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Standard vs Distal Roux-en-Y Gastric Bypass in Patients With Body Mass Index 50 to 60

A Double-blind, Randomized Clinical Trial

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IMPORTANCE Up to one-third of patients undergoing bariatric surgery have a body mass index (BMI) of more than 50. Following standard gastric bypass, many of these patients still have a BMI greater than 40 after peak weight loss.

OBJECTIVE To assess the efficacy and safety of standard gastric bypass vs distal gastric bypass in patients with a BMI of 50 to 60.

DESIGN, SETTING, AND PARTICIPANTS Double-blind, randomized clinical parallel-group trial at 2 tertiary care centers in Norway (Oslo University Hospital and Vestfold Hospital Trust) between May 2011 and April 2013. The study included 113 patients with a BMI of 50 to 60 aged 20 to 60 years. The 2-year follow-up was completed in May 2015.

INTERVENTIONS Standard gastric bypass (alimentary limb, 150 cm) and distal gastric bypass (common channel, 150 cm), both with a biliopancreatic limb of 50 cm and a gastric pouch of about 25 mL.

MAIN OUTCOMES AND MEASURES Primary outcome was the change in BMI from baseline until 2 years after surgery. Secondary outcomes were cardiometabolic risk factors, nutritional outcomes, adverse events, gastrointestinal symptoms, and health-related quality of life.

RESULTS At baseline, the mean age of the patients was 40 years (95% CI, 38-41 years), 65% were women, mean BMI was 53.5 (95% CI, 52.9-54.0), and mean weight was 158.8 kg (95% CI, 155.3-162.3 kg). The mean reduction in BMI was 17.8 (95% CI, 16.9-18.6) after standard gastric bypass and 17.2 (95% CI, 16.3-18.0) after distal gastric bypass, and the mean between-group difference was 0.6 (95% CI, −0.6 to 1.8; $P = .32$). Reductions in mean levels of total and low-density lipoprotein cholesterol were greater after distal gastric bypass than standard gastric bypass, and between-group differences were 19 mg/dL (95% CI, 11-27 mg/dL) and 28 mg/dL (95% CI, 21 to 34 mg/dL), respectively ($P < .001$ for both). Reductions in fasting glucose levels and hemoglobin A_{1c} were greater after distal gastric bypass. Secondary hyperparathyroidism and loose stools were more frequent after distal gastric bypass. The number of adverse events and changes in health-related quality of life did not differ between the groups. Importantly, 1 patient developed liver failure and 2 patients developed protein-caloric malnutrition treated by elongation of the common channel following distal gastric bypass.

CONCLUSIONS AND RELEVANCE Distal gastric bypass was not associated with a greater BMI reduction than standard gastric bypass 2 years after surgery. However, we observed different changes in cardiometabolic risk factors and nutritional markers between the groups.

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In the United States, up to one-third of patients undergoing bariatric surgery have a preoperative body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) of more than 50.[1] Laparoscopic Roux-en-Y gastric bypass is a commonly used bariatric procedure that leads to sustained weight loss and improves weight-related disease. The average percentage of body weight loss appears to be remarkably consistent across patient cohorts and range of BMIs.[2-7] This may help explain the observation that among patients with very high BMI, many still experience morbid obesity after a gastric bypass procedure.[8-10] We have previously shown that 5 years after standard gastric bypass, more than half of the patients with initial BMI of 50 to 60 had a BMI of more than 40.[11]

Different modifications of gastric bypass have been used to improve weight loss and outcome with regard to obesity-related diseases in patients with very high BMI. However, few randomized studies have been undertaken to compare the outcomes obtained with different lengths of the intestinal limbs involved (the alimentary limb, biliopancreatic limb, and common channel).[12-14] Empirical findings with various gastric bypass limb lengths suggest that there exists a delicate balance between greater weight loss, with its associated health benefits, and the risk of surgical complications, diarrhea, and nutritional deficiencies.[15-17] Distal gastric bypass refers to a variant of gastric bypass where the distance from the small bowel anastomosis (enteroenteroanastomosis) to the ileocecal valve is short, giving a short common channel. Distal gastric bypass could lead to greater weight loss and greater improvements of comorbid conditions compared with standard gastric bypass, but possibly at the cost of greater adverse nutritional effects. To our knowledge, this has not previously been tested in a randomized clinical study.

We therefore conducted a randomized clinical trial of standard and distal gastric bypass in patients with a BMI between 50 and 60. We aimed to test the hypothesis that BMI loss would be larger after distal gastric bypass than standard gastric bypass. We also compared the effects of the procedures with regards to cardiometabolic risk factors, nutritional outcomes, adverse events, health-related quality of life, and gastrointestinal adverse effects.

Key Points

Question What is the difference in body weight loss during 2 years after either standard or distal Roux-en-Y gastric bypass in patients with severe obesity?

Findings In this double-blind, randomized clinical trial that included 113 patients with a body mass index of 50 to 60, the body mass index loss was 17.8 two years after standard gastric bypass and 17.2 two years after distal gastric bypass, a nonsignificant difference.

Meaning Distal gastric bypass was not associated with a greater body mass index reduction than standard gastric bypass 2 years after surgery.

Methods

Trial Design and Participants

The methods applied in our double-blind, parallel-group randomized clinical trial of standard vs distal gastric bypass have previously been described in a report of perioperative outcome.[18] Briefly, all referred patients aged 18 to 60 years with a BMI of 50 to 60 were assessed for inclusion at 2 tertiary care centers in Norway between May 2011 and April 2013. Patients with previous bariatric or major abdominal surgery, previously diagnosed urolithiasis, chronic liver disease, other severe somatic illness, or psychiatric diseases or substance abuse were excluded. The 2-year follow-up was completed in May 2015.

We used permuted-block randomization with random blocks of 4 and 6 generated by a person not involved in patient treatment. Eligible patients were randomly assigned to undergo either standard gastric bypass or distal gastric bypass in a 1:1 allocation ratio. Patients, follow-up study personnel at the outpatient clinic, clinicians providing outpatient follow-up care, and the statistician were unaware of treatment allocation.

The study was approved by the Regional Ethics Committees for Medical and Health Research. The formal trial protocols can be found in Supplement 1. All patients provided written and informed consent.

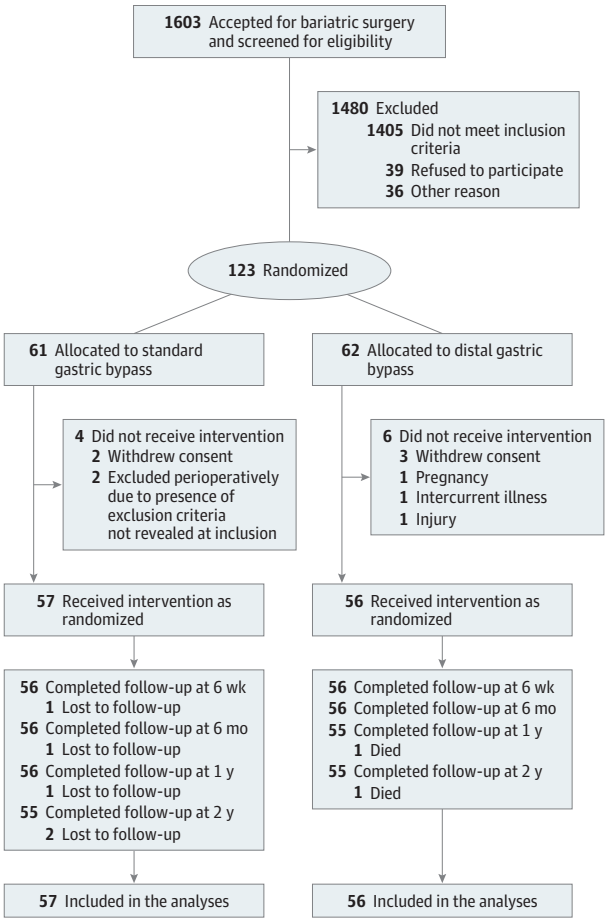
Interventions and Follow-up

All patients followed a low-calorie diet (approximately 1000 kcal/d) 3 weeks prior to surgery. An antegastric antecolic Roux-en-Y configuration with a gastric pouch of about 25 mL and a biliopancreatic limb of 50 cm were constructed during both procedures. The standard gastric bypass included an alimentary limb of 150 cm, whereas the distal gastric bypass had a common channel of 150 cm (eFigure 1 in Supplement 2). Identical vitamin and mineral supplementation was prescribed to both groups: oral daily supplementation with 1-tablet multivitamins, 1000-mg calcium carbonate, 800-IU vitamin D_3, and 65- to 200-mg iron. Intramuscular injections of 1 mg vitamin B_{12} were given every third month. Daily oral supplementation with 500 mg ursodeoxycholic acid was prescribed for 6 months postsurgery to reduce the risk of gallstone formation. Follow-up included a physical examination and blood tests at 6 weeks, 6 months, 1 year, and 2 years after surgery.

Body weight, fat mass, and fat-free mass were measured to the nearest 0.1 kg using a calibrated digital scale (Tanita-BC 418 MA; Tanita Corporation) with the patient wearing light clothing and no shoes. Height was measured with a fixed stadiometer.

Venous blood samples were obtained after an overnight fast. Comorbidities were assessed, and medications and supplements were adjusted according to predefined treatment algorithms. Blood pressure was measured 3 times in the sitting position after a few minutes of rest, and the last 2 measurements were averaged. Hypertension was defined as either systolic blood pressure of at least 140 mm Hg, diastolic blood pressure of at least 90 mm Hg, or the use of antihypertensive medication.[19] Type 2 diabetes was defined as hemoglobin A_{1c} (HbA_{1c}) level of at least 6.5% (to convert to proportion of total hemoglobin, multiply by 0.01) or the use of glucose-lowering medication.[20] Complete remission of type 2 diabetes was defined as HbA_{1c} level of 6.0% or lower and fasting glucose level

Figure 1. Flow of Patients Through Recruitment and Follow-up



less than 101 mg/dL (to convert to millimoles per liter, multiply by 0.0555), and partial remission was defined as as HbA_{1c} level less than 6.5% and fasting glucose level of 101 to 124 mg/dL, both assuming no use of glucose-lowering drugs for at least a year.[21] Metabolic syndrome was defined according to established criteria.[22] The presence of sleep apnea was based on previously confirmed diagnosis. Secondary hyperparathyroidism was defined as parathyroid hormone greater than upper reference limit (>66 pg/mL; to convert to nanograms per liter, mulitply by 1) in the absence of hypercalcemia. Iron deficiency was defined as ferritin levels less than 15 ng/mL (to convert to picomoles per liter, multiply by 2.247).

Adverse Events

All adverse events requiring intervention from 30 days postoperatively until 2 years were included regardless of whether they were judged related to the initial procedure or not. Information regarding adverse events (medical visits, examinations, operations, or hospital admissions) was retrieved from all patients at each study visit. Earlier complications have previously been reported and are excluded here because differing surgical experiences of the 2 procedures might bias the findings.[18] The classification of adverse events was performed without prior knowledge of the assigned treatment.

Patient-Reported Outcome Measures

The patients completed the Gastrointestinal Symptoms Rating Scale and a bowel function questionnaire to assess gastrointestinal symptoms and bowel habits at 2 years.[23,24]

Generic health-related quality of life was assessed using validated Norwegian versions of the Short Form-36 Health Survey and scored with certified software (QualityMetric Health Outcomes Scoring Software 4.0/4.5).[25]

Sample Size

The sample size estimates have been described elsewhere.[18] We calculated that 88 patients would give a power of more than 80% to detect a BMI difference between groups of 3.0 at follow-up (α = .05). To allow for possible dropouts, we included 113 patients in total.

Statistical Analyses

We fitted linear mixed models to all continuous outcomes with repeated measurements. Each model contained fixed effects for treatment, time (measured in weeks after surgery), treatment × time interaction, and a random intercept. The time development was modeled as piecewise linear with a knot at 1 year after surgery, such that the models allowed for 1 development from baseline to 1 year after surgery and another development from 1 year to 2 years after surgery. Based on the linear mixed models, we estimated mean treatment group values with 95% CIs for 2 time points: baseline and 2 years after surgery. We also estimated the mean group changes from baseline to 2 years and the between-group difference in change from baseline to 2 years. The Fisher mid-*P* test (2 categories) or the Fisher-Freeman-Halton test (more than 2 categories) was used to compare independent proportions. Patient-reported gastrointestinal symptoms were analyzed with the Mann-Whitney *U* test or independent-samples *t* test. A 2-sided 5% level of significance was used for all analyses. We used Stata 13.1 (StataCorp LP) and IBM SPSS Statistics for Windows, version 22.0, to perform the statistical analyses (IBM Corporation).

Results

One hundred thirteen patients received treatment as randomized; 57 receiving a standard gastric bypass and 56 receiving a distal gastric bypass (**Figure 1**). Baseline characteristics are presented in **Table 1**. At baseline, there was a random imbalance between patients with type 2 diabetes (13 vs 18 patients in the standard and distal gastric bypass group, respectively). The 2-year follow-up rate was 97% (110 of 113 patients).

The mean reduction in BMI was 17.8 (95% CI, 16.9-18.6) after standard gastric bypass and 17.2 (95% CI, 16.3-18.0) after distal gastric bypass, and the mean between-group difference was 0.6 (95% CI, −0.6 to 1.8; *P* = .32) (**Table 2**, **Figure 2**). Mean total weight loss was 35.1% (95% CI, 32.1%-38.1%) after standard gastric bypass and 34.0% (95% CI, 32.1%-35.9%) after distal gastric bypass (*P* = .54). Similarly, excess BMI lost was 66.1% (60.5%-71.7%) and 63.6% (60.0%-67.3%) (*P* = .46).

Comorbidities and Cardiometabolic Risk Factors

Total and low-density lipoprotein cholesterol decreased more after distal gastric bypass compared with standard gastric bypass (Figure 2, Table 2), while high-density lipoprotein cholesterol increased more after standard gastric bypass. The reductions in fasting triglycerides did not differ between the groups. The reductions in fasting serum glucose and in HbA_{1c} were greater after distal than standard gastric bypass (Table 2, Figure 2). Of patients with type 2 diabetes at baseline, 9 of 11 with standard gastric bypass (82%) and 12 of 16 with distal gastric bypass (75%) achieved complete remission, 1 (9%) vs 3 (19%) had partial remission, and 1 patient in both groups still had type 2 diabetes at follow-up (P = .81 between groups). At 2 years, 1 patient with standard gastric bypass was taking metformin, whereas all other patients had stopped using glucose-lowering medication. No patients developed new-onset type 2 diabetes.

There were no differences in changes in systolic and diastolic blood pressure across the groups (Table 2). Of patients with hypertension at baseline, 26 of 34 with standard gastric bypass (77%) and 14 of 34 with distal gastric bypass (41%) did not have hypertension at 2 years (P = .004 between groups). Furthermore, 16 of 20 patients (80%) and 17 of 25 patients (68%) had stopped using antihypertensive medication after standard and distal gastric bypass, respectively (P = .41). Ten of 16 patients (63%) and 10 of 13 patients (77%) using continuous positive airway pressure for obstructive sleep apnea at baseline had stopped the treatment 2 years after standard and distal gastric bypass, respectively (P = .34). At 2 years, 38 of 44 patients (86%) and 34 of 47 patients (72%) no longer fulfilled the criteria for the metabolic syndrome after standard and distal gastric bypass, respectively (P = .10 between groups). No patients developed new-onset metabolic syndrome.

Nutritional Outcome and Adverse Events

There was no difference in the reported use of vitamin and mineral supplements between the groups at 2 years (eTable 1 in Supplement 2). Changes in mean concentrations of some of the vitamins were different in the 2 groups, but for all measured vitamins, the mean concentrations were either stable or increased from baseline to 2 years (eTable 2 in Supplement 2). We observed a larger increase in the mean concentration of parathyroid hormone after distal gastric bypass as opposed to standard gastric bypass (eTable 2 in Supplement 2). At 2 years, 19 of 54 patients (35%) had secondary hyperparathyroidism after standard gastric bypass compared with 32 of 53 patients (60%) after distal gastric bypass (P = .01). The mean concentrations of hemoglobin and ferritin were reduced without between-group differences. Two patients who had distal gastric bypass developed severe iron deficiency that was treated by either blood transfusions or iron injections (**Table 3**). At 2 years, 11 of 54 patients (20%) with standard gastric bypass and 8 of 52 patients (15%) with distal gastric bypass had iron deficiency (P = .53). Two of 54 patients (4%) in the standard gastric bypass group and 5 of 52 patients (10%) in the distal gastric bypass group had albumin levels below reference values (P = .19). One patient in the standard gastric bypass group and 3 patients in the distal gastric bypass group developed protein-caloric malnutrition (Table 3). Two of the patients with distal gastric bypass had the elongation of the common channel reoperated on after 22 and 24 months, both with improved nutritional status. The third patient had liver cirrhosis not diagnosed prior to surgery and developed severe protein-caloric malnutrition and liver failure that did not improve after nutritional support and later died of liver failure 11 months after surgery. Overall, we found no statistically significant differences between the groups with regard to adverse events, but patients with standard gastric bypass had more hospital admissions than patients with distal gastric bypass (Table 3).

Table 1. Observed Baseline Data by Treatment Group

Characteristic	Gastric Bypass	
	Standard (n = 57)	Distal (n = 56)
Demographics		
Age, mean (SD), y	38.2 (9.2)	41.3 (8.3)
Sex, women, No. (%)	36 (63.2)	37 (66.1)
Race/ethnicity, white, No. (%)	57 (100)	55 (98)
General measures, mean (SD)		
BMI	53.3 (2.6)	53.6 (3.3)
Weight, kg	160.2 (19.9)	157.4 (17.3)
Height, cm	173 (10)	171 (10)
Waist circumference, cm	146 (14)	144 (11)
Blood pressure, mm Hg		
Systolic	131 (16)	137 (17)
Diastolic	80 (11)	81 (10)
Fasting laboratory values		
Cholesterol, mean (SD), mg/dL		
Total	199 (41)	204 (34)
LDL	124 (34)	129 (32)
HDL	44 (8)	45 (7)
Triglycerides, mean (SD), mg/dL	157 (79)	157 (66)
Glucose, mean (SD), mg/dL	106 (34)	114 (34)
Hemoglobin A_{1c}, mean (SD), %	5.9 (1.4)	6.0 (0.9)
Medical conditions, No. (%)		
Type 2 diabetes[a]	13 (22.8)	18 (32.1)
Use of glucose-lowering medication	10 (17.5)	14 (25.0)
Insulin users	3 (5.3)	2 (3.6)
Duration type 2 diabetes, median (range), y	4.0 (0-21)	2.5 (0-16)
Hypertension[b]	36 (63.2)	35 (62.5)
Use of antihypertensive medication	22 (38.6)	26 (46.4)
Use of lipid-lowering medication	4 (7.0)	9 (16.1)
Sleep apnea	21 (36.8)	19 (33.9)
CPAP use	17 (29.8)	13 (23.2)
Metabolic syndrome	47 (82.5)	51 (91.1)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CPAP, continuous positive airway pressure; HbA_{1c}, hemoglobin A_{1c}; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

SI conversion factors: To convert glucose to millimoles per liter, multiply by 0.0555; to convert HbA_{1c} to proportion of total hemoglobin, multiply by 0.01; to convert total cholesterol, LDL cholesterol, and HDL cholesterol to millimoles per liter, multiply by 0.0259; to convert triglycerides to millimoles per liter, multiply by 0.0113.

[a] Defined as HbA_{1c} level at least 6.5% and/or use of glucose-lowering medication.

[b] Defined as systolic blood pressure at least 140 mm Hg, diastolic blood pressure at least 90 mm Hg, and/or use of antihypertensive medication.

Table 2. Anthropometric Measures and Cardiometabolic Risk Factors

Outcome Variable	Mean (95% CI)	Change From Baseline to 2 y Postoperation, Mean (95% CI)	*P* Value for Within Group	Between-Group Difference in Change, Mean (95% CI)	*P* Value
BMI					
Standard GB					
Baseline	52.7 (51.7-53.6)	−17.8 (−18.6 to −16.9)	<.001		
2 y	34.9 (33.8-35.9)				
Distal GB				−0.6 (−1.8 to 0.6)	.32
Baseline	52.7 (51.8-53.6)	−17.2 (−18.0 to −16.3)	<.001		
2 y	35.6 (34.5-36.6)				
Weight, kg					
Standard GB					
Baseline	158.1 (154.0-162.3)	−54.1 (−56.8 to −51.3)	<.001		
2 y	104.1 (99.6-108.6)				
Distal GB				−3.2 (−7.1 to 0.7)	.11
Baseline	154.7 (150.5-158.9)	−50.8 (−53.6 to −48.1)	<.001		
2 y	103.9 (99.4-108.4)				
Waist circumference, cm					
Standard GB					
Baseline	146.1 (142.8-149.5)	−36.6 (−39.6 to −33.5)	<.001		
2 y	109.6 (106.2-112.9)				
Distal GB				−3.3 (−7.6 to 1.0)	.13
Baseline	143.3 (139.9-146.6)	−33.3 (−36.3 to −30.3)	<.001		
2 y	110.0 (106.7-113.3)				
Fat mass, kg					
Standard GB					
Baseline	78.8 (75.4-82.1)	−41.8 (−44.7 to −38.9)	<.001		
2 y	37.0 (33.8-40.1)				
Distal GB				−2.4 (−6.5 to 1.7)	.25
Baseline	79.8 (76.-83.1)	−39.4 (−42.2 to −36.5)	<.001		
2 y	40.4 (37.-43.6)				
Fat-free mass, kg					
Standard GB					
Baseline	81.2 (77.-84.9)	−14.0 (−15.4 to −12.7)	<.001		
2 y	67.2 (63.-70.8)				
Distal GB				−1.4 (−3.3 to 0.5)	.15
Baseline	77.0 (73.-80.8)	−12.6 (−14.0 to −11.3)	<.001		
2 y	64.4 (60.-68.1)				
Total cholesterol, mg/dL					
Standard GB					
Baseline	186 (-193)	−19 (−27 to −11)	<.001		
2 y	166 (-175)				
Distal GB				29 (17 to 41)	<.001
Baseline	182 (174-190)	−48 (−56 to −40)	<.001		
2 y	134 (125-142)				
LDL cholesterol, mg/dL					
Standard GB					
Baseline	117 (110-123)	−28 (−34 to −21)	<.001		
2 y	89 (82-96)				
Distal GB				20 (10 to 30)	<.001
Baseline	112 (106-119)	−48 (−54 to −41)	<.001		
2 y	64 (58-71)				

(continued)

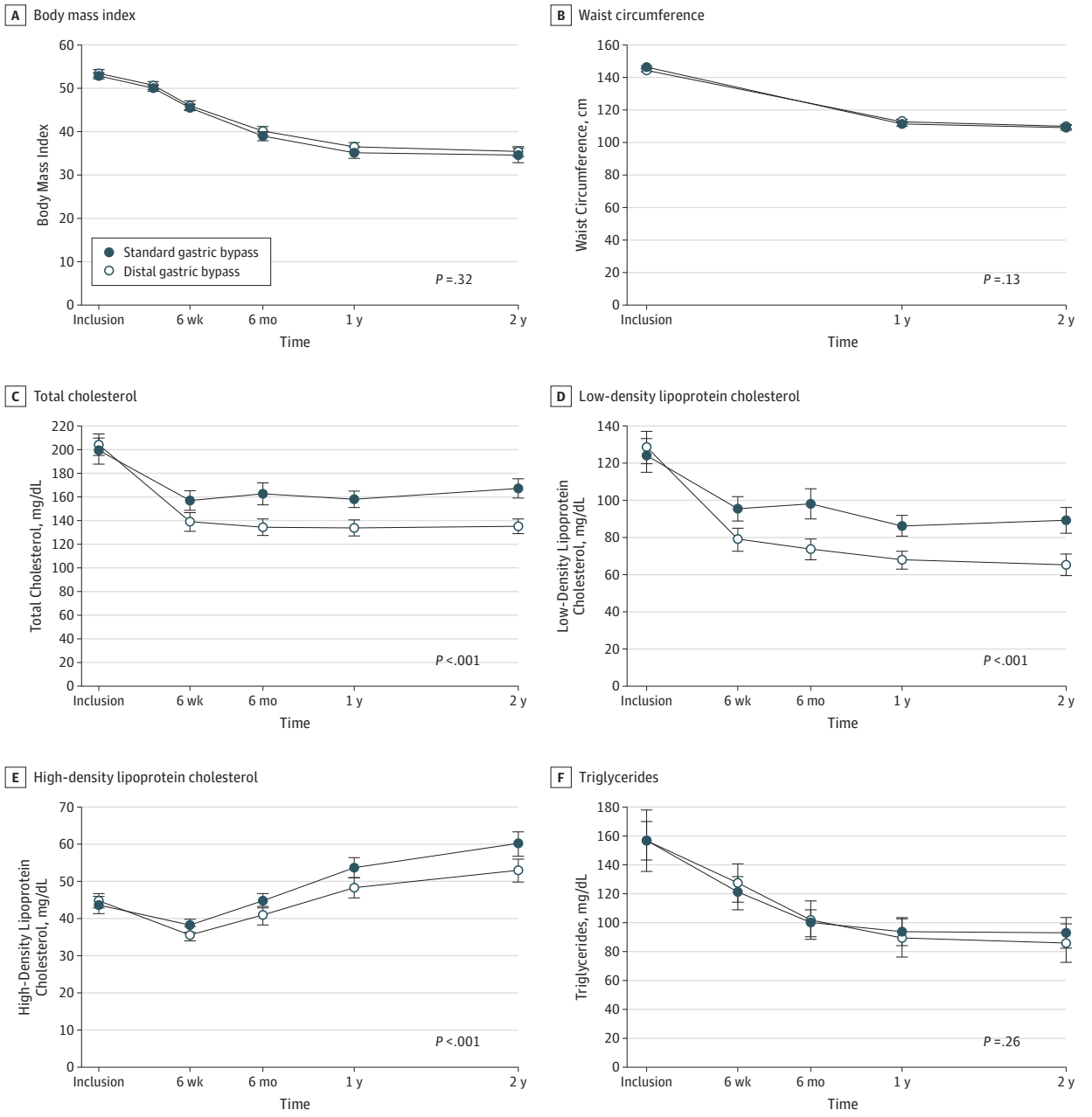
Table 2. Anthropometric Measures and Cardiometabolic Risk Factors (continued)

Outcome Variable	Mean (95% CI)	Change From Baseline to 2 y Postoperation, Mean (95% CI)	*P* Value for Within Group	Between-Group Difference in Change, Mean (95% CI)	*P* Value
HDL cholesterol, mg/dL					
Standard GB					
Baseline	40 (37-42)	20 (17-22)	<.001	8 (4 to 11)	<.001
2 y	59 (57-62)				
Distal GB					
Baseline	40 (38-42)	12 (10 to 14)	<.001		
2 y	52 (49-54)				
Total-HDL cholesterol ratio					
Standard GB					
Baseline	4.7 (4.4-4.9)	−1.8 (−2.0 to −1.5)	<.001	0.1 (−0.2 to 0.4)	.50
2 y	2.9 (2.7-3.2)				
Distal GB					
Baseline	4.6 (4.4-4.8)	−1.9 (−2.1 to −1.6)	<.001		
2 y	2.7 (2.5-3.0)				
Triglycerides, mg/dL					
Standard GB					
Baseline	148 (136-158)	−53 (−65 to −42)	<.001	10 (−7 to 26)	.26
2 y	94 (82-106)				
Distal GB					
Baseline	150 (138-160)	−63 (−74 to −51)	<.001		
2 y	87 (74-98)				
Systolic blood pressure, mm Hg					
Standard GB					
Baseline	129 (126-133)	−5 (−8 to −1)	.01	2 (−3 to 8)	.39
2 y	125 (-129)				
Distal GB					
Baseline	135 (-138)	−7 (−11 to −3)	<.001		
2 y	128 (-132)				
Diastolic blood pressure, mm Hg					
Standard GB					
Baseline	79 (77-81)	−1 (−4 to 1)	.35	−1 (−4 to 3)	.70
2 y	78 (75-80)				
Distal GB					
Baseline	81 (78-83)	−1 (−3 to 2)	.69		
2 y	80 (78-83)				
Glucose, mg/dL					
Standard GB					
Baseline	102 (97-107)	−13 (−17 to −8)	<.001	8 (1 to 14)	.03
2 y	89 (83-95)				
Distal GB					
Baseline	107 (102-113)	−20 (−25 to −16)	<.001		
2 y	87 (81-93)				
HbA_{1c}, %					
Standard GB					
Baseline	5.7 (5.6-5.9)	−0.4 (−0.6 to −0.3)	<.001	0.3 (0.1 to 0.5)	.02
2 y	5.3 (5.1-5.5)				
Distal GB					
Baseline	5.8 (5.6.-6.0)	−0.7 (−0.9 to −0.5)	<.001		
2 y	5.1 (4.9-5.3)				

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); GB, gastric bypass; HbA_{1c}, hemoglobin A_{1c}; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol.

SI conversion factors: To convert glucose to millimoles per liter, multiply by 0.0555; to convert HbA_{1c} to proportion of total hemoglobin, multiply by 0.01; to convert total cholesterol, LDL cholesterol, and HDL cholesterol to millimoles per liter, multiply by 0.0259; to convert triglycerides to millimoles per liter, multiply by 0.0113.

Figure 2. Time Profile of Observed Anthropometric Measures and Selected Cardiometabolic Risk Factors



P values are from modeled between-group changes from baseline to 2 years. To convert total, low-density lipoprotein, and high-density lipoprotein cholesterol to millimoles per liter, multiply by 0.259; to convert triglycerides to millimoles per liter, multiply by 0.0113.

Patient-Reported Outcomes

At 2 years, there were no between-group differences in the Gastrointestinal Symptoms Rating Scale symptom dimensions including diarrhea, indigestion, constipation, abdominal pain, or gastroesophageal reflux (eFigure 2A in Supplement 2). However, patients reported more frequent and loose stools and greater social limitations owing to bowel function after distal gastric bypass (eFigure 2B in Supplement 2). In general, health-related quality of life improved in both groups after surgery, with the highest increases in physical functioning and general health and with no between-group differences (eTable 3 in Supplement 2). The physical summary score was improved and the mental summary score was unchanged for both surgical groups, with no between-group differences.

Discussion

In contrast with our hypothesis, we observed no difference in weight reduction between standard and distal Roux-en-Y gas-

Table 3. All Adverse Events Requiring Intervention 30 Days to 2 Years After Standard and Distal Gastric Bypass

Event	Gastric Bypass, No. (%)		*P* Value
	Standard (n = 57)	Distal (n = 56)	
Total adverse events, No.	48	50	.83[a]
Patients with adverse events	32 (56)	28 (50)	.51
Operations related to the initial procedure, No.[b]	11	4	NA
Patients with operations related to the initial procedure	9 (16)	3 (5)	.10
Hospital admissions for all reasons, No.	30	17	.18[a]
Patients with hospital admissions	20 (35)	10 (18)	.04
Specification of adverse events			
Gastrointestinal			
Internal herniation	5 (9)	0	NA
Gastrojejunal ulcer	2 (4)	0	NA
Small-bowel obstruction	1 (2)	0	NA
Incisional hernia	1 (2)	3 (5)	NA
Acute liver failure	0	1 (2)	NA
Cholelithiasis	2 (4)	0	NA
Acute abdominal pain	0	1 (2)	NA
Chronic abdominal pain	2 (4)[c]	3 (5)	NA
Diarrhea	0	4 (7)	NA
Nausea/vomiting	0	2 (4)	NA
Other	2	4	NA
Nutritional			
Protein-calorie malnutrition	1 (2)	3 (5)[d]	NA
Anemia[d,e]	0	3 (5)	NA
Severe vitamin deficiency	0	3 (5)	NA
Other			
Hypoglycemia	1 (2)	5 (9)	NA
Urolithiasis	4 (7)	1 (2)	NA
Infectious disease	9 (16)	8(14)	NA
Other	11 (19)	7 (13)	NA

Abbreviation: NA, not applicable.

[a] *P* value from between-group comparison of mean events per patient.

[b] Events related to the initial procedure: internal herniation, small-bowel obstruction, cholelithiasis, incisional hernia, chronic abdominal pain, and protein-calorie malnutrition.

[c] One patient with chronic abdominal pain and protein-calorie malnutrition received enteral nutrition via a percutaneously positioned gastrostomy. The patient had 2 negative diagnostic laparoscopies.

[d] Patient 1 had liver cirrhosis unknown prior to surgery and developed protein-calorie malnutrition, vitamin deficiencies, and acute liver failure unresponsive to treatment. The patient died of liver failure (11 months). Patient 2 had protein-calorie malnutrition, diarrhea, and vitamin deficiencies treated with elongation of the common channel (22 months). Patient 3 had chronic abdominal pain and developed protein-caloric malnutrition and vitamin deficiencies during pregnancy treated with elongation of the common channel.

[e] Anemia in need of blood transfusion or iron injection.

tric bypass at 2 years. The study demonstrates that creating a distal gastric bypass with a common channel of 150 cm was not associated with greater weight loss or other anthropometric measures up to 2 years when the biliopancreatic limb was kept at 50 cm. This contrasts with the findings of most of the existing literature that addresses the importance of intestinal limb lengths on weight loss.[12,13] However, one small nonrandomized study found similar weight loss after comparing standard and distal gastric bypass with the same limb lengths as applied in our study.[26] Our findings also contrast reports of distal gastric bypass performed as a secondary procedure owing to insufficient weight loss after standard gastric bypass. However, in many series, other limb lengths than explored in the present study were applied.[27-29]

Studies suggest a critical limit of the common channel length at around 100 cm or less for developing severe nutritional adverse effects, although the threshold varies between individuals.[15,27] We used a common channel of 150 cm in an attempt to improve weight loss while lowering the risk of nutritional adverse effects. Although our observation of similar weight loss (51 kg) in the 2 surgical groups may indicate comparable macronutrient absorption, we observed more signs of malabsorption after distal gastric bypass including lower albumin levels, a higher prevalence of secondary hyperparathyroidism, and more patient-reported loose stools. Accordingly, we cannot exclude the possibility that patients who underwent distal gastric bypass surgery had a compensatory larger calorie intake or lower energy expenditure than patients who underwent standard gastric bypass. A distal gastric bypass variant with a longer biliopancreatic limb and a shorter alimentary limb[30] or a variant with shorter common channel may also induce greater weight loss but at the cost of greater nutritional adverse effects.[15,16,27,31]

We selected patients with a BMI between 50 and 60 because for patients with lower BMIs, weight loss is often considered sufficient after standard gastric bypass, and for patients with higher BMIs, other procedures may be considered necessary. In a previous randomized study of standard gastric bypass or duodenal switch in patients with a BMI of 50 to 60, we have reported significantly more weight loss after duodenal switch but at the expense of more adverse effects.[11,32-34] Because most bariatric surgeons have experience with gastric bypass, surgeons may consider distal gastric bypass a less technically challenging procedure than duodenal switch. Our variant of distal gastric bypass included a short biliopancreatic limb, which means that most of the small bowel still was kept in the digestive stream. In duodenal switch, the biliopancreatic limb is longer and the common channel shorter than in our variant of distal gastric bypass. Both these factors could contribute to explain the superior weight loss of duodenal switch over distal gastric bypass.

Except for more patients with hospital admissions after standard gastric bypass, we found no differences with regard to long-term adverse events or in changes in health-related quality of life between the groups. However, the risk of nutritional detrimental effects in our variant of distal gastric bypass should not be ignored. Two patients developed severe diarrhea and protein-caloric malnutrition after distal gastric bypass and required reoperation with prolongation of the common channel, and 1 patient with liver cirrhosis died of liver failure. These findings could illustrate an individual threshold for developing adverse effects and the need for close monitoring of patients. As described in our report on perioperative outcomes, all early reoperations were in the distal gastric bypass group, which may indicate different technical challenges or surgeon-related experience with the techniques.[18]

Serum total cholesterol and low-density lipoprotein cholesterol levels declined more after distal than standard gastric bypass. The between-group differences are comparable with the beneficial effect of high vs low doses of lipid-lowering therapy with statins and could potentially affect cardiovascular risk.[35,36] A similar pattern has been demonstrated in studies of standard gastric bypass in comparison with more malabsorptive procedures.[33,37,38] This difference could relate to larger weight loss and/or reduced cholesterol and bile acid reabsorption in the small intestine.[39] The greater increase in high-density lipoprotein cholesterol after standard gastric bypass is consistent with a 2015 review that observed greater increase in high-density lipoprotein cholesterol after gastric bypass than after more malabsorptive procedures.[40] Despite similar changes in mean levels of blood pressure, we found a greater remission rate of hypertension after standard gastric bypass. The finding of larger reductions of fasting glucose and HbA_{1c} should be interpreted with caution because it may be owing to a random unbalanced distribution of patients with type 2 diabetes at baseline.

Overall, our findings indicate that distal gastric bypass may have greater beneficial effects on some cardiometabolic risk factors than standard gastric bypass. However, the distal gastric bypass group had a greater increase in parathyroid hormone and a higher prevalence of secondary hyperparathyroidism as well as a lower increase in high-density lipoprotein cholesterol and lower remission of hypertension, with a possibly negative effect on bone health[41] and cardiovascular disease.[42,43]

The strengths of this study include the randomized, double-blind design, standardized surgical procedures, nearly complete follow-up at all study visits, and the comprehensive evaluation. Our patients were recruited from public hospitals, and treatment was independent of insurance or personal finance and health insurance status, which may limit some forms of patient selection bias. Our findings may not extrapolate to cohorts where distal gastric bypass is performed as a secondary procedure owing to insufficient weight loss. The study was not powered to assess differences in secondary outcomes. We did not quantify malabsorption of calories, record dietary intakes, or investigate other mechanisms potentially contributing to weight loss.

Two ongoing randomized trials are investigating the outcome of other variants of distal gastric bypass. One of these studies uses a 100-cm common channel,[44] and the other combines a 150-cm common channel with a 200-cm biliopancreatic limb.[45] When long-term findings from these randomized trials are reported, well-conducted systematic literature reviews will hopefully provide patients, clinicians, and policy makers with further robust and relevant information regarding the role of distal gastric bypass in the surgical treatment of severe obesity.

Conclusions

Weight loss was not larger after distal compared with standard gastric bypass 2 years after surgery. Changes in several cardiometabolic risk factors and nutritional markers were different in the 2 groups.

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