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ORIGINAL CONTRIBUTIONS

Medium-Term Outcomes after Reversal of Roux-en-Y Gastric Bypass

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Abstract
Background Roux-en-Y gastric bypass (RYGB) can be reversed into normal anatomy (NA) or into sleeve gastrectomy (NASG) to address undesired side effects. Concomitant hiatal hernia repair (HHR) may be required. Before reversal, some patients benefit from placement of a gastrostomy, mostly to predict the result of recreating the native anatomy.
Methods Retrospective study on mid-term effects of RYGB reversal to NA and NASG, including clinical and weight evolution, surgical complications, and incidence of gastroesophageal reflux (GERD).
Results Undesired side effects leading to reversal included early dumping syndrome, hypoglycemia, malnutrition, severe diarrhea and excessive nausea and vomiting. Twenty-five participants to the study, 13 NA, 12 NASG, and 15 HHR. Mean follow-up time was 5.3 ± 2.3 years. Reversal corrected early dumping, malnutrition, diarrhea, and nausea/vomiting. For hypoglycemic syndrome, resolution rate was 6/8 (75%). NA caused significant weight regain (14.2 ± 13.7 kg, (p = .003)). NASG caused some weight loss (4.8 ± 15.7 kg (NS)). Gastrostomy placement gave complications at reversal in five of seven individuals. Eight patients suffered a severe complication, including leaks (one NA vs. three NASGs). Eight out of 14 (57.1%) patients who previously had never experienced GERD developed de novo GERD after reversal, despite HHR.
Conclusions RYGB reversal is effective but pre-reversal gastrostomy and concomitant HHR may be aggravating factors for complications and development of de novo GERD, respectively.

Keywords RYGB undesired side-effects · RYGB reversal · Weight evolution · Clinical evolution · Surgical complications

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Introduction

Roux-en-Y gastric bypass (RYGB) creates well-demonstrated long-term effects on weight and metabolic conditions [1–4]. However, for the past few years, sleeve gastrectomy (SG) has become a more popular obesity procedure [5–7], probably because RYGB is associated with a higher risk of complications and reoperations [8–10].

RYGB may cause specific undesired side effects related to the bypassing of a great part of the stomach, duodenum, and the proximal jejunum. Well-documented side effects include early dumping syndrome, hypoglycemia, malnutrition, severe diarrhea and excessive nausea, and vomiting [11]. These conditions usually can be managed conservatively, i.e., by behavioral and medical therapy, but occasionally, a surgical reintervention may be needed, which in extreme cases may consist of reversal to normal anatomy (NA). In specific cases, the reversal procedure is preceded by the laparoscopic placement of a gastrostomy tube, which allows to address malnutrition, or, more frequently, to predict the outcome of reversal because food stuffs through the gastrostomy follow the not-bypassed route. In the literature, different techniques of reversal, including endoscopic approaches [12, 13], have been described. In our department, the reversal operation is performed laparoscopically and routinely includes full mobilization of the upper pole of the stomach pouch and extensive dissection of the hiatus to detect a hernia (hiatal hernia repair, HHR) and repair it whenever needed.

In specific cases, i.e., when weight loss has been judged insufficient or when future weight regain is feared, SG or sleeve-like resection (NASG) complements reversal [14–17].

Literature data regarding outcomes after reversal are, so far, only available in short term. They include two previously published articles from our team [14, 18]. It is the aim of the current study to establish if the reported good short-term results of laparoscopic reversal of RYGB to the initial anatomy or to SG are maintained through mid-term.

Materials and Methods

This retrospective study evaluates all consecutive patients from our department, who, by May 2016, had reached a follow-up of at least 2 years after reversal of RYGB with or without SG. Outcomes were reported both overall and separately for the NA and the NASG group.

The following typical symptoms in connection with the condition that demanded reversal of the bypass were assessed:

For early dumping syndrome: abdominal pain, flushing, and sweating occurring 15–60 min after a meal.

For hypoglycemic syndrome: sweating, shakiness, loss of concentration, hunger, and fainting [19, 20], linked with severe hypoglycemia (plasma glucose < 55 mg/dl) appearing 1–3 h after a meal and relieved by normalization of the plasma glucose levels (Whipple triad [21]); use of medication such as acarbose, diazoxide, octreotide, or any drug interfering with glucose metabolism.

For malnutrition: disabling fatigue and symptomatic hypoalbuminemia and/or hypoproteinemia (serum levels of albumin < 3.0 g/dl and/or total protein < 6 g/dl, respectively) and/or vitamin/mineral malnutrition insufficiently responsive to enteral or parenteral nutrition.

*For atypical (*i.e., *unrelated to dumping syndrome) diarrhea*: frequency of loose stools and dependency on medication such as loperamide, cholestyramine, probiotics, and/or antibiotics.

For nausea and vomiting (N/V): symptoms requiring medication such as domperidone or ondansetron.

For weight loss failure: the weight readings in the charts and as reported by the patient.

– Patients' data was retrieved from the electronic charts with the follow-up notes of all physicians, psychologists, and dieticians involved in the patient's care. Data included operative reports, perioperative and postoperative complications, intake of medication such as proton pump inhibitors (PPI) and glucose mimetics, clinical symptoms, evolution of weight, and blood work parameters such as kidney and liver function tests, glycated hemoglobin (HbA1c), fasting plasma glucose, plasma protein and albumin concentration, vitamin B complex, fat-soluble vitamin levels, and zinc.
– A questionnaire was submitted by telephone to all participants to evaluate their current clinical status as well as their subjective impression on the effects of the reversal operation. The answers were gathered by one of the authors (RB).

Assessment of the relevant symptoms was obtained by attributing a score to the answers to the questionnaire (Likert score) from 1 to 5, in increasing order of success. A score of 5 corresponded to disappearance of the symptoms without medication.

Technical Aspects

Briefly, RYGB reversal starts with the transection of the alimentary loop close to the gastro-jejunal anastomosis. The jejuno-jejunostomy was then identified, dissected, and transected separating the biliary from the alimentary-common limb care being taken to avoid stenosis of the latter. The proximal end of the alimentary limb and the distal end of the biliary limb were anastomosed by linear stapler technique. The gastric pouch was sectioned just proximal to the previous gastro-jejunal anastomosis, which allowed to discard the anastomotic staple line; subsequently a hand-sewn, end-to-side, one-layer anastomosis was created with the remnant, incorporating the staple line of the remnant that was located just across the newly performed staple line.

When reversal to NA included construction of a "gastric sleeve" (NASG), the remnant stomach fundus (i.e., the part proximal to the level of the gastro-gastrostomy) was removed, followed by resection or, alternatively and more recently, imbrication of the greater curvature down to some 3–4 cm proximal to the pylorus under guidance of a 34 French in the gastric lumen [14, 18].

Primary Endpoints

Primary endpoints were, first, the clinical evolution (i.e., improvement or not of the condition that had demanded the reversal) and, second, the weight evolution after the reversal procedure. Weight was reported in kilograms (kg) and in body mass index (BMI), expressed as weight/body length [2] (kg/m^2). Weight progression was reported in % total weight loss (%TWL), in % excess weight loss (%EWL), and in difference in %TWL (Δ%TWL) [22].

Formulas used were

$$\%\mathrm{TWL} = (\textit{weight} \text{ at } \textit{baseline} - \textit{weight} \text{ at } \textit{evaluation time point}) / (\textit{weight} \text{ at } \textit{baseline}) \times 100 \quad (1)$$

$$\%EWL = (weight \text{ at } baseline - weight \text{ at } evaluation\ time\ point) / (weight \text{ at } baseline - ideal\ weight\ [corresponding\ to \text{ BMI } of\ 25 \text{ kg/m}^2]) \times 100 \quad (2)$$

$$\Delta\%TWL = \%TWL \text{ at FU} - \%TWL \text{ at } reversal \quad (3)$$

Weight analysis at FU was reported in intention to treat, i.e., the final weight after all procedures (e.g., DS). Weight loss was judged satisfactory when %EWL > 50% [23].

Secondary Endpoints

Secondary endpoints were:

1. Mortality and major postoperative complications,
2. Incidence and evolution of gastro-esophageal reflux disease (GERD),

 – Postoperative complications were considered major when Clavien-Dindo type III or more (modified classification) [24] (i.e., requiring surgical, endoscopic, or radiological intervention). They were divided in early (< 30 days) and late (> 30 days) complications [22].
 – GERD was assessed by the intake or not of PPI to address typical reflux symptoms (heartburn with or without regurgitations).

This study was conducted in accordance with the ethical committee of our institutions, and all patients gave consent for the inclusion of their data in the study.

Statistics

Categorical variables were summarized with the use of frequencies and analyzed with the χ^2 test. Progression was evaluated with the McNemar test.

The normally distributed continuous variables were reported as mean ± standard deviation (SD) and range. Intergroup differences were tested by a two-sample *t* test. Intragroup-paired analyses were performed with the paired *t* test. A two-sided $p < .05$ (with 95% confidence interval (CI)) indicated statistical significance. All statistical analyses were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL).

Results

Between January 2005 and April 2014, 25 consecutive patients who either came from our own practice or who had been referred from elsewhere underwent RYGB reversal with or without concomitant "SG" (13 NA, 12 NASG). The demographic information and main indication for reversal and procedural details are summarized in Table 1.

Seven patients (five NA and two NASG) had a gastrostomy placed laparoscopically 97.4 ± 78.8 days (13–241) before reversal. The reversal operation was completed laparoscopically in 100% of the patients. Mean follow-up after reversal was 5.3 ± 2.3 years (2–11.2).

Primary Endpoints

1. Clinical evolution is shown in Table 2.

For the indications "early" dumping, malnutrition, diarrhea, and N/V reversal was successful in all participants.

For hypoglycemia, six out of eight reversals (75%) were successful. For two patients, medication consisting of octreotide could not be stopped.

For the indication "weight loss failure" reversal (to NASG) resulted in success in two out of four; one by NASG alone and one by two-stage duodenal switch (DS).

2. The overall weight evolution is shown in Table 3 and Fig. 1.

The group evaluated in its entirety ($n = 25$) experienced a weight gain of 2 ± 6.5 (95% CI, −.7 to 4.7) BMI units ($p = .142$), but when the NA and NASG were evaluated separately, Δ%TWL reached statistical significance (NA = −12.9% vs. NASG = 4.3%; $p = .005$; 95% CI, −28.6 to − 5.9). In intragroup analysis, for NA, there was a weight gain that reached statistical significance; conversely, for NASG, there was a weight loss compared to the pre-reversal weight recording but this did not reach statistical significance.

Secondary Endpoints

1. There was no postoperative mortality.

– Eight patients (32%) suffered one or more early complications (Table 4).

Early complications included a leak at the gastro-gastric anastomosis in four participants (16%), one (1/13–7.7%) in

Table 1 Demographic data, main indications, and procedural details for patients who required reversal to NA/NASG for post-RYGB therapy resistant side effects/complications

Number and gender of patients treated	25 (all females)
Age at reversal (years)	41.9 ± 11.2 (21–67.4)
Time between RYGB and reversal (years)	5.1 ± 2.9 (0.6–9.8)
Follow-up period after reversal (years)	5.3 ± 2.3 (2–11.2)
BMI at baseline (kg/m^2)	41.4 ± 5.2 (33.7–52.1)
BMI at reversal (kg/m^2)	27.5 ± 6.3 (18.7–40.3)
Main indication for reversal	Dumping syndrome = 3 (3 NA)
	Hypoglycemic syndrome = 8 (3 NA, 5 NASG)
	Malnutrition = 5 (2 PD, 2 NA; 3 VD, 1 NA, 2 NASG)
	Diarrhea = 3 (3 NA)
	Primary weight loss failure = 4 (4 NASG)
	Nausea/vomiting = 2 (1 NA, 1 NASG)
Procedure performed	Reversal to NA = 13
	Reversal to NASG = 12
Sleeve configuration	Stapled = 7
	Imbricated distal stomach = 5
Pre-reversal gastrostomy	Dumping syndrome = 2 (2 NA)
	Hypoglycemic syndrome = 3 (1 NA, 2 NASG)
	Malnutrition (PD) = 2 (2 NA)

Results are expressed as mean ± standard deviation and (range)

NA reversal to normal anatomy, *NASG* reversal to normal anatomy + sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass, *BMI* body mass index, *PD* protein deficiency, *VD* vitamin deficiency

the NA group vs. three (3/12–25%) in the NASG group (p = .24). All the leaks in the NASG group occurred in individuals who had had resection (as opposed to imbrication) of the distal greater curvature (leak rate 3/7 = 42.9%).

Of note, of the seven patients who previously had undergone gastrostomy placement, five suffered an early major complication after reversal (p = .008): 5/7 versus 2/18: two leaks (one NA, one NASG), two abscesses (two NA), and one bleeding (one NA).

– Seven patients (28%) suffered late complications (Table 4) that required surgical reintervention in our institutions or elsewhere.

2. The progression of GERD is shown in Tables 5 and 6, and Fig. 2.

At FU, 17 patients (68%) suffered from GERD, including 8 of the 14 who had never suffered from the condition previously (incidence of de novo GERD 8/14 = 51.7%). In analysis of the possible effect of HHR on GERD, 15 HHR were performed (including two patients in whom the HH had recurred after HHR at RYGB). Four patients who benefited from HHR were GERD sufferers preoperatively, whereas 11 did not complain of GERD preoperatively. The 4 individuals who suffered from GERD before reversal did not improve despite HHR at

Table 2 Outcome of RYGB reversal in the treatment of therapy-resistant post-RYGB side effects/complications. Numbers of patients for each indication, number of patients with insufficient Likert score, and relevant objective parameters (pre- and post-reversal)

RYGB side effects/complications	*N* = resolved (% of total)	Likert score	Objective assessment
Dumping syndrome *N* = 3	3 (100)	5, 5, 5	–
Hypoglycemic syndrome *N* = 8	6 (75)	1, 3, 4, 4, 5, 5, 5, 5	–
Malnutrition *N* = 5	5 (100)	4, 5, 5, 5, 5	PD 1, PD 2: pre < 5.1 g/dl; post > 6.9 g/dl VD 1, VD 2, VD 3: vitamin B_{12} pre < 100 pg/ml; post > 260 pg/ml
Diarrhea *N* = 3	3 (100)	4, 4, 5	–
Weight issues *N* = 4*	2 (50)	3, 5	EWL pre = 38.8%; post = 29.1% EWL pre = 45.5%; post = 71%
N/V *N* = 2	2 (100)	5, 5	–

RYGB Roux-en-Y gastric bypass, *PD* protein deficiency (total protein levels), *VD* vitamin deficiency, *EWL* excess weight loss, *N/V* nausea and vomiting

*Patients with only NASG

Table 3 Weight progression at different time points

Overall = 25	At baseline	At reversal	At follow-up	*p*-value[§]
Weight (kg)	110.9 ± 16.4	73.7 ± 17.5	78.8 ± 15.7	.157
95% CI	(104.1–117.7)	(66.5–81)	(72.3–85.3)	
BMI (kg/m^2)	41.4 ± 5.2	27.5 ± 6.4	29.5 ± 6.3	.142
95% CI	(39.2–43.5)	(24.9–30.2)	(26.9–32.1)	
%TWL	–	33.1 ± 14.5	28.4 ± 13.6	.161
95% CI		(27.1–39.5)	(22.8–34.1)	
%EWL	–	86.3 ± 38.6	75.8 ± 39.5	.258
95% CI		(70.4–102.3)	(59.6–92.1)	
Δ%TWL	–	–	− 4.6 ± 16	
95% CI			(− 11.3–2)	
NA = 13				
Weight (kg)	113.5 ± 15.8	70.4 ± 13.4	84.6 ± 13.4	*.003*
95% CI	(104–123.1)	(62.3–78.5)	(76.5–92.7)	
BMI (kg/m^2)	41.2 ± 5.1	25.6 ± 5.1	31 ± 6.3	*.004*
95% CI	(38.1–44.3)	(22.5–28.7)	(27.2–34.8)	
%TWL	–	37.3 ± 12.4	24.4 ± 14.7	*.004*
95% CI		(29.8–44.8)	(15.5–33.3)	
%EWL	–	98.7 ± 35	64.8 ± 43.2	*.004*
95% CI		(77.6–119.8)	(38.7–91)	
Δ%TWL	–	–	− 12.9 ± 13.1	
95% CI			(− 20.8 to − 5)	
NASG = 12				
Weight (kg)	108 ± 17.3	77.3 ± 21.2	72.5 ± 16.1	.313
95% CI	(97–119)	(63.9–90.8)	(62.3–82.7)	
BMI (kg/m^2)	41.6 ± 5.6	29.6 ± 7.1	27.9 ± 6.2	.329
95% CI	(38–45.1)	(25.1–34.1)	(24–31.8)	
%TWL	–	28.4 ± 15.7	32.8 ± 11.4	.316
95% CI		(18.5–38.4)	(25.6–40)	
%EWL	–	73 ± 39.2	87.8 ± 32.5	.258
95% CI		(48–97.9)	(67.1–108.4)	
Δ%TWL	–	–	4.3 ± 14.3	
95% CI			(− 4.7–13.4)	

Values are expressed in means ± standard deviation and 95% CI

BMI body mass index, *%TWL* percent total weight loss, *%EWL* percent excess weight loss, *Δ%TWL* difference in %TWL, *NA* reversal to normal anatomy, *NASG* reversal to normal anatomy + sleeve gastrectomy, *CI* confidence interval, *RYGB* Roux-en-Y gastric bypass

[§] Comparison of weight parameters at reversal (RYGB anatomy) versus at follow-up using the paired two-tailed student *t* test

reversal; of the 11 individuals who were not GERD sufferers, 8 (73%) developed GERD despite HHR. Consequently, 12 of the 15 HHR patients (80%) suffered from GERD at FU (4 NA vs. 8 NASG).

Discussion

For a part of the patients in this cohort, the overall short-term outcomes remained good as initially reported [14]. The present study seems to indicate that the short-term outcomes of the reversal procedure apply for a larger group and essentially persist for some 5 years.

Our cohort was almost equally composed of NA and NASG participants. NASG was performed in those individuals for whom weight was a key issue (either too little weight loss or fear of weight regain). Our data seems to confirm that adding a SG at reversal does protect against weight gain, as indicated by the significant difference in Δ%TWL between the NA and the NASG group. This finding is in line with the

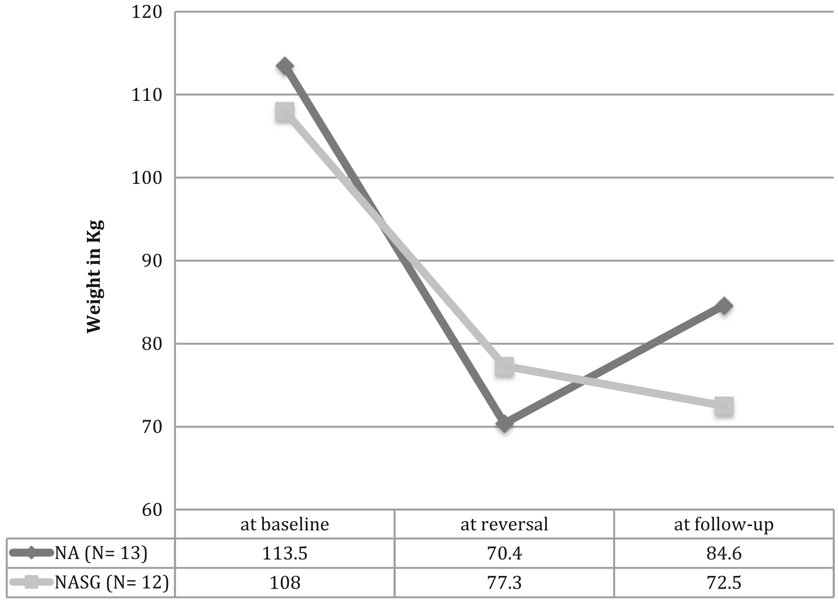

Fig. 1 Mean weight at different time points. Baseline data was statistically comparable for NA (reversal to normal anatomy) and NASG (reversal to normal anatomy + sleeve gastrectomy) in terms of weight (in kg and in BMI body mass index, (kg/m^2)). At reversal, i.e., RYGB (Roux-en-Y gastric bypass) anatomy, no statistical differences were found between NA vs. NASG in terms of weight progression (kg, BMI, %TWL percent total weight loss and %EWL percent excess weight loss). At follow-up, the difference between NA and NASG (including two patients with DS (duodenal switch)) was significant (p = .005) in terms of Δ%TWL (difference in %TWL), intention-to-treat, Table 3

short-term (14.7 months) weight outcomes reported by Carter et al., who, after reversal of RYGB with SG in 12 patients, found a moderate additional weight loss (i.e., 2.2 BMI points) [15]. Weight loss was not significant and may be explained by a number of mechanisms such as magnitude of the surgical trauma, possibly accompanied by a complication, activation of new metabolic pathways typical for the sleeve construction, and an improved follow-up in this category of patients. On the other hand, in our experience, in accordance with our redo-algorithm, reversal of RYGB into NASG and at a later-stage DS primarily to address insufficient weight loss seems to be only moderately efficient (success rate of 50%, be it in a small number of individuals (Table 2)) [25, 26].

Reversal to NA proved to be effective in resolving the symptoms early dumping and N/V. Reversal to NA effectively addressed non-dumping diarrhea, possibly by restoring the normal biliary acid resorption cycle. Of note, for early dumping and diarrhea, we avoided NASG because of concerns that the sleeve anatomy may actually accelerate gastric emptying [27] and counteract the slowing effect on gastric clearance of reincorporating the pylorus. Carter et al. [15] mentioned symptom worsening in the only patient treated by NASG because of dumping. Nevertheless, Zurita et al. [28] reported complete remission of dumping syndrome in two patients who benefited from reversal of RYGB with SG.

Conversely, we did not avoid NASG in the cases of hypoglycemic syndrome (also called "late dumping") [29] because the pathophysiology of this condition is quite different from "early dumping." Late dumping is linked with the incretin effect of bypassing the duodenum [30] and unlike early

Table 4 Early (< 30 days) complications (≥ Clavien-Dindo type III) and late (> 30 days) laparoscopic reinterventions for complications after RYGB reversal

Early complications = 8 (32%)	Treatment
Anastomotic leakage N = 4	Laparoscopic revision N = 1 (1 NASG)
1 NA – 3 NASG (3 St – 0 It)	Stent placement N = 3
	(+ Radiological drainage in 1 NASG)
Small bowel perforation N = 1 (1 NASG)	Surgical revision N = 1
Intraperitoneal abscess (Douglas, sub-phrenic) N = 2 (2 NA)	Radiological drainage N = 2
Abdominal bleeding N = 1 (1 NA)	Laparoscopic revision for mesocolic vessel injury N = 1
Late reinterventions = 7 (28%)	Reason
Re-reversal to RYGB N = 2 (elsewhere)	GERD N = 1 − hypoglycemia N = 1 (alleged)
Pyloroplasty N = 1 (elsewhere)	Hypertonic pylorus
Incisional hernia repair N = 2	Incisional hernia
CCE N = 2	Cholecystolithiasis

RYGB Roux-en-Y gastric bypass, *NA* normal anatomy, *NASG* normal anatomy + sleeve gastrectomy, *St* stapled technique, *It* imbrication technique, *CCE* cholecystectomy

Table 5 GERD incidence at different time points (different anatomies)

	N = 25	p value	NA (N = 13)	NASG (N = 12)	p value
GERD at baseline	11–44%	.125[α]	7	4	.302
GERD at reversal	7–28%	.109[¶]	5	2	.225
GERD at follow-up	17–68%	.002*	9	8	.891
De Novo GERD [§]	8/14–57.1%		2	6	.119

Categorical data were compared between independent groups (NA vs. NASG) by the chi-squared test. Progression was assessed using the McNemar test

GERD gastro-esophageal reflux disease, *NA* reversal to normal anatomy, *NASG* reversal to normal anatomy + sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass

[α] Comparison for GERD incidence at baseline vs. at reversal (RYGB anatomy)

[¶] Comparison for GERD incidence at baseline vs. at follow-up

*Comparison for GERD incidence at reversal vs. at follow-up

[§] De novo *GERD* meant a patient suffer GERD at follow-up without a history of GERD neither at baseline nor at reversal

dumping probably has little to do with the pace of gastric emptying [29]. Consequently, NASG should not influence the incretin secretion differently from NA. Along these lines, Campos et al. reported successful treatment of late dumping in the two patients they converted to NASG [16].

Qvigstad et al. [31] and Lee et al. [32] in post-reversal patients also reported a tapered response of GLP1, one of the incretins, to oral mixed-meal intake. Conversely, the influence of reversal on GIP [32]. another incretin, is less clear, which may explain the failure of the procedure in some cases, as we experienced on two occasions.

As any revisional bariatric surgery, reversal is fraught with an elevated (up to 32.2%) risk for postoperative complications [33, 34]. Carter et al. reported a major complication rate of 25% including a leak rate of 8.3% [15]. Chen et al., who used a standard stapling technique, reported a major complication rate of 8.1% and a leak rate of 6.1% [17]. We in our cohort recorded a postoperative early major complication rate of 32 and a 16% leak rate. Of note, three out of the four patients suffering a leak in our study had undergone a NASG, and in two of those three, a gastrostomy had been performed as well. Our leak rate is higher than reported in literature, which may be partly explained by technical issues, such as the poor quality of tissues induced by the gastrostomy. Interestingly, in the two gastrostomy cases that leaked, the antral segment with the G-tube had been resected. Along the same lines, the impaired vascular supply at the "angle of sorrow" created at NASG (Fig. 3) may have facilitated leaks. Concerning the latter, imbricating rather than resecting the distal stomach may be valuable in improving the vascular supply, and, actually, no leaks were observed since we initiated this approach after the third gastro-gastric leak suffered. Along the same lines, Campos et al. on five patients (three NASG) reported no complications using a suture reinforcement strategy [16]. Another factor that could partly explain the anastomotic lake rate is the impairment of the pyloric function secondary to the parasympathetic denervation we may have inflicted during the RYGB confection. An argument in favor of vagal denervation can be found in the fact that one of our patients did suffer functional stenosis of the pylorus and needed pyloric balloon dilation.

Table 6 GERD outcomes depending on reversal technique and concomitant (or not) HHR for the 14 individuals who had no history of GERD before reversal

Technique (N = 14)	GERD (N = 8)	No GERD (N = 6)
NASG (N = 2)	0	2
NASG + HHR (N = 6)	6[α]	0
NA (N = 3)	1	2
NA + HHR (N = 3)	1	2

GERD gastro-oesophageal reflux disease, *HHR* hiatal hernia repair, *NA* reversal to normal anatomy, *NASG* reversal to normal anatomy + sleeve gastrectomy

[α] χ^2 test = .036

Of note, in our series, leaks only occurred at the gastro-gastrostomy site and no complications were noted at the jejuno-jejunostomy (i.e., the anastomosis between the distal end of the biliary limb and the proximal end of the alimentary limb).

While placing a gastrostomy before the reversal operation does not appear to be innocuous, it can provide valuable information. Because gastrostomy feedings follow the "normal" route, they allow to evaluate the later effect of reversal on conditions such as "early" and "late" dumping [35]. In a case report, Qvigstad et al. observed that the attenuation of the GLP-1 response and the symptomatic hypoglycemia episodes that started 4 weeks after trial gastrostomy feeding indeed persisted after the

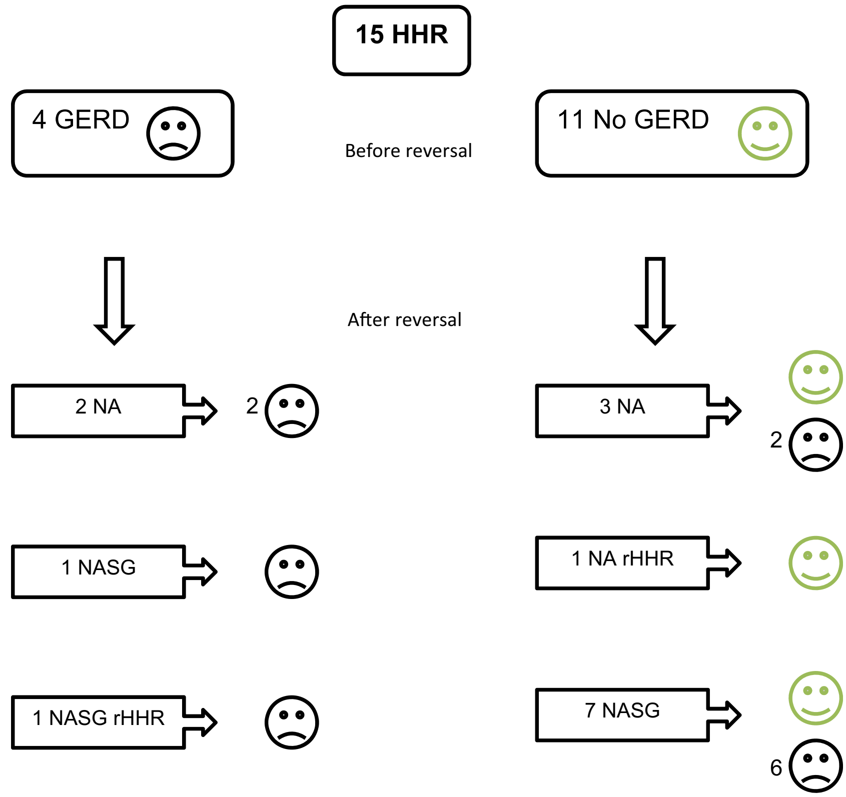

Fig. 2 GERD (gastro-esophageal reflux disease) outcomes in the 15 patients in which a hiatal hernia repair (HHR) or a repeat HHR (rHHR) was performed during reversal to (NA (normal anatomy) or to NASG (NA + sleeve gastrectomy)

reversal procedure [31]. Similarly, Campos et al. reported good efficiency of the reversal procedure in four patients in whom preoperative trial-gastrostomy for therapy resistant hypoglycemic syndrome had been conclusive [16]. In addition, in case of malnutrition, enteral alimentation via the gastrostomy may

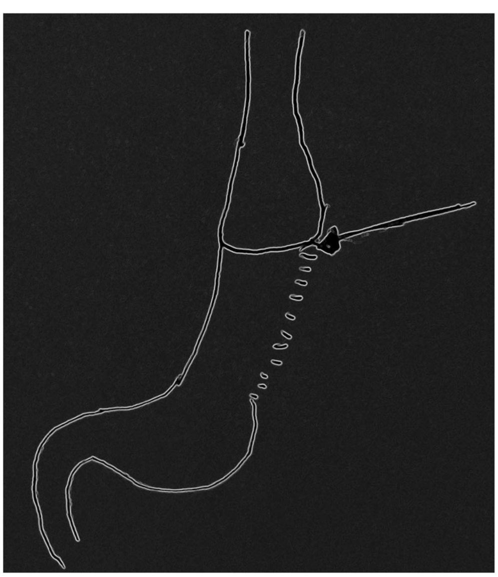

Fig. 3 Schematic representation of a stomach post-reversal after Roux-en-Y gastric bypass with sleeve resection. The arrow points at the "angle of sorrow"

actually reduce the incidence of surgical complications at the time of reversal and avoid the refeeding syndrome [36].

We therefore believe that rather than abandoning the strategy of placing a "trial-gastrostomy" improving our surgical technique (e.g., by placing the gastrostomy in the fundus of the remnant, using a smaller bore tube) may be beneficial.

GERD appears to be an important and frequent issue in the context of reversal after RYGB [14]. Nevertheless, compared with the situation before the reversal, the overall incidence of GERD was significantly higher after reversal, with a rate of 57.1% for de novo GERD.

While the pathogenesis of GERD at reversal is likely multifactorial, a significant causative factor may be our surgical technique, i.e., the anatomical changes we inflicted to the hiatus. In analogy with our strategy of primary SG, at reversal, we systematically explored the hiatus and repaired a HH when present. Our data, however, suggest that HHR is ineffective in terms of GERD control. None of the GERD sufferers was cured by HHR and only a minority (3/15, i.e., 20.0%) of the individuals who underwent HHR were GERD-free at follow-up (Fig. 2). Moreover, performing HHR during NASG seems to actually induce GERD: all the individuals from the NASG group who underwent HHR developed GERD (Table 6). Our findings are in sharp contrast with primary SG where HHR appears to significantly improve the GERD outcome [37, 38], even though there is no consensus on this issue in the literature [39].

To address the ill consequences of our technique of HHR, we recently started approaching the hiatus posteriorly and from left to right, which allows good visualization, and usually helps avoid severing the phreno-esophageal ligament. According to Tom DeMeester, preserving the phreno-esophageal membrane while dissecting the hiatus is critical in maintaining the anti-reflux mechanism because it transmits the intra-abdominal pressure to the distal esophagus, even in the presence of a small sliding hernia [40]. At this stage, it is, however, premature to advocate any benefit of this novel technique in terms of GERD.

Limitations of this study are the retrospective design and the small size of our cohort, which obviously weakens the value of our subgroup analysis. Nevertheless, while small, our cohort is the largest in literature on the topic of RYGB reversal to NA/NASG. Moreover, the fact that both groups (NA and NASG) were approximately of the same size did allow for some intergroup comparison.

Another limitation is constituted by the method of telephone query we used. The reliability of data that are self-reported by telephone, especially concerning weight, may be questionable. Nevertheless, the discrepancy between self-reported and measured weight data appears to be acceptable [41].

A last limitation is the absence of objective data in evaluating GERD, such as endoscopy, high-resolution manometry, and impedance-metry. Nevertheless, GERD-related questionnaires and the criterion we used in our study, i.e., PPI use, has been shown to be a reliable diagnostic tool in the evaluation of GERD [42–44].

Conclusion

In mid-term (> 2 years) evaluation, NA/NASG appears to achieve a high remission rate for early dumping symptoms, malnutrition, nausea/vomiting, diarrhea, and, to a lesser extent, for the hypoglycemic syndrome. Reversal to NA is accompanied by weight regain. Reversal to NASG causes some weight loss but does not guarantee sufficient weight reduction when performed for weight loss failure. In addition, NASG is fraught with a high surgical complication rate—especially when a gastrostomy has been placed before the reversal procedure—and appears to frequently induce GERD, especially when HHR is performed concomitantly.

Compliance with Ethical Standards

Conflict of Interest GA Arman, R Bolckmans, D Van Compernolle, R Villalonga, and G Leman have no conflicts of interest or financial ties to disclose. J Himpens reports personal fees from Ethicon and Medtronic.

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