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SURGERY FOR OBESITY AND RELATED DISEASES

Position statement

ASMBS Position Statement on medium- and long-term durability of weight loss and diabetic outcomes after conventional stapled bariatric procedures

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Preamble

The American Society issues the following position statement for Metabolic and Bariatric Surgery for the purpose of enhancing quality of care in bariatric surgery. In this statement, suggestions for management are presented that are derived from available knowledge, peer-reviewed scientific literature, and expert opinion. This was accomplished by performing a systematic review of currently available literature regarding weight outcomes after metabolic and bariatric surgery. The intent of issuing such a statement is to provide objective information regarding the durability of weight loss and diabetes improvement after metabolic and bariatric surgery. The statement may be revised in the future should additional evidence become available. This position statement is not intended to serve as training, a standard of care, or scientific consensus. It is the responsibility of professionals to determine individual patient variations when formulating a plan of care.

Obesity globally affects men and women of all races, economic backgrounds, and education status. It is both a multifactorial and chronic disease and, as such, patients who lose weight by any available means are at lifelong risk of recurrence. The 1991 National Institutes of Health consensus statement on surgery for obesity states that "severe obesity is a chronic intractable disorder; any therapeutic program must, therefore, be lifelong" [1]. Indeed, the most recent population survey showed an increase in weight over time between the ages of 20 and 60, with the incidence of obesity increasing from 34% before 40 years of age to 41% in patients 40 to 60 years old [2].

Bariatric and metabolic surgeries are the most effective treatments available for clinically severe obesity. However, severe obesity is a disease afflicted with substantial recidivism, as seen after medical weight loss and dieting programs [3,4]. Bariatric procedures are highly effective at achieving very significant weight loss over the first postoperative year, and their comparative effectiveness is often measured at that time point. This statement aims to report on the durability of weight loss ≥5 years after bariatric surgery.

The primary goal of these procedures is to provide sufficient weight loss to reduce health burden related to obesity. Indeed, a body mass index (BMI) >40 kg/m^2 carries a 3.7 × increased mortality risk in 20- to 49-year-old nonsmokers [5]. For a 20- to 30-year old, a BMI >45 kg/m^2 means an expected 13 years of life lost for males and 8 years for females [6]. The primary goal of bariatric surgery is therefore to provide sufficient weight loss to increase lifespan [7,8] and improve obesity-related

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co-morbidities, most predominantly diabetes [9,10]. We will therefore review the long-term weight loss results as well as improvement and resolution rates of diabetes after some of the more common current bariatric procedures currently approved by the American Society for Metabolic and Bariatric Surgery.

Definitions and methods

Significant variability exists in the way weight loss is reported among studies: percent excess weight loss (%EBWL) relies on a measurement of initial weight and determination of ideal weight. However, the values of initial weight and ideal weight, on which the calculation of %EBWL relies, are not uniform and can lead to wide variability in the meaning of reported outcomes. "Initial weight" can mean different things in different studies. It may reflect a measurement taken months before surgery or may reflect a measurement taken on the day of surgery. There is no established standard, and the method used to measure the initial weight is rarely specified in literature reports. A recent Clinical Issues Committee position statement on standardized outcomes reporting recommends using initial mean BMI of the cohort; change in BMI (ΔBMI) (ΔBMI = [initial BMI] – [postoperative BMI]); percent of total weight loss (%TWL): %TWL = ([Initial Weight]) – [Postoperative Weight]) / ([Initial Weight]) × 100); and percent excess BMI loss (%EBMIL): %EBMIL = (ΔBMI / [Initial BMI – 25] × 100); as well as reporting the weight most proximal to the time of surgery as the initial weight [11]. Studies published up to December 2017 were included. Studies were excluded if the number of patients at the end of the study period was <10.

Methods

Average excess weight loss for each time period was calculated across studies by weighing each study's average excess weight loss by the number of patients it included. Weighted averages of TWL and EBMIL were calculated in a similar fashion.

Long-term weight loss results

Roux en-Y gastric bypass

Long-term weight loss after Roux en-Y gastric bypass (RYGB) is detailed in Table 1.

Several studies were not included in this statement because the reported weight loss was depicted in a graph format without reporting of discreet data. The follow-up in the studies reported ranged from 5 to 25 years. The alimentary limb length ranged from 40 to 570 cm with most techniques describing a 75- to 150-cm limb. The biliopancreatic limb ranged from 10 to 200 cm with most techniques describing a 30- to 50-cm limb.

The %EBWL ranged from 42% to 93% (weighted average: 65%) at 5 years, from 42% to 69% (weighted average: 56%) at 6 to 9 years, from 52% to 82% (weighted average: 59%) at 10 years, from 49% to 59% (weighted average: 51%) at 14 years, and from 28% to 31% (weighted average: 28%) at 25 years (1 study with horizontal RYGB).

The %TWL ranged from 19% to 44% (weighted average: 33%) at 5 years, from 23% to 30% (weighted average: 26%) at 5 to 10 years, from 25% to 32% (weighted average: 28%) at 10 years, and from 19% to 27% (weighted average: 26%) at 11 to 15 years. The %EBMIL ranged from 58% to 74% (weighted average: 68%) at 5 years and from 53% to 71% (weighted average: 57%) at 10 years.

Laparoscopic sleeve gastrectomy

Long-term weight loss after laparoscopic sleeve gastrectomy (LSG) is detailed in Table 2.

Several groups have published their 5-year outcomes; unfortunately, it is consistently shown that the follow-up rates are very low after the first year.

Early results at 1- to 2-years follow-up have revealed %EBWL varying from 53% to 88% and %EBMIL from 58.5% to 81%. For the patients who did maintain a regular follow-up and were evaluated at 5 years, outcomes were 40% to 86% EBWL (weighted average: 58%) and 46% to 78.7% %EBMIL (weighted average: 68%).

Long-term results between 6 and 11 years were reported by several groups, with the biggest sample reported by Abdellatif et al. [12], following 519 patients and showing a consistent weight loss with %EBWL of 57% at 7-year follow-up. Arman et al. [13] reported the longest follow-up, at 11 years, following 47 patients and calculating %EBMIL at 62.5%. The majority of published papers showed %EBWL ranging from 46% to 76.6% (weighted average: 58%) at 6 to 10 years.

Biliopancreatic diversion and duodenal switch

Long-term weight loss results after biliopancreatic diversion (BPD) and duodenal switch (DS) are reported in Tables 3 and 4, respectively. Several published reports have reviewed the 10-year outcomes with better follow-up rates than reported with other bariatric procedures.

Early results at 1 year showed a %EBWL from 64.7% to 81.6% for BPD and 64% to 76% for DS, and it seems that those results are maintained long term with reports of %EBWL between 63.7% to 77.8% at ≥10 years for BPD (weighted average: 68%) and between 73% and 93.7% at 10 years for DS (weighted average: 81%).

Table 1
Long-term weight loss after gastric bypass.

Author (publication yr)	Country	Procedure	AL/BP limbs (cm) technique	Criteria	FU yr	N eligible patients	N FU patients	% FU	WL at 1 year	WL	% weight lost at 1 year maintained at end of f/u	T2D Remission* at ≥5 yr	WL criteria
Adams et al. (2012) [37]	USA	RYGB		Age 18–72	6	406	387	95		27.7%		62% at 6 yr normal A1C	%TWL
Adams et al. (2017) [35]	USA	RYGB		Age 18–72	12	392	353	90		26.9%		51% at 12 yr A1C <6.5	%TWL
Aftab et al. (2014) [38]	Norway	LRYGB	AL: 150 BP: 50	Age 20–60	5	203	184	91		59% 27% 58%		67% A1C <6.5	%EBWL %TWL %EBMIL
Alger-Mayer et al. (2009) [39]	USA	RYGB			6		20			52% 30.2%		-	%EBWL %TWL
Angrisani et al. (2013) [40]	Italy	LRYGB			10	24	21	87.5	51.3%	69%	134.5	-	%EBWL
Arterburn et al. (2013) [41]	USA	RYGB		Patients with T2D	5	4434	3006	67.8	-	-	-	37% A1C <6	-
Awad et al. (2012) [42]	Chile	Open RYGB and LRYGB comparison between banded and nonbanded	AL:150 BP:50 A: Banded B: Nonbanded		10	A: 49 B: 24	A: 34 B: 17	A: 69 B: 71		A: 81.7% B: 62.3%		-	%EBWL
Bhasker et al. (2015) [43]	India	LRYGB	AL: 250 BP: 50	Age 18–75 patients with T2D	5	106	90	85%	58.2%	61.4%	105.5	-	%EBWL
Boza et al. (2010) [44]	Chile	LRYGB	AL: 150 BP: 25–30		5	91	67	74%		92.9%		-	%EBWL
Brethauer et al. (2013) [45]	USA	LRYGB		Patients with T2D	6 (median)		162		66.8% 30.9%	60.5% 28.1%	90.6 90.9	31% A1C <6	%EBWL %TWL
Brolin et al. (2002) [46]	USA	Open RYGB comparison of 3 different Roux limbs	AL: A: 50–75 B: 150 C: 265–570 BP: 15–25	BMI >50	5		A: 88 B: 56 C: 22	A: 66% B: 64% C: 78%		A: 45% B: 51% C: 60%		-	%EBWL
Caiazzo et al. (2014) [47]	France	LRYGB		Patients with T2D	5	274	167	61%	60.5% 29.5%	51.6% 25.5%	85.3 86.4	-	%EBWL %TWL
Chen et al. (2016) [48]	USA	LRYGB			11 (median)	173	78	45%		66.5%		52.6% at 10 yr A1C <6	%EBWL
Christou et al. (2006) [49]	Canada	Open RYGB comparison of 2 different Roux limbs	69.5% AL: 40 BP: 10 30.5% AL: 100 BP: 100		11.4 (median)	272	161	59%		67.6%		-	%EBWL
Courcoulas et al. (2017) [50]	USA	LRYGB			7	1122	978	87%		28.4%			%TWL
Davies et al. (2015) [51]	USA	Open and LRYGB	AL:100–150 BP: 50		5	1457	232	16%	35%	34%	97.1	-	%TWL
Dogan (2014)[24]	The Netherlands	LRYGB	AL: 75–175 BP: 50	Patients with T2D	6.9 (mean)	89	52	58%		59.5% 26.3%		52% A1C <6	%EBWL %TWL

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Table 1 (*continued*)

Author (publication yr)	Country	Procedure	AL/BP limbs (cm) technique	Criteria	FU yr	N eligible patients	N FU patients	% FU	WL at 1 year	WL	% weight lost at 1 year maintained at end of f/u	T2D Remission* at ≥5 yr	WL criteria
Duvoisin et al. (2017) [52]	Switzerland	Open and LRYGB	AL: 100–150 BP: 30–50		10	625†	566†	91%†		65.8% 28.6%			%EBWL %TWL
Edholm et al. (2013) [53]	Sweden	Open and LRYGB			11.4 (med ian)	539	384	71%		63.3%		-	%EBMIL
Fobi (1993) [54]	USA	Open RYGB			10	100	46	46%		55%		-	%EBWL
Gleysteen (2009) [55]	USA	Open RYGB comparison of 3 different Roux limbs	AL A: 41–61 B: 130–160 C: 115–250 BP: 18–30		5	344	169	49%		A 12.7 (BMI <50) 14.7 (BMI >50) B 13.9 (BMI <50) 20.8 (BMI >50) C: 16.2 (BMI <50) 21.7 (BMI >50)		-	dBMI
Golzarand et al. (2017) [56]	Iran	RYGB meta-analysis			5–10 >10		1427 27			13.75 14.75		-	dBMI
Gullick et al. (2015) [57]	USA	LRYGB			5	663	118	18%	67.3% 37.1%	60.7% 33.3%	90.2 89.8	-	%EBWL %TWL
Gunther et al. (2006) [58]	Germany	Open RYGP comparison of 3 different techniques	AL: 40 A: Stapled horizontal RYGB B: Transected horizontal RYGB C: Horizontal gastroplasty		25	A: 33 B: 129 C: 33	A: 8 B: 62 C: 2	A: 24% B: 48% C: 6%	A: 59.2% B: 49.1% C: −3.3%	A: 31.1% B: 27.5% C: 7.9%		-	%EBWL
Higa et al. (2011) [59]	USA	LRYGB	AL: 100–150		10	242	65	27%		57.1% 28.8% 66.4%		-	%EBWL %TWL %EBMIL
Himpens et al. (2012) [60]	Belgium	LRYGB	AL: 150 BP: 50		9.4 (mean)	126	77	61%		62.9%		-	%EBMIL
Jones (2000) [61]	USA	RYGB	AL: 60–90 BP: 60–90		10	71	36	51%	78%	62%	79.5	-	%EBWL
Kothari et al. (2017) [62]	USA	LRYGB	AL: 50–75 BP: 30–40		10	244	191	78%		56%		30% at 6 yr A1C <6	%EBWL
Kruger et al. (2014) [63]	USA	LRYGB	AL: 75–100 BP: 45		7–9		46			55%		-	%EBWL
Lager et al. (2017) [64]	USA	LRYGB			7	64	28	44%	31.8%	23.6%	74.2	-	%TWL
Langer et al. (2013) [65]	Austria	LRYGB comparing circular versus linear staplers	A: circular B: linear		5	150		A: 81% B: 76%	70.9%	70.2%	99	-	%EBMIL
Laurino Neto et al. (2012) [66]	Brazil	Open banded RYGB			7.5 (mean)		140	37%		69.3%		77% FBS <126	%EBWL
Lee et al. (2015) [67]	Taiwan	LRYGB	AL: 150 BP: 100		5	519	218	42%		69.6% 28.5%		-	%EBWL %TWL
Lemmens (2017) [68]	Belgium	LRYGB compared with banded LRYGB	AL: 100 BP: 50–75 A: LRYGB B: Banded LRYGB		5	A: 254 B: 178	A: 227 B: 158	A: 89% B: 89%	A: 71.9% B: 75.2%	A: 65.2% 35.4% B: 74% 43.9%	90.7 99.1	-	%EBWL %TWL

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Table 1 (*continued*)

Author (publication yr)	Country	Procedure	AL/BP limbs (cm) technique	Criteria	FU yr	N eligible patients	N FU patients	% FU	WL at 1 year	WL	% weight lost at 1 year maintained at end of f/u	T2D Remission* at ≥5 yr	WL criteria
Leyba et al. (2014) [69]	Venezuela	LRYGB	AL: 150		5	75	47	63%		69.8%		-	%EBWL
Lim et al. (2014) [70]	USA	LRYGB	AL: 100 BP: 30–60	Naval Medical Center	5	42	12	29%	72%	68.3%	94.9	-	%EBWL
Maciejewski et al. (2016) [71]	USA	RYGB		VA study	10	700	573	82%	31%	28.6%	92.3	-	%TWL
Mathus-Vliegen (2006) [72]	The Netherlands	RYGB			11.7 (mean)		35			34.6% 18.6%		-	%EBWL %TWL
Mehaffey et al. (2016) [73]	USA	Open RYGB (51.5%) LRYGB (48.5%)			10	1087	651	60%	35.8% 71%	27.7% 52.5%	77.4 73.9		%TWL %EBMIL
Mingrone et al. (2015) [26]	Italy	RYGB		Age 30–60 patients with T2D	5	19	19	100%		28.4%		37% A1C ≤6.5	%TWL
Nergaard et al. (2014) [74]	Iceland	LRYGB comparing 2 different BP lengths	A AL: 150 BP: 60 B AL: 60 BP: 200		7	187	110	59%		A: 67.1% B: 78.4%		A: 71% B: 77% A1C ≤6.5	%EBMIL
Obeid et al. (2016) [75]	USA	LRYGB	AL: 100–150 BP: 50–100		10–13	294	134	46%	61.9% 33.6% 74.2%	58.9% 31.6% 70.7%	95.2 94 95.3	58% at 10 yr A1C ≤6.5	%EBWL %TWL %EBMIL
Obeid et al. (2012) [76]	USA	LRYGB	AL: 100–150 BP: 40		6.25 (median)	770	172	22%		65%		82%	%EBWL
Pajecki et al. (2015) [77]	Brazil	Open RYGB		Age >60	5.9 (mean)		46			68% (60–65 yr) 72% (>65 yr)		77% A1 C ≤6.5	%EBWL
Pekkarinen et al. (2016) [78]	Finland	LRYGB		Age <65	5 (median)	163	134	82%		42.1% 19.1%		-	%EBWL %TWL
Perrone et al. (2017) [79]	Italy	LRYGB	AL: 150 BP: 75		5	142	141	99%	55.8%	72.3%	129.6	-	%EBWL
Pories et al. (1995) [14]	USA	Open RYGB	AL: 60 BP: 40–60		14	574	553	96%	68.9%	49.2%	71.4	-	%EBWL
Risstad et al. (2015) [80]	Norway and Sweden	LRYGB	AL: 150 BP: 50	BMI 50–60 age: 20–50	5	31	27	87%		26.4%		-	%TWL
Rutledge et al. (2012) [81]	USA	RYGB		VA study age <65	5		45		58.6%	49.3%	84.1	-	%EBWL
Salinas et al. (2009) [82]	Venezuela	SRVGB	AL: 100 BP: 35–45		5	160	133	83%		83%		-	%EBWL
Schauer et al. (2017) [23]	USA	LRYGB			5	50	49	98%		21.8%		29% A1C <6	%TWL
Sima et al. (2016) [83]	Sweden	RYGB	AL: 70–120 BP: 50		5	593	489	82%		70% (median) 30% (median)		-	%EBWL %TWL
Sjöström (2013) [84]	Sweden	RYGB		BMI >34 (M) BMI >38 (W) Age 37–60	10 15	265	180 37	68%		25% 27%		-	%TWL

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Table 1 (*continued*)

Author (publication yr)	Country	Procedure	AL/BP limbs (cm) technique	Criteria	FU yr	N eligible patients	N FU patients	% FU	WL at 1 year	WL	% weight lost at 1 year maintained at end of f/u	T2D Remission* at ≥5 yr	WL criteria
Skroubis et al. (2014) [85]	Greece	Open RYGB compared with open long-limb RYGB	A: open RYGB AL: 100 BP: 60 B: long-limb RYGB BP: 150–200 CC: 100	BMI 35–50	8		A: 38 B: 38		A: 73.7% B: 83.1%	A:64.5% B:71.5%	A: 87.5 B: 86	-	%EBWL
Smith et al. (2011) [86]	USA	LRYGB comparing 2 different circular staplers	A: 21 mm B: 25 mm		5	261	A: 47 B: 28	29%		A: 62.7% (74.2%) B: 57.5% (65.9%)		-	%EBWL (%EBMIL)
Spivak et al. (2012) [87]	USA	LRYGB	AL: 80–120 BP: 35–45		7	77	56	73%		58.6%		-	%EBWL
Sugerman et al. (2003) [88]	USA	Open RYGB			10–12	361	135	37%	66% 35%	52% 28%	78.8 80	-	%EBWL %TWL
Suter et al. (2011) [89]	Switzerland	LRYGB	AL: 100–150 BP: 20–30		5	379	360	95%		62.7% 72.1%		-	%EBWL %EBMIL
Thereaux et al. (2015) [90]	France	LRYGB	AL: 120–150 BP: 30–40		5		45			68.4% 30.8%		-	%EBWL %TWL
Valezi et al. (2013) [91]	Brazil	Open banded RYGB	AL: 100 BP: 50		10	211	116	55%	67.6%	65.3%	96.6	-	%EBWL
Velcu et al. (2005) [92]	USA	Open long-limb RYBP	AL: 150–270		5	57	41	72%	60.7%	57.5%	94.7	-	%EBWL
White et al. (2005) [93]	New Zealand	Open banded RYGB	AL: 70 BP: 40–60		14	342	133	39% (> 5 yr FU)	88.5%	58.5%	66.1	-	%EBWL
Wood et al. (2016) [94]	USA	RYGB			9.3 (median)	1033	726	70%		50.2% 22.5%		-	%EBWL %TWL
Zarate et al. (2013) [95]	Mexico	Banded versus nonbanded RYGB	AL: 150 BP: 50 A: banded B: nonbanded		5	60	A: 22 B: 21	72%		A: 61.6% B: 59.8%		-	%EBWL
Zhang et al. (2014) [96]	China	LRYGB	AL: 150 BP: 75		5	32	28	87.5%		76.2%		-	%EBWL
Total						20378 20228‡	13218 12351‡	62%‡					

AL = alimentary limb; BP = biliopancreatic limb; FU = follow-up; WL = weight loss; T2D = type 2 diabetes; RYGB = Roux-en-Y gastric bypass; %TWL = percent total weight loss; LRYGB = laparoscopic RYGB; %EBWL = percent excess body weight loss; %EBMIL = percent excess body mass index loss; BMI = body mass index; dBMI = delta in body mass index; FBS = fasting blood sugar; VA = Veterans Affairs; SRVGB = silastic ring vertical gastric bypass; M = men; W = women; CC = common channel length.

*T2D remission data are provided for studies that evaluated patients with chemical markers. Remission assumes no diabetic medication use. The specific A1C threshold used by the study to define remission, if provided, is listed.

†These numbers include a small group of patients with revisional surgery, but the weight loss results refer only to primary cases.

‡Based on studies that report both eligible and follow-up patients.

Table 2
Long-term weight loss after laparoscopic sleeve gastrectomy.

Author (publication yr)	Country	FU yr	N eligible patients	N FU patients	% FU	Weight loss at 1–2 yr	Weight loss (at end of FU)	% weight lost at 1 yr maintained at end of FU	T2D Remission at ≥5 yr*	Criteria used by the authors
Abbatini et al. (2013) [97]	Italy	5	-	13	-	-	55.9 ± 20.5		76.9% A1C ≤6.5	%EBWL
Abdellatif et al. (2014) [12]	Egypt	7	-	519	-	53%	57%	107.5	-	%EBWL
Alexandrou et al. (2015) [98]	Greece	5	25	25	100	65.2 ± 6.1	56.4 ± 5.8%	86.5	66% A1C <6.5	%EBWL
Alvarenga et al. (2016) [99]	USA	8	-	81	-	86 ± 22.3%	52 ± 9.2%	60.5	-	%EBWL
Aminian et al. (2016) [100]	USA	5	154	134	87	20.9 ± 9.3%	16.8 ± 9.7% 42.6 ± 27.1%		26% A1C <6%	%TBWL %EBWL
Aridi et al. (2016) [101]	Lebanon	7	18	14	77.8	-	76.6 ± 21%		37.5% A1C <6	%EBWL
Arman et al. (2016) [13]	Belgium	11	90	47	52	-	62.5%		-	%EBMIL
Boza et al. (2014) [102]	Chile	5	161	112	70	88%	62.9%	71.5	-	%EBWL
Braghetto et al. (2012) [103]	Chile	5	-	60	-	84.8%	57.3%	67.6	-	%EBWL
Casella et al. (2016) [104]	Italy	7	178	148	81	70.4%	67.3%	95.6	83.8% at 6 yr A1C ≤6.5	%EBWL
Catheline et al. (2013) [105]	France	5	57	45	79	54.4%	53.7%	98.7	-	%EBWL
D'Hondt et al. (2011) [106]	Belgium	6	-	23	-	81.51%	55.9 ± 25.55%	68.6	-	%EBWL
Del Genio et al. (2016) [107]	Italy	5	-	36	-	-	56%		-	%EBWL
Eid et al. (2012) [108]	USA	8	41	21	51	-	46%(super-obese patients; BMI >50)		-	%EBWL
Felsenreich et al. (2016) [109]	Austria	10	32	32	100	71 ± 25%	53 ± 25%	74.6	-	%EBWL
Gadiot et al. (2017) [110]	Netherland	8	30	26	87	-	53.9%		-	%EBMIL
Golomb et al. (2015) [111]	Israel	5	56	39	69.6	76.8%	56.1%	73.0	20% A1C <6	%EBWL
Hirth et al. (2015) [112]	USA	7	16	14	87.5	-	59.6 ± 89.9%		-	%EBWL
Kehagias et al. (2013) [113]	Greece	5	27	21	77.7	79.2%	57.6%	72.7	-	%EBWL
Keren et al. (2016) [114]	Israel	5	123	32	26	-	49.1 ± 19.6% 45.3 ± 19.5%		-	%EBMIL %EBWL

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Table 2 (*continued*)

Author (publication yr)	Country	FU yr	N eligible patients	N FU patients	% FU	Weight loss at 1–2 yr	Weight loss (at end of FU)	% weight lost at 1 yr maintained at end of FU	T2D Remission at ≥5 yr*	Criteria used by the authors
Lemanu et al. (2015) [115]	New Zealand	5	93	55	59	56%	40%	71.4	-	%EBWL
Lim et al. (2014) [70]	USA	5	15	14	93	64.7%	57.4%	88.7	-	%EBWL
Musella et al. (2014) [116]	Italy	5	175	102	58	61.4%	68.1%	110.9	-	%EBWL
Noel et al. (2017) [117]	UAE	8	145	116	80	81%	67%	82.7	43.4% at 8 yr A1C <6	%EBMIL
Perrone et al. (2016) [118]	Italy	5	162	161	99.4	75%	78.8 ± 23.5%	105.1	-	%EBMIL
Pok et al. (2016) [119]	Taiwan	5	119	61	51.2	76%	72.6%	95.5	-	%EBWL
Prevot et al. (2013) [120]	France	5	118	95	81	-	46 ± 26%		-	%EBWL
Rawlins et al. (2013) [121]	USA	5	55	49	89	-	86% (super super-obese patients (BMI >65)		100% A1C <6	%EBWL
Ruiz-Tovar et al. (2016) [122]	Spain	5	50	47	94	81.8%	78.7%	96.2	69.2% A1C <6	%EBWL
Saif et al. (2012) [123]	USA	5	-	30	-	58.5%	46.1%	78.8	-	%EBMIL
Sarela et al. (2012) [124]	UK	8	20	13	65	76%	69%	90.8	-	%EBWL
Sieber et al. (2014) [125]	Switzerland	5	60	54	91	61.5 ± 23.4%	57.4 ± 24.7%	93.3	85% A1C <6	%EBMIL
Van Rutte et al. (2014) [126]	The Nether-lands	5	-	19	-	68.4%	58.3%	85.2	-	%EBWL
Zhang et al. (2014) [96]	China	5	32	26	81	73.9%	63.2 ± 24.5%	85.5	88.9% at 5 yr	%EBWL
Total			2052 2052†	2284 1503†	73†					

FU = follow-up; T2D = type 2 diabetes; %EBWL = percent excess weight loss; %TWL = percent total weight lost; %EBMIL = percent excess body mass index lost; BMI = body mass index.

*T2D remission data are provided for studies that evaluated patients with chemical markers. Remission assumes no diabetic medication use. The specific A1C threshold used by the study to define remission, if provided, is listed.

†Based on studies that report both eligible and follow-up patients.

Table 3
Long-term weight loss after BPD.

Author (publication year)	Country	FU yr	Number of eligible patients	Number of FU patients	% FU	Weight loss at 1–2 yr	Weight loss (at end of FU)	% weight lost at 1 yr maintained at end of FU	Diabetes resolution	Criteria used by the authors
Ballestros-Pomar et al. (2016) [127]	Spain	10	42	34	64.7	64.7%	63.7%	98.5	-	%EBWL
Larrad et al. (2007) [128]	Spain	10	- modified BPD with long alimentary limb	29 MO 36 SO	-	81.6 ± 16.1% MO 70.2 ± 16.7% SO	77.8 ± 11.2% MO 63.2 ± 11.8% SO	90.0 MO 95.3 SO	98%	%EBWL
Marinari et al. (2004) [129]	Italy	14	-	60	-	67 ± 18%	69 ± 15%	103	100%	%EBWL
Total			42 (if reported)	159	n/a					

BPD = biliopancreatic diversion; FU = follow-up; %EBWL = percent excess weight loss; MO: morbidly obese (body mass index <50 kg/m^2), SO = super-obese (body mass index >50 kg/m^2); n/a = not applicable.

Long-term resolution of diabetes

In 1995, Pories et al. [14], described remission of type 2 diabetes (T2D) after RYGB, occurring within days of surgery and persisting with an 82.9% remission rate at 14 years. Although the exact mechanism of action of bariatric surgery on diabetes is unknown, it is understood that a variety of complex neuroendocrine and metabolic changes involved in glucose homeostasis occur as a direct result of surgical manipulation of the gastrointestinal tract, which appear independent of weight loss. In 2002, Rubino and Gagner [15] furthered the concept of bariatric surgery as metabolic surgery for the primary treatment of diabetes and discussed the role that the foregut and changes in gastrointestinal hormones might play in insulin resistance. Since then, a substantial body of evidence has accumulated, including numerous randomized controlled trials (RCTs), some with long-term follow-up, showing that metabolic surgery achieves superior glycemic control and reduction of cardiovascular risk factors in obese patients with T2D compared with various lifestyle/medical interventions [16] resulting in the development of new position statements and guidelines, including the International Federation of Diabetes 2011 guidelines, which formally recognized bariatric surgery as an appropriate treatment for T2D in patients with clinically severe obesity but also as an "an alternative treatment option in patients with a BMI between 30 and 35 kg/m^2 when diabetes cannot be adequately controlled by optimal medical regimen, especially in the presence of other major cardiovascular disease risk factors" [17]. These recommendations are also supported by recent published guidelines from the American Diabetes Association, which recommend metabolic surgery for all patients who are appropriate surgical candidates with a diagnosis of T2D and a BMI $\geq$40 kg/m^2 regardless of the complexity of the glucose-lowering regimen [18], and by the American Association of Clinical Endocrinologists in collaboration with the American College of Endocrinology [19], reflecting a major shift in the treatment algorithm of T2D in the United States.

The majority of outcomes data after bariatric surgery has historically been presented as observational studies reflecting short- and medium-length follow-up with high rates of remission of many obesity-related diseases, including T2D, hypertension, and lipid disorders [20,21]. These benefits have been associated with reduced mortality and increased long-term survival, previously reviewed and published in 2015 as the American Society for Metabolic and Bariatric Surgery position statement on long-term survival benefit after metabolic and bariatric surgery [22]. Data from emerging studies with longer-term follow-up of $\geq$5 years have revealed several trends regarding long-term maintenance of T2D remission after bariatric surgery: remission rates vary depending on the primary procedure type, long-term relapse of T2D is possible, long-term remission rates

Table 4
Long-term weight loss after DS.

Author (publication yr)	Country	FU yr	Number of eligible patients	Number of FU patients	% FU	Weight loss at 1–2 yr	Weight loss (at end of FU)	% weight lost at 1 year maintained at end of FU	Diabetes resolution	Criteria used by the authors
Aasprang et al. (2016) [130]	Norway	10	50	38	76	-	66.2%		-	%EBMIL
Anthone et al. (2003) [131]	USA	5	701	50 (20 MO, 30 SO)	-	69% (76% MO, 64% SO)	66% (71% MO, 63% SO)	95.7	-	%EBWL
Bolckmans et al. (2016) [132]	Belgium	10	153	113	78.5%	-	93.7 ± 24.4%		87.5% at 10 y	%EBWL
Hess et al. (2005) [133]	USA	10	182	167	92%	-	75%			%EBWL
Marceau et al. (2015) [134]	Canada	20	383	313	82%	-	70.9 ± 20%	Same weight loss at 15 and 20 yr	93.4% at >5 yr	%EBWL
Michaud et al. (2016) [135]	Canada	7.1 ± 4.1	105 (age <55) 105 (age >60)	102 104	97% 99%	-	73% 68%		91.7% 83.3% at mean (7.1 4.1 yr)	%EBWL
Strain et al. (2017) [136]	USA	9	228	68	30%	70.7%	76.8%	108.6	100% at 9 yr	%EBWL
Topart et al. (2017) [137]	France	10	80	64	88%	-	73.4 ± 26.7%		-	%EBWL
Total			1987 (if reported)	906	46%*					

DS = duodenal switch; FU = follow-up; %EBMIL = percent excess body mass index lost; %EBWL = percent excess weight loss; MO = morbidly obese (body mass index <50 kg/m^2), SO = super-obese (body mass index >50 kg/m^2).

*Based on studies that report both eligible and follow-up patients.

after any bariatric surgery far surpasses that of best medical management, and bariatric surgery may prevent de novo development of diabetes.

Remission rates vary depending on the primary procedure type

Buchwald et al. [20] reported findings from a large systematic review and meta-analysis of 22,094 patients documenting resolution of T2D in 84% of patients who underwent RYGB and 98% of patients who underwent BPD and DS. In a subsequent systematic review and meta-analysis in 2009, looking more specifically at weight loss and T2D after bariatric surgery, Buchwald et al. [21] reported on data from 19 studies involving 11,175 patients. Overall, 78.1% of diabetic patients had complete resolution, and diabetes was improved or resolved in 86.6% of patients up to 2 years after surgery with no significant difference just beyond 2 years. The resolution of T2D was again greatest for patients undergoing BPD/DS, followed by RYGB, and least for laparoscopic adjustable gastric band [21]. Consistent with previously published studies with short- or midlength follow-up, remission of T2D at ≥5 years is greatest with BPD and DS, followed by RYGB and LSG, as can be seen in Tables 1 to 5 with resolution ranges of 98% to 100% after BPD, 87.5% to 100% after DS, 29% to 82% after RYGB, and 9% to 85% after LSG.

Long-term relapse of T2D after bariatric surgery is possible

Although long-term durability of T2D remission is reported after bariatric surgery, the longer-duration studies have also brought to light the possibility of relapse, regardless of procedure type, although the recurrence of T2D appears to be lowest with BPD/DS. Relapse, however, did not necessarily imply poor control and/or insulin requirement. Schauer et al. [10,23] recently reported 5-year results from the STAMPEDE trial, an RCT comparing bariatric surgery to best medical management of T2D, with a primary endpoint of A1C of ≤6% off medications, and noted a change in percent of patients meeting the primary endpoint compared with the 3-year follow-up, 38% to 29% in the RYGB group and 24% to 23% in the LSG group. More than 88% of the surgical patients, however, had glycemic control that was considered to be very good to acceptable (mean A1C 7.0%), without the use of insulin. They also reported, similar to other studies [24–26], the relevance of the presurgical length of T2D diagnosis, as duration of T2D of <8 years was the main predictor of achieving an A1C level of ≤6.0%, emphasizing the importance of earlier intervention. Although there was some reported weight regain in all cohorts between the 3- and 5-year follow-up, relapse of poor glycemic control was not associated with weight regain in the surgical cohorts. Other observational studies, however, have associated weight regain and/or degree of achieved weight loss with relapse of T2D after bariatric surgery [24,27]. Conversely, data from medical weight loss studies have shown benefit from even modest weight loss of 5% to 10% of initial weight with significant reduction of cardiovascular risk factors [28,29]. Therefore, even in situations of poor or less than expected weight loss after bariatric surgery, there may not be universal return of metabolic disorders. Aminian et al. [30] looked at the long-term metabolic outcomes of 31 patients with T2D with post-RYGB weight loss of ≤25% and reported findings after mean follow-up of 6 years (range, 5–9 yr); remission and clinical improvement of diabetes occurred in 7 (23%) and 13 (42%) patients, respectively. Finally, the value of any sustained period of metabolic normalization/glycemic control in regard to micro- and macrovascular complications cannot be underscored and needs to be further evaluated in the postbariatric population. Large long-term prospective studies such as the United Kingdom Prospective Diabetes Study ([31], Diabetes Control and Complications Trial [21], and Epidemiology of Diabetes Interventions and Complications (long-term follow-up of Diabetes Control and Complications Trial patients) [32] trials have demonstrated a "legacy effect" [33] or sustained benefit with respect to cardiovascular disease outcomes seen long after the conclusion of the trial. Periods of tight glycemic control were associated with reduced risk for any diabetes-related endpoint, long-term all-cause mortality and myocardial infarction [33]. These findings were also reported by Sjöström et al. [34] in 2014, where cumulative incidence of microvascular and macrovascular complications remained significantly reduced in the surgical cohort compared with usual treatment, despite a reduction in T2D remission from 72.3% to 30.4% over a 15-year period.

A recent prospective study compared 418 patients who underwent RYGB, 417 patients who sought but did not undergo surgery, and 321 patients who did not seek surgery, over 12 years. The study demonstrated that the surgery group not only had maintained weight loss at 12 years with minimal weight regain between years 6 and 12 but that diabetes remission was 75% at 2 years, 62% at 6 years, and 51% at 12 years [35].

Long-term remission rates after any bariatric surgery far surpasses that of best medical management

There are several ongoing RCTs comparing diabetic outcomes after bariatric surgery and medical management. At the current time, we report findings from 2 RCTs, 3 prospective cohort studies, and 1 systematic review with meta-analysis. The findings from these high-level studies reveal significant and sustainable remission and improvement of T2D after bariatric surgery compared with best medical management. Schauer et al. [23] and Sjöström et

Table 5
Long-term follow-up of diabetes remission: RCTs, prospective cohort, and systematic reviews.

Author (publication yr)	Procedure	Total N	Follow-up	Study type	Diabetes	Biochemical definition of remission
Adams et al. (2017) [35]	RYGB	1156 418 (surgical) 417 (nonsurgical 1) 321 (nonsurgical 2)	12 yr	Nonmatched cohort	OR 8.9 (95% CI 2.0–40.0) surgery versus nonsurgery 1 and 14.8 (95% CI 2.9–75.5) versus nonsurgery 2	
Bolen et al. (2012) [138]	Mixed	2108 (surgery) 2108 (control)	5 yr	Matched cohort	OR .31, 95% CI .26–0.38	
Mingrone et al. (2015) [26]	RYGB, BPD	Control = 20 LRYGB = 20 DS = 20	5 yr	RCT	50% Res in surgery group versus 0% in control	A1C <6.5%
Schauer et al. (2017) [23]	RYGB, LSG, Medical	134 = 90% FU	5 yr	RCT	5% Res in medical versus 29% Res (RYGB; $P = 0.01$) 23% Res (LSG P = 0.03)	A1C <6% off all medications
Sjöström et al. (2014) [34]	AGB, VBG, RYGB	Control n = 260 Surgery n = 343	15 yr	*P*, matched cohort	Res 6.5% (control) versus 30.4% (surgery)	Blood glucose <110 mg/dL and no diabetes medication
Yan et al. (2016) [36]	RYGB versus Medical	410 (6 RCTs) = 210 (surgery) 206 (medical)	Up to 5 yr	Meta-analysis, systematic review	56.81% (surgery) versus 0% (medical) (OR: 76.37, 95% CI: 20.70–281.73, $P < .001$)	A1C 5.7%–6.5% off all medications

RCT = randomized control trial; RYGB = Roux-en-Y gastric bypass; OR = odds ratio; CI = confidence; BPD = ; LRYGB = laparoscopic RYGB; DS = ; Res = resolution; FU = follow-up; LSG = laparoscopic sleeve gastrectomy; AGB = adjustable gastric band; VGB = vertical gastric band.

al. [34] reported T2D remission rates of 5% and 6.5%, respectively, in the nonsurgical groups, whereas Mingrone et al. [26] and Yan et al. [36] reported 0% remission. The findings from such studies have supported the significant change in the treatment algorithm for T2D by the American Diabetes Association and the American Association of Clinical Endocrinologists in collaboration with the American College of Endocrinology, as previously mentioned. Adams et al. [35] reported their 12-year results, and the adjusted odds ratio for remission was 8.9 for the surgery group versus patients who sought but did not undergo surgery, and 14.8 for the surgery group versus patients who did not seek surgery. The odds ratio for the incidence of T2D at 12 years was .08 and .09 versus the 2 nonsurgery groups [35].

Conclusions

The studies reviewed here encompass over 12,000 RYGB patients, 2000 LSG patients, and 1000 BPD and/or DS patients with long-term weight loss. The results reported confirm that bariatric surgery is the most effective treatment currently available at reducing significant excess weight in patients with severe obesity. Current data summarized here show long-term persistence of significant weight lost ≥5 years after bariatric surgery.

Weighted average weight loss reported in these studies were as follows:

- 5 years
  - RYGB: 65% EBWL (range, 42%–93%; N = 2988)
  - LSG: 58% EBWL (range, 40%–86%; N = 953)
  - DS: 66% EBWL (N = 50)
- 6 to 9 years
  - RYGB: 56% EBWL (range, 42%–69%; N = 1421)
  - LSG: 58% EBWL (range, 46%–77%; N = 865)
  - DS: 72% EBWL (range, 68%–77%; N = 274)
- 10 years
  - RYGB: 59% EBWL (range, 52%–82%; N = 795)
  - LSG: 53% EBWL (N = 32)
  - BPD: 68% EBWL% (range, 63%–78%; N = 99)
  - DS: 81% EBWL (range, 73%–94%; N = 344)
- >10 years
  - RYGB: 51% EBWL at 14 years (range, 49%–59%; N = 686)
  - LSG: 28% EBWL at 25 years (range, 28%–31%; N = 70)
  - BPD: 69% EBWL at 14 years (N = 60)
  - DS: 71% EBWL at 20 years (N = 313)

Data demonstrate that although weight loss decreases moderately over time, the majority of patients will maintain most of their weight lost over a period of ≥10 years after RYGB and BPD and/or DS and ≥5 years after LSG.

Multiple RCTs have demonstrated high remission rates of diabetes after bariatric procedures compared with best medical management. Recent studies have confirmed that these remissions can be long lasting with >50% of patients still in remission 12 years after RYGB.

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