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CLINICAL RESEARCH

Radical Resection of the Pyloric Antrum and Its Effect on Gastric Emptying After Sleeve Gastrectomy

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Abstract
Background The surgical technique of laparoscopic sleeve gastrectomy (LSG) has not been fully standardized yet and there is the unresolved question of what is the optimum size of retained pyloric antrum. The aim of our research was to prove that even after a radical resection of the pyloric antrum the physiological stomach evacuation function can still be preserved.
Methods Our study was based on 12 patients, who were randomly divided into two groups. Patients undergoing radical antrum resection (RA group) underwent gastric emptying scintigraphy to determine the evacuation half-time (T1/2) and food retention in the 90th minute of the test (%GE) both before the operation and 3 months afterward. Patients in whom the antrum was preserved (PA group) served as a control group for comparison of postoperative weight loss (in kilogram), decrease in body mass index (BMI), and decline in excess weight (%EWL). The resulting changes were statistically processed.
Results In the RA group, the average time T1/2 declined from 57.5 to 32.25 min (p=0.016) and average retention %GE dropped from 20.5 to 9.5 % (p=0.073). Differences in the average values of weight, BMI, or %EWL between both groups were of no statistical significance (p>0.8).
Conclusions In the RA group, an increase in gastric emptying postoperatively was noted. Complications such as failure of stomach evacuation were not observed in the RA group. Our results suggest that even more radical resection of the pyloric antrum performed by LSG is possible without concerns of postoperative disorder of the stomach evacuation function.

Keywords Sleeve gastrectomy · Scintigraphy · Pyloric antrum · Gastric emptying

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Introduction

Since 2003, laparoscopic sleeve gastrectomy (LSG) has been applied increasingly often as an independent operating procedure within bariatric surgery. Until then, it had been performed only as a preparatory phase ("first step") before the definitive biliopancreatic diversion-duodenal switch or Roux-en-Y gastric bypass in super–super obese patients (body mass index (BMI) >60) [1, 2]. The goal of this procedure was the initial loss of body weight in order to decrease perioperative morbidity and mortality. Thanks to its relative technical simplicity and significant reduction of excess weight (%EWL) by around 60 % within a 3-year monitoring period, the procedure is becoming ever more popular [3].

Sleeve gastrectomy is primarily considered a restrictive type of bariatric surgery, where surgical technique plays a major role in the resulting weight loss and maintenance thereof [4]. In the professional journals, several different studies can be found focusing on the relation between BMI reduction and the remaining size of the gastric sleeve [5, 6], length of the retained pyloric antrum [7, 8], the radical resection of the stomach fundus [9], the diameter of the orogastric tube [10, 11], and the treatment method of the resection line [12, 13], wherein all these techniques may contribute, to a certain extent, to the residual gastric volume and thus the final outcome of the surgery.

When we compare the conclusions of 2007, 2009, and 2010 summits on sleeve gastrectomy, we see an overall tendency towards support for stomach capacity restriction using a smaller orogastric tube (mean tube diameter went from 37.3 French (Fr) down to 35.6 Fr) and leaving a shorter segment of the pyloric antrum (gradual shortening from mean 5.6 to 5.0 and 4.8 cm) [14–16].

In our department, we first introduced sleeve gastrectomy in 2006. In the beginning, the standard procedure was leaving 7 cm of intact pyloric antrum and using a 42-Fr orogastric tube. Nonetheless, over time and with regards to an overall tendency heading rather towards a more significant restrictive effect of sleeve gastrectomy, we gradually shortened the size of the retained pyloric antrum to 6 cm and started using a 36-Fr orogastric tube. In 2010, as a part of our prospective pilot study, we started to apply intermittently the method of radical resection of the pyloric antrum with the edge of the resection line 2.5 cm orally from the pylorus. In our study, we aimed to prove safety of the pyloric antrum radical resection with preservation of the physiological stomach evacuation function after the sleeve gastrectomy. We were inspired by data published by bariatric surgeons supporting the radical resection of the pyloric antrum within sleeve gastrectomy [17], as well as a study led by Japanese authors on stomach evacuation after subtotal gastrectomy (pylorus-preserving procedure) indicated in patients for the early stage of gastric cancer [18, 19].

Patients and Methods

Patients

In our pilot study (January 2010–January 2011), we included 12 morbidly obese patients indicated for sleeve gastrectomy as the primary bariatric procedure, where the conservative therapy (1–3 years) had already failed. We randomly divided our 12 patients into two groups of six. Patients undergoing radically antrum resection (the RA group) were sent for gastric emptying scintigraphy before and 3 months after the operation to determine stomach emptying half-time (T1/2) and retention of irradiated food within 90 min of the examination process (%GE). We recorded changes of both the gastric emptying half-time and the food retention. Patients in the second group (the PA group) with approximately the same initial values of BMI and excess weight served as a control group. They also underwent LSG; however, the antrum was not radically resected. To compare the LSG effect on the body weight loss, a drop in BMI values and %EWL, both groups were examined after a 3- and 12-month interval after the operation, and their values were thoroughly recorded and subsequently evaluated by repeated measures ANOVA methodology (for RA vs PA groups defined as a fixed factor) and t tests. The patients came to see their surgeon for the postoperative check-up examination after 1, 3, 6, 9, and 12 months, where among other things, we also checked for pyrosis occurrence, nausea, vomiting, and possibly for symptoms of early or late dumping syndrome, where the occurrence of one symptom with repeated frequency minimally once a week during the last month before the outpatient check-up was considered to be a positive result [20].

Demographic Data

The average age of patients in the RA group was 45 years (36–56), average body weight was 124.8 kg (107–143), mean BMI was 41.9 kg/m^2 (38–44.3), and the average excess weight was 57.4 kg (44.6–68.8). In the PA group, the average age was 43 years (31–51), average body weight was 122.3 kg (98–160), mean BMI was 41 kg/m^2 (37.3–49), and the average excess weight was 56.2 kg (40.5–84; Table 1).

Operative Technique

The surgical technique of the sleeve gastrectomy (one surgeon) was identical in all patients, as for the applied orogastric calibration tube (36 Fr), the skeletization of the greater curvature of the stomach up to the angle of His (Harmonic scalpel, Ethicon Endo-Surgery), and the complete mobilization and resection of the stomach fundus (Stapler Echelon 60 Endopath Ethicon Endo-Surgery, blue cartridge). The resection line in the RA group started 2.5 cm orally from the pylorus, while in the PA group, we always

Table 1 Demographic data

	Group RA (n=6)	Group PA (n=6)
Sex (male/female)	4/2	2/4
Age (years)	45 (35–56)	43 (31–51)
Weight (kg)	124.8 (107–143)	122.3 (98–160)
BMI (kg/m^2)	41.9 (38–44)	41 (37.3–49)
Overweight EW (kg)	57.4 (44.6–68.8)	56.2 (40.5–84)

EW excess weight

Table 2 Postoperative changes in body weight, BMI, and %EWL in the RA group

Group RA	Patients (n=6)	After 3 months	After 12 months	p value
Weight (kg)	124.8 (107–143)	103 (92–119)	89 (82–104)	<0.001
BMI (kg/m^2)	41.9	34.6 (32.6–35.9)	29.9 (28.7–30.2)	<0.001
% EWL (%)		36.8 (29.1–42.2)	61.1 (51.6–70)	<0.001

led the section 6 cm orally from the pylorus. The resection line was left without any additional treatment (over-sewing, biological sealants, or reinforcing material). Prior to the end of the operation, all patients were tested with methylene blue to rule out stomach perforation.

Gastric Emptying Scintigraphy

To examine the stomach evacuation function, we chose gastric emptying scintigraphy since we see it as optimal and since it is generally regarded as the gold standard among examination methods for gastric motor functions [21]. We performed scintigraphic examination in all patients from the RA group prior to and 3 months after the operation. With regard to standardization of methods and comparability of obtained results, we served a semisolid standardized breakfast before scintigraphic examination, as it is very close to physiological conditions during food intake and complies with recommendations of expert societies [22].

The patient attended an examination on an outpatient basis on an empty stomach, then he/she was served a standardized semisolid breakfast comprising two slices of white bread, 250 ml of mild black tea, and two scrambled eggs marked with ^{99m}Tc radionuclide of 40 MBq activity. By means of scintigraphy camera (Infinia GE Medical System with LEHR collimator), we then recorded gamma-ray activity in the seated patient above his/her abdomen with front projection for 60 s and repeated it in a 10-min interval for a total of 90 min. Data were stored to a PC memory, and subsequently, the individual images were used to generate an activity decline curve over time with a correction for used radionuclide degradation.

We were able to express the following parameters:

1. T1/2—rate of evacuation curve decline to one half of its initial value
2. %GE in the 90th minute—percentage of irradiated food evacuation from the stomach within a specified period

All T1/2 and %GE values obtained prior to and after the operation were statistically compared.

Statistical Analysis

Statistical analysis was performed by ANOVA methodology. P values were used to evaluate the statistical significance of changed values of followed parameters (evacuation half-time T1/2, and retention %GE after 3 months, respective body weight, BMI, and %EWL 3 and 12 months after the operation)—using one-way ANOVA for repeated measurement taking. Differences in mean values (body weight, BMI, and %EWL) between groups (RA and PA) were evaluated by means of a special dual-choice t test.

For simultaneous comparison of the decrease of the weight loss, %EWL, and BMI between groups (RA and PA), we tested the significance of interactive effects by means of two-way ANOVA using one fixed factor (groups) and one repetition factor (measurements taken prior to and 3 and 12 months after the operation). All indexes used in our calculation were certified and classified according to standard skewness and kurtosis tests, Kolmogorov–Smirnov and Shapiro–Wilk tests; all calculations were processed by SPSS (ver. 17.0) and STATISTICA (ver. 10.0) programs.

Results

The postoperative period after LSG in ten patients passed without complications. In two patients from the RA group, we had to perform laparoscopic revision on the first postoperative day due to signs of hemoperitoneum. The perioperative finding in the first patient revealed multisource bleeding from the staple line, small curvature, and retrogastric area within the aa. gastricae breves. In the second patient, bleeding was detected during the surgical revision in the middle part of the staple line.

Table 3 Postoperative changes in body weight, BMI, and %EWL in the PA group

Group PA	Patients (n=6)	After 3 months	After 12 months	p value
Weight (kg)	122.3 (98–160)	103.3 (80–138)	88.7 (72–122)	<0.001
BMI (kg/m^2)	41	34.5 (29.8–42.4)	29.7 (24.6–35.3)	<0.001
% EWL (%)		35.6 (23.8–52.5)	62.5 (44.4–89.3)	<0.027

Table 4 Comparison of postoperative weight losses, BMI, and %EWL in the RA and the PA groups

	Group RA (n=6)	Group PA (n=6)	t statistic	p value
Preoperative weight	124.8 (107–143)	122.3 (98–160)	0.207	0.840
Postoperative weight + 3 months	103 (92–119)	103.3 (80–138)	0.000	1.000
Postoperative weight + 12 months	89 (82–104)	88.7 (72–122)	0.070	0.946
Preoperative BMI	41.9 (38–44.3)	41 (37.3–42.1)	0.459	0.656
Postoperative BMI + 3 months	34.6 (32.6–35.9)	34.5 (29–42.4)	0.035	0.973
Postoperative BMI + 12 months	29.9 (28.7–30.2)	29.7 (24.6–35.3)	0.170	0.868
Postoperative %EWL + 3 months	36.8 (29.1–42.2)	35.6 (23.8–52.5)	0.217	0.832
Postoperative %EWL + 12 months	61 (51.6–70)	62.5 (44.4–89.3)	0.163	0.874

Legend: The last but one column of the table shows t statistics for dual-choice t test at 10° latitude with corresponding p values in the last column. All tested differences between groups are insignificant

Resection line in the place of pyloric antrum radical resection was always intact. Hemoperitoneum (first patient 600 ml, second patient 800 ml) was sucked out and the bleeding was treated with metal clips and bipolar coagulation. The following postoperative course proceeded without complications. On the first postoperative day, each patient underwent a test for stomach passage done with aqueous iodine contrast agent (Telebrix). The test did not detect any leakage of contrast agent beyond the lumen of the stomach or the stomach obstruction.

The average preoperative body weight in the RA group of 124.8 kg dropped to 103 and 89 kg 3 and 12 months after the operation (p<0.001), the mean preoperative BMI of 41.9 went down to 34.6 and 29.9 in the 3rd and 12th month (p< 0.001), and the average decrease of %EWL was 36.8 % in the 3rd month and 61.2 % in the 12th month (p<0.001; Table 2).

In the PA group, the average preoperative body weight of 122.3 kg dropped to 103 and 88.7 kg 3 and 12 months after the operation (p<0.001), the mean preoperative BMI of 41 went down to 34.5 and 29.7 in the 3rd and 12th month (p< 0,001), and the average decrease of %EWL was 35.6 % in the 3rd month and 62.5 % in the 12th month (p<0.027; Table 3).

By simultaneous comparison of the weight loss, as well as BMI and %EWL between the RA and PA groups, we found that all p values were insignificant, which means that individual profiles of weight loss did not statistically differ (Table 4).

Scintigraphic examinations were both realized within the stated periods (preoperatively and 3 months after the operation), yet only in four patients from the RA group (one patient developed an intolerance to eggs, and one patient came for a follow-up scintigraphic examination for the first time 12 months after the operation). Results of examinations proved that the average preoperative stomach emptying half-time (T1/2) declined from 57.5 to 32.25 min (p=0.016), and the average preoperative retention of irradiated food (%GE) decreased from 20.5 to 9.5 % (p=0.073; Table 5). There was no epigastric fullness, nausea, vomiting, or pyrosis recorded in the RA group.

By contrast, three patients from the PA group, in whom we preoperatively detected during a fibroscopic examination a minor sliding hiatus hernia with silent clinical symptoms, postoperatively developed previously absent reflux disorder requiring medical therapy with H2 blockers. The symptoms typical for early or late dumping syndrome were not recorded in either group.

Discussion

The mechanism of action of the sleeve gastrectomy is believed to involve a combination of gastric restriction, hormonal effects, and changes in gastric motility and eating habits [23]. Despite this clearly multifactorial mechanism, the size of restriction performed is the most significant factor for weight reduction and maintenance. Residual gastric volume is a result of surgical technique, which is not yet fully standardized, and one of the issues requiring further attention is the necessity to preserve the pyloric antrum intact in order to maintain the physiological emptying

Table 5 Changes in evacuation half-time (T1/2) and retention of food (%GE) in the RA group

Patient	T1/2 (min) Preoperative	Postoperative	% GE (%) Preoperative	Postoperative
1	72	58	40	22
2	54	21	22	5
3	42	23	15	5
4	62	27	5	5
Mean	57.5	32.3*	20.5	9.3**

*p=0.016, **p=0.073

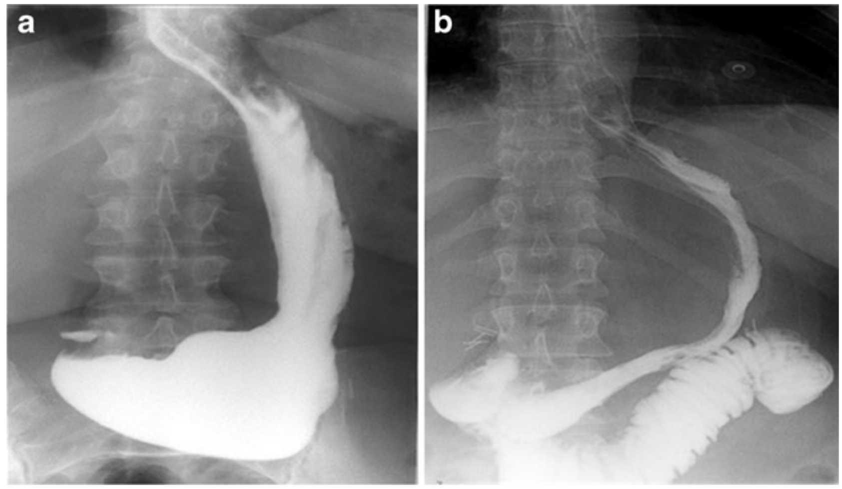

Fig 1 Postoperative X-rays of two patients after resection of the pyloric antrum starting 6 cm (**a**) and 2.5 cm (**b**) proximally from pylorus, respectively

capacity of the stomach [10], or on the contrary, the need for radical resection of the pyloric antrum to increase the restrictive effect [17, 24].

The most frequently heard argument against the technique of pyloric antrum radical resection is the concern regarding developing a stomach evacuation function disorder [10, 11, 25], although there is no study available supporting this argument. Other authors claim that the stomach capacity decrease in the case of the pyloric antrum radical resection is insignificant [10], yet by comparison of postoperative X-rays of patients with different lengths of retained pyloric antrum, their argument becomes relative (Fig. 1).

Authors investigating in their comparison study the impact of the left antrum segment size on stomach evacuation function after pylorus-preserving subtotal gastrectomy due to an early stage of stomach cancer proved better results in patients with a remaining pyloric antrum segment of 2.5 cm compared to those with 1.5 cm segments, where the main precondition for preserved function in both patient groups seemed to be the intact pyloric branch of the vagus nerve [18, 19].

Discussions on participation of increased intragastric pressure as a cause of possible complications point out the risk of postoperative leak and gastroesophageal reflux occurrence rather than the risk of resection line bleeding; the incidence of which is approximately 2.4 % [26–28]. We assume that the most probable cause of hemoperitoneum in our first patient was an insufficient time lapse (only 4 days) from the chronic antiaggregation therapy—aspirin cutoff—where the standard interval for discontinuance in elective procedures is 7 days. We also do not consider both hemoperitoneum cases in our RA patients (particularly in the first case) to be a consequence of increased intragastric pressure. We also did not detect any symptoms of dumping syndrome in relation to acceleration of stomach evacuation in patients after LSG, as described by Tzovaras [29].

At first, the sleeve gastrectomy was regarded only as a bariatric procedure with restrictive effect [17, 30], yet recently, it is to be seen as an operation where the weight loss effect is partially enhanced also by enterohormonal changes [31], which have not been fully clarified so far. We assume that changes in acceleration of stomach evacuation ability, among other things, might be behind this process [32].

Currently, there are only five valid and statistically supported studies available dealing with the speed of gastric emptying in patients after sleeve gastrectomy [33–37], and only three of them focus on comparison of gastric emptying

Table 6 Evacuation study prior to and after sleeve gastrectomy

Author	Antral length (cm)	Number of patients	Ø bougie (cm)	Trial diet	Gastric evacuation	Scintigraphy prior to SG	Scintigraphy after SG
Melissas et al. [33]	7	9	34	Solid	Accelerated	Yes	Yes
Bernstine et al. [34]	6	21	48	Semisolid	Unchanged	Yes	Yes
Braghetto et al. [5, 35]	2	20	32	Liquid + solid	Accelerated	No	Yes
Shah et al. [37]	–[a]	23	–[a]	Solid	Accelerated	No	Yes
Baumann et al. [36]	5–6	5	32	Liquid	Accelerated	Yes[b]	Yes[b]
Kasalicky et al. [12]	2.5	4	36	Semisolid	Accelerated	Yes	Yes

[a] Not stated

[b] Magnetic resonance

speed prior to and after operation within the same group of patients. The outcomes of those three studies are not quite clear (2× gastric evacuation accelerated, 1× unchanged) and the numbers of patients included in the tested samples are relatively small (5, 9, or 20 patients; Table 6).

Although in 12-month monitoring interval the RA and PA groups do not differ much as regards the achieved weight loss, in a mid-/long-term interval (3–5 years), the comparison of weight loss between both groups will be more interesting, and we hope that the long-lasting effect of achieved excess weight loss will be more significant in patients with radical resection of the pyloric antrum.

Conclusions

In our opinion, the potentiation of restriction by sleeve gastrectomy (among other things by radical resection of the pyloric antrum) is the easiest way to achieve greater and more sustainable weight loss over time. The aim of our pilot study was not to compare changes in speeds of stomach emptying after differently sized resections of the pyloric antrum within two patients groups, but to prove that even a radical resection of the pyloric antrum is not necessarily accompanied by gastric emptying disorder with clinical symptoms such as gastroesophageal reflux or dumping syndrome. To support our findings, we also state data proving statistically significant acceleration of gastric emptying after radical resection of the pyloric antrum.

However, our study sample is too small and the monitoring interval is too short to draw clear outcomes comparing two different operating techniques as regards the number of complications or loss of weight. We understand that this study lacks statistical importance for the final determination of pyloric antrum resection technique in sleeve gastrectomy patients. Yet, the obtained data clearly support our statement on feasibility of a more radical surgical approach to pyloric antrum resection while still potentiating the restrictive component and preserving physiological evacuation function of the stomach.

We regard this study to be supportive of arguments of those surgeons who deem restriction as the main mechanism of weight loss after this type of bariatric procedure. Whether radical resection of the pyloric antrum can prevent new weight gain in the mid-/long-term or not will be the subject matter of our next study. The hypothesis that changes in the stomach evacuation rate potentiate weight loss by means of enterohormonal response of the organism is still waiting to be confirmed.

Conflict of interest The authors declare that they have no conflict of interest.

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