

Surgical Technique Affects the Incidence of Marginal Ulceration after Roux-en-Y in Gastric Bypass

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Received September 18, 2013; revised October 15, 2013; accepted October 23, 2013

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ABSTRACT

Background: Marginal ulceration (MU) is a recognized complication of Roux-en-Y gastric bypass (RYGB) surgery. While several possible risk factors have been reported, the mechanism of MU remains incompletely understood. The aim of this study was to compare the effect of surgical technique on the incidence of MU. **Methods and Material:** This was a retrospective study of 749 patients undergoing RYGB over a ten-year period with at least one year of follow-up. The diagnosis of MU was made based on clinical symptoms and confirmed by postoperative endoscopy (POE). We assessed four different gastric bypass (GBP) techniques: T1—Open, non-divided stomach, circular stapler, non-vagotomy (n = 332); T2—Open, divided stomach, circular stapler, vagotomy (n = 91); T3—Laparoscopic, divided, circular stapler, vagotomy (n = 152); T4—Laparoscopic, divided, linear stapler, vagotomy (n = 174). **Results:** The four groups were similar with respect to age and mean BMI. The frequency of POE was 16%, 25%, 28% and 27% in groups T1-T4 respectively (NS). The incidence of MU was significantly lower in T1 (2.1%) compared to T2 (5.5%), T3 (15.1%) and T4 (12.6%), $p < 0.05$. MU occurred significantly more frequently with an antecolic Roux limb versus retrocolic (14.5% vs 5.6%, $p < 0.05$). **Conclusion:** The incidence of MU after RYGB surgery is influenced by surgical technique. The lowest incidence of MU was with a non-divided stomach, no vagotomy, transverse staple line, and circular stapled anastomosis. A retrocolic Roux limb was protective. There was no difference in the incidence of MU using laparoscopic versus open bypass if a similar technique was employed or using linear versus circular stapler for the gastrojejunostomy.

Keywords: Gastric Bypass; Marginal Ulceration

1. Introduction

Marginal ulceration (MU) is a well-known complication after Roux-en-Y gastric bypass (RYGB). The symptoms can range from minimal abdominal discomfort to life threatening bleeding or perforation [1]. The reported incidence of MU has varied widely in the literature from 1% to 16% [1-10]. These differences may be related to differences in surgical technique and patient factors, but also vary depending on definition, method of detection and follow-up.

The mechanism of MU formation after RYGB is incompletely understood. Several technical factors have been implicated, including pouch size and orientation, an association with foreign material, staple line disruption and gastrogastric fistula, and anastomotic technique [5,9,11,12]. A variety of patient-related factors such as non-steroidal antiinflammatory medication (NSAID), helico-

bacter pylori infection and smoking may also be important [13]. The aim of the present study was to evaluate the influence of different surgical techniques of RYGB on MU.

2. Methods

Patients

This was a retrospective study of 749 adult patients (>19 years of age), who underwent primary open or laparoscopic RYGB procedures. Inclusion criteria were preoperative BMI ≥ 35 , patient with unsuccessful non-surgical weight loss treatment and one of the four RYGB techniques received (**Table 1**). We had excluded techniques that had less than 50 procedures performed (n = 18) and revisional procedures (n = 90). All operations were performed by four surgeons at a single institution from October 1995 to November 2005. Overall, there were 653

Table 1. Comparison of surgical techniques.

	Technique 1	Technique 2	Technique 3	Technique 4
Surgical Access	Open	Open	Laparoscopic	Laparoscopic
Gastric Pouch Orientation	Transverse	Vertical	Vertical	Vertical
Staple Line	Nondivided	Divided	Divided	Divided
Pouch Size	<30 cc	<30 cc	<30 cc	<30 cc
Vagotomy	No	Yes	Yes	Yes
Anastomosis	Circular Stapler	Circular Stapler	Circular Stapler	Linear Stapler
Roux Limb	Ante or Retrocolic	Ante or Retrocolic	Ante or Retrocolic	Ante or Retrocolic

(87%) females and 96 (13%) males. Patients had a mean age of 46 years with a range from 22 to 74 years. The mean BMI was 51.5 with a range from 32 - 88 kg/m². Mean follow up was 52 months with a range of 12 to 133 months. Local internal review board (IRB) approval was obtained.

The following variables were collected and analyzed. Patient factors at the time of RYGB included age, gender, BMI, active smoking, history of smoking (off cigarettes at least 6 months), alcohol use, NSAID use, history of peptic ulcer disease and follow up. Technical factors included surgical access (open and laparoscopic), antecolic versus retrocolic Roux limb and gastro-jejunal anastomosis techniques. Postoperative endoscopy included indications and findings. MU included any ulceration within 2 cm of the anastomosis. The incidence of MU was compared using the Kaplan and Meier log rank test. If the overall log rank test yielded a p-value < 0.05, pairwise log rank tests were conducted using a Bonferroni adjustment for multiple comparisons. The Cox regression model for censored data was used to examine combinations of patient characteristics associated with a multivariate analysis.

3. Surgical Procedures

3.1. Technique 1

Through a midline incision the gastrocolic ligament was divided to gain access to the lesser sac. Windows were created in the gastrohepatic ligament along the lesser curve 4 cm from the GE junction and on the greater curve. A TA-90B stapler was passed transversely from the lesser to greater curve side sparing the vagus nerve and positioned it in order to get a 30 cc pouch. This pouch size is confirmed by insufflation with 30 cc of fluid. The anvil of a 21-EEA stapler was placed in the gastric pouch and secured with a 3-0 Prolene purse string. The jejunum was divided 40 cm distal to the ligament of Treitz between bowel clamps and an end-to-side hand-sewn anastomosis was created between the proximal je-

junum and the side of the Roux limb, 150 cm distal. The mesenteric defect was closed. The end of the Roux limb was brought through the transverse mesocolon in retrocolic or antecolic fashion. The EEA stapler was introduced through the end of the Roux limb for a few cm and exited the sidewall. It was connected to the anvil and fired. The end of the Roux limb was amputated with the TA60 stapler and imbricated with 3-0 silk. The anterior two thirds of anastomosis were reinforced with horizontal mattresses of 3-0 silk.

3.2. Technique 2

Through a midline incision the gastrocolic ligament was divided to gain access to the lesser sac. A window was created in the gastrohepatic ligament along the lesser curve 4 cm from the GE junction to just below the first branch of the left gastric artery. At this point, a partial (4 cm) horizontal transection of the stomach was carried out with a GIA stapler. This divided the vagus nerve. A small gastrotomy was created in the lower gastric segment laterally. This was used to introduce the 21 EEA anvil into the upper gastric pouch, bring it through the gastric wall and secure it with a pursestring in the proximal pouch. The gastric transection was then completed with the GIA-60 stapler firing in a vertical fashion to the angle of His. The small bowel was divided with a GIA stapler 40 cm distal to the ligament of Treitz. A 150 cm Roux limb cm was measured and the side-to-side jejuno-jejunosotomy performed. The mesenteric defect was closed. The end of the Roux limb was brought through the transverse mesocolon in an antecolic or retrocolic fashion. The 21-EEA stapler was introduced through the end of the Roux limb for a few cm and exited the side wall. It was connected to the anvil and fired. The end of the jejunum was amputated with the TA-60 stapler and imbricated with 3-0 silk. The anastomosis was reinforced with horizontal mattresses of 3-0 silk.

3.3. Technique 3

Pneumoperitoneum was established and five laparoscopic ports were placed. We identified the angle of His and dissected a window. An opening was created in the gastrohepatic ligament along the lesser curve 4 cm from the GE junction just below the first branch of the left gastric artery. The GIA was then used to go across the stomach transversely 4 cm. This divided the vagus nerve. A small opening was made in the midpoint of that staple line. We then placed two stay sutures in the distal stomach and made a gastrotomy. The anvil of a 21 EA stapler was passed through the left sided port site and brought through the distal gastrotomy and up through the transverse staple line. The distal gastrotomy was then closed with a GIA stapler. The GIA-60 was fired in a vertical

fashion up to the angle of His to complete the pouch. The small bowel was divided with a GIA stapler 40 cm distal to the ligament of Treitz. We then performed a side-to-side stapled anastomosis between the proximal jejunum and the side of the Roux limb 150 cm distal. The Roux limb was brought in an antecolic or retrocolic fashion. Next, we positioned with the anvil and fired. We amputated the end of the Roux limb with the GIA-60. Non-absorbable antitension sutures were placed at each corner of the anastomosis.

3.4. Technique 4

Pneumoperitoneum was established and five laparoscopic ports were placed. We identified the angle of this and dissected a window. The small bowel was run 40 cm from the Ligament of Treitz and transected using an Endo GIA 60-2.5 stapler. The Roux limb was measured 150 cm distally. We then performed a side to side stapled anastomosis between the proximal jejunum and the side of the Roux Limb. The Roux limb was brought up an antecolic or retrocolic fashion. The mesenteric defect was closed. The gastrohepatic ligament was opened and the lesser curve was identified 4 cm from the GE junction just below the first branch of the left gastric artery. The gastric pouch was created using a series of Endo GIA 60-3.5 staples going 4 cm transversely, including a vagotomy. Complete gastric transection was assured in a vertical fashion. An Endo GIA 45-3.5 stapler was inserted intraluminally to 2.5 cm and fired. The anastomosis was completed in a handsewn fashion with an inner layer of absorbable suture and outer layer of non-absorbable suture. The gastroscope was directed down the esophagus and across the gastrojejunal anastomosis.

4. Results

The four patient groups were similar in age and BMI. There was no difference in the incidence of a history of ulcer disease, alcohol consumption and use of NSAID (**Table 2**). Active smoking, history of smoking and gender were the variables which were significantly different among groups. There were a lesser proportion of females in technique 2 versus technique 3. Both active smoking and history of smoking were significantly less frequent in patients undergoing technique 4.

Overall, POE was performed in 166 (22%) patients. There was a statistically significant difference in the incidence of POE among the groups (**Table 3**). The main indications for POE were nausea and vomiting (40%), followed by abdominal pain (23%) (**Table 4**). The findings of POE were the following: normal $n = 85$ (50%), MU $n = 57$ (34%), stricture $n = 23$ (14%), bleeding $n = 2$ (1%) and more than 2 pathologic sign $n = 1$ (1%). The incidence of MU at POE ranged from 13% - 53% among the different techniques.

Table 2. Comparison of clinical characteristics.

	Technique 1	Technique 2	Technique 3	Technique 4
Number	332	91	152	174
Mean BMI (range)	51.4 (32 - 88)	52.1 (36 - 76)	52.1 (32 - 78)	50.8 (36 - 79)
Mean age years (range)	47 (25 - 72)	44 (25 - 71)	44 (22 - 74)	46 (26 - 71)
Gender (% female)	88	78 [#]	91	89
Alcohol use				
No	330 (99%)	88 (97%)	150 (99%)	173 (99%)
Yes	2 (1%)	3 (3%)	2 (1%)	1 (1%)
Active smoking				
No	264 (80%)	73 (80%)	122 (80%)	160 (92%) [*]
Yes	68 (20%)	18 (20%)	30 (20%)	14 (8%)
History of smoking				
No	216 (65%)	66 (73%)	98 (64%)	139 (80%) [*]
Yes	116 (35%)	25 (27%)	54 (36%)	35 (20%)
NSAID				
No	296 (89%)	72 (79%)	126 (83%)	144 (83%)
Yes	36 (11%)	19 (21%)	26 (17%)	30 (17%)
History of Peptic ulcer				
No	326 (98%)	89 (98%)	148 (97%)	173 (99%)
Yes	6 (2%)	2 (2%)	4 (3%)	1 (1%)

^{*} $p < 0.05$ vs other; [#] $p < 0.05$ vs T3.

Overall, MU occurred in 57 (7.6%) of patients (**Table 3**). Fifteen (26%) occurred in the first two postoperative years. The specific location of the ulcers at endoscopy was gastro-jejunal anastomosis $n = 27$ (47%), jejunal $n = 22$ (39%), gastric $n = 7$ (12%) and multiple sites $n = 1$ (2%). All of the ulcers were localized within 2 cm from the anastomotic site.

Univariate analysis using a log-rank test revealed a significant difference in incidence of MU by technique (**Tables 3 and 5**). Specifically, the incidence of MU was smaller for the technique 1 compared with each of the other techniques. There were no differences among T2, T3, and T4. In univariate analysis there was evidence that MU was associated with retrocolic Roux limb route ($p < 0.0001$) and a tendency with history of smoking ($p = 0.1453$).

In the multivariate Cox proportional hazards regression model, these three variables (technique, history of smoking, and Roux limb fashion) were included in the model (**Table 6**). After accounting for history of smoking and Roux limb fashion, technique was significantly associated with MU. The risk of MU is 43 times higher for subjects treated with technique 2 ($p < 0.0001$), 19 times higher for patients treated with technique 3 ($p < 0.0001$) and 52 times higher for subjects treated with technique 4 ($p \leq 0.0001$) compared with technique 1. After ac-

Table 3. Incidence of marginal ulceration and endoscopy.

	Technique 1	Technique 2	Technique 3	Technique 4	Total
Number of Marginal Ulcer (%)	7 (2.1%)*	5 (5.5%)	23 (15.1%)	22 (12.6%)	57 (7.6%)
Number of Postoperative Endoscopy (%)	53 (16%) [#]	23 (25%)	43 (28%)	47 (27%)	166 (22%)
Endoscopy with Marginal Ulcer (%)	13% [#]	22%	53%	46%	34%

*p < 0.05 vs T2, T3, T4; [#]p < 0.05 vs T3, T4.

Table 4. Indications for postoperative endoscopy.

Nausea and vomiting	66 (40%)
Abdominal pain	38 (23%)
Multiple symptoms	20 (12%)
Symptomatic reflux	18 (10%)
Anemia	10 (6%)
Gastrointestinal bleeding	9 (5%)
Other	7 (4%)

Table 5. Results of univariate analysis.

Comparison	p-value (log-rank test)
Technique Overall	<0.0001
T1 vs T2	<0.0006
T1 vs T3	<0.0006
T1 vs T4	<0.0006
T2 vs T3	0.4392
T2 vs T4	0.99
T3 vs T4	0.6414
Active smoking	0.3984
Age quartile	0.3317
Alcohol use	0.5156
BMI quartile	0.5599
Gender	0.8269
History of smoking	0.1453
NSAID	0.4081
Peptic ulcer disease	0.3432
Roux limb route	<0.0001

counting for technique and Roux limb fashion, the risk of MU is 2.2 times higher for those with a history of smoking compared to those with no history of smoking (p = 0.0054). After accounting for technique and history of smoking, the risk of MU for patients with a retrocolic Roux limb is 0.15 times that of patients with antecolic fashion (p < 0.0001).

Overall 171 (23%) Roux Limbs were antecolic and 578 (77%) were retrocolic (**Table 7**). The incidence of

Table 6. Results of multivariate analysis.

Variable	Hazard Ratio	p-value
T2 vs T1	42.577	<0.0001
T3 vs T1	19.151	<0.0001
T4 vs T1	52.342	<0.0001
History of smoking yes vs no	2.172	0.0054
Retrocolic vs antecolic route	0.152	<0.0001

MU was higher with antecolic versus with retrocolic Roux Limb (14.0% vs 5.7%, p < 0.05). The majority of procedures in T1 (99%), T2 (96%) and T3 (70%) were with a retrocolic limb compared to T4 (33%).

5. Discussion

Marginal ulcer (MU) formation is a common complication after RYGB. Overall, our incidence of MU was 7.5% which is consistent with others studies published [1-12]. The present study focused on the potential relationship between MU and the technique of RYGB employed. We demonstrated that the RYGB technique used strongly influences MU formation.

Univariate analysis revealed a significant difference in incidence of MU by technique. Specifically, incidence of MU was smaller for technique 1 (Open, non-divided stomach, circular stapler, non-vagotomy) compared with each of the other techniques. There was no difference among the other groups. Using multivariate analysis, history of smoking and Roux limb route were significantly associated with MU. After accounting for history of smoking and Roux limb route, technique was significantly associated with MU. The risk of MU is 19 times higher for subjects treated with technique 2, 52 times higher for patients treated with technique 3, and 43 times higher for subjects treated with technique 4 compared with technique 1.

The patient groups undergoing the different procedures were similar with respect to age, BMI and several relevant patient factors. However, there was a significantly lower incidence of active smoking and history of smoking in technique 4. After accounting for technical factors, the risk of MU is 2.2 times higher for those with a history of smoking compared to those with no history

Table 7. Comparison of marginal ulcer and roux limb route.

Antecolic			
	No ulcer	Ulcer	Total number
Technique 1	4	0	4
Technique 2	4	0	4
Technique 3	36	10	46
Technique 4	103	14	117
Total	147	24 (14.0%)	171
Retrocolic			
	No ulcer	Ulcer	Total number
Technique 1	321	7	328
Technique 2	82	5	87
Technique 3	93	13	106
Technique 4	49	8	57
Total	545	33 (5.7%)*	578

*p < 0.05 vs antecolic.

of smoking. This was the only patient-related factor that we identified. The incidence of postoperative endoscopy was also similar in the four groups.

Since there are several different technical aspects in the techniques, the reasons for the lower MU rate in Technique 1 are not clear. This was an open technique. However, the similar outcomes in techniques 2 and 3 where surgical access is the only difference in technique suggest that surgical access is not an important issue. There are few studies comparing the effect of surgical access. Patel *et al.* [1] reported similar incidence of MU (5.4% and 5.1%) with an open technique identical to our technique 1 and laparoscopic technique similar to our technique 3.

Technique 1 included a non-divided stomach. This might improve blood supply, which is presumed to contribute significantly to preventing formation of MU. There may also be less inflammation since wound healing occurs at a transection site. Pope *et al.* [4] found that increasing the number of staple rows from 4 to 8 in the non-divided stomach increased the incidence of MU. However, the study by Patel *et al.* [1] mentioned above would argue against this point.

The vagus nerve was not divided in technique 1. Vagus nerve preservation, which will preserve stimulation of parietal cells in the pouch and distal stomach to increase acid production, may subsequently irritate the gastric mucosa as well as anastomotic site [14]. However, normal gastric peristalsis will remain intact, which may act as clearance of acid from surgical site avoiding a

formation of MU [15]. Ikramuddin, S. *et al.* (poster presentation at Society for Surgery of the Alimentary Tract in San Francisco, May 2002) compared laparoscopic gastric bypass with (n = 91) and without (n = 84) vagotomy along the greater curve and found a similar incidence of MU (4.3% vs. 1.1%), suggesting vagotomy at this location is not an important factor. Interestingly, truncal vagotomy has been employed therapeutically with success for intractable MU [16].

The gastric pouch in technique 1 had a transverse rather than vertical orientation, similar to the technique of Patel *et al.* [1]. As noted, they found no difference in MU rate. Since the gastric pouch is known to contain parietal cells and have acid production, making a small pouch has been emphasized in preventing MU [9,10,12,14,17,18]. Printen [18] demonstrated that reducing pouch size decreased MU. Others have found that the length of a vertically oriented pouch correlates with MU rate [9,19].

Technique 1 included a circular stapled anastomosis. This is unlikely to be an important factor. Techniques 3 and 4 were similar techniques except for a circular or linear stapled anastomosis. However, the incidence of marginal ulcer was similar. Similarly, others have found no difference in MU rate with type of anastomosis, including hand sewn vs. circular stapled [20] and linear vs. circular [21,22]. Suggs *et al.* [23] found fewer ulcers with the 21-mm vs 25-mm circular stapler, however. Thus, type of anastomosis does not appear to be an important factor.

After accounting for technique and history of smoking, the risk of MU for patients with Roux Limb in a retrocolic fashion was 0.15 times that of patients with antecolic fashion. We feel this may be related to more tension and potential ischemia at the anastomosis. Taylor *et al.* [24] compared Roux limb route and found no difference in the incidence of stricture, but did not evaluate MU.

This study has several limitations. We employed selective endoscopy for symptoms in the present study. This will affect the detection of MU. Several studies suggest MU is fairly frequent in the early postoperative period [25,26]. Only 24% of MU in the present study occurred early. Our endoscopy rate of 22% and findings of MU in 34% of endoscopy is similar to other reports with selective endoscopy [27,28]. Asymptomatic ulcers would have been missed since routine endoscopic screening was not carried out. Not all surgeons performed all four operations. Open procedures were performed predominantly early in the study period. *H. pylori* was not routinely sought in patients with MU. Some non-absorbable sutures were used in the seromuscular layers at the anastomosis in all four groups but not in a standard fashion.

6. Conclusion

In conclusion, the incidence of MU after RGBP surgery is influenced by surgical technique. The overall 7.5% incidence of MU is consistent with other studies. The lowest incidence of MU was the technique with a non-divided stomach, no vagotomy, and a circular anastomosis. A retrocolic Roux limb was protective. There was no difference of MU using linear or circular stapler for the gastrojejunostomy and no difference in laparoscopic versus open bypass if a similar technique was employed.

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