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ORIGINAL ARTICLE

Postoperative Body Mass Index Changes in Gastric Cancer Patients according to Reconstruction Type: Effectiveness of Long Jejunal Bypass on Weight Loss in Obese Patients after Distal Gastrectomy

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Abstract The aim of this study was to investigate and compare the change of body mass index (BMI) in patients after gastrectomy for cancer according to the type of reconstruction. BMI was followed in 260 patients who had undergone curative surgery for gastric cancer from March 2003 to December 2009. The procedures were Billroth I in 63 patients, Billroth II in 52 patients, Roux-en-Y in 54 patients, long Roux-en-Y (bypassed proximal jejunum over 100 cm) in 47 patients, and total gastrectomy in 44 patients. BMI reduction was greatest in the total gastrectomy group at postoperative 6 months, 1 year, and 2 years. Postoperative 3-year BMI reduction was greatest in the long Roux-en-Y group. BMI reductions of the total gastrectomy and long Roux-en-Y groups were similar during the follow-up period. Among the subtotal gastrectomy groups, BMI reduction was greatest in the long Roux-en-Y group, and there was statistical significance in comparing with Billroth I and II groups, but no statistical difference with the Roux-en-Y group. Given the limitations of patient number and follow-up period, it can be concluded that obese patients with gastric cancer not requiring total gastrectomy may benefit from long Roux-en-Y reconstruction with adequate BMI reduction and accompanying health improvement.

Keywords Gastric cancer · Gastrectomy · Reconstruction · Weight loss · Body mass index

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Introduction

A variety of reconstructions after gastrectomy for cancer have been devised. However, a universally accepted method of reconstruction has not yet been established. There are many late problems related to these procedures, such as reflux esophagitis, gastritis induced by bile juice, afferent loop syndrome, stasis of food passage, nutritional problems including weight loss, and carcinogenesis of remnant stomach. Especially, weight loss is usually regarded as an inevitable consequence after gastric resection. The weight loss could be a significant problem with respect to quality of life in some preoperatively normal and low body mass index (BMI) patients, but in obese patients of higher BMI, adequate weight reduction is beneficial to health problem. The Korean Society for the Study of Obesity defines obesity for Koreans as BMI $\geq$25 kg/m^2 having increased risk of obesity-related morbidity [1]. Weight loss with typically performed reconstruction methods such as Billroth I, Billroth II, and Roux-en-Y procedures is not sufficient for obese individuals with higher BMI [2–4].

This study was undertaken to compare the amount of postoperative BMI changes according to the reconstruction methods including long Roux-en-Y reconstruction of bypassed proximal jejunum of 100 cm or more and to determine the effectiveness of this alternative method for the obese gastric cancer patients who need adequate weight reduction for health.

Materials and Methods

Patients and Patient Groups

The current investigation was a single-centre study. Gastric tumor patients without recurrence (n=260; 258 cases of

adenocarcinoma, 1 gastrointestinal stromal tumor, and 1 carcinoid) who underwent standard radical gastrectomy at the Department of Surgery, College of Medicine, Hallym University, from March 2003 to December 2009 were followed concerning their postoperative BMIs at a surgical outpatient clinic. This retrospective study compared five groups of reconstruction: the gastroduodenostomy (Billroth I) group (n=63), the loop gastrojejunostomy (Billroth II) group (n=52), the conventional Roux-en-Y gastrojejunostomy (Roux-en-Y) group (n=54), the long limb Roux-en-Y gastrojejunostomy (long Roux-en-Y) group (n=47), and the total gastrectomy with Roux-en-Y esophagojejunostomy (total gastrectomy) group (n=44). The long Roux-en-Y reconstruction was defined as Roux-en-Y gastrojejunostomy with bypassed proximal jejunum of 100 cm or more (100–190 cm) as a similar structure of Roux-en-Y gastric bypass for morbid obesity. After IRB (Institutional Review Board) approval, since June 2007, we applied Roux-en-Y gastrojejunostomy to 36 obese gastric cancer patients who had a high BMI (≥25 kg/m^2) and, since 2008, to 11 non-obese gastric cancer patients (BMI <25 kg/m^2) with type 2 diabetes mellitus to study the antidiabetic effect of long duodenojejunal bypass (DJB). We classified patients receiving distal gastrectomy with conventional reconstruction (Billroth I, Billroth II, Roux-en-Y) as the no or short DJB group (Billroth I or bypass of duodenum and proximal jejunum <100 cm) and patients receiving long Roux-en-Y reconstruction as the long DJB group (bypass of duodenum and proximal jejunum ≥100 cm) to enable comparison of these two groups. Although no consensus exists about how long the alimentary and biliopancreatic limbs should be for optimal weight reduction in Roux-en-Y gastric bypass for morbidly obese patients, in general the total length of the bypassed proximal jejunum was ≥150 cm [5–7]. Patients of the long Roux-en-Y group were not morbidly obese, and we adjusted the length of bypassed jejunum from 100 to 190 cm according to the severity of obesity. The length of the bypassed jejunum in the long Roux-en-Y group and preoperative average BMI are summarized in Table 1. The patients were followed up at intervals of 3–6 months and body weight was measured at each postoperative visit. We compared postoperative and preoperative BMI values and evaluated the effect on type 2 diabetes. The recurrence of malignancy had been ruled out through regular follow-up examinations of laboratory tests including tumor markers, abdominal computed tomography scan, and endoscopy.

Table 1 Length of bypassed jejunum and preoperative average BMI in the long Roux en Y group

Length of bypassed jejunum	Number of cases (n=47)	Preoperative average BMI (all patients in long RY)	Preoperative average BMI (patients of BMI >25 kg/m^2)
100 cm	8	25.0	25.7
110–120 cm	15	26.7	28.1
130–150 cm	12	28.2	28.5
160–190 cm	12	27.7	29.9

Surgical Procedures of Long Roux-en-Y Gastrojejunostomy

After partial gastrectomy of 60–80 % distal stomach including cancer, the jejunum was divided at 50–90 cm distal to the ligament of Treitz, and the distal limb of the jejunum was anastomosed to the remnant stomach in an antecolic fashion. Jejunojejunostomy was undertaken at 50–100 cm distal to the gastrojejunostomy with total jejunal bypass of 100–190 cm (Fig. 1). The length of bypassed jejunum was 70–90 cm in conventional Roux-en-Y of subtotal and total gastrectomy, 20–30 cm in Billroth II, and 0 cm in Billroth I anastomoses.

Statistical Analyses

Statistical analyses were performed with the SPSS 13.0 program (SPSS, Chicago, IL). Data were expressed as mean± standard deviation. Statistical analysis included one-way ANOVA and independent t-test and P values <0.05 were considered significant.

Results

Patient characteristics for five groups are summarized in Table 2. The preoperative average BMIs were 22.8 kg/m^2 in Billroth I, 24.3 kg/m^2 in Billroth II, 24 kg/m^2 in Roux-en-Y, 27 kg/m^2 in long Roux-en–Y, and 23.9 kg/m^2 in total gastrectomy group. The long Roux-en-Y group displayed a

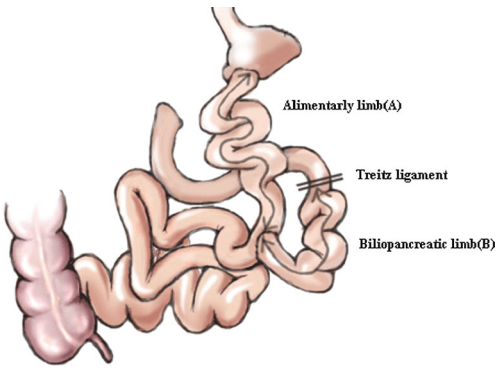

Fig. 1 Diagram of long Roux-en-Y reconstruction. The length of alimentary limb(A, from the gastrojejunostomy site to the jejunojejunostomy site) : 50–100 cm, the length of biliopancreatic limb (B, from the ligament of Treitz to the jejunojejunostomy site) : 50–90 cm

Table 2 Clinicopathological characteristics

	Type of reconstruction				
	Billroth I (n=63)	Billroth II (n=52)	Roux en Y (n=54)	Long Roux en Y (n=47)	TG (n=44)
Gender (male/female)	42/21	42/10	35/19	29/18	31/13
Age (mean)	56	58.4	61.4	60.6	62

significantly higher preoperative average BMI than the other groups (P=0.000). The statistical analysis of postoperative BMI change is shown in Table 3. The mean ratio of postoperative BMI to preoperative BMI was 93.5, 94.1, 94.1, and 93.9 % at postoperative 6 months, 1 year, 2 years, and 3 years, respectively, in the Billroth I group; 90.4, 90.7, 91.5, and 92 %, respectively, in the Billroth II group; 90.1, 90.1, 89.5, and 90.5 %, respectively, in the Roux-en-Y group; 86.7, 85.8, 87.8, and 84.4 %, respectively, in the long Roux-en-Y group; and 85.2, 84.9, 86.6, and 87.4 %, respectively, in the total gastrectomy group (Fig. 2). At postoperative 6 months and 1 year, the extent of BMI reduction in the total gastrectomy group was significantly greater than in the Billroth I, Billroth II, and Roux-en-Y groups (P<0.05) and was similar to or slightly greater than that of the long Roux-en-Y group (P=1.0). At postoperative 2 years, the BMI reduction in the total gastrectomy group was greatest and was significantly different between the total gastrectomy group and the Billroth I and II groups (P=0.000, P=0.006, respectively). However, no significant differences in BMI reduction were observed between the total gastrectomy group and the Roux-en-Y and long Roux-en-Y groups (P=0.639, P=1.000, respectively). At postoperative 3 years, the BMI reduction of the long Roux-en-Y group was greatest and there were significant differences between this group and the Billroth I and II groups (P=0.000, P=0.002, respectively). Significant differences were not noted between the long Roux-en-Y and Roux-en-Y groups (P=0.054), and between the long Roux-en-Y and total gastrectomy groups (P=1.000). Among the subtotal gastrectomy groups, the BMI reduction of the long Roux-en-Y group was greatest at each postoperative 6-month or 1-year interval. There were statistical significances between the long Roux-en-Y group and the Billroth I group (P=0.000 at each postoperative time), and also between the long Roux-en-Y group and the Billroth II group (P=0.032 at

Table 3 Statistical analysis of postoperative BMI change (postoperative BMI/preoperative BMI) in each group

		Postoperative 6 month Sig.	Postoperative 1 year Sig.	Postoperative 2 year Sig.	Postoperative 3 year Sig.
Billroth I	Billroth II	0.102	0.087	0.414	1.000
	RY	0.035	0.014	0.004	0.335
	Long RY	0.000	0.000	0.000	0.000
	TG	0.000	0.000	0.000	0.000
Billroth II	Billroth I	0.102	0.087	0.414	1.000
	RY	1.000	1.000	1.000	1.000
	Long RY	0.075	0.004	0.175	0.002
	TG	0.000	0.000	0.006	0.028
RY	Billroth I	0.035	0.014	0.004	0.335
	Billroth II	1.000	1.000	1.000	1.000
	Long RY	0.075	0.022	1.000	0.054
	TG	0.001	0.002	0.639	0.823
Long RY	Billroth I	0.000	0.000	0.000	0.000
	Billroth II	0.032	0.004	0.175	0.002
	RY	0.075	0.022	1.000	0.054
	TG	1.000	1.000	1.000	1.000
TG	Billroth I	0.000	0.000	0.000	0.000
	Billroth II	0.000	0.000	0.006	0.028
	RY	0.001	0.002	0.639	0.823
	Long RY	1.000	1.000	1.000	1.000

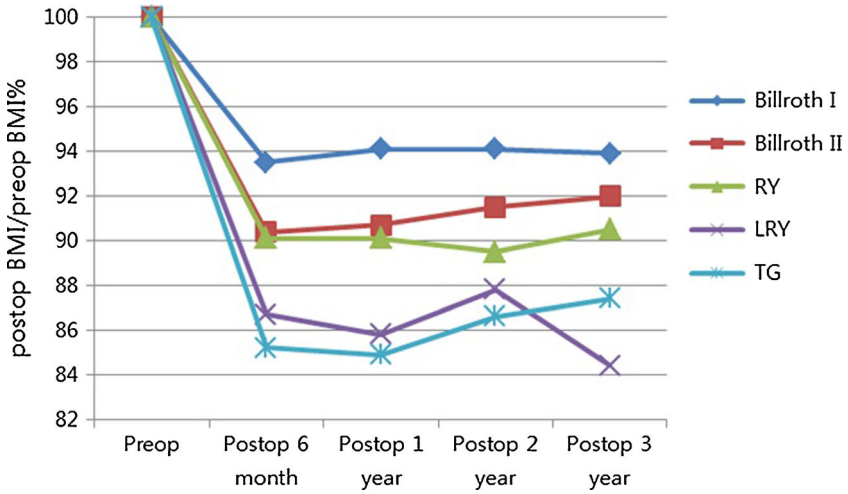

Fig. 2 The mean ratio of postoperative BMI to preoperative BMI with time. *Preop* preoperative; *postop* postoperative; *RY* Roux-en-Y reconstruction; *LRY* long Roux-en-Y reconstruction; *TG* total gastrectomy

postoperative 6 months, P=0.004 at postoperative 1 year, P=0.002 at postoperative 3 years), except at postoperative 2 years (P=0.175). The BMI reduction of the long Roux-en-Y group tended to be greater than that of the Roux-en-Y group without statistical significance, except at postoperative 2 years, when statistical significance was observed (P=0.022). In comparing the no or short DJB group and the long DJB group, the BMI reduction of the long DJB group (long Roux-en-Y reconstruction) was greater than the no or short DJB group (Billroth I, Billroth II, Roux-en-Y reconstruction) with statistical significance (P=0.000 at postoperative 6 months, 1 year, and 3 years; P=0.001 at postoperative 2 years) (Table 4). In the long Roux-en-Y group, there were no cases of internal herniation and short bowel syndrome due to long limbs.

Discussion

Small remnant stomach or no stomach with reduced food intake is the main reason for weight reduction after gastrectomy. Many factors responsible for weight reduction have been suggested. Gastrectomy alters gastrointestinal hormone production by removing some part of the hormone-producing gastric mucosa and rearranging the gastrointestinal tract for the passage of food and digestive juice. Ghrelin, a natural ligand for growth hormone secretagogue receptor (GHS-R), is secreted by the ghrelin/endocrine/neurocrine cells that are present predominantly in the lining of the lower part of the oxyntic glands in the mucosa of the gastric fundus and body [8]. It is the circulatory intestinal hormone secreted by the fasting stomach that enhances food intake and maintains energy homeostasis as the most powerful endogenous appetite-stimulating hormone, opposing leptin and gastrointestinal activity through the vagal nerve. After gastrectomy, the decreased serum ghrelin level induces satiety with early meal termination [9–13]. Another important mechanism of weight reduction after gastrectomy is the duodenal bypass of food and digestive juice [4]. With duodenal bypass, decreased secretion of cholecystokinine (CCK) and reduced exocrine activity of the gallbladder result in decreased fat digestion and absorption [14–16]. In Roux-en-Y gastrojejunostomy, no contact between the food bolus and the biliopancreatic secretions occurs until the site of the jejunojejunostomy, blocking the absorption of nutrients impossible in the biliopancreatic and alimentary (Roux) limbs. Thus, the degree of malabsorption can be modified by altering the length of these limbs. Other mechanisms including reflux esophagitis, alteration of intestinal floral, increased peristalsis, and diarrhea have also been suggested, but there has been no satisfactory explanation [17]. Currently, the extent of weight loss was stationary with

Table 4 Ratio (%) of postoperative to preoperative BMIs in no or short DJB group and long DJB group

	Postoperative 6 months	Postoperative 1 year	Postoperative 2 years	Postoperative 3 years
No or Short DJB group	91.4	91.8	91.9	92.4
Long DJB group	86.7	85.8	87.8	84.4
P value	0.000	0.000	0.001	0.000

No or short DJB (duodenojejunal bypass) group: reconstruction of Billroth I, Billroth II, Roux en Y gastrojejunostomy; Long DJB group: reconstruction of Roux en Y gastrojejunostom with bypassed jejunum ≥100 cm

time in all groups except the long Roux-en-Y group, with the greatest decreased ratio at 3 years. Our results suggest that ghrelin tends to be overproduced by ghrelin-secreting cells in remnant stomach as compensation [18] and, in the early postoperative period, ghrelin reduction that is induced by removal of gastric body and/or fundus has more influence on weight reduction than malabsorptive mechanism. This supports the view that long Roux-en-Y reconstruction could be more effective in maintenance of reduced weight loss than other reconstruction methods. There have been many studies concerning nutritional status after gastrectomy, but a few studies have addressed weight loss through a comparison of the various reconstruction methods. Moreover, no studies assessing the appropriate length of the bypassed jejunal limb that is necessary to maintain adequate weight reduction for the obese after gastrectomy for cancer were uncovered in a Pubmed search. Although our study is retrospective and included various clinical backgrounds such as early and advanced stage, involving a limited number of cases, the present study is important as it is, to our knowledge, the first study to examine the extent of weight reduction according to a comparison of conventional postgastrectomy reconstruction methods with a novel technique involving adjustment of the bypassed jejunal limb. Although not related to the gastric malignancy and criteria, as the length of bypassed jejunum was different in categorizing short and long limb groups, a number of comparative studies have reported on the length of limbs of gastric bypass for morbidly obese patients. It has been concluded that increasing the length of jejunum bypassed improves the degree of weight reduction [19–22], but others have reported that increasing Roux and biliopancreatic limb length does not improve weight loss [5, 23]. In one study, the weight reduction for patients with BMI≤50 was similar during their follow-up (up to 3 years), independent of the length of the bypassed jejunum; the authors opined that patients with a BMI >50 might benefit from a longer bypassed jejunum [24]. Limitations of the present study included the small number of study subjects and the fact that weight reduction after gastrectomy is multifactorial and, therefore, more than one mechanism may account for the maintenance of weight reduction, restricting a clear indication of which of the various mechanisms is the causal mechanism. Also, we did not investigate the involvement of intestinal hormones. Another limitation was that the statistically significantly greater average preoperative BMI of the long Roux-en-Y group might have reflected a selection bias. However, our goal was to explore the overall trend of weight reduction after gastrectomy. To support the hypothesis that long Roux-en-Y reconstruction could be more effective in maintenance of reduced weight loss than other reconstruction methods, it will be necessary to investigate and analyze intestinal hormones in each reconstruction group and accumulate more cases of high BMI (>25 kg/m^2) in all groups with long-term follow-up for the establishment of long Roux-en-Y reconstruction as the effective weight reduction method for the obese patients with gastric malignancy as well as understanding its mechanism of weight loss.

Conclusion

In summary, for obese gastric cancer patients, the long Roux-en-Y jejunal bypass could be a promising reconstructive method with potential advantages of weight reduction. Future studies will focus on not only case accumulation and long-term follow-up to ascertain the efficacy of the long Roux-en-Y reconstruction but also the surgical procedure including correlation between the extent of the weight loss and the length of jejunal bypass.

References

1. Oh SW (2011) Obesity and metabolic syndrome in Korea. Diabetes Metab J 35(6):561–566
2. Tanaka S, Matsuo K, Matsumoto H, Maki T, Nakano M, Sasaki T et al (2011) Clinical outcomes of Roux-en-Y and Billroth I reconstruction after a distal gastrectomy for gastric cancer: What is the optimal reconstructive procedure? Hepatogastroenterology 58 (105):257–262
3. Stael von Holstein C, Walther B, Ibrahimbegovic E, Akesson B (1991) Nutritional status after total and partial gastrectomy with Roux-en-Y reconstruction. Br J Surg 78(9):1084–1087
4. Chareton B, Landen S, Manganas D, Meunier B, Launois B (1996) Prospective randomized trial comparing Billroth I and Billroth II procedures for carcinoma of the gastric antrum. J Am Coll Surg 183(3):190–194
5. Inabnet WB, Quinn T, Gagner M, Urban M, Pomp A (2005) Laparoscopic Roux-en-Y gastric bypass in patients with BMI <50: a prospective randomized trial comparing short and long limb lengths. Obes Surg 15(1):51–57
6. Stefanidis D, Kuwada TS, Gersin KS (2011) The importance of the length of the limbs for gastric bypass patients—an evidence-based review. Obes Surg 21(1):119–124
7. Leifsson BG, Gislason HG (2005) Laparoscopic Roux-en-Y gastric bypass with 2-metre long biliopancreatic limb for morbid obesity: technique and experience with the first 150 patients. Obes Surg 15(1):35–42
8. Zub-Pokrowiecka A, Rembiasz K, Konturek PC, Budzynski A, Konturek SJ, Winiarski M et al (2011) Ghrelin and gastrin in advanced gastric cancer before and after gastrectomy. World J Gastroenterol 17(4):449–458
9. Scheufler O, Erdmann D (2007) Current concepts and trends in post-bariatric plastic surgery. Chirurg 78(4):316–325
10. Konturek SJ, Konturek JW, Pawlik T, Brzozowski T (2004) Brain-gut axis and its role in the control of food intake. J Physiol Pharmacol 55(1 Pt 2):137–154
11. De Ambrogi M, Volpe S, Tamanini C (2003) Ghrelin: central and peripheral effects of a novel peptydil hormone. Med Sci Monit 9 (9):RA217–RA224

12. Castaneda TR, Tong J, Datta R, Culler M, Tschop MH (2010) Ghrelin in the regulation of body weight and metabolism. Front Neuroendocrinol 31(1):44–60
13. Abeles D, Shikora SA (2008) Bariatric surgery: current concepts and future directions. Aesthet Surg J 28(1):79–84
14. Lamers CB, Diemel CM, Jansen JB (1982) Serum pancreatic polypeptide responses to food and secretion in patients with Billroth I and Billroth II gastrectomies and in normal subjects. Surgery 91(3):288–292
15. Paakkonen M, Alhava EM, Karjalainen P, Korhonen R, Savolainen K, Syrjanen K (1984) Long-term follow-up after Billroth I and II partial gastrectomy. Gastrointestinal tract function and changes in bone metabolism. Acta Chir Scand 150(6):485–458
16. Nakamura H, Murakami Y, Morifuji M, Uemura K, Hayashidani Y, Sudo T et al (2009) Analysis of fat digestive and absorptive function after subtotal gastrectomy by a 13 C-labeled mixed triglyceride breath test. Digestion 80(2):98–103
17. Takachi K, Doki Y, Ishikawa O, Miyashiro I, Sasaki Y, Ohigashi H et al (2006) Postoperative ghrelin levels and delayed recovery from body weight loss after distal or total gastrectomy. J Surg Res 130 (1):1–7
18. Kim S, Lee JH, Heo JS, Kwak MJ, Kim SJ, Sohn YB et al (2009) Serum obestatin/ghrelin ratio is altered in patients after distal gastrectomy. Dig Surg 26(2):143–148
19. Brolin RE, Kenler HA, Gorman JH, Cody RP (1992) Long-limb gastric bypass in the superobese. A prospective randomized study. Ann Surg 215(4):387–395
20. Brolin RE, LaMarca LB, Kenler HA, Cody RP (2002) Malabsorptive gastric bypass in patients with superobesity. J Gastrointest Surg 6(2):195–203, discussion 4–5
21. Bruder SJ, Freeman JB, Brazeau-Gravelle P (1991) Lengthening the Roux-Y limb increases weight loss after gastric bypass: a preliminary report. Obes Surg 1(1):73–77
22. Ciovica R, Takata M, Vittinghoff E, Lin F, Posselt AM, Rabl C et al (2008) The impact of roux limb length on weight loss after gastric bypass. Obes Surg 18(1):5–10
23. Christou NV, Look D, Maclean LD (2006) Weight gain after short- and long-limb gastric bypass in patients followed for longer than 10 years. Ann Surg 244(5):734–740
24. Choban PS, Flancbaum L (2002) The effect of Roux limb lengths on outcome after Roux-en-Y gastric bypass: a prospective, randomized clinical trial. Obes Surg 12(4):540–545