a national registry [14].

As most complications reported are minor, this could skew the complication rate upward. Nevertheless, it is noteworthy that SO conferred no additional complications compared with NSO.

In terms of risk prediction, age, a known predictor of operative adverse outcomes [15], appeared in our findings as predictive (for both groups) $OD = 1.055$ for early complications ($P = 0.004$). Preoperative co-morbidities, however, were not associated with complications, except for hypertension, a finding consistent with some previous studies but in conflict with others [10,13].

Patients with SO underwent RYGB significantly more than patients with NSO ($P = 0.051$), presumably because a malabsorptive component was considered adequate on account of the higher BMI. At long-term follow-up, 86.5% patients with SO were still obese (BMI ≥ 30 kg/m²), significantly more than patients with NSO ($P < 0.001$), although no patient (from either group) underwent a second bariatric procedure. Past studies have recommended performing SG as a first-stage procedure for SO, with surgical revision later (mainly RYGB or biliopancreatic diversion/duodenal switch) [16]. Yet, more recent publications advocate a single-stage bariatric procedure [5,7,17]. Unfortunately, our study could not shed more light on this topic due to very small sample sizes when stratified by surgery type. The rising popularity of OAGB, especially in parts of Europe, the Far East, and Middle East [18] is not yet reflected in our cohort, OAGB being the least common surgery type performed (2.2% of all patients). These results will probably change in later studies.

Time to nadir weight in our study was approximately 1.5 years for the entire population and approximately 2 years for patients with SO, similar to previous studies that showed a slower reduction in weight in this sub-population [19,20]. As shown in Figure 1, in all three time-points patients with SO maintained higher mean BMI values than patients with NSO, yet an initial difference of approximately 12 kg/m² between the two groups was eventually reduced to about 6 kg/m², a finding also evident in the difference in %TBWL (31.5% vs. 25.8%, $P = 0.001$). This result can be interpreted as a form of *catch-up* or *upgrading* from having SO to NSO, and may explain the overall general satisfaction with bariatric outcomes expressed by patients with SO.

Despite inadequate success in terms of weight loss, our study demonstrated that in terms of improvement in co-morbidities, patients with SO benefit from bariatric surgery as shown previously [4,21]. This finding is reflected most prominently in diabetes, which improved for 24 patients with SO (92.3%) and in fact resolved completely for 17. Regardless of changes in weight, this outcome alone may justify bariatric surgery for patients with co-morbid SO and diabetes, as it has a massive impact on patient morbidity and mortality [22,23].

Several recurring comments made by patients in both groups, although not amenable for robust statistical analysis, are worth noting. Some patients were extremely satisfied with their operation and postoperative course, yet stated they would not have repeated it. Usually referring to SG, many said they would have

preferred some form of bypass (RYGB or OAGB) because of disappointment with rebound weight gain. Second, the emergence of acylated glucagon-like peptide-1 agonists (e.g., liraglutide and semaglutide) as optional weight-reducing medications was evident, with several patients taking these drugs regularly. They referred to the benefits of this novel treatment as surpassing those of surgery due to a better side-effect profile, an observation that should be explored in future research. Third, March 2020, when the coronavirus disease 2019 (COVID-19) pandemic first hit the Israeli population, was a breaking point for many patients in terms of weight maintenance, and the start of bariatric deterioration including not only weight gain but also lack of adherence to supplements and timely follow-up. Extensive research on the effects of COVID-19 on the bariatric population is already underway.

A prominent strength of the study is that by matching for gender and age we precluded any potential confounding by these parameters. Another is the completeness of long-term data collected. Only 12/190 patients (6.3%) were lost to follow-up, and for the included sample complete data were obtained except for 4/178 patients (2.2%) for which nadir weight was not recorded. Last, follow-up was truly long-term, at a minimum of 58 months post-operatively.

A limitation of the study regards the acquisition of long-term data as a cross-sectional observation, which may not truly convey trends and fluctuations over time. Other limitations include comparison of groups undergoing different bariatric procedures, data collection by phone, and the subjective nature of self-reporting regarding co-morbidity status. Study results are also limited by sample size and it being retrospective in design.

CONCLUSIONS

Patients with SO benefited from a single bariatric surgery by a reduction in BMI coupled with improvement in co-morbidities. They were highly satisfied with the outcomes. Compared to patients with NSO, patients with SO have a significantly higher long-term %TBWL yet have no added risk of operative complications. However, issues such as choice of primary operation in this sub-population and necessity of a revisional surgery to further reduce weight are still unresolved and must be further explored.

Correspondence

Dr. D. Goitein

Dept. Surgery C, Sheba Medical Center, Tel Hashomer 52621, Israel

Phone: (972-3) 530-2714

Fax: (972-3) 534-1562

Email: david.goitein@sheba.health.gov.il

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