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# IV. 研究成果の刊行物・別刷

# Impact of reconstruction method on visceral fat change after distal gastrectomy: Results from a randomized controlled trial comparing Billroth I reconstruction and Roux-en-Y reconstruction

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***Background.*** *Visceral fat is one of the causes of metabolic syndrome. Among the various types of bariatric surgery, duodenal–jejunal bypass is one of the most common procedures. However, the effect of duodenal bypass on fat changes is not completely understood. We examined the effect of duodenal bypass on visceral fat changes by comparing Billroth I (BI) and roux-en Y (RY) reconstruction in distal gastrectomy.*

***Methods.*** *This retrospective study used data from 221 patients registered for a prospective randomized trial that compared BI to RY in distal gastrectomy with lymphadenectomy to treat gastric cancer. With a software package, we first quantified the visceral fat area (VFA) on cross-sectional computed tomography scans obtained at the level of the umbilicus before and 1 year after surgery, and then determined the impact of duodenal bypass on visceral fat changes.*

***Results.*** *Clinicopathological background data did not differ between BI and RY. Rates of BMI reduction for BI and RY also did not differ. The VFA reduction rate for RY (47.2 ± 25.5%) was greater than for BI (36.8 ± 34.2%,* P = *.0104). Adjuvant chemotherapy (chemotherapy versus no chemotherapy,* P = *.0136), type of reconstruction (BI versus RY,* P < *.0001), and pathologic stage (p stage I versus p stage II–IV,* P = *.0468) correlated significantly with postoperative visceral fat loss. Multivariate logistic regression analysis identified reconstruction (BI versus RY,* P = *.0078) as a significant determinant of visceral fat loss.*

***Conclusion.*** *Visceral fat loss after distal gastrectomy was greater for RY than for BI, and duodenal bypass may be associated with reduction of visceral fat. (Surgery 2014;155:424-31.)*

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IT HAS BEEN PROVEN that gastric bypass surgery affects the release of gastrointestinal hormones[1] and induces malabsorption,[2] but there are no conclusive data about the effects of duodenal bypass on visceral fat changes. There are various types of bariatric procedures, including gastric banding, sleeve gastrectomy, roux-en Y bypass, biliopancreatic diversion with duodenal switch, and duodenal-jejunal bypass. However, to the best of our knowledge, no authors have evaluated fat reduction specifically caused by duodenal bypass because the size of the remnant stomach and the

length of the jejunal bypass differ among the various procedures.

The selection of the reconstruction method, either Billroth I (BI) or roux-en Y (RY), after distal or subtotal gastrectomy is still controversial. A large, multi-institutional, randomized controlled trial was conducted by the Osaka University Clinical Research Group for Gastroenterological Study (Japan)[3,4] to address this problem. The primary endpoint of this study was to compare body weight loss 1 year after surgery between the BI and RY groups. Secondary endpoints were postoperative complications, nutritional state, and quality of life. This trial gave us an opportunity to prospectively evaluate data about the effects of BI and RY on visceral and subcutaneous fat loss because patients whose remnant stomachs were large enough so that either technique could be performed were assigned randomly intraoperatively to undergo either BI and RY, and the reconstruction methods were prescribed by the protocol.

Visceral fat areas (VFAs) estimated from a single computed tomography (CT) scan at the level of the umbilicus are known to correlate with the total volume of visceral fat.[5,6] On the basis of this knowledge, a practical, standardized technique has been developed to determine the VFA from a single CT scan.[7]

In the present study, we used CT and a software package to quantify the VFA of patients before and 1 year after surgery. We then determined the impact of the type of reconstructive procedure on visceral fat changes in patients with gastric cancer who underwent distal gastrectomy with lymphadenectomy.

## METHODS

**Patients.** Between May 2004 and October 2009, a total of 332 patients with gastric cancer were registered in the original study. After completion of the informed consent process, patients were included in the study if they met the eligibility criteria.[4] After initial laparotomy, the location of the tumor was confirmed to be in the middle or lower third of the stomach and the proportion of residual stomach was regulated as one-third of the original stomach. The operator also checked the length of the residual stomach to confirm that either reconstruction procedure could be performed after distal gastrectomy. The surgeon confirmed the eligibility and exclusion criteria immediately after the initial laparotomy, and patients were then randomized intraoperatively to either the BI group or the RY group. Randomization was performed by the minimization method according to the patient's body mass index (BMI) ($<25$ or $\geq 25$ kg/m$^2$) and institution.

To evaluate visceral fat changes, we collected CT scans both before and 1 year after surgery. A total of 221 patients, whose CT scans at the umbilicus level both before and 1 year after surgery could be obtained, were retrospectively analyzed in this study. Information about the patients' backgrounds and clinicopathological data were extracted from the data collected by the original study. This study was approved by the institutional review boards of all participating hospitals and was conducted in accordance with the Declaration of Helsinki.

**Operative procedure.** Patients underwent gastrectomy with systematic lymphadenectomy at 18 high-volume institutions in Osaka, Japan. All 18 institutions were participants in the surgical study group "Osaka University Clinical Research Group for Gastroenterological Study." Overall, more than 50 gastrectomies were performed each year in these 18 hospitals. All operations were performed or supervised by senior surgeons who were members of the Japanese Gastric Cancer Association. During the planning of the study, all participating surgeons reached an agreement concerning the technical details of the reconstructive procedures.

Endotracheal general anesthesia and standard laparotomy or laparoscopic operations were used for all patients in each institution. Gastric tumors located in the lower or middle third of the stomach were treated with distal gastrectomy. Lymphadenectomy approaches were categorized as D1–3, as defined by the Japanese Classification for Standard Dissection.[8] D1 involves dissecting the paragastric nodes, whereas D2 also includes dissection of the nodes along the left gastric, common hepatic, and celiac arteries. D3 includes the nodes dissected in D1 and D2, as well as dissection of the hepatoduodenal and retropancreatic nodes, the nodes along the superior mesenteric vein, and the para-aortic nodes between the level of the celiac axis and the inferior mesenteric artery.

For BI reconstruction, the duodenum and remnant stomach were sutured. For RY reconstruction, the jejunum was divided 20 cm distal to the ligament of Treitz, and the portion of the jejunum closest to the patient's head was closed, followed by the remaining gastric pouch, which was anastomosed to the jejunum. The oral portion of the jejunum was then anastomosed to the mid-jejunum 30 cm distal to the gastrojejunostomy.

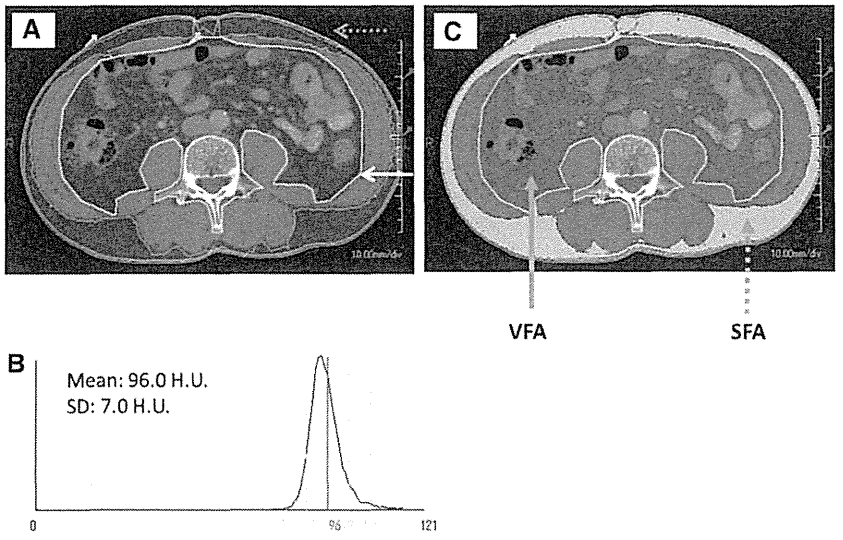


**Fig 1.** Illustration of method used to determine abdominal fat distribution on a CT scan obtained at the umbilicus level. (*A*) White line (*solid arrow*) outlines the intraperitoneal area. Gray line (*dotted arrow*), drawn with a cursor automatically or manually, outlines the subcutaneous fat layer, in which attenuation is measured. (*B*) Histogram of the CT numbers (in Hounsfield units) in the lesion outlined in (*A*) (mean ± 2 SD). (*C*) Region defined as visceral fat tissue (*solid arrow*). Total fat area was calculated from the region outlining the circumference of the abdominal wall. The VFA was subtracted, and the remainder was regarded as the SFA (*dotted arrow*).

The basic anastomotic procedures, such as sutures made by hand or machine and standard laparotomy or laparoscopic operations, were not prescribed in detail by the protocol.

Of the 118 patients in the RY group, gastrojejunostomy was performed by hand in 8 patients, by circular stapler in 82 patients, and by linear stapler in 28 patients. The Roux-en-Y limb was ascended through the retrocolic route in 71 patients and the antecolic route in 47 patients.

**Quantification of VFAs and subcutaneous fat areas (SFAs).** The VFA was measured with "FatScan," which was described previously,[7] on one cross-sectional CT scan obtained at the level of the umbilicus. Figure 1 illustrates the method used to determine the fat tissue area on a CT scan. First, the intraperitoneal area was defined by tracing its contour manually on the scan. Thereafter, a region of interest on the subcutaneous fat layer was defined by tracing its contour on each scan either automatically or manually; then, the attenuation range of the CT numbers (in Hounsfield units) for fat tissue was calculated (Fig 1, *A*). A histogram for fat tissue was computed based on the mean attenuation ± 2 SD (Fig 1, *B*). Within the region outlined in Fig 1, *A*, the tissue with attenuation within the mean ± 2 SD was considered to be the VFA. Pixels with attenuation values in the selected attenuation range are depicted. The total fat area was calculated in the region outlining the circumference of the abdominal wall. The VFA (solid arrow) was subtracted, and the remainder was regarded as the SFA (dotted arrow) (Fig. 1, *C*).

**Statistical analysis.** Differences between groups were examined for statistical significance with the Student *t*-test with Yates' correction, $\chi^2$ test, Fisher's exact probability test, or Wilcoxon rank-sum test. Statistical analysis was performed with JMP version 9.0 (SAS Institute, Cary, NC). Univariate analysis was performed to identify the factors associated with visceral fat loss. The identified variables were subsequently entered into multivariate analysis, and logistic regression analysis was used to identify independent factors that influence visceral fat loss.

## RESULTS

**Comparison of characteristics of patients who underwent BI or RY.** Table I compares the background characteristics of patients who underwent BI or RY. Age, sex, preoperative BMI, preoperative VFA, preoperative SFA, preoperative serum albumin levels, preoperative lymphocyte counts, preoperative prognostic nutritional index values,[9] operative approach, and lymphadenectomy were not significantly different between the two groups. With regard to operative factors, such as operative approach (ie, the proportion of patients who underwent laparoscopy versus

**Table I.** Patient demographics, tumor characteristics, and operative details

| | *BI group,* n = *103* | *RY group,* n = *118* | P *value* |
|---|---|---|---|
| Age, y* | 64.1 ± 9.2 | 64.1 ± 10.3 | .9765 |
| Men/women | 65/38 | 85/33 | .1563 |
| Preoperative BMI,* kg/m$^2$ | 22.4 ± 3.2 | 22.7 ± 3.0 | .3846 |
| Preoperative total fat area, cm$^2$* | 204.0 ± 73.9 | 215.6 ± 90.5 | .3023 |
| Preoperative VFA, cm$^2$* | 83.9 ± 38.9 | 92.6 ± 43.6 | .1175 |
| Preoperative SFA, cm$^2$* | 120.1 ± 54.8 | 122.9 ± 62.5 | .7243 |
| Preoperative serum albumin, mg/dL | 4.12 ± 0.39 | 4.12 ± 0.51 | .9864 |
| Preoperative lymphocyte count | 1,846 ± 699 | 1,924 ± 596 | .3966 |
| Preoperative PNI* | 50.6 ± 5.7 | 51.2 ± 6.1 | .4862 |
| Operative approach (laparoscopy/ laparotomy) | 24/79 | 28/90 | .9404 |
| Lymphadenectomy (D1/D2+D3) | 38/57 | 46/62 | .9503 |
| Adjuvant chemotherapy (yes/no) | 13/90 | 16/102 | .8368 |
| Recurrence (yes/no) | 5/98 | 4/114 | .7372 |

*Data are mean ± SD. Comparisons between BI and RY groups with the Student *t* test. Other parameters were compared with $\chi^2$ or Fisher exact test.
*BI,* Billroth I reconstruction; *BMI,* body mass index; *PNI,* prognostic nutritional index; *RY,* roux-en Y reconstruction; *SFA,* subcutaneous fat area; *VFA,* visceral fat area.

**Table II.** Comparison of postoperative nutritional status of patients in the BI and RY groups

| | *BI group,* n = *103* | *RY group,* n = *118* | P *value* |
|---|---|---|---|
| Postoperative BMI, kg/m$^2$ | 20.3 ± 2.8 | 20.5 ± 2.4 | .6106* |
| Postoperative total fat area, cm$^2$ | 139.3 ± 63.2 | 127.2 ± 61.2 | .1497* |
| Postoperative VFA, cm$^2$ | 50.0 ± 27.3 | 43.9 ± 22.2 | .0821* |
| Postoperative SFA, cm$^2$ | 89.7 ± 46.6 | 83.4 ± 47.8 | .3239* |
| Postoperative serum albumin, mg/dL | 4.21 ± 0.34 | 4.18 ± 0.42 | .5789 |
| Postoperative lymphocyte count | 1,891 ± 625 | 1,908 ± 575 | .8429 |
| Postoperative PNI* | 51.2 ± 5.1 | 51.3 ± 5.6 | .8379 |
| ΔBMI% | 8.9 ± 6.6 | 9.5 ± 7.1 | .2634† |
| Δ Total fat area % | 29.6 ± 25.8 | 37.0 ± 25.4 | .0117† |
| ΔVFA% | 36.8 ± 34.2 | 47.2 ± 25.5 | .0032† |
| ΔSFA% | 22.2 ± 28.4 | 27.3 ± 32.8 | .0732† |

*Student *t*-test.
†Wilcoxon rank-sum test.
Data are mean ± SD.
*BI,* Billroth I reconstruction; *BMI,* body mass index; *PNI,* prognostic nutritional index; *Δ Total fat area %,* rate of reduction of total fat area; *ΔBMI%,* rate of reduction of BMI; *ΔSFA%,* rate of reduction of SFA; *ΔVFA%,* rate of reduction of VFA; *RY,* roux-en Y reconstruction; *SFA,* subcutaneous fat area; *VFA,* visceral fat area.

laparotomy) and field of lymphadenectomy, there were no significant differences between the groups. There were also no significant differences between the groups with regard to adjuvant chemotherapy and cancer recurrence. Information about the composition of food consumed after surgery was collected by questionnaire. Most of the patients who underwent BI (90.9%) and RY (86.9%) consumed a normal diet, whereas 9.1% of BI and 13.1% of RY patients consumed a soft or liquid diet ($P$ = .3824). The mean intervals for when the follow-up CT was performed after surgery were 376 ± 111 days for BI and 374 ± 77 days for RY ($P$ = .9980).

**Comparison of postoperative nutritional states of patients who underwent BI or RY.** Table II lists comparative data for BMI, VFA, and SFA. Postoperative BMI, postoperative SFA, postoperative serum albumin levels, postoperative lymphocyte counts, postoperative prognostic nutritional index values, and the rate of reduction of BMI (ΔBMI %) were not substantially different between the BI and RY groups. The postoperative VFA of the RY group (43.9 ± 22.2 cm$^2$) was smaller than that of the BI group (50.0 ± 27.3 cm$^2$), but the difference was not clinically important ($P$ = .0821). The rate of reduction of the VFA (ΔVFA%) in the RY group (47.2 ± 25.5%) was greater than in the BI group (36.8 ± 34.2%; $P$ = .0032). For the muscle reduction rate, there was no difference between the BI (2.5 ± 18.1%) and RY (3.1 ± 16.8%; $P$ = .7970) groups. Figure 2 shows the correlation between preoperative BMI and ΔVFA% according to the reconstruction method used. The ΔVFA% for the RY group was greater in patients with greater BMI than in patients with lesser BMI. In contrast, the ΔVFA% for the BI group was similar between patients with greater and lesser BMI. Patients were divided into two BMI groups according to the median of the preoperative BMI (22.5 kg/m$^2$). Tables III and IV show postoperative data for the BMI ≥22.5 kg/m$^2$ and the BMI <22.5 kg/m$^2$ groups. In the BMI ≥22.5 kg/m$^2$ group, preoperative BMI, postoperative BMI, and ΔBMI% were not different between the BI and RY groups. The postoperative VFA of the RY group (50.4 ± 21.9 cm$^2$) was less than that of the BI group (61.9 ± 30.0 cm$^2$; $P$ = .0218). The ΔVFA% of the RY group (52.1 ± 19.5%) was also greater than that of the BI group (35.4 ± 42.9%;

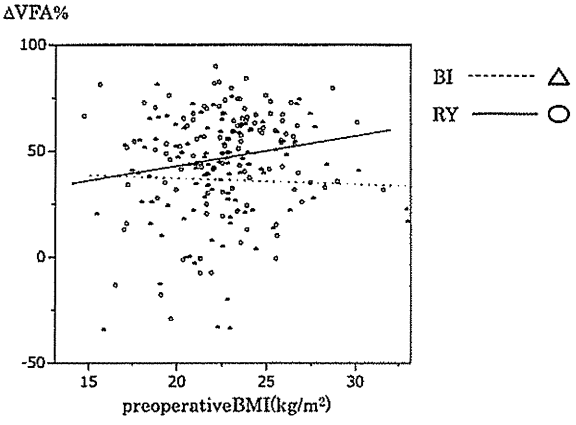


**Fig 2.** Comparison between BI and RY groups of changes in visceral fat according to preoperative BMI.

**Table III.** Postoperative BMI and fat areas of the BMI ≥22.5 kg/m$^2$ group

| *High BMI group* | *BI group,* n = *47* | *RY group,* n = *62* | P *value* |
|---|---|---|---|
| Preoperative BMI, kg/m$^2$ | 24.9 ± 2.5 | 24.9 ± 1.9 | .9607* |
| Postoperative BMI, kg/m$^2$ | 21.4 ± 2.9 | 21.3 ± 2.4 | .7931* |
| ΔBMI% | 10.2 ± 6.7 | 12.2 ± 5.6 | .1012* |
| Preoperative VFA, cm$^2$ | 104.7 ± 40.7 | 112.3 ± 42.0 | .3461* |
| Postoperative VFA, cm$^2$ | 61.9 ± 30.0 | 50.4 ± 21.9 | .0218* |
| ΔVFA% | 35.4 ± 42.9 | 52.1 ± 19.5 | .0041† |
| Preoperative SFA, cm$^2$ | 143.0 ± 59.2 | 152.0 ± 63.2 | .4510* |
| Postoperative SFA, cm$^2$ | 110.2 ± 50.9 | 104.5 ± 51.7 | .5663* |
| ΔSFA% | 20.0 ± 28.6 | 29.6 ± 21.9 | .0930† |

*Student *t*-test.
†Wilcoxon rank-sum test.
Data are mean ± SD.
*BI*, Billroth I reconstruction; *BMI*, body mass index; *ΔBMI%*, rate of reduction of BMI; *ΔSFA%*, rate of reduction of SFA; *ΔVFA%*, rate of reduction of VFA; *RY*, roux-en Y reconstruction; *SFA*, subcutaneous fat area; *VFA*, visceral fat area.

$P$ = .0041). In the BMI <22.5 kg/m$^2$ group, there were no significant differences between the BI and RY groups in terms of postoperative BMI, ΔBMI%, postoperative VFA, and ΔVFA%.

**Determinants of postoperative visceral fat loss.** Before the factors associated with visceral fat loss were analyzed, the study population was divided into a high ΔVFA% group and a low ΔVFA% group by the median ΔVFA% (48.5%). Univariate analysis was used to identify significant factors associated with visceral fat loss. As shown in Table V, among the

**Table IV.** Postoperative BMI and fat area of the BMI <22.5 kg/m$^2$ group

| *Low BMI group* | *BI group,* n = *56* | *RY group,* n = *56* | P *value* |
|---|---|---|---|
| Preoperative BMI (kg/m$^2$) | 20.2 ± 1.8 | 20.2 ± 2.0 | .8691* |
| Postoperative BMI (kg/m$^2$) | 19.4 ± 2.3 | 19.3 ± 1.8 | .7537* |
| ΔBMI% | 7.7 ± 6.2 | 6.4 ± 7.4 | .2949† |
| Preoperative VFA (cm$^2$) | 66.4 ± 27.1 | 70.9 ± 34.1 | .4384* |
| Postoperative VFA (cm$^2$) | 39.4 ± 19.8 | 36.7 ± 20.4 | .4720* |
| ΔVFA% | 38.0 ± 25.2 | 41.7 ± 30.1 | .4729† |
| Preoperative SFA (cm$^2$) | 100.9 ± 42.6 | 90.7 ± 43.1 | .2117* |
| Postoperative SFA (cm$^2$) | 72.4 ± 34.6 | 60.0 ± 28.9 | .0410* |
| ΔSFA% | 24.0 ± 28.2 | 24.7 ± 41.7 | .3594† |

*Student *t*-test.
†Wilcoxon rank-sum test.
Data are mean ± SD.
*BI*, Billroth I reconstruction; *BMI*, body mass index; *ΔBMI%*, rate of reduction of BMI; *ΔSFA%*, rate of reduction of SFA; *ΔVFA%*, rate of reduction of VFA; *RY*, roux-en Y reconstruction; *SFA*, subcutaneous fat area; *VFA*, visceral fat area.

clinicopathologic factors that we examined, adjuvant chemotherapy (performed versus not performed, $P$ = .0046), type of reconstruction (BI versus RY, $P$ = .0087), and p stage (p stage I versus p stage II–IV, $P$ = .0468) correlated with postoperative visceral fat loss. No deaths occurred during the course of this study. There was no significant difference in morbidity/postoperative complications between the low (10/111; 9.0%) and high (11/110; 10%) VFA groups ($P$ = .8017) when patients were divided by the median of the preoperative VFA value. Multivariate logistic regression analysis that included the above factors identified reconstruction (BI versus RY, $P$ = .0078) and adjuvant chemotherapy (performed versus not performed, $P$ = .0172) as significant predictors of visceral fat loss.

## DISCUSSION

Gastrectomy usually leads to body weight loss. The mechanisms of postgastrectomy weight loss include impaired food intake and malabsorption.[10-12] In previous studies authors reported that body weight loss is mainly caused by loss of body fat.[13,14] With respect to anatomical localization, body fat is divided into subcutaneous fat and visceral fat. To our knowledge, there is little information on the changes that take place in visceral and subcutaneous fat after gastrectomy. We found that visceral fat loss after distal gastrectomy was greater in patients who underwent

**Table V.** Univariate and multivariate analysis of risk factors for visceral fat loss

| *Factors* | *High/low* | *Univariate P value* | *Odds ratio* | *95% CI* | *Multivariate P value* |
|---|---|---|---|---|---|
| Reconstruction | | .0087 | 2.0965 | 1.2142–3.6573 | .0078 |
| RY | 69/49 | | | | |
| BI | 42/61 | | | | |
| Sex | | .6323 | | | |
| Men | 77/73 | | | | |
| Women | 34/37 | | | | |
| Lymphadenectomy | | .3324 | | | |
| D2 or D3 | 64/71 | | | | |
| D1 | 46/39 | | | | |
| Operative approach | | .2182 | | | |
| Laparotomy | 81/88 | | | | |
| Laparoscopy | 30/22 | | | | |
| Adjuvant chemotherapy | | .0046 | 4.6106 | 1.3056–17.9177 | .0172 |
| Yes | 22/7 | | | | |
| No | 89/103 | | | | |
| Recurrence | | 1.0000 | | | |
| Yes | 5/4 | | | | |
| No | 105/106 | | | | |
| Location of tumor | | .6364 | | | |
| M | 37/40 | | | | |
| L | 74/70 | | | | |
| Age, y | | .1582 | | | |
| ≥65 | 64/53 | | | | |
| <65 | 47/57 | | | | |
| Pathologic stage | | .0468 | 1.26856 | 0.4556–3.7129 | .6501 |
| II or III | 28/16 | | | | |
| I | 83/94 | | | | |
| Postoperative complications | | .1656 | | | |
| Yes | 10/4 | | | | |
| No | 101/106 | | | | |

*BI*, Billroth I reconstruction; *L*, lower third of stomach; *M*, middle third of stomach; *RY*, roux-en Y reconstruction.

RY compared with those who underwent BI. In a previous study investigators reported that visceral fat reduction is greater after RY gastric bypass compared to vertical banded gastroplasty.[14] Our results are comparable with other reports in the field of bariatric surgery.

However, in previous reports there were differences, such as the size of the remnant stomach and the length of the jejunal bypass, between the operative procedures. To the best of our knowledge, this was the first study to focus on the specific impact of duodenal bypass on visceral fat loss. Because the jejunal bypass was made as short as possible (the afferent limb was as close as 20 cm) and the size of the remnant stomach was equivalent between the BI and RY groups, variations in malabsorption between the groups were minimized. Thus, we believe that this study was also the first to evaluate prospectively collected data to determine the specific effects of duodenal bypass on visceral and subcutaneous fat loss in a population in which the remnant stomach was of a similar size.

It is assumed that the number of patients with gastric cancer who are obese is increasing because of the high prevalence of obesity among the general population. The number of patients diagnosed with early gastric cancer is increasing as the result of earlier detection of cancer, and the 5-year survival rate for patients with early gastric cancer (most often treated with radical resection) is approximately 95%.[15] Consequently, death by causes other than cancer is the most common cause of death among patients with early gastric cancer. Cerebrovascular disorders, cardiac disease, and respiratory disease are reported to be common causes of death in patients with early gastric cancer.[16] When treating these patients, we should therefore consider the most effective means of reducing the risk of death due to causes other than cancer. In recent years, visceral fat accumulation has been identified as one of the underlying causes of metabolic syndrome. This syndrome is characterized by glucose intolerance, obesity, hypertension, and dyslipidemia. Many

studies have demonstrated that body fat distribution is associated with the development of metabolic disorders, and that excessive abdominal fat, especially intra-abdominal visceral fat, is associated with various obesity-related complications and poor prognosis.[17,18] Visceral fat is becoming a target for the treatment of obesity-related complications such as hypertension, dyslipidemia, diabetes mellitus, and cardiovascular disease.[19]

Our study revealed that duodenal bypass in addition to gastrectomy promoted visceral fat loss, especially in obese patients. Previous studies of bariatric surgery have reported that the decrease in absolute BMI in lower BMI groups is less than that of the groups with greater BMI 1 year after RY bypass operation.[20] This finding is consistent with our results. RY reconstruction might be a better choice for obese patients who require distal gastrectomy to treat gastric cancer. Our results also suggest that duodenal bypass is a useful procedure for nonobese patients with metabolic syndrome–associated conditions such as diabetes mellitus, hypertension, and hyperlipidemia, because the reduction in visceral fat was greater after this procedure.

There have been a few reports about the effect on diabetes of rearrangements of gastrointestinal anatomy after surgery for gastric cancer.[21-23] Lanzarini et al[21] reported that gastrectomy with RY reconstruction (60–70 cm limb) in type 2 diabetes patients who underwent operation mainly for gastric cancer correlated with remission of diabetes in 65% and improvement in 30.4% of patients. Another study reported that patients who underwent duodenal bypass had significantly improved diabetes compared with those who did not.[23]

The mechanism by which duodenal bypass reduces visceral fat could not be elucidated in this study. However, previous studies of bariatric operation have reported that visceral fat reduction is greater after RY gastric bypass than after vertical banded gastroplasty.[14] Although the mechanisms of fat reduction or improvement in insulin resistance are not understood completely within the context of bariatric surgery, gut hormones are thought to play a critical role. Among the various gut hormones, gastric inhibitory polypeptide (GIP) is reported to regulate fat metabolism. GIP is released from the duodenal endocrine K cells immediately after the absorption of fat or glucose.[24] Furthermore, fat intake induces hypersecretion of GIP, which increases nutrient uptake and triglyceride accumulation in adipocytes.[25] Korner et al[26] reported lower GIP levels after RY gastric bypass compared to adjustable gastric banding, and concluded that blunted GIP secretion after RY may contribute to the greater weight loss and improved glucose homeostasis compared to adjustable gastric banding. Fat malabsorption may be another factor; clinical tests after RY revealed significantly lower fat absorption than after BI and double-tract reconstruction, in which the passage of food through the duodenum is accommodated.[27]

Our study has several limitations. First, we could not elucidate the mechanism of greater reduction of visceral fat after duodenal bypass, because data about gut hormones were not acquired. In addition, the long-term results are unknown, because we examined CT data only 1 year after surgery. In studies of the long-term results of bariatric surgery, compared with nonsurgical control patients, the use of RY gastric bypass operation in severely obese patients was associated with a greater rate of diabetes remission and a lesser risk of cardiovascular disease and other poor health outcomes after 6 years. On the other hand, there are some reports of recurrence or worsening of diabetes mellitus, especially in nonobese patients, after RY gastric bypass.[28,29] Further investigations will be necessary to provide long-term follow-up data and to understand how duodenal bypass markedly decreases fat.

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TOPIC HIGHLIGHT

WJG 20th Anniversary Special Issues (8): Gastric cancer

# Current status of function-preserving surgery for gastric cancer

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## Abstract

Recent advances in diagnostic techniques have allowed the diagnosis of gastric cancer (GC) at an early stage. Due to the low incidence of lymph node metastasis and favorable prognosis in early GC, function-preserving surgery which improves postoperative quality of life may be possible. Pylorus-preserving gastrectomy (PPG) is one such function-preserving procedure, which is expected to offer advantages with regards to dumping syndrome, bile reflux gastritis, and the frequency of flatus, although PPG may induce delayed gastric emptying. Proximal gastrectomy (PG) is another function-preserving procedure, which is thought to be advantageous in terms of decreased duodenogastric reflux and good food reservoir function in the remnant stomach, although the incidence of heartburn or gastric fullness associated with this procedure is high. However, these disadvantages may be overcome by the reconstruction method used. The other important problem after PG is remnant GC, which was reported to occur in approximately 5% of patients. Therefore, the reconstruction technique used with PG should facilitate postoperative endoscopic examinations for early detection and treatment of remnant gastric carcinoma. Oncologic safety seems to be assured in both procedures, if the preoperative diagnosis is accurate. Patient selection should be carefully considered. Although many retrospective studies have demonstrated the utility of function-preserving surgery, no consensus on whether to adopt function-preserving surgery as the standard of care has been reached. Further prospective randomized controlled trials are necessary to evaluate survival and postoperative quality of life associated with function-preserving surgery.



**Key words:** Gastric cancer; Function preserving surgery; Quality of life; Pylorus preserving surgery; Proximal gastrectomy

**Core tip:** We reviewed the current status of two function-preserving surgeries for gastric cancer (GC), pylorus-preserving surgery and proximal gastrectomy (PG). Although both procedures appear to be oncologically safe for early GC, issues regarding postoperative quality of life remain, especially with PG. The effect of the reconstruction method after PG on postoperative quality of life was analyzed, including the novel double tract reconstruction method, which is expected to overcome disadvantages associated with esophagogastrostomy and jejunal interposition reconstruction. Although some reports showed a benefit with function-preserving surgery, further randomized trials are needed.

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