Estimation Of Excessive Weight Loss In Bariatric Surgery Patients: A Prediction Model Retrospective Cohort Study

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Research Article

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Abstract

Background and Objective: Bariatric surgery has been recognized as the most effective long-term treatment for morbid obesity. Despite the considerable positive results, adverse consequence can develop. Excessive Weight Loss (EXWL), a rare consequence of bariatric surgery, can lead to a broad adverse consequence. The aim of this study was determining of prevalence and the predicting model of EXWL in patient underwent bariatric surgery until 24 months after surgery.

Material and Methods: Data have been extracted from the National Obesity Surgery Database in obesity clinic of * University of Medical Sciences. The subjects of this retrospective cohort study were morbid obese individuals who underwent three various types of bariatric surgery (One Anastomosis Gastric Bypass (OAGB), Roux-en-Y gastric bypass (RYGB) or sleeve gastrectomy (SG)) in period of 24 months ago. EXWL has been defined as excess weight loss more than 100% at any time until 24 months after surgery. SPSS (version 23) was used in data analysis.

Results: Among 4214 subjects of this study, most excess weight loss after surgery has taken place in 18 months after surgery. 18.5% (n=407) of patients experienced EXWL with highest percentage among OAGB patients (22.6%). The females (20.4% vs.9.9%) and younger persons (35.45 ± 10.25 vs. 39.06 ± 10.76) were more susceptible to EXWL. patients with EXWL had significantly lower BMI (body mass index) (41.11± 4.51 vs. 46.73±6.26) (Kg/m^2), and were less probable to had emotional eating. Visceral fat level, fat percentage and BMI were the best predictor of EXWL (P-value for all <0.05).

Conclusions: Surgery should be adjusted in younger females with a lower BMI and healthy metabolic status who are more prone to EXWL. In such a way that minimize weight loss speed/value. It may be possible by selection of other surgery procedures, rather than OAGB, tighter follow ups and consultations of patients after surgery is emphasized for more EXWL vulnerable patients.

Introduction

Bariatric surgery has been recognized as the most effective long-term treatment for morbid obesity. Despite the considerable positive results, adverse consequence can develop [1]. One of the undesirable side effects which the literature is not reported well, is Excessive Weight Loss (EXWL) after bariatric surgery. A few number of patients become underweight (i.e. body mass index (BMI) < 18.5) and/or develop protein energy malnutrition after gastric bypass surgery [2]. Regarding that the effectiveness of bariatric surgery and the surgery induced weight loss is varied among different types of obesity surgery and also between individuals, the probability and prevalence of EXWL is different among various types of bariatric surgeries [3]. In addition, the length of the different limbs, i.e., the Roux limb, the bilio-pancreatic limb (BPL), and the bougie size will result in difference in amount of weight loss. So that, the longer Roux limb and BPL and smaller bougie size can potentially result in more significant weight loss [4]. Recent studies also suggested that the successfulness of weight loss after obesity surgery are dependent on some characteristics of patients before surgery; including age, gender, weight, BMI, fat percentage and also fat distribution and visceral fat level. So that the younger, lower BMI, lower body fat percentage and android fat distribution phenotype of bariatric candidates probably have more successful weight loss and also, they are more vulnerable to have EXWL [5–8]. Most of the studies in subject of EXWL are in the case reports level of evidences, all over the world [9–11]. So, there is not an accurate statistics respect of prevalence or probability of EXWL after bariatric surgery. Some studies suggested that the before surgery metabolic syndrome, insulin resistance and also nutritional status of some micronutrient could affect the after surgery weight loss amount and/or speed [12, 13].

In spite of EXWL is a rare consequence of bariatric surgery, it can lead to a broad adverse consequence such as severe protein calorie malnutrition, serum albumin reduction, hepatic failure, patient's dissatisfaction, and poor quality of life (QOL), even if tacked place in mild levels. Based on recent investigation, EXWL following gastric bypass is the most likely indication for reversal of bariatric surgery [2]. Definition of an Excessive Weight Loss predicting model to recognize the more susceptible individuals before surgery is very important. Adjusting the surgery procedure may be through limb length, bougie size or nutritional support early after surgery could result in a standard weight loss and prevent occur of EXWL. Hence, the aim of this study was determining of EXWL prevalence and predicting model of EXWL in patient underwent bariatric surgery until 24 months after surgery.

Material And Methods

Study design, setting and participants

This was a retrospective cohort study conducted in obesity clinic of * University of Medical Sciences. In the present research, the subjects who had morbid obesity (BMI ≥ 40 and/or BMI ≥ 35 with more than one obesity-related co-morbidities (such as type 2 diabetes (T2D), hypertension, sleep apnea and other respiratory disorders, non-alcoholic fatty liver disease, osteoarthritis, lipid abnormalities, gastrointestinal disorders, or heart disease)) underwent the various types of bariatric surgery. The data used in this study has been extracted from the National Obesity Surgery Database in March 2019. The patient with morbid obesity who are the candidate of bariatric surgery have the regular visit to obesity clinic before and at 10th day, 30th day, 3rd, 6th, 9th, 12th, 18th, 24th months and then on annually after surgery. The several information including anthropometric indexes, body composition analysis and also laboratory test results were measured and recorded in National Obesity Surgery Database for every follow up visit by physicians. Some variables including lifestyle and socioeconomic factors, dietary pattern, psychiatric or emotional status, and physical activity, were not recorded in National Obesity Surgery Database.

We included cases who underwent one of the three types of bariatric surgery (One Anastomosis Gastric Bypass (OAGB), Roux-en-Y gastric bypass (RYGB) or sleeve gastrectomy (SG)) and had been followed at least up to six months after surgery.

Variables, Data sources/measurement

To determine the effects of various types of surgery on probability of EXWL, we included three types of obesity surgery occurred in this center, included SG, RYGB and OAGB. The estimated limbs length such as Roux limb and BPL had been recorded in the database, by the surgeon at the time of surgery. One surgeon has done all surgeries.

Based on standardized outcomes reporting in metabolic and bariatric surgery [14], EWL was determined according the below formula which ideal body weight was calculated based on height and BMI of 25 kg/m2 [14] despite many large epidemiologic studies suggest that in non-bariatric surgery person BMI in the 21–22 range may be "ideal" with respect to long-term mortality and metabolic disease risk and the CDC includes BMI 18.5–25 as a "normal" weight range, but Executive summary of American Society for Metabolic and Bariatric Surgery (ASMBS) outcome reporting standards ASMBS determined that ideal weight is defined by the weight corresponding to a BMI of 25 kg/m2.[14]

% EWL = (Initial weight − Postoperative weight) / (Initial weight − Ideal weight) ×100

Regarding the definition of EXWL in this study, there has not been a uniform method to report EXWL in bariatric literature. Moreover, the limited studies in the field of malnutrition after bariatric surgery are in the case report, case series evidence-based level [15, 16], or they only assessed the micro- and/or macro-nutrient deficiency (i.e., hypo-albuminemia)[17], but not the weight loss status after surgery. In attention to that the primarily aim of this study was to exploration of EXWL pre-op predictive variables to prevent the malnutrition incidence including micro-nutrient deficiency and/or hypo-albuminuria. So, based on our case studies and clinical experiences of our surgeons' team, EXWL has been defined as EWL more than 100% at any time until 24 months after surgery. Accordingly, a recent case series of eleven malnutrition patients after bariatric surgery reported that the mean % EWL in this hypo-albuminemia malnourished patients were about 88% [18]. Hence, it could be a confirmation sign that % EWL more than 100% could be a reliable cut-off to detect the patients with the higher risk of malnutrition. However, the further study for the evidence-based definition of EXWL are required.

The weight, height, hip and waist circumference, were measured by a trained expert. For measuring the weight (with the SECA 711 scale, Medical Measuring Systems and Scales Factory, USA), it has been requested from participant to remove the heavy clothes and shoes. Their height was read while the back of the head, shoulder blades, buttocks and heels were touching the stadiometer. Waist circumference as the indexes of central obesity was measured in the horizontal plane midway between lowest rib and the iliac crest. The body composition components such as fat percentage and fat free mass was measured with the Bioelectrical impedance analyzer (BIA), (TANITA BC-418, Japan) while they are fast with empty bladder. The before surgery psychiatric disorder (depression, anxiety) and emotional eating that were assumed to potentially affect the after-surgery trend of weight loss and also the incidence of EXWL, was extracted from the database, which had been diagnosed by clinical psychiatrist using the Diagnostic and Statistical Manual of Mental Disorders-5th Edition, and Eating Disorder Examination Questionnaire, respectively.

Some Metabolic syndrome parameters including Fasting blood sugar (FBS), lipid Profile together with other glucose metabolism indices (insulin resistance, A1C (hemoglobin A1c)), Liver function tests (SGOT, SGPT) were assessed using the before surgery lab tests.

Visceral fat level (ranges: 1–59) was measured through BIA by the portable Body Composition Analyzer TANITA AB 140Viscan, which its validity for the prediction of metabolic syndrome was assessed and confirmed in recent study [19]

The incidence of early (up to the 30th postoperative day) or late complication of surgery including bleeding, leak, obstruction, wound infection, pulmonary complication, deep vein thrombosis (DVT) was entered in the database in different follow ups by trained physicians and paramedics. For qualitative analysis the age cut-off 20, 40 and/or 60 years old was used. In addition, BMI cut-off 25, 30, 35 and/or 40 kg/m^2 were used to define the overweight, obese and morbid obese persons, respectively. All assessed variables except EXWL are related to pre-operation data of participant.

Study size, Statistical methods

Considering type one error (alpha), incidence of EXWL, [according to a pilot study on a subsample from our database] and accuracy around this incidence equal to 5%, 5%, and 2.5%, sample size was estimated as 292 subjects using the estimating a proportion formula. The data are presented as mean and standard deviation, 95% confidence interval (CI) or frequencies and percentage. Differences in two group of EXWL and non-EXWL regarding anthropometric indices, body composition measurements and biochemical parameters of the study were analyzed using independent t-test or Mann-Whitney U and chi square. The comparison of type of surgeries for variables was done with one-way ANOVA, Kruskal Wallis H tests. Logistic regression was used to define a prediction model of EXWL. Age, Sex and BMI was adjusted in multivariable Analysis as covariates. All statistical analyses were accomplished by SPSS software. P-value lower than 0.05 was considered significant.

Results

Participants and Descriptive Data

Among 4330 obese patients under bariatric surgery, 4214 cases were finally entered in our analysis after exclusion of the patients who were lost to regular follow up. The most common types of operation were OAGB (n = 2090), RYGB (n = 1417) and SG (n = 707), respectively. Approximately 79% (n = 3340) of subjects were female and the mean age of patients was 39.1 ± 11.1 years old. The mean weight and BMI of the bariatric candidates were 122.43 ± 22.38 (Kg) and 45.59 ± 6.41 (Kg/m^2). Nearly, 70% of patients reported the degrees of emotional eating before surgery. Most prevalent operation type was OAGB (about half of the patients). All other baseline characteristics of patients are listed in Table 1.

Table 1
Baseline pre-op characteristics of patients underwent bariatric surgery

Variables		Value
Age, mean ± SD, Year		39.1 ± 11.1
Female Sex, no (%)		3340 (79.3)
Weight, mean ± SD, Kg		122.43 ± 22.38
Hip Circumference, mean ± SD, Cm		136.65 ± 13.87
Waist Circumference, mean ± SD, Cm		122.0 ± 15.06
BMI, mean ± SD, Kg/m2		45.59 ± 6.41
Fat Percentage, mean ± SD, %		46.66 ± 5.49
Visceral Fat Level, mean ± SD, Level		16.27 ± 5.17
Fat free mass, mean ± SD, Kg		65.21 ± .47
Emotional Eating, no (%)		2927 (69.5)
Psychiatric Problem, no (%)		1341 (31.8)
Hb, mean ± SD, g/dL		13.72 ± 1.52
Ferritin, mean ± SD, ng/mL		81.00 ± 9.17
FBS, mean ± SD, mg/dL		108.43 ± 36.35
HbA1c, mean ± SD, %		5.89 ± 1.28
c-Peptide, mean ± SD, ng/mL		3.97 ± 4.41
SGPT, mean ± SD, IU/L		24.39 ± 15.56
SGOT, mean ± SD, IU/L		30.67 ± 23.00
Insulin, mean ± SD, µIU/mL		22.94 ± 19.63
TSH, mean ± SD, mIU/L		2.95 ± 5.14
Cholesterol, mean ± SD, mg/dL		192.18 ± 40.23
HDL, mean ± SD, mg/dL		46.33 ± 13.6
LDL, mean ± SD, mg/dL		113.61 ± 31.92
TG, mean ± SD, mg/dL		160.31 ± 112.32
Albumin, mean ± SD, g/L		4.34 ± 0.41
Zn, mean ± SD, mg/dL		87.03 ± 21.33
Vitamin B12, mean ± SD, ng/mL		343.83 ± 21.5
Vitamin D3, mean ± SD, ng/mL		25.93 ± 20.63
PTH, mean ± SD, pg/mL		55.80 ± 35.35
Folic Acid, mean ± SD, ng/dL		9.79 ± 5.37
Type of Operation, no (%)	SG	707 (16.8)
	RYGB	1417 (33.6)
	OAGB	2090 (49.6)

Pre-op: Pre-operation, BMI: Body Mass Index, FBS: Fasting Blood Sugar, Hb: Hemoglobin, HbA1c: Hemoglobin A1c, HDL: high-density lipoprotein, LDL: Low-density lipoprotein, PTH: Parathyroid hormone, SGOT: Aspartate Transaminase, SGPT: alanine aminotransferase, TG: triglyceride, Zn: Zinc, SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass

Variables	Value
Length of Alimentary Limb, Mean ± SD, Cm	92.81 ± 34.87
Length of Biliopancreatic Limb, Mean ± SD, Cm	152.44 ± 51.80
Bougie Size, mean ± SD, Cm	37.50 ± 5.37
Gastric Pouch, mean ± SD, ml	24.31 ± 12.85
Pre-op: Pre-operation, BMI: Body Mass Index, FBS: Fasting Blood Sugar, Hb: Hemoglobin, HbA1c: Hemoglobin A1c, HDL: high-density lipoprotein, LDL: Low-density lipoprotein, PTH: Parathyroid hormone, SGOT: Aspartate Transaminase, SGPT: alanine aminotransferase, TG: triglyceride, Zn: Zinc, SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass	

Excess weight loss

The maximum excess weight loss until two years after surgery was occurred at 18 months after surgery, this time trend was similar in three types of surgeries (Fig. 1). In the time period of 3–6 months following operation, the patients under all types of bariatric surgery could lose at least 50% of their excess weights with similar pattern (Fig. 1). Difference in EWL in view of type of operation was revealed following 6th month after surgery. The most excess weight loss at 18 months after operation was obtained in OAGB (85.3%) and then RYGB (79%) and SG (76%), respectively (Fig. 1).

Early and post-operation complication

Most prevalent complication early after surgery was bleeding (1.6%). Regarding the late adverse bariatric complication; leak, bleeding and obstruction were the most frequent problem with the prevalence of 0.6%, 0.5%, and 0.4%, respectively (Table 2).

Table 2
Complications after bariatric surgery

Complications	n (%)
Early Complication (< 30 day)	
Bleeding	68 (1.6)
Leak	12 (0.3)
Obstruction	3 (0.1)
Wound infection	3 (0.1)
Wound dehiscence	0
Pulmonary complication	2 (0.001)
DVT	4 (0.1)
Pulmonary embolism	2 (0.001)
Intra-abdominal abscess	1 (0.001)
Post-Operation Complication	
Bleeding	19 (0.5)
Leak	25 (0.6)
Obstruction	18 (0.4)
Port infection	2 (0.001)
GERD-Esophagitis	10 (0.2)
Gastric/stomal ulcer	14 (0.3)
Protein malnutrition	7 (0.2)
Incisional hernia	4 (0.1)
Intolerance of bariatric procedure	0
Esophageal Dilatation	0
Stomach/Band slippage	0
Poutch dilatation	2 (0.001)
Band erosion into the stomach	0
Intra-abdominal abscess	5 (0.1)
Anastomotic stricture	0
n: Number, DVT: Deep vein thrombosis, GERD: Gastro-esophageal reflux disease,	

Excessive Weight Loss (EXWL)

In General, 18.5% (n = 407) of patients experienced EXWL. The prevalence of EXWL was significantly different between various types of surgery with highest percentage among OAGB patients (22.6%). The females (female 20.4% vs. male 9.9%) and younger persons (35.45 ± 10.2 vs. 39.06 ± 10.76) were more susceptible to EXWL at any time until 24 months after surgery. The before surgery BMI mean in EXWL patients was significantly lower than others (41.11 ± 4.51 vs. 46.73 ± 6.26) (P-value for all < 0.05). The patients with EXWL had significantly lower level but within the normal range of pre-operation visceral fat level, Hb, ferritin, FBS, A1C, SGOT, SGPT, insulin, C-peptide, TG (Triglyceride) and HOMA-IR in before surgery lab tests (P-value for all < 0.05). The EXWL patients were less probable to had emotional eating (P-value for all < 0.05). The limbs length and bougie size have not significant association with the prevalence of EXWL (Table 3, Fig. 2).

Table 3
Baseline pre-op characteristics of patients based on post-op excessive weight loss.

Pre-op characteristics		**EXWL** **n = 407**	**Non-EXWL** **n = 1811**	**P-Value**
Type of Operation, n (%)				
	SG	43 (15.0)	243 (85)	**< 0.001**
	RYGB	136 (15.5)	740 (84.5)	
	OAGB	316 (22.6)	1085 (77.4)	
Age (mean ± SD), year		35.45 ± 10.25	39.06 ± 10.76	**< 0.001**
(n), %	< 20	16 (25.4)	47 (74.6)	**< 0.001**
	20-39.9	259 (21.9)	921 (78.1)	
	40-59.9	116 (13.7)	733 (86.3)	
	≥ 60	10 (13.5)	64 (86.5)	
Sex (n), %				**< 0.001**
	Male	41 (9.9)	375 (90.1)	
	Female	366 (20.4)	1436 (79.7)	
BMI (mean ± SD), kg/m^2		41.11 ± 4.51	46.73 ± 6.26	**< 0.001**
(n), %	≤ 35	33 (74)	18 (26)	**< 0.001**
	35.01-40	97 (39.8)	147 (60.2)	
	40.01-50	256 (18.7)	1116 (81.3)	
	50.01-60	10 (2.3)	427 (97.7)	
	≥ 60.01	1 (1.8)	55 (98.2)	
Fat Percentage (mean ± SD)		47.35 ± 3.75	46.99 ± 5.62	0.858
Visceral Fat Level (mean ± SD), %		13.4 ± 3.98	16.8 ± 5.26	**< 0.001**
Length of Alimentary (mean ± SD), Cm		102.4 ± 34.3	105.3 ± 36.4	0.435
Length of Biliopancreatic (mean ± SD), Cm		160.1 ± 50.29	157.01 ± 54.5	0.456
Bougie Size (mean ± SD), Cm		36.2 ± 2.09	36.7 ± 2.81	0.305
Emotional Eating (n), %		279 (68.6)	1322 (73.0)	**0.041**
Psychiatric Problem (n), %		152 (37.3)	673 (37.2)	0.494
Bleeding (n), %		2 (5.3)	20 (16.9)	0.193
Leak (n), %		4 (10.5)	13 (11.0)	0.600
Obstruction (n), %		5 (13.2)	8 (6.8)	0.181
Wound Infection (n), %		1 (2.6)	1(0.8)	0.429
Hb (mean ± SD), g/dL		13.45 ± 1.40	13.68 ± 1.55	**0.007**

Pre-op: Pre-operation, post-op: post-operation, n: number, EXWL: Excessive weight loss, Non-EXWL: without Excessive weight loss, SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass, WC: Waist Circumference, HP: Hip Circumference, Fat%: Fat Percentage, FFM: Fat free Mass, VFL: Visceral Fat Level, BMI: Body Mass Index, FBS: Fasting Blood Sugar, Hb: Hemoglobin, HbA1c: Hemoglobin A1c, HDL: high-density lipoprotein, LDL: Low-density lipoprotein, PTH: Parathyroid hormone, SGOT: Aspartate Transaminase, SGPT: alanine aminotransferase, TG: triglyceride, Zn: Zinc, HOMA-IR: homeostatic model assessment-insulin resistance, HOMA-β: homeostatic model assessment- β-cell function

Pre-op characteristics	EXWL n = 407	Non-EXWL n = 1811	P-Value
Ferritin (mean ± SD), ng/mL	60.67 ± 63.12	81.24 ± 86.16	**< 0.001**
FBS (mean ± SD), mg/dL	104.03 ± 34.95	108.00 ± 33.54	**< 0.001**
HbA1c (mean ± SD), %	5.70 ± 1.24	5.9239 ± 1.28	**< 0.001**
SGPT (mean ± SD), IU/L	22.12 ± 12.13	25.37 ± 17.86	**< 0.001**
SGOT (mean ± SD), IU/L	27.58 ± 21.51	31.81 ± 24.96	**< 0.001**
Insulin (mean ± SD), µIU/mL	12.96 ± 12.62	22.89 ± 19.33	**0.05**
c-Peptide (mean ± SD), ng/mL	2.80 ± 1.61	4.43 ± 7.55	**0.002**
TSH (mean ± SD), mIU/L	3.25 ± 5.72	3.19 ± 7.04	0.85
Cholesterol (mean ± SD), mg/dL	193.46 ± 39.53	193.58 ± 36.77	0.88
HDL (mean ± SD), mg/dL	46.70 ± 11.30	46.46 ± 11.19	0.63
LDL (mean ± SD), mg/dL	115.83 ± 32.89	114.13 ± 30.62	0.46
TG (mean ± SD), mg/dL	150.66 ± 71.68	158.17 ± 74 ± 65	**0.03**
Albumin (mean ± SD), g/L	4.34 ± 0.44	4.32 ± 0.44	0.27
Zn (mean ± SD), mg/dL	88.49 ± 24.63	89.08 ± 22.53	0.61
Vitamin B12 (mean ± SD), ng/mL	339.09 ± 222.04	334.86 ± 204.27	0.99
Vitamin D3 (mean ± SD), ng/mL	21.61 ± 19.14	24.06 ± 20.96	**0.01**
PTH (mean ± SD), pg/mL	52.01 ± 40.57	58.75 ± 36.47	**< 0.001**
Folic Acid (mean ± SD), ng/dL	9.80 ± 5.10	10.30 ± 6.04	0.38
Number of visit (n, %)	3.32 ± 2.45	3.28 ± 2.53	0.10
HOMA-IR (mean ± SD)	4.52 ± 4.74	7.22 ± 6.24	**0.003**
HOMA-β (mean ± SD)	79.25 ± 89.61	152.29 ± 220.11	**0.01**

Pre-op: Pre-operation, post-op: post-operation, n: number, EXWL: Excessive weight loss, Non-EXWL: without Excessive weight loss, SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass, WC: Waist Circumference, HP: Hip Circumference, Fat%: Fat Percentage, FFM: Fat free Mass, VFL: Visceral Fat Level, BMI: Body Mass Index, FBS: Fasting Blood Sugar, Hb: Hemoglobin, HbA1c: Hemoglobin A1c, HDL: high-density lipoprotein, LDL: Low-density lipoprotein, PTH: Parathyroid hormone, SGOT: Aspartate Transaminase, SGPT: alanine aminotransferase, TG: triglyceride, Zn: Zinc, HOMA-IR: homeostatic model assessment-insulin resistance, HOMA-β: homeostatic model assessment- β-cell function

Univariate analysis of effective factors on EWL

The univariate analysis based on types of surgery was done to answer the question if type of surgery should be considered as an effect modifier (Table 4).

Table 4
Univariate analysis of pre-op effective factors on post-op excessive weight loss

Pre-op characteristics		**SG** **n = 707**			**RYGB** **n = 1417**			**OABG** **n = 2090**			**P-Value**
		EXWL **(n = 25)**	**Non-EXWL** **(167) ***	**P-Value**	**EXWL** **(n = 108)**	**Non-EXWL** **(670)**	**P-Value**	**EXWL** **(n = 274)**	**Non-EXWL** **(974)**	**P-Value**	
Age (mean ± SD), year		33.92 ± 10.82	37.03 ± 10.71	0.15	34.65 ± 10.60	39.28 ± 10.37	**< 0.001**	35.91 ± 10.06	39.26 ± 1.00	**< 0.001**	0.41
Sex (n), %	Male	7(16.3)	57(23.5)	0.20	10(7.4)	134(18.1)	**0.001**	42(13.3)	245(22.6)	**< 0.001**	0.38
	Female	36(83.7)	186(76.5)		126(92.6)	606(81.9)		274(86.7)	840(77.4)		
BMI (mean ± SD), kg/m^2		39.87 ± 4.64	47.20 ± 7.22	**< 0.001**	41.26 ± 4.04	45.93 ± 5.57	**< 0.001**	41.16 ± 4.67	47.20 ± 6.47	**< 0.001**	0.36
WC (mean ± SD), Cm		110.23 ± 14.71	123.48 ± 17.09	**0.004**	115.54 ± 12.65	124.41 ± 14.18	**< 0.001**	114.81 ± 11.48	125.91 ± 14.35	**< 0.001**	0.28
HC (mean ± SD), Cm		127.67 ± 16.70	139.60 ± 16.22	**0.01**	130.99 ± 10.27	138.90 ± 12.83	**< 0.001**	130.40 ± 11.13	140.81	**< 0.001**	0.57
Fat mass (mean ± SD), %		45.96 ± 3.92	45.70 ± 5.81	0.87	48.39 ± 2.91	47.21 ± 5.07	0.41	47.30 ± 3.94	47.16 ± 5.79	0.50	0.29
FFM (mean ± SD), Kg		61.94 ± 16.65	70.28 ± 16.51	0.13	55.89 ± 4.49	64.62 ± 12.01	**< 0.001**	59.60 ± 7.16	66.99 ± 13.83	**< 0.001**	0.08
VFL (mean ± SD), Level		15.5 ± 10.23	18.37 ± 6.76	0.06	13.26 ± 2.10	15.88 ± 4.78	**0.01**	13.32 ± 3.57	16.88 ± 5.05	**< 0.001**	0.65
Alimentary limb (Mean ± SD), Cm		—	—	**—**	101.69 ± 34.72	106.72 ± 38.78	0.28	—	—	—	—
Biliopancreatic limb (Mean ± SD), Cm		—	—	**—**	79.33 ± 36.08	84.05 ± 39.58	0.30	184.24 ± 18.01	189.37 ± 16.85	**< 0.001**	**< 0.001**
Bougie Size (Mean ± SD), Cm	< 35	4(11.8)	6(3.1)	0.071	—	—	—	—	—	—	—
	35–40	27(79.4)	170(86.7)		—	—		—	—	—	
	≥ 40	3(8.8)	20(10.2)		—	—		—	—	—	
Emotional Eating (n), %		25 (58.1)	177 (72.8)	**0.041**	107(78.7)	529(71.5)	0.05	214(67.7)	797(73.5)	**0.028**	**0.002**
Psychiatric Problem (n), %		16(37.2)	84(34.6)	0.23	68(50.0)	322(43.5)	0.09	100(31.6)	337(31.1)	0.45	**0.006**
After surgery visit (Mean ± SD), n		2.92 ± 2.48	2.65 ± 2.68	0.59	1.62 ± 2.31	1.74 ± 2.34	0.13	3.80 ± 2.35	4.17 ± 2.27	**0.01**	**< 0.001**
Bleeding (n), %		0(0)	1(6.7)	0.83	0(0)	6(15.8)	0.22	3(8.3)	13(20.0)	0.11	0.72
Leak (n), %		1(33.3)	2(13.5)	0.44	2(20.0)	4(10.5)	0.36	2(5.6)	7(10.8)	0.31	**0.026**
Obstruction (n), %		—	—	**—**	5(50)	5(13.2)	**0.02**	1(2.8)	2(3.1)	0.71	**0.001**
Wound infection (n), %		0	0	**—**	1(10)	0(0)	0.20	0(0)	1(1.5)	0.64	0.10

Pre-op: Pre-operation, post-op: post-operation. EXWL: Excessive weight loss, Non-EXWL: without Excessive weight loss, SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass, WC: Waist Circumference, HP: Hip Circumference, Fat%: Fat Percentage, FFM: Fat free Mass, VFL: Visceral Fat Level, BMI: Body Mass Index, FBS: Fasting Blood Sugar, Hb: Hemoglobin, HbA1c: Hemoglobin A1c, HDL: high-density lipoprotein, LDL: Low-density lipoprotein, PTH: Parathyroid hormone, SGOT: Aspartate Transaminase, SGPT: alanine aminotransferase, TG: triglyceride, Zn: Zinc, HOMA-IR: homeostatic model assessment-insulin resistance, HOMA-β: homeostatic model assessment- β-cell function,

Pre-op characteristics	SG n = 707			RYGB n = 1417			OABG n = 2090			P-Value
	EXWL (n = 25)	Non-EXWL (167) *	P-Value	EXWL (n = 108)	Non-EXWL (670)	P-Value	EXWL (n = 274)	Non-EXWL (974)	P-Value	
Hb (mean ± SD), g/dL	13.64 ± 1.81	13.78 ± 1.50	0.60	13.43 ± 1.31	13.58 ± 1.51	0.40	13.44 ± 1.40	13.73 ± 1.58	**0.006**	0.81
Ferritin (mean ± SD), ng/mL	68.26 ± 39.5	80.91 ± 86.71	0.53	60.93 ± 67.00	75.18 ± 74.02	0.07	60.11 ± 62.97	85.03 ± 92.68	**< 0.001**	0.88
FBS (mean ± SD), mg/dL	96.15 ± 12.05	100.09 ± 18.99	0.58	106.51 ± 42.78	106.87 ± 32.07	0.09	103.73 ± 32.92	109.97 ± 35.98	**< 0.001**	0.46
HbA1c (mean ± SD), %	5.36 ± 0.53	5.63 ± 0.81	0.24	5.95 ± 1.50	6.03 ± 1.36	0.48	5.66 ± 1.19	5.91 ± 1.29	**< 0.001**	0.13
SGPT (mean ± SD), IU/L	22.45 ± 9.56	23.74 ± 11.74	0.93	22.25 ± 14.55	25.20 ± 19.92	**0.04**	22.05 ± 11.34	25.73 ± 17.32	**0.001**	0.98
SGOT (mean ± SD), IU/L	25.7 ± 15.11	30.12 ± 19.04	0.37	27.48 ± 25.90	31.17 ± 27.59	**0.01**	27.76 ± 20.16	32.48 ± 24.06	**0.004**	0.91
Insulin (mean ± SD), µIU/mL	9.00 ± 0	39.49 ± 39.25	0.44	6.22 ± 7.38	21.61 ± 13.01	**0.018**	15.00 ± 13.64	21.92 ± 17.88	0.065	0.46
c-Peptide (mean ± SD), ng/mL	—	4.59 ± 1.61	**—**	2.81 ± 2.91	4.40 ± 2.76	0.386	2.79 ± 1.19	4.43 ± 8.24	0.07	1
TSH (mean ± SD), mIU/L	2.46 ± 1.19	2.95 ± 39.25	0.60	3.21 ± 3.86	3.23 ± 7.52	0.75	3.33 ± 6.46	3.20 ± 7.25	0.72	0.79
Cholesterol (mean ± SD), mg/dL	190.95 ± 32.05	193.51 ± 38.04	0.68	190.6 ± 34.73	195.9 ± 38.61	0.339	194.69 ± 41.68	192.13 ± 35.32	0.49	0.65
HDL (mean ± SD), mg/dL	47.05 ± 12.31	45.74 ± 10.25	0.70	46.21 ± 10.04	47.49 ± 12.47	0.55	46.85 ± 11.69	45.92 ± 10.43	0.34	0.88
LDL (mean ± SD), mg/dL	110.50 ± 25.50	114.02 ± 33.55	0.65	115.85 ± 29.31	115.36 ± 31.88	0.84	116.21 ± 30.60	113.37 ± 29.31	0.29	0.76
TG (mean ± SD), mg/dL	144.14 ± 60.22	157.14 ± 68.99	0.38	138.94 ± 54.22	157.2 ± 74.40	**0.05**	155.44 ± 77.53	158.50 ± 75.75	0.22	0.45
Albumin (mean ± SD), g/L	4.41 ± 0.29	4.31 ± 0.45	0.16	4.31 ± 0.47	4.33 ± 0.46	0.91	4.34 ± 0.44	4.32 ± 0.43	0.33	0.49
Zn (mean ± SD), mg/dL	84.70 ± 50.71	86.66 ± 20.54	0.24	89.06 ± 26.48	91.49 ± 24.22	0.29	88.55 ± 21.42	88.04 ± 21.69	0.62	0.37
Vitamin B12 (mean ± SD), ng/mL	364.57 ± 274.77	338.64 ± 222.88	0.92	334.22 ± 173.22	324.56 ± 186.66	0.54	338.72 ± 229.09	338.89 ± 209.06	0.64	0.89
Vitamin D3 (mean ± SD), ng/mL	22.67 ± 19.06	22.87 ± 17.11	0.95	21.96 ± 21.15	24.80 ± 23.41	0.27	21.40 ± 18.46	23.82 ± 20.04	**0.02**	0.94
PTH (mean ± SD), pg/mL	46.60 ± 27.60	60.83 ± 35.64	0.24	53.55 ± 43.34	63.22 ± 39.73	**0.006**	51.58 ± 40.07	53.95 ± 32.54	0.12	0.83
Folic Acid (mean ± SD), ng/dL	8.38 ± 2.57	9.70 ± 4.94	0.86	9.79 ± 5.04	10.15 ± 4.80	0.48	10.02 ± 5.45	10.55 ± 7.17	0.68	0.70

Pre-op: Pre-operation, post-op: post-operation. EXWL: Excessive weight loss, Non-EXWL: without Excessive weight loss, SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass, WC: Waist Circumference, HP: Hip Circumference, Fat%: Fat Percentage, FFM: Fat free Mass, VFL: Visceral Fat Level, BMI: Body Mass Index, FBS: Fasting Blood Sugar, Hb: Hemoglobin, HbA1c: Hemoglobin A1c, HDL: high-density lipoprotein, LDL: Low-density lipoprotein, PTH: Parathyroid hormone, SGOT: Aspartate Transaminase, SGPT: alanine aminotransferase, TG: triglyceride, Zn: Zinc, HOMA-IR: homeostatic model assessment-insulin resistance, HOMA-β: homeostatic model assessment- β-cell function,

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	EXWL (n = 25)	Non-EXWL (167) *	P-Value	EXWL (n = 108)	Non-EXWL (670)	P-Value	EXWL (n = 274)	Non-EXWL (974)	P-Value	
HOMA-IR (mean ± SD)	2.1	9.70 ± 7.47	0.22	1.65 ± 1.08	7.30 ± 5.49	**0.002**	5.45 ± 5.15	7.03 ± 6.30	0.13	0.16
HOMA-β (mean ± SD)	77.14	406.47 ± 619.72	0.44	76.19 ± 136.94	116.41 ± 77.04	0.13	80.21 ± 82.91	140.32 ± 173.39	0.09	0.99
Pre-op: Pre-operation, post-op: post-operation. EXWL: Excessive weight loss, Non-EXWL: without Excessive weight loss, SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass, WC: Waist Circumference, HP: Hip Circumference, Fat%: Fat Percentage, FFM: Fat free Mass, VFL: Visceral Fat Level, BMI: Body Mass Index, FBS: Fasting Blood Sugar, Hb: Hemoglobin, HbA1c: Hemoglobin A1c, HDL: high-density lipoprotein, LDL: Low-density lipoprotein, PTH: Parathyroid hormone, SGOT: Aspartate Transaminase, SGPT: alanine aminotransferase, TG: triglyceride, Zn: Zinc, HOMA-IR: homeostatic model assessment-insulin resistance, HOMA-β: homeostatic model assessment- β-cell function,										

In patients underwent SG surgery, the prevalence of EXWL has a negative and significant association with pre-operation BMI, waist circumference (WC), hip circumferences (HC) and emotional eating habits (P value for all < 0.05) (Table 4).

For RYGB patients, younger age, female sex, lower pre-operation level of BMI, WC, HC, visceral fat and lower insulin resistance was related to more susceptibility to have EXWL. In addition, experience of obstruction, as an after-surgery complication, and absence of emotional eating before surgery were the effective factors in predicting EXWL (P value for all < 0.05) (Table 4).

In OAGB patients, similar to RYGB, the presence of EXWL has a positive and significant association with female sex, lower age, pre-operation BMI, WC, HC and visceral fat level. The OAGB subjects who has the lower level of Hb, ferritin, FBS, A1C, SGOT, SGPT and vitamin D3 level before surgery, had the more vulnerability to have EXWL at two years after surgery. The OAGB patients with EXWL had a significant lower follow up visit to obesity clinic (3.80 ± 2.35 vs. 4.17 ± 2.27, P value < 0.05) (Table 4). The association between EXWL and emotional eating, psychiatric problem, presence of leak obstruction and number of visits was significantly different among three type of surgery (P value for all < 0.05) (Table 4).

Multivariable analysis of effective factors on EXWL

Based on multivariable analysis using logistic regression, visceral fat level before surgery was a significant predictor of EXWL in SG and OAGB surgery patients (OR = 0.47; % CI: 0.32, 0.71) and (OR = 0.61; % CI: 0.43, 0.85), respectively. So that per level increase in visceral fat, decreases the probability of EXWL as 47% and 61% in SG and OAGB, respectively. In RYGB, BMI, fat free mass and TG Level before surgery were independent predictors of the EXWL two year after surgery (OR = 0.98; % CI: 0.97, 0.99), (OR = 0.88; % CI: 0.79, 0.97), (OR = 0.80; % CI: 0.65, 0.98) respectively. It means that each unit lower BMI, fat free mass and TG leads to 25%, 13% and 0.2% higher susceptibility to experience EXWL, respectively. However, for OAGB, fat percentage and visceral fat level were independent predictors for EXWL (OR = 0.27; % CI: 1.01, 1.60), (OR = 0.61; % CI: 0.43, 0.85) respectively. Potential confounder variables including age, BMI, waist and hip circumference were adjusted in multivariable analysis (Table 5).

Table 5
Multivariable Analysis[¥] of excessive weight loss pre-op Predictors

Type of Operation	Independent Variable (pre-op)	Odds Ratio (95% CI)	Model P-value, R-square
SG [a]	Visceral Fat Level	0.47 (0.32, 0.71)	< 0.001, 44.1
RYGB [b]	BMI	0.80 (0.65, 0.98)	< 0.001, 33.4
	Fat free mass	0.88 (0.79, 0.97)	
	TG	0.98 (0.97, 0.99)	
OAGB [C]	Visceral Fat Level	0.61 (0.43, 0.85)	< 0.001, 35.8
	Fat percentage	0.27 (0.19, 0.35)	
[¥]: Based on Logistic Regression			
[a] Adjusted for Age, BMI, waist, hip			
[b] Adjusted for visceral fat level and Hip Circumference			
c Adjusted for Ferritin, Vitamin D3			
SG: Sleeve Gastrectomy, RYGB: Roux-en-Y Gastric Bypass, OAGB: One anastomosis Gastric Bypass			

Discussion

The finding of present study showed that the most excess weight loss after surgery has taken place in 18 months after surgery in all three types of surgery. Weight loss trend after 6 months following surgery was differed based on type of surgery. The most susceptible subjects to EXWL were younger females who have lower BMI and underwent OAGB surgery.

Present study findings illustrated that aging could be a protective factor against EXWL. The fewer than 20 years old patients have the most prevalence of EXWL and mostly, one out of four patients under 20 has experienced EXWL. This finding was in line with Erkinuresin, T. et al study which found the younger age patients could have the more considerable EWL%. The decrease in lean body mass usually is together with increase in the fat mass in elderly peoples, a state defined as sarcopenic obesity which resulted from declining basal metabolic rates [20]. The more fat mass resulted in less EWL% and also the lower prevalence of EXWL, a status was seen in older patients. So, it is suggested that in under 20 and/or 30 years old morbid obese patient, with considering the probability of EXWL, the bariatric procedure must be chosen with more precaution.

This study showed that the most of EXWL patients were who has BMI < 40 (kg/m2). In particular in BMI < 35 individuals, 74% of patients have suffered from EXWL; while, only 1–2% of super or super-super obese patients have led to EXWL. This finding was consistent with recent study [21] that has indicated the lower BMI is accompanied with greater EWL after SG surgery. The patients with lower degree of obesity have less distance to reach the ideal weight and lower degree of insulin resistance [22]. More favorable metabolic syndrome parameters and greater insulin sensitivity could attenuate the weight loss resistance and speed up the bariatric induced weight reductions [23]. It was well shown in our study which suffering from EXWL was associated with before surgery patient’s metabolic status. In OAGB and RYGB, the lower before surgery insulin level, insulin resistance, FBS and A1C were related to greater EXWL. In addition, the elevated level of liver enzymes and TG were the predictor of lower probability of suffering from EXWL two year after surgery. Thus, the bariatric surgery team must consider the patient’s metabolic status. In metabolically healthy status such as the absence of diabetes, insulin resistance and/or dyslipidemia; the EXWL potential should be considered in tailoring the surgery procedure and even post-operation monitoring follow ups.

These results revealed that the patients with emotional eating habit had the lower EWL%, so they had the lower vulnerability to have EXWL. Similar to our results, the emotional eating was related to fewer EWL% in Hubert PA et al. study [24].

Although literature has shown the depressive and psychiatric problem improved significantly after bariatric surgery mainly due to body image dissatisfaction and self-esteem [25]. It seems that a small subset of psychiatric or depressive patients, almost 3–4%, have experienced worsening of their depressive status [26]. They have the increased risk of substance abuse [27], more frequent using hypnotics and/or sedatives medications [28], and even more engagement in suicide perception or self-harm after a bariatric surgery [29].

These subpopulation (accounted for 3–4%) were not associated with insufficient weight loss or weight regain after obesity surgery; but also, in the opposite way, they have the optimum or even the greater weight loss than others [26, 28, 29] which is in line with our findings. The prevalence of EXWL was greater in patients with psychiatric problem; although this was not statistically significant. Based on our case studies and clinical experiences, we believe that our data is not sufficient to conclude in this regard because our study was not focused on psychiatric problems and we may have been lost related data about psychiatric problems, specifically when such persons are not sufficiently cooperative in comparison with cases who are not involved. This finding indicates a need for thorough preoperative psychiatric history assessment and even postoperative surveillance with particular attention to mental health.

Among three types of surgery, the OAGB subjects were more vulnerable to have EXWL than SG and RYGB. In the recent studies [30–32], similar to our results the rate of EWL among SG and RYGB was not differed significantly.

Based on the finding of present study, the alimentary limb length has no effect on EXWL. This finding confirmed the results of Ahmed, B. et al study [33] which did not observe any association between alimentary and BPL length and the rate of EWL% in RYGB. About the BPL, in this study it seems that the shorter BPL Limb in OAGB was associated with more EXWL prevalence. It may be the consequence of shorter BPL was used in patients with lower pre-op BMI, so it leads to higher probability of EXWL in our finding. Despite, some studies recommend tailoring BPL based on the factors like BMI and indicated that BPL has an association with weight loss outcome[34], others emphasizes that BPL has no effect on weight loss, especially in non-super obese patients [35, 36]. Worth to notice that the large sample size in our study may resulted in the small BPL differences seems statistically significant, but this narrow BPL differences in point of clinical view has not considerable importance.

Moreover, the whole small bowel length has a large variation in persons and could have a significant effect on weight loss outcomes. In present and most of other similar studies, the whole small bowel length did not measure especially in OAGB [37, 38]. Most of the studies in field of SG surgery reported that the different bougie size had no effect on EWL% rate [39, 40], which this was confirmed in present study.

The serum concentration of some nutrient before surgery was associated to incidence of EXWL, especially in OAGB surgery which induces more considerable vitamin and mineral mal-absorption. The OAGB patient with lower level of ferritin and vitamin D3 had the higher probability to experience EXWL, two year after surgery. This finding was inconsistent with recent study, which is suggested the pre-bariatric lower serum Hb could result in the lower EWL [41]. In another study, A U-shaped relationship of Hb level with cardiovascular morbidity has been proposed in the general population [42]. Similarly, it seems that the lower Hb has a dual effect on EWL. So that, in one hand the presence of iron deficiency decreases the appetite and food intake through induces mood disorder and also reduces the ghrelin level [43] that could result in greater EWL and EXWL. On the other hand, the lower level of Hb and ferritin by reducing exercise endurance and aerobic capacity could prevent the optimal physical activity and then slow down the EWL after bariatric surgery [41]. This finding, therefore, highlighted the importance of evaluating and maintaining an optimal pre-Hb and ferritin levels before and after surgery. This subject, in addition to lower EXWL in cases with regular follow up after OAGB, highlights the importance of regular monitoring of patients after surgery.

The current study showed the lower pre-surgery vitamin D serum level in patients underwent OAGB increased the probability of after surgery EXWL. However, one study in this context suggested that vitamin D deficiency could have a negative effect on success weight loss and induced insufficient weight loss after bariatric operation [44]. Moreover, several studies illustrated that the vitamin D3 deficiency could result in insulin resistance and metabolic disorders. Therefore, metabolic disorder and insulin resistance decrease the rate of EWL and EXWL prevalence. However, the negative significant association between vitamin D3 and EXWL in this study may be the effect of large sample size which makes the small vitamin D3 differences seems significant. Otherwise, this small difference is not clinically considerable, particular when the mean vitamin D3 level in all groups is not in the deficient level.

In spite of successful and optimal weight loss correlates with better QOL due to better metabolically healthy status after bariatric surgery, we believe that EXWL could decreases the QOL as a result of Weakness, reduced strength and usual performance of EXWL patients, Based on our case studies and clinical experiences. However, we have not sufficient data at this regard and it was not possible to extract this kind of data from the database queried.

To the best of our knowledge the present article is the first study assessed the prevalence and determinant of EXWL following bariatric surgery. Some other strengths of this study were desirable large sample size which increase the power of analysis. The wide range of subjects regarding age and BMI in this study increase the generalizability of our findings and considering them in regression models eliminate the probably of their confounder effects. In this study, the three most prevalent bariatric surgeries were evaluated and compare regarding EXWL predictors. Using data from a nationwide obesity surgery registry, and multivariable analysis to determine the predictors of EXWL were also among strength points of this investigation. One limitation of this study was retrospective evaluation. In addition, some data which may affect the EWL% outcomes and EXWL vulnerability were unavailable for evaluation in this study. Including lifestyle factors, dietary pattern, smoking, alcohol or substance abuse, psychiatric problems, personality disorders, behavior habits, socioeconomic factors and physical activity of the participants. regarding the other aspect of eating disorder like binge eating or night eating there were not sufficient data to assess in this study. Moreover, the clinical characteristics and post-op biochemical parameters (i.e., Albumin) of EXWL subjects were not assessed in this study. Further study in this regard to compare the clinical and biochemical properties would be valuable to better clarify the clinical relevance of EXWL and even malnutrition patients.

In addition, future Study of different subpopulations of patients with more or less EXWL might reveal more clinically significance, and allow the possibly define a precise threshold that EXWL beyond which cut-off could be more detrimental and should consider as priority to intervention. Evaluation of the effect of various dietary pattern, physical activity level, alcohol or substance abuse and socioeconomic factors on EXWL are suggested in further studies.

Conclusion

Excessive weight loss is a rare consequence of bariatric surgery, but it can lead to a broad adverse consequence, patient's dissatisfaction, and poor QOL. Tailoring bariatric surgery procedure based on patient's age, preoperative BMI, preexisting T2D or insulin resistance symptoms, and the presence of any eating disorder such as emotional eating would result in, as much as possible, excellent results in weight loss outcomes and less EXWL in long term with minimal complications. Moreover, adjustment of surgical details should be performed especially and with more caution in younger females with a lower BMI and healthy metabolic status who are more prone to experience EXWL following bariatric surgery. In such a way that minimize weight loss speed/value. It may be possible by selection of other surgery procedures, rather than OAGB, lower limbs, bigger pouch size, and tighter follow ups and consultations of patients after surgery is emphasized for more EXWL vulnerable patients.

Declarations

Conflict of Interest Statement: The authors declared no conflicts of interest regarding the publication of the present article.

Ethical Approval Statement: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Statement:

Informed consent was obtained from all individual participants included in the study.

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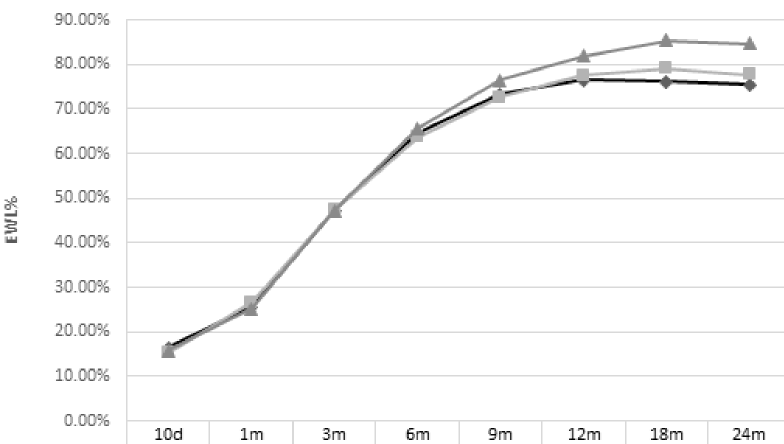
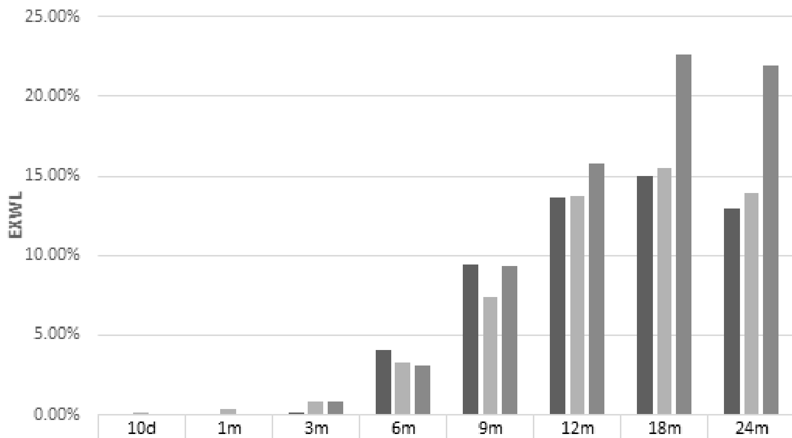
Figures



	10d	1m	3m	6m	9m	12m	18m	24m
Sleeve	16.46%	25.60%	47.21%	64.70%	73.41%	76.42%	76.17%	75.40%
Reny	15.37%	26.59%	47.34%	63.76%	72.66%	77.56%	79.07%	77.76%
OAGB	15.81%	25.27%	47.22%	65.66%	76.41%	81.86%	85.29%	84.67%

Figure 1

Excess weight loss trend in three types of bariatric surgery until two year after operation. EWL; Excess weight loss, Sleeve; Sleeve Gastrectomy, RYGB; Roux-en-Y Gastric Bypass, OAGB; One anastomosis Gastric Bypass.



	10d	1m	3m	6m	9m	12m	18m	24m
Sleeve	0.00%	0.00%	0.20%	4.10%	9.40%	13.60%	15.00%	13.00%
RenY	0.20%	0.40%	0.80%	3.30%	7.40%	13.70%	15.50%	13.90%
OAGB	0.10%	0.10%	0.80%	3.10%	9.30%	15.80%	22.60%	22.00%

Figure 2

Excessive Weight Loss prevalence in three types of bariatric surgery until two year after operation. EXWL; Excessive weight loss, Sleeve; Sleeve Gastrectomy, RYGB; Roux-en-Y Gastric Bypass, OAGB; One anastomosis Gastric Bypass.