Int Surg 2017;**102:**95–99
DOI: 10.9738/INTSURG-D-16-00212.1

Influence of Visceral Fat on Early Postoperative Outcomes After Distal and Total Gastrectomy for Gastric Cancer

Chikashi Shibata, Hitoshi Ogawa, Kaori Koyama, Kazuaki Mukouda, Hajime Iwasashi, Takaaki Araki, Shunichi Kimura, Natsuki Nakajima

Division of Gastroenterologic Surgery, Department of Surgery, Tohoku Medical and Pharmaceutical University, Sendai, Japan

We studied the influence of visceral fat area (VFA) on early postoperative outcomes separately after distal and total gastrectomy. The influence of obesity on outcomes might differ between distal and total gastrectomy, but few studies have directly compared the effects of VFA on early postoperative results between these 2 procedures. We reviewed clinical records of 124 patients with gastric cancer undergoing curative distal or total gastrectomy. Patients were classified into 2 groups: low ($<$100 cm^2) or high ($\geq$100 cm^2) VFA. Patient characteristics and early postoperative outcomes were compared between 2 groups separately in distal or total gastrectomy. There were 77 and 47 patients who underwent distal and total gastrectomy, respectively. After distal gastrectomy, operation time (268 $\pm$ 44 versus 239 $\pm$ 39 minutes, $P < 0.05$) as well as blood loss (351 $\pm$ 231 versus 239 $\pm$ 147 mL, $P < 0.05$) was increased in the high VFA group (N = 32) compared to the low VFA group (N = 45), but morbidity rates did not differ between the 2 groups (50% versus 36%). After total gastrectomy; operation time (285 $\pm$ 42 versus 260 $\pm$ 53 minutes, $P < 0.05$); blood loss (427 $\pm$ 326 versus 280 $\pm$ 179 mL, $P < 0.05$); rate of morbidity (56% versus 24%, $P < 0.05$); and intra-abdominal infection (17% versus 0%, $P < 0.05$) were increased in the high VFA group (N = 18) compared to the low VFA group (N = 29). These results suggest that postoperative morbidity increases after total gastrectomy but not after distal gastrectomy in patients with excessive visceral fat.

Key words: Gastric cancer – Obesity – Visceral fat

Corresponding author: Chikashi Shibata, MD, Division of Gastroenterologic Surgery, Department of Surgery, Tohoku Medical and Pharmaceutical University, 1-12-1 Fukumuro, Miyagino-ku, Sendai 983-8512, Japan.
Tel.: +81 22 259 1221; Fax: +81 22 259 0507; E-mail: cshibata@hosp.tohoku-mpu.ac.jp

Obesity is considered a risk factor for the development of malignancies including gastric carcinoma.[1,2] After gastric resection for gastric cancer, obesity and especially visceral fat have been known to affect early postoperative outcomes in terms of intraoperative blood loss, operation time, number of retrieved lymph nodes (LNs), postoperative complications, and overall survival.[3,4] The following 3 factors should be considered when investigating the effect of obesity on perioperative outcomes: (1) parameters for obesity [body mass index (BMI) and visceral fat area (VFA)]; (2) operative procedures [distal gastrectomy (DG) or total gastrectomy (TG)]; and (3) the operative approach (open or laparoscopic surgery).

The use of a laparoscopic approach to gastrectomy for gastric cancer has increased rapidly; operation time is prolonged but intraoperative blood loss is less in laparoscopic gastrectomy compared to open gastrectomy.[5] At our institution, a laparoscopic gastrectomy is performed only in patients with early gastric cancer, and accumulation of results in enough patients is not yet available for analysis. Therefore, the present study focused on patients with gastric cancer who underwent open gastrectomy.

BMI is the best overall representative parameter for obesity,[6,7] and a BMI >25 is defined as obese in Japan. VFA is being recognized more recently as being even more important because of its metabolic implications.[8] VFA is measurable in the computed tomography (CT) performed preoperatively as a routine examination to evaluate distant and LN metastases in patients with gastric cancer. Because visceral fat directly affects operative handling, VFA is likely to be more useful than BMI as a predictive factor for early postoperative outcomes. Several reports compared the effects of BMI and VFA on postoperative outcomes in patients after open gastrectomy[9–12]; although results are somewhat different in each report, none has regarded BMI better than VFA as a predictive factor. The same is true for laparoscopic gastrectomy.[13,14] Thus it is considered generally accepted that VFA is more useful than BMI as a predictive factor for postoperative outcomes.

Regarding resection procedures for gastric cancer, the influence of obesity on perioperative outcomes might differ between DG and TG, but few studies have directly compared the effects of BMI or VFA on early postoperative results between DG and TG.

The aim of the present study was to investigate whether the effects of visceral fat on early postoperative outcomes differ between DG and TG in patients with gastric cancer who underwent open gastrectomy.

Materials and Methods

Patients

In total, 124 patients underwent DG or TG for gastric cancer with stage I∼III diseases between January 2010 and June 2015. Patients with remnant gastric cancer after gastrectomy were excluded. Also excluded were those who underwent noncurative resection, neoadjuvant chemotherapy, and concomitant resection of other organs due to another synchronous malignancy other than gastric cancer. Clinical records were reviewed retrospectively. This study was approved by our institutional review board.

Methods

We studied sex, age, VFA, BMI, resection procedure, reconstruction method, degree of LN dissection, and pathologic stage. We also investigated intraoperative blood loss, operation time, number of retrieved LNs, and postoperative morbidity as early postoperative outcomes. Morbidity was defined according to Clavien-Dindo classification,[15] as well as overall grade II through V morbidity. Anastomotic leakage and intra-abdominal abscess were defined as postoperative, intra-abdominal infection. Patients were classified into 2 groups: VFA < 100 cm^2 (low VFA group) or VFA ≥ 100 cm^2 (high VFA group). Patient characteristics and early postoperative outcomes were compared between low and high VFA groups in patients undergoing DG and TG separately. The degree of LN dissection (D2, D1+, D1) and pathologic stage of the gastric cancer were described based on the Japanese classification of gastric carcinoma[16] and the gastric cancer treatment guidelines in Japan.[17] All patients underwent preoperative CT for diagnosis of distant and LN metastasis, and VFA was measured with commercial software (FatScan, N2 systems, Osaka, Japan) at the level of the umbilicus.

Statistical analysis

Values are shown in mean ± SD. Mann-Whitney's *U*-test was used for comparison of intraoperative blood loss, operation time, and number of retrieved LNs. We used χ^2 test to compare distribution of degree of LN dissection, stage, and form of operative reconstruction, and morbidity between

Table 1 Patient characteristics

	DG (N = 77)	TG (N = 47)
Male/female	49/28	33/14
Age (range)	68 ± 9 (51–83)	68 ± 11 (41–91)
BMI (range)	23.3 ± 3.2 (17.1–34.0)	23.3 ± 3.9 (16.5–30.0)
VFA (range)	93.1 ± 50.4 (13.0–211.3)	83.6 ± 51.2 (5.0–211.2)
LN dissection, D2:D1, D1+	52:27	11:36
Stage, I:II:III	38:15:24	21:9:17
Intraoperative blood loss, mL (range)	285 ± 193 (40–945)	336 ± 264 (70–1625)
Operation time, min (range)	251 ± 44 (145–364)	270 ± 50 (184–427)
Retrieved LN, n (range)	30.3 ± 14.2 (6–68)	29.8 ± 14.0 (9–79)
Overall morbidity	32 (42%)	17 (36%)
Morbidity grades II–IV, n (%)	19 (25)	9 (19)
Intra-abdominal infection, n	1	3

Values are mean ± SD.

the groups. A value of $P < 0.05$ was regarded as significant.

Results

Patient characteristics

DG and TG were performed in 77 and 47 patients, respectively (Table 1). After DG, 41 of the 77 patients underwent Billroth-I gastroduodenostomy for reconstruction, while 33 underwent Roux-en-Y (RY) gastrojejunostomy; the remaining 3 patients underwent Billroth-II gastrojejunostomy with a Braun anastomosis. After TG, conventional RY esophagojejunostomy was performed in 45 patients, and 2 underwent RY with pouch reconstruction. The rate of patients who underwent D2 LN dissection in DG (52/77 = 67%) was greater than that in TG (11/47 = 23%, $P < 0.05$). Overall postoperative morbidity was observed in 32 of 77 (42%) in DG and 17 of 47 (36%) in TG. Grade II through IV morbidity was identified in 19 of 77 (25%) in DG and 9 of 47 (19%) in TG. Intra-abdominal infection was observed in 1 patient after DG and 3 after TG.

Effects of VFA on perioperative outcomes after DG

Table 2 shows early postoperative results in the low and high VFA groups. There were 45 and 32 patients in the low and high VFA groups, respectively. In 32 patients of the high VFA group, BMI was greater than 25 in17 patients (53%). BMI as well as VFA was greater in the high VFA group than in the low VFA group ($P < 0.05$). The characteristics of patients undergoing DG did not differ between the low and high VFA groups. In patients with high VFA, however, blood loss was somewhat greater than patients with low VFA as was operation time ($P < 0.05$). Number of retrieved LN was not different between the 2 groups. Rates of overall and grade II through V postoperative morbidities did not differ between the low and high VFA groups. Because there was only 1 patient who had an intra-abdominal infection after DG, VFA was not considered associated with intra-abdominal infection.

Effects of VFA on perioperative outcomes after TG

There were 29 and 18 patients in the low and high VFA groups, respectively (Table 3). BMI was greater than 25 in 13 of 18 patients (72%) in the high VFA group. There were no differences in patient characteristics between the low and high VFA groups (Table 3). In the high VFA group, intraoperative blood loss (427 ± 326 versus 280 ± 179 mL, $P < 0.05$) and operation time (285 ± 42 versus 260 ± 53 minutes, $P < 0.05$), but not number of retrieved LNs,

Table 2 Comparison of perioperative results after DG between low and high VFA

	Low VFA (N = 45)	High VFA (N = 32)
Age (male:female)	67 ± 9 (25:20)	71 ± 9 (24:8)
BMI	21.7 ± 2.6	25.5 ± 2.7*
VFA	58.6 ± 28.8	141.6 ± 29.8*
LN dissection, D2:D1, D1+	28:17	24:8
Stage, I:II:III	25:8:12	13:7:12
Reconstruction, B-I:RY:B-II	27:15:3	14:18:0
Intraoperative blood loss, mL	239 ± 147	351 ± 231*
Operation time, min	239 ± 39	268 ± 44*
Retrieved LN, n	32.5 ± 15.2	27.1 ± 12.5
Overall morbidity, n (%)	16 (36)	16 (50)
Morbidity grades II–IV, n (%)	10 (22)	9 (28)
Intra-abdominal infection, n	0	1

Values are mean ± SD

* $P < 0.05$ compared to low VFA

Table 3 Comparison of perioperative results after TG between low and high VFA

	Low VFA (N = 29)	High VFA (N = 18)
Age (male:female)	68 ± 13 (19:10)	69 ± 8 (14:4)
BMI	21.5 ± 3.3	26.5 ± 2.5*
VFA	50.3 ± 28.6	137.3 ± 28.2*
LN dissection, D2:D1, D1+	7:22	4:14
Stage, I:II:III	16:4:9	5:5:8
Reconstruction, RY:Pouch RY	27:2	18:0
Intraoperative blood loss, mL	280 ± 179	427 ± 326*
Operation time, min	260 ± 53	285 ± 42*
Retrieved LN, n	31.2 ± 15.2	27.6 ± 11.9
Overall morbidity, n (%)	7 (24)	10 (56)*
Morbidity grades II–IV, n (%)	2 (7)	7 (39)*
Intra-abdominal infection, n (%)	0	3 (17)*

Values are mean ± SD.

* $P < 0.05$ compared to low VFA.

were greater (Table 3). Postoperative morbidity rate in the high VFA group was greater than that in the low VFA group [10/18 (56%) versus 7/29 (24%) for overall rate and 7/18 (39%) versus 2/29 (7%) for grades II through V, $P < 0.05$ each, Table 3]. The rate of intra-abdominal infection was also increased in high VFA group [3/18 (17%)] compared with the low VFA (0/29) group ($P < 0.05$, Table 3).

Discussion

Our data suggested that the influence of obesity on early postoperative outcomes is more obvious in patients after TG than DG. In the high VFA group, operation time and blood loss were increased compared to the low VFA group; these effects were seen regardless of type of gastric resection, DG, or TG. The effects of obesity on postoperative morbidity, however, were different between DG and TG. While the rates of overall and grade II through V morbidity in the high VFA group were greater than that in the low VFA group after TG, after DG, VFA did not affect overall and grade II through V morbidity. These results suggest that postoperative morbidity is more likely to occur after TG as appeared to DG in patients with excessive visceral fat. Our results showing an increased rate of intra-abdominal infection after TG but not after DG in the high VFA group also support our conclusions above. The rate of patients whose BMI was more than 25 in the high VFA group after TG (72%) was greater than that after DG (53%); this fact may be associated with a high morbidity rate after TG.

One study in patients after DG showed that BMI did not affect the rate of postoperative complication, but BMI was associated with blood loss and operation time.[18] In contrast, studies in patients after TG showed that an increased BMI was associated with greater blood loss, longer operation times, and increased rate of postoperative morbidity.[19,20] Although all of these studies used BMI alone without measurement of VFA as a parameter for obesity, results in these studies support our findings above. We consider that visceral fat is likely to have crucial influence on operative procedures during TG rather than DG. Esophagojejunostomy in TG is a much more difficult and risky anastomosis than gastroduodenostomy and gastrojejunostomy in DG, and visceral fat may further increase the difficulty and complications related to this high risk anastomosis.

Several previous reports concluded that VFA was more useful than BMI for predicting perioperative outcomes after gastrectomy for gastric cancer.[13,14,21] We also showed that VFA appears to be a risk factor for postoperative morbidities, intraoperative blood loss, and operation time. However, the measurement of VFA on CT requires unique software, and a more simple predictive factor is awaited that is much easier to measure and as useful as VFA.

A limitation in this study is that this is retrospective. As long as we have investigated, however, there has been no study that reported the differing effects of VFA on early postoperative outcomes between DG and TG. When we clinically determine the operative procedure, DG or TG, our results indicate that, in patients with excessive visceral fat, DG rather than TG should be chosen as long as DG does not impair curability.

In conclusion, our results suggest that visceral fat may be associated with increased intraoperative blood loss and operation time. and postoperative morbidity is increased after TG but not after DG in patients with excessive visceral fat.

Acknowledgments

The authors thank Michael G. Sarr, Emeritus Professor of Surgery, Mayo Clinic (Rochester, Minnesota), for reviewing this manuscript. This study was not supported by any sources including grant.

References

1. Calle EE, Rodriguez C, Walker-Thurmond K, Thun MJ. Overweight, obesity, and mortality from cancer in a prospec-

tively studied cohort of U.S. adults. *N Engl J Med* 2003;**348**(17): 1625–1638
2. Lagergren J, Bergström R, Nyrén O. Association between body mass and adenocarcinoma of the esophagus and gastric cardia. *Ann Intern Med* 1999;**130**(11):883–890
3. Nozoe T, Kohno M, Iguchi T, Mori E, Maeda T, Matsukuma A *et al*. Analysis of the impact of the body mass index in patients with gastric carcinoma. *Surg Today* 2012;**42**(10):945–949
4. Ojima T, Iwahashi M, Nakamori M, Nakamura M, Naka T, Ishida K *et al*. Influence of overweight on patients with gastric cancer after undergoing curative gastrectomy: an analysis of 689 consecutive cases managed by a single center. *Arch Surg* 2009;**144**(4):351–358
5. Quan Y, Huang A, Ye M, Xu M, Zhuang B, Zhang P *et al*. Comparison of laparoscopic versus open gastrectomy for advanced gastric cancer: an updated meta-analysis. *Gastric Cancer* 2016;**19**(3):939–950
6. Choban PS, Flancbaum L. The impact of obesity on surgical outcomes: a review. *J Am Coll Surg* 1997;**185**(6):593–603
7. Katzmarzyk PT, Bray GA, Greenway FL, Johnson WD, Newton RL Jr, Ravussin E *et al*. Ethnic-specific BMI and waist circumference thresholds. *Obesity (Silver Spring)* 2011;**19**(6): 1272–1278
8. Examination Committee of Criteria for 'Obesity Disease' in Japan; Japan Society for the Study of Obesity. New criteria for 'obesity disease' in Japan. *Circ J* 2002;**66**(11):987–992
9. Tokunaga M, Hiki N, Fukunaga T, Ogura T, Miyata S, Yamaguchi T. Effect of individual fat areas on early surgical outcomes after open gastrectomy for gastric cancer. *Br J Surg* 2009;**96**(5):496–500
10. Tanaka K, Miyashiro I, Yano M, Kishi K, Motoori M, Seki Y *et al*. Accumulation of excess visceral fat is a risk factor for pancreatic fistula formation after total gastrectomy. *Ann Surg Oncol* 2009;**16**(6):1520–1525
11. Makino H, Kunisaki C, Akiyama H, Ono HA, Kosaka T, Takagawa R *et al*. Effect of obesity on intraoperative bleeding volume in open gastrectomy with D2 lymph-node dissection for gastric cancer. *Patient Saf Surg* 2008;2:7
12. Sugisawa N, Tokunaga M, Tanizawa Y, Bando E, Kawamura T, Terashima M. Intra-abdominal infectious complications following gastrectomy in patients with excessive visceral fat. *Gastric Cancer* 2012;**15**(2):206–212
13. Miyaki A, Imamura K, Kobayashi R, Takami M, Matsumoto J. Impact of visceral fat on laparoscopy-assisted distal gastrectomy. *Surgeon* 2013;**11**(2):76–81
14. Yoshikawa K, Shimada M, Kurita N, Iwata T, Nishioka M, Morimoto S *et al*. Visceral fat area is superior to body mass index as a predictive factor for risk with laparoscopy-assisted gastrectomy for gastric cancer. *Surg Endosc* 2011;**25**(12):3825–3830
15. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a ne proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;**240**(2): 205–213
16. Japanese Gastric Cancer Association: Japanese classification of gastric carcinoma: 3rd English edition. *Gastric Cancer* 2011; **14**(2):101–112
17. Japanese Gastric Cancer Association: Japanese gastric cancer treatment guidelines 2010 (ver. 3). *Gastric Cancer* 2011;**14**(2): 113–123
18. Yamada H, Kojima K, Inokuchi M, Kawano T, Sugihara K. Effect of obesity on technical feasibility and postoperative outcomes of laparoscopy-assisted distal gastrectomy–comparison with open distal gastrectomy. *J Gastrointest Surg* 2008; **12**(6):997–1004
19. Nobuoka D, Gotohda N, Kato Y, Takahashi S, Konishi M, Kinoshita T. Influence of excess body weight on the surgical outcomes of total gastrectomy. *Surg Today* 2011;**418**(7):928–934
20. Pata G, Solaini L, Roncali S, Pasini M, Ragni F. Impact of obesity on early surgical and oncologic outcomes after total gastrectomy with "over-D1" lymphadenectomy for gastric cancer. *World J Surg* 2013;**37**(5):1072–1081
21. Go JE, Kim MC, Kim KH, Oh JY, Kim YM. Effect of visceral fat area on outcomes of laparoscopy assisted distal gastrectomy for gastric cancer: subgroup analysis by gender and parameters of obesity. *Ann Surg Treat Res* 2015;**88**(6):318–324