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Original article

Long-term self-reported symptom prevalence of early and late dumping in a patient population after sleeve gastrectomy, primary, and revisional gastric bypass surgery

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Abstract

Background: Early and late dumping are side effects of bariatric surgery. Almost no data are available on the prevalence of dumping after different surgical procedures.

Objectives: Comparison of the relative risks of dumping in a large population of patients having undergone primary Roux-en-Y gastric bypass (pRYGB), sleeve gastrectomy (SG), or revisional RYGB (rRYGB; after removal of band).

Setting: Bariatric center of a teaching hospital.

Methods: In this descriptive cohort study, all patients who underwent a pRYGB (n = 615), SG (n = 157), or rRYGB (n = 274) between 2008 and 2011 were approached by mail and asked to complete and return a questionnaire of general and disease-specific questions related to dumping syndrome. Relative risks (RR) were calculated (mean with 95% confidence intervals) by comparing the prevalence of high suspicion for early and late dumping between different surgical procedure groups and primary gastric bypass surgery.

Results: The questionnaire was completed and returned by 593 (57%) of 1046 patients. Fewer patients with SG were at high suspicion of early dumping than after pRYGB (RR [95% confidence interval] .46 [.22–.99], $P = .049$). No differences for early dumping were seen between rRYGB and pRYGB (RR 1.21 [.77–1.91], $P = .40$). More patients were at high suspicion for late dumping after rRYGB compared with after pRYGB (RR 1.78 [1.09–2.90] $P = .021$). No differences for late dumping were seen between SG and pRYGB (RR .59 [.22–1.61], $P = .30$).

Conclusion: Fewer complaints of early dumping are reported after SG, while patients report more complaints of late dumping after rRYGB compared with pRYGB. (Surg Obes Relat Dis 2018;14:1173–1181.)

Keywords: Bariatric surgery; Early dumping; Late dumping; Sleeve gastrectomy; Gastric bypass

Morbid obesity is a growing healthcare problem in the world. Its prevalence is increasing; consequently, effective weight loss strategies are needed. Bariatric surgery is the most effective way to achieve sustained weight loss, resolve co-morbidity, and improve survival in morbidly obese

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persons [1]. Different surgical procedures are performed to obtain this durable weight loss.

In earlier days, gastric banding was thought to be a simple and effective way to lose weight. However, because of a high percentage of late complications, such as slipping, erosion, and migration, and disappointing weight loss results, many patients have their bands taken out and convert to another bariatric procedure [2,3]. Currently, one of the most frequently performed weight loss operations is the laparoscopic Roux-en-Y gastric bypass (RYGB). This is effective both as a primary procedure and a revisional procedure in case of failure of gastric banding [4–6]. Over the last few years, sleeve gastrectomy (SG) has gained popularity because of its relative simplicity and reduced risk of vitamin and mineral deficiency and steatorrhea [7,8].

One of the side effects of bariatric surgery in the long term can be dumping syndrome. Two variants have been distinguished, early and late dumping. Early dumping is characterized by abdominal symptoms such as bloating, abdominal pain, and nausea, as well as autonomic symptoms, such as sweating and flushes within 1 hour after a meal. Late dumping (also known as post–gastric bypass hypoglycemia) is caused by a hyperinsulinemic hypoglycemic event 1 to 3 hours after a meal [9,10]. Symptoms exist of neurologic impairment because of reduced glucose availability to the brain (e.g., impaired judgment, irritability, confusion, seizures, and coma) and autonomic/adrenergic symptoms (e.g., palpitations, tremor, and anxiety) due to the release of counter-regulatory hormones, especially (nor)epinephrine. Mechanisms of early dumping are not well understood, but for late dumping, glucagon-like peptide 1 is thought to play a crucial role in the exaggerated insulin release because glucagon-like peptide 1 receptor blockade abolishes hypoglycemia [11,12].

The prevalence of dumping syndrome is dependent on the diagnostic test used and the population being tested. Studies using provocation tests report the prevalence of early dumping at approximately 42% [13–15] and of late dumping at as high as 72% [16–18]. These studies using provocation tests have been criticized because of the absent relationship with daily complaints, and most of the tests are carried out in a selected group of patients with known symptoms. Studies on patient-reported outcomes after bariatric surgery regarding dumping complaints are scarce. Lee et al. [19] showed that patients after bariatric surgery (RYGB and SG) had a prevalence of high suspicion for late dumping of 34% and that RYGB had an increased risk of developing late dumping compared with patients after SG (odds ratio 2.5). In addition, we recently estimated, in a large cohort study of patients after primary gastric bypass surgery, that the prevalence of complaints suggestive of early and late dumping of moderate-to-severe intensity would be 19% and 12%, respectively. We also found that dumping syndrome was inversely related to quality of life, mood, and postoperative treatment satisfaction [20].

Because various bariatric procedures are currently performed and the prevalence and consequences of dumping syndrome are likely to be of influence on treatment results and satisfaction, we assessed the effects of three different surgical procedures (SG, primary RYGB, and revisional RYGB) on the symptom prevalence of early and late dumping.

Methods

Study population

All patients who underwent bariatric surgery for morbid obesity at a teaching hospital in the Netherlands between 2008 and 2011 were included in a database. All patients were screened before their operation according to the criteria outlined by the International Federation for Surgery of Obesity and Metabolic Disorders [21]. In 2013, all patients were invited by mail to participate in a questionnaire survey. Four rounds of invitations were sent out (3 by postal mail and 1 by e-mail). For the purpose of this study, all patients who underwent SG, primary gastric bypass, and revisional RYGB were selected. Patients who had undergone extra revisional surgery were excluded. The Regional Ethical Review Board of the Medical Center Leeuwarden approved the study protocol (registered at ISRCTN, ISRCTN17666669).

Surgical technique

In all patients a standardized operation technique was used, and all 3 surgeons complied with this standard. Routine antibiotic prophylaxis was administered.

The techniques for primary and revisional gastric bypass are previously described [6]. In short, we create a pouch of approximately 30 to 60 cc in primary gastric bypass and 60 to 80 cc in revisional bypass because we start the creation of the pouch beneath the scar tissue of the former banding. Most bands were placed in our and surrounding hospitals. The technique of band placing was mostly the "pars flaccida" technique, in which the anterior and posterior nerves of Latarjet are not preserved.

In both procedures we used the omentum-sparing procedure for creation of the pouch, in which the lesser sac was entered via perigastric dissection with care taken to preserve the anterior and posterior nerves of Latarjet [22].

The other difference with the primary RYGB technique is that we covered all our anastomosis at the end of the revisional procedure with tissue col (Baxter, Utrecht, the Netherlands).

Karmali et al. [23] earlier described the technique of SG. We started transection at 6 cm before the pylorus and

used a 34-F gastric tube for calibration of the sleeve. The sleeve was made "floppy" around this tube.

Control of integrity of anastomoses or staple line was performed in all procedures by methylene and air-leak testing after introduction of a gastric tube by the anesthesiologist. In case of leakage, additional sutures were placed.

Patient groups

Primary gastric bypass

In total, 615 patients received a primary laparoscopic gastric bypass. Of this group, 2 patients died during follow-up (both of malignancies). Thus, 613 patients were contacted and asked to participate in this study. The questionnaire was filled in and returned by 360 patients; 9 were not usable because the questionnaires could not be linked to the right patients. Thus, the total number of questionnaires available for analysis was 351 (57.3%).

The participants in this study were highly comparable to the nonresponders, with the exception of age. Participants were slightly older (median [interquartile range]: 44 [37, 49] versus 41 [40–54] years; $P = .02$). No differences were seen in excess weight loss, weight before operation, and preoperative co-morbidities (diabetes, hypertension, and hyperlipidemia). This group has been previously described [20].

Sleeve gastrectomy

In total, 192 patients received SG. Of these, 35 patients had received a revisional procedure (1 duodenal switch, 1 mini-gastric bypass, and 33 RYGB) and were excluded. Of the remaining 157 patients, 89 (57%) filled in the questionnaire and were included in this study. The participants were slightly older than the nonresponders (42 versus 38 yr, $P = .02$) and had a lower weight before operation (127 versus 138 kg, $P = .011$). No differences were seen in excess weight loss and presence of preoperative co-morbidities (diabetes, hypertension, and hyperlipidemia).

Revisional gastric bypass

In total, 274 patients underwent a revisional gastric bypass procedure. Of these, 153 (56%) filled in the questionnaire and were available for analysis in this study. No differences were seen between participants and nonresponders in terms of weight at revisional surgery and weight at last visit, or in prevalence of diabetes and remission of diabetes. The nonresponders were slightly older (45 versus 42 yr, $P = .011$), and had more hypertension at the time of revisional surgery (32% versus 17%, $P = .005$).

Reason for former band placement was mostly because the other techniques were not available, or the banding procedure was suggests by the surgeon.

Questionnaires

Dumping severity score

The dumping severity score developed by Arts et al. [17] was used for assessment of the severity of early and late dumping syndrome, using a 4-point Likert scale (Supplemental Tables 1 and 2). Patients were asked to grade the intensity (0 = absent; 1 = mild; 2 = moderate, and 3 = severe, i.e., interfering with daily activities) of 8 early dumping symptoms within 1 hour of food ingestion and of 6 hypoglycemia symptoms >1 hour after food ingestion [17]. To assess the psychological impact of these complaints, we also asked if the symptoms provoked any anxiety or a feeling of unsafety.

Patients were classified based on the results of this questionnaire in 2 groups, high and low suspicion of dumping syndrome. We defined high suspicion of early dumping as someone with ≥3 moderate or severe symptoms, including at least 1 autonomic symptom, on the early dumping severity score. A high suspicion of late dumping (postgastric bypass hypoglycemia) was defined with the presence of ≥3 moderate or severe symptoms, including at least 1 neuroglycopenic symptom, on the late dumping severity score. Additional questions were asked with regard to dumping (self-measured blood glucose levels, the occurrence of neuroglycopenia and the potential related use of healthcare and treatment), weight development, co-morbidities, and use of medication. These data were checked against the data collected at the last outpatient visit.

Statistics

Data are presented as mean (±standard deviation), median (interquartile ranges), frequencies, or percentages where appropriate. Differences were assessed with *t* tests (for continuous variables) or χ^2 tests (for categoric variables). A P value $< .05$ was used for determining statistical significance. Relative risks (RR) were calculated (mean with 95% confidence intervals) by comparing the prevalence of high suspicion for early and late dumping between different surgical procedure groups and primary gastric bypass surgery (the comparator). All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS, Inc., Armonk, NY, USA), version 23.

Results

Patient characteristics: comparison between sleeve gastrectomy and primary gastric bypass (Table 1)

The excess weight loss did not differ significantly between patients after SG and primary gastric bypass (72 versus 77%, $P = .067$). Follow-up time between surgery and study date was significantly shorter (27 versus 32 mo,

Table 1
Patient characteristics of patients after primary RYGB and sleeve gastrectomy

	Primary RYGB	Sleeve gastrectomy	*P* value
Number	351	89	
Age, yr	46 [39; 53]	45 [38; 54]	.349
Female (%)	282 (80.3)	73 (82.0)	.766
Time between last surgery and study, mo	27 [19; 34]	32 [19; 42]	**<.001**
Weight and weight loss			
Weight at primary surgery, kg	129 [116; 144]	124 [112; 139]	.092
BMI at primary surgery, kg/m^2	43 [40; 48]	41 [39; 46]	.08
Weight at revisional surgery, kg			
Minimum weight after last surgery: self-reported, kg	81 [70; 98]	84 [75; 95]	.255
Current weight: self-reported, kg	86 [75; 102]	89 [80; 98]	.437
EWL from primary procedure to study, %	77 [61; 95]	72 [57; 88]	.067
Co-morbidities preoperative			
Type 2 diabetes	104 (29.6)	21 (23.6)	.294
Hypertension	157 (44.7)	32 (36.0)	.150
Dyslipidemia	70 (19.9)	18 (20.2)	>0.999
Sleep apnea	38 (10.8)	14 (15.7)	.202
Co-morbidities postoperative			
Type 2 diabetes: self-reported	37 (10.5)	8 (9.0)	.845
Hypertension: self-reported	62 (17.7)	15 (16.9)	>0.999
Dyslipidemia: self-reported	41 (11.7)	13 (14.6)	.470
Sleep apnea: self-reported	13 (3.7)	4 (4.5)	.758
Postoperative support and lifestyle			
Support of psychologist*	33 (9.4)	12 (13.5)	.246
Sport (>30 min/wk)	199 (57.3)	53 (59.6)	.911
Smoking	60 (17.1)	19 (21.3)	.356
Treatment satisfaction†			
Satisfaction with result of operation (yes)	320 (91.2)	81 (91.0)	>0.999
Would you do the operation again? (yes)	340 (96.9)	83 (93.3)	.126

RYGB = Roux-en-Y gastric bypass; BMI = body mass index; EWL = excess weight loss.
Data are shown as numbers (percentage), mean ± standard deviation, or median and [interquartile range].
Bold type *p*-values are significant ($p < 0.05$).
* Support of a psychologist is defined as regular visits to a psychologist to help coping eating or postbariatric surgery problems.
† With treatment satisfaction in the revisional group is meant the revisional operation (not the first operation or both).

$P < .001$) for gastric bypass versus SG patients. Satisfaction with the results was equal between patients with SG and primary gastric bypass.

Demographic characteristics as prevalence of co-morbidities, remission of co-morbidities, weight at surgery, and age were not different between patients with SG and primary gastric bypass.

Patient characteristics: comparison between revisional and primary gastric bypass (Table 2)

Patients with revisional gastric bypass had lower prevalence of co-morbidities than patients with primary gastric bypass at day of (revisional) surgery, but self-reported co-morbidities at time of questionnaire were equal. Patients after revisional surgery were less satisfied than after primary gastric bypass (73.2% versus 91.2%, respectively, $P \leq .001$). More patients would not have had the gastric bypass operation done again if they had the choice (12.4% versus 3.1%, $P \leq .001$). Patients after revisional gastric bypass had less excess weight loss than patients after primary gastric bypass when calculated from the prebariatric weight (71% versus 77%, $P = .039$).

Perceived complaints of early dumping (Table 3)

Fewer patients with SG were at high suspicion of early dumping than after primary RYGB (RR [95% confidence interval] .46 [.22–.99], $P = .0497$). This finding was mainly based on the lower prevalence of palpitations and flushing in the SG group. No differences for early dumping were seen between revisional and primary RYGB (RR 1.21 [.77–1.91], $P = .40$) but the emotional impact of these complaints was more often moderate to severe in patients having undergone a revisional procedure (17% versus 9%, $P = .016$).

Perceived complaints of late dumping (Table 3)

More patients after revisional RYGB were at high suspicion for late dumping compared with primary RYGB (RR 1.78 [1.09–2.90] $P = .021$). This was mainly based on the higher incidence of tremor, hunger, and irritabil-

Table 2
Patient characteristics of patients after primary RYGB and revisional RYGB

	Primary RYGB	Revisional RYGB	*P* value
Number	351	153	
Age, yr	46 [39; 53]	46 [42; 54]	.138
Female (%)	282 (80.3)	128 (83.7)	.456
Time between last surgery and study, mo	27 [19; 34]	25 [18; 34]	.715
Weight and weight loss			
Weight at primary surgery, kg	129 [116; 144]	130 [120; 146]	.612
BMI at primary surgery, kg/m^2	43 [40; 48]	45 [41; 48]	.889
Weight at revisional surgery, kg		118 [103; 130]	
Minimum weight after last surgery: self-reported, kg	81 [70; 98]	85 [77; 101]	.063
Current weight: self-reported, kg	86 [75; 102]	90 [79; 103]	.202
EWL from primary procedure to study, %	77 [61; 95]	71 [50; 89]	**.039**
Co-morbidities preoperative			
Type 2 diabetes	104 (29.6)	32 (20.9)	**.049**
Hypertension	157 (44.7)	49 (32.0)	**.008**
Dyslipidemia	70 (19.9)	12 (7.8)	**<.001**
Sleep apnea	38 (10.8)	6 (3.9)	**.003**
Co-morbidities postoperative			
Type 2 diabetes: self-reported	37 (10.5)	24 (15.7)	.105
Hypertension: self-reported	62 (17.7)	35 (22.9)	.174
Dyslipidemia: self-reported	41 (11.7)	16 (10.7)	.878
Sleep apnea: self-reported	13 (3.7)	5 (3.3)	1.00
Postoperative support and lifestyle			
Support of psychologist[†]	33 (9.4)	17 (11.1)	.517
Sport (>30 min/wk)	199 (57.3)	87 (58.2)	.294
Smoking	60 (17.1)	28 (18.3)	.702
Treatment satisfaction[‡]			
Satisfaction with result of operation (yes)	320 (91.2)	112 (73.2)	**<.001**
Would you do the operation again? (yes)	340 (96.9)	134 (87.6)	**<.001**

RYGB = Roux-en-Y gastric bypass; BMI = body mass index; EWL = excess weight loss.
Data are shown as numbers (percentage), mean ± standard deviation, or median and [interquartile range].
Bold type *p*-values are significant ($p < 0.05$).
[†] Support of a psychologist is defined as regular visits to a psychologist to help coping eating or postbariatric surgery problems.
[‡] With treatment satisfaction in the revisional group is meant the revisional operation (not the first operation or both).

ity in the revisional surgery group. The revisional surgery group also had more complaints of anxiety and feelings of unsafety as a consequence of these symptoms (8.5% versus 15.7%, $P = .027$). No differences for late dumping were seen between SG and primary RYGB (RR .59 [0.22–1.61], $P = .30$).

Late dumping by other estimates *(Table 4)*

In spite of similarly perceived complaints of late dumping between patients after SG, fewer low-plasma glucose levels after the meal were noticed in patients after SG compared with those who had primary gastric bypass surgery. Also, less help by others for hypoglycemia and fewer neuroglycopenic complaints were reported. No differences between revisional and primary gastric bypass surgery were noted.

Discussion

This study shows that self-reported symptoms of early and late dumping were observed after all the included bariatric procedures. However, SG showed a lower prevalence of early dumping while revisional gastric bypass surgery showed more late dumping compared with primary gastric bypass surgery.

The prevalence described in literature of early and late dumping symptoms depends on the type and extent of surgery, the definition of dumping syndrome used by study investigators, and whether the diagnosis is based on questionnaires, random labs, or provocation tests. Papamargaritis et al. [14] performed a prospective study after SG. They described that 10 of 25 patients (40%) had complaints of dumping after 6 months and 33% after 12 months, according to the Arts et al. [17] questionnaire mainly due to early dumping. However, 8 patients had a hypoglycemia after an oral glucose tolerance test 6 months postoperatively (33%) [14]. More literature is available about gastric bypass and late dumping, which is present in 30% to 72% of the cases studied [9,24–26]. These high percentages were all observed after provocation tests (oral glucose tolerance test, mixed meal tolerance test, continuous glucose monitoring). However, Lee and co-workers [27] studied late dumping by means of questionnaire, with

Table 3
Prevalence of self-reported moderate to severe symptoms of early and late dumping in patients after primary RYGB, sleeve gastrectomy, and revisional RYGB

Early dumping	Primary RYGB 351	Sleeve gastrectomy 89	*P* value*	Revisional RYGB 153	*P* value†
Abdominal symptoms					
Abdominal pain (%)	70 (19.9)	11 (12.5)	.125	33 (21.6)	.719
Diarrhea (%)	52 (14.8)	7 (8.0)	.115	31 (20.3)	.151
Bloating (%)	76 (21.7)	21 (23.9)	.669	39 (25.5)	.359
Autonomic symptoms					
Nausea (%)	67 (19.1)	11(12.5)	.163	39 (25.7)	.121
Sweating (%)	43 (12.3)	8 (9.1)	.462	25 (16.3)	.257
Flushing (%)	50 (14.2)	5 (5.7)	**.030**	22 (14.4)	>0.999
Dizziness (%)	51 (14.5)	7 (8.0)	.114	30 (19.6)	.188
Palpitations (%)	52 (14.8)	5 (5.7)	**.021**	26 (17.0)	.592
High suspicion of early dumping‡	68 (19.4)	8 (9.1)	**.026**	36 (23.5)	.285
I feel anxious or insecure about the above-mentioned complaints (%)	33 (9.4)	6 (6.7)	.534	26 (17.0)	**.016**
Late dumping					
Autonomic symptoms					
Sweating (%)	24 (6.8)	2 (2.3)	.131	16 (10.5)	.209
Palpitations (%)	23 (6.6)	6 (6.7)	>0.999	13 (8.5)	.455
Hunger (%)	68 (19.4)	20 (22.5)	.554	44 (28.8)	**.027**
Tremor (%)	45 (12.8)	6 (6.7)	.138	38 (24.8)	**.002**
Neuroglycopenic symptoms					
Drowsiness/unconsciousness (%)	70 (19.9)	10 (11.2)	.065	36 (23.5)	.406
Irritability (%)	60 (17.1)	9 (10.1)	.141	41 (26.8)	**.015**
High suspicion of late dumping‡	40 (11.4)	6 (6.7)	.246	31 (20.3)	**.012**
I feel anxious or insecure by above-mentioned complaints (%)	30 (8.5)	9 (10.1)	.677	24 (15.7)	**.027**

RYGB = Roux-en-Y gastric bypass.
Bold type *p*-values are significant ($p < 0.05$).
* *P* value of primary gastric bypass versus sleeve gastrectomy.
† *P* value of primary gastric bypass versus revisional gastric bypass.
‡ A high suspicion of early dumping was defined as having ≥3 symptoms (including at least 1 autonomic symptom) with an intensity of 2 or 3 (i.e., moderate or severe, interfering with daily activities) on the early dumping severity score. A high suspicion of late dumping (postgastric bypass hypoglycemia) was defined as having three or more symptoms (including at least 1 neuroglycopenic symptom) with an intensity of 2 or 3 (i.e., moderate or severe, interfering with daily activities) on the late dumping severity score.

a response rate of 40% in patients after RYGB and SG. They used the Edinburgh hypoglycemia questionnaire, developed for use in diabetic patients to measure the intensity of commonly experienced hypoglycemic symptoms. The prevalence in their total study population of a high suspicion for hypoglycemia was 34%. They found that gastric bypass surgery, longer time since surgery, female sex, and preoperative symptoms of hypoglycemia were independent factors of a higher prevalence of late dumping. The odds of RYGB surgery in the high-suspicion group for hypoglycemia was 2.5 compared with the low-suspicion group. The increased prevalence of late dumping in this study compared with ours is likely to be a result of their operational definition of late dumping, in which patients were included in the high-suspicion group if they had only autonomic symptoms. In another study, Ramadan et al. [28] compared patients after SG and RYGB at 1 and 6 months after surgery. They invited patients with a Sigstad score ≥7 for a glucose-tolerance test and an orthostatic hypotension test. The Sigstad score is a questionnaire that was initially developed as a clinical score for early dumping to be administered by a doctor. The prevalence of late dumping in the SG group was much lower than in our study (1.5% versus 6.7%), the prevalence in the RYGB was higher in patients with a stapled anastomoses of 3-cm long (18% after 6 mo) and a lower prevalence of dumping after a hand-sewn technique 1.5-cm long (0% at 6 mo). Of interest, the prevalence of dumping was also found to be positively associated with postoperative time, which may be the reason why Ramadan reported such low numbers at 6 months postoperatively [27].

The pathophysiology behind early and late dumping symptoms after different procedures can be explained in several ways. Much emphasis is given to plasma-glucose concentrations, insulin sensitivity, and beta-cell glucose sensitivity [24,29]. In addition, a strong association is seen between the levels of incretins in blood and the onset of dumping (especially late dumping) [9,10,12]. The entry of undigested food to the jejunum triggers the early onset of incretin production. It can be hypothesized that the quicker

Table 4
Prevalence of self-measured hypoglycemia, neuroglycopenia, and related consumption of healthcare in patients after primary gastric bypass, gastric sleeve, and revisional gastric bypass surgery

	Primary RYGB 350*	Sleeve gastrectomy 85*	*P* value†	Revisional RYGB 148*	*P* value‡
Low self-measured blood glucose after a meal (%)	70 (20.0)	5 (5.9)	**.001**	17 (11.5)	**.028**
Concentration of low self-measured blood glucose			.101		.150
>4 mmol/L (%)	9 (2.8)	3 (3.5)		1 (.7)	
3–4 mmol/L (%)	16 (4.6)	1 (1.2)		6 (4.1)	
2–3 mmol/L (%)	24 (6.8)	1 (1.2)		10 (6.8)	
1–2 mmol/L (%)	9 (2.6)	0 (.0)		5 (3.4)	
Unknown (%)	12 (3.4)	3 (3.5)		13 (8.8)	
Symptoms of neuroglycopenia§ (%)	26 (7.4)	0 (.0)	**.02**	15 (10.1)	.564
Hypoglycemia for which help of others was necessary (%)	19 (5.4)	1 (1.2)	.058	13 (8.8)	.367
Hypoglycemia for which help of healthcare workers or admission to hospital was necessary (%)	9 (2.6)	0 (.0)	.214	7 (4.7)	.350
Medical treatment for early or late dumping	8 (2.3)	0 (.0)	.369	6 (3.9)	.231

RYGB = Roux-en-Y gastric bypass.
Bold type *p*-values are significant ($p < 0.05$).
* Patients still using insulin are left out.
† *P* value of primary gastric bypass versus sleeve gastrectomy.
‡ *P* value of primary gastric bypass versus revisional gastric bypass.
§ Symptoms of neuroglycopenia include feelings of loss of control (e.g., disorientation, impaired speech, loss of consciousness).

undigested food enters the jejunum, the higher the levels of incretins become, and thus the higher the chance of dumping symptoms. Possible influencers of slowing or accelerating the entry of food into the small bowel are the function of the pylorus and the activity or integrity of the vagal nerve [30]. In agreement with this finding, Humphrey et al. [31] found in a nonbariatric population of patients after vagotomy with or without pyloroplasty that in cases of highly selective vagotomy less dumping occurred, and thus the function of the pylorus and/or vagal nerve plays a role. Our data are in agreement with this hypothesis, with fewer complaints in SG patients in whom pyloric function remains intact and more complaints in revisional gastric bypass patients in whom a higher likelihood of vagal nerve damage is present.

In addition, Frantzides et al. [22] and Fujita et al. [32] both published studies in which the vagal nerve was either damaged/transected or spared during a gastric bypass or a gastrectomy. Both showed that patients with the vagal nerve spared had lower prevalence of late dumping. This finding may also be relevant in patients with revisional gastric bypass surgery after gastric banding. In these cases, the band is usually placed high on the stomach and with the use of the pars flaccida technique in which the anterior and posterior branches of the vagal nerve are not preserved. For this reasons and scarring caused by banding causes vagal nerve entrapment, resulting in alterations in innervation. We propose that revisional gastric bypass after earlier gastric banding can, by damaging vagal nerve fibers, cause more complaints of late dumping.

Some limitations of the study must be mentioned. First, the participation rate was slightly <60%, raising the possibly of an inclusion bias that may have resulted in an overestimation of dumping prevalence. The percentage of patients participating was equal in all surgical procedure groups. A second limitation is the fact that no validated questionnaire for early and late dumping is available [9]. The only questionnaire that is available and that differentiates between the onset of complaints after eating and the kind of symptoms is the dumping severity score, which provides a quantitative assessment of symptom severity. By identifying high-suspicion groups for early and late dumping, and calculating odds ratios, relative effects compared with the primary RYGB were calculated. This reduces the need for validation of the questionnaire.

A third limitation of the questionnaire is the lower prevalence of late dumping in case of development of hypoglycemia unawareness. Hypoglycemia unawareness is the phenomenon used in the diabetic population that a patient has no symptoms of the hypoglycemia. This phenomenon is also seen in patients with tightly controlled type 1 diabetes who have frequent episodes of hypoglycemia [33]. Our results show no difference in the prevalence of late dumping between SG and primary gastric bypass. However, significantly more patients reported low blood sugar levels after primary gastric bypass in comparison with SG (Table 4). This discrepancy between complaints versus self-reported measurements of glucose might also potentially be related to accessibility to a glucose meter, which may have differed between groups. Revisional gastric bypass patients reported significantly more complaints of late dumping, and they significantly more often reported low blood sugars but only a slightly raised prevalence of neuroglycopenia (Table 4). These 2 seemingly conflicting find-

ings, potentially indicative of hypoglycemia unawareness, may have played a role in the perceived complaints. Ten percent of the patients after revisional RYGB reported low to very low blood sugars (between 1.0 and 3.0), and this is also suggestive for increased severity of hypoglycemia and therefore fits in the profile of hypoglycemia unawareness. Other limitations of the study are the possibility of inducing bias due to a follow-up of only 2 to 3 years and that we used a retrospective cohort. With a follow-up of 2 to 3 years it is possible that we miss patients with a late onset of post–gastric bypass hypoglycemia.

Conclusion

SG is associated with reduced complaints of early dumping, while revisional gastric bypass surgery after gastric banding is associated with more complaints of late dumping compared with primary gastric bypass surgery.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.soard.2018.04.011.

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