The effect of the body mass index on the short-term surgical outcomes of laparoscopic total gastrectomy: A propensity score-matched study

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Abstract

Purpose: This study aimed to evaluate the relationship between the body mass index (BMI) and the short-term outcomes of laparoscopic total gastrectomy (LTG).

Subjects and Methods: Data of patients who underwent LTG for gastric cancer at six institutions between 2004 and 2018 were retrospectively collected. The patients were classified into three groups: low BMI (<18.5 kg/m²), normal BMI (≥18.5 and <25 kg/m²) and high BMI (≥25 kg/m²). In these patients, clinicopathological variables were analysed using propensity score matching for age, sex, the American Society of Anaesthesiologists physical state, clinical stage, surgical method, D2 lymph node dissection, combined resection of other organs, anastomosis method and jejunal pouch reconstruction. The surgical results and post-operative outcomes were compared among the three groups.

Results: A total of 82 patients were matched in the analysis of the low BMI and normal BMI groups. There were no differences in operative time (P = 0.693), blood loss (P = 0.150), post-operative complication (P = 0.762) and post-operative hospital stay (P = 0.448). In the analysis of the normal BMI and high BMI groups, 208 patients were matched. There were also no differences in blood loss (P = 0.377), post-operative complication (P = 0.249) and post-operative hospital stay (P = 0.676). However, the operative time was significantly longer in the high BMI group (P = 0.023).

Conclusions: Despite the association with a longer operative time in the high BMI group, BMI had no significant effect on the surgical outcomes of LTG. LTG could be performed safely regardless of BMI.

Keywords: Body mass index, laparoscopic total gastrectomy, propensity score matching, surgical outcome

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Submitted: 22-Aug-2019, Accepted in Revised Form: 27-Oct-2019, Published: 17-Sep-2020

How to cite this article: Miyasaka M, Ebihara Y, Tanaka K, Nakanishi Y, Asano T, Noji T, et al. The effect of the body mass index on the short-term surgical outcomes of laparoscopic total gastrectomy: A propensity score-matched study. J Min Access Surg 2020;16:376-80.
INTRODUCTION

Gastric cancer (GC) is one of the most common cancers worldwide. Although various treatments such as surgery and chemotherapy are used in patients with GC, laparoscopic gastrectomy (LG) has gradually become popular in recent years. With the increasing use of LG, there has been an increasing number of studies investigating the relationship between the body mass index (BMI) and clinical outcomes in patients undergoing LG. BMI has long been known as an indicator of obesity and nutritional status. However, it remains controversial whether BMI is associated with the surgical outcomes of gastrectomy for GC. Some previous studies reported that BMI was associated with post-operative complications. In contrast, other studies reported that there was no association between BMI and the clinical outcomes of GC. The impact of BMI on LG is also unclear. In particular, there are few reports on the relationship between BMI and LG including laparoscopic total gastrectomy (LTG). Thus, the aim of this study was to evaluate the relationship between BMI and the surgical outcomes of LTG.

SUBJECTS AND METHODS

Patients

A retrospective review of patients who underwent LTG for GC at six institutions between January 2004 and December 2018 was performed. The surgical procedure was based on the recommendations of the Japanese Gastric Cancer Treatment Guidelines. Clinopathological data including age, sex, BMI, the American Society of Anaesthesiologist’s physical status (ASA-PS), clinical stage, surgical method (laparoscopy-assisted total gastrectomy or totally LTG), combined resection of other organs, lymph node dissection, anastomosis method (circumferential stapler or linear stapler) and jejunal pouch reconstruction were collected. Surgical outcomes including operative time, estimated blood loss, post-operative complication and length of post-operative hospital stay were recorded.

Data evaluation

BMI was calculated as body weight in kilograms divided by height in meters squared. The patients were classified into three groups according to the BMI level: low BMI group (BMI <18.5 kg/m²), normal BMI group (18.5 kg/m² ≤BMI <25.0 kg/m²) and high BMI group (BMI ≥25.0 kg/m²). Although the World Health Organisation defined obesity as a BMI of >30 kg/m², we used 25 kg/m² as our cutoff because the average BMI for Asian people is lower than the BMI for non-Asian people, especially when compared with the Western populations. Of the 440 patients collected in our study, only 13 patients (3.0%) had a BMI of >30 kg/m². Clinical staging was determined according to the tumour-node-metastasis model and the American Joint Committee on Cancer 8th edition. Post-operative complication was evaluated using the Clavien–Dindo classification.

Statistical analysis

To mitigate the selection bias in the present study, propensity score matching was performed using a logistic regression model. The parameters used for propensity score matching were age, sex, BMI, ASA-PS, clinical stage, surgical method, combined resection of other organs, lymph node dissection, anastomosis method and jejunal pouch reconstruction. Following the recommendations by Austin, we matched the logit of the propensity score within the caliper of 0.2 standard deviation of the value. Categorical variables were analysed using the Chi-square test before propensity score matching and the McNemar and Wilcoxon signed-rank tests after propensity score matching. Continuous variables were examined using the unpaired t-test before propensity score matching and the paired t-test or the Wilcoxon signed-rank test after propensity score matching. P<0.05 was considered statistically significant. Statistical analysis was performed using JMP® 14 software (SAS Institute Inc., Cary, NC, USA).

RESULTS

Clinical features and surgical outcomes of the study population before matching

Table 1 shows the clinical characteristics and surgical outcomes of the study population. A total of 440 patients were included, comprising 305 men (69.3%) and 135 women (30.7%). There were 42 patients in the low BMI group (9.5%), 290 patients in the normal BMI group (65.9%) and 108 patients in the high BMI group (24.6%). Clinical staging was distributed as follows: stage IA (25.0%), II (27.9%), III (29.1%) and IV (18.0%). The post-operative hospital stays were 107.4±187.9 days (mean±standard deviation).

Table 1: Clinical features and surgical outcomes of the study population

| Variable | Overall (n=440) |
|----------|----------------|
| Age (years, mean±SD) | 66.3±11.1 |
| Gender (M/F) | 305:135 |
| BMI (kg/m², mean±SD) | 22.7±3.5 |
| (<18.5:18.5≤25:25≤) | (42:290:108) |
| ASA-PS* ( II< ) | 318 (72.3%) |
| Clinical stage* ( II< ) | 135 (30.7%) |
| Method of surgery (LATG, TLTG) | 130:310 |
| Combined resection of other organs | 141 (32.0%) |
| Lymph node dissection (D2< ) | 68 (15.5%) |
| Method of anastomosis (Circular:Linear) | 170:267 (Unknown=3) |
| Jejunal pouch reconstruction | 71 (16.1%) |
| Operation time (min, mean±SD) | 332.8±83.6 |
| Blood loss (ml, mean±SD) | 107.4±187.9 |
| Postoperative complication (C-D, III; c) | 66 (15.0%) |
| Postoperative hospital stays (days, mean±SD) | 18±16.6 |
| (<14:14<) | (222:218) |

*The American Society of Anaesthesiologist’s physical status, †According to the American Joint Committee on Cancer Cancer Staging, Manual 8th edition, ‡LATG, laparoscopic-assisted total gastrectomy, §TLTG, totally laparoscopic total gastrectomy, Clavien-Dindo, classification
BMI group (24.5%). Table 2 shows the association between clinical features and BMI. BMI did not seem to affect the clinical features of age, sex, clinical stage, surgical method, combined resection of other organs, lymph node dissection and anastomosis method. However, significant differences were found in jejunal pouch reconstruction between the low BMI group and the normal BMI group (35.7% vs. 13.1%, P < 0.01) and in ASA-PS between the normal BMI group and the high BMI group (65.9% vs. 90.7%, P < 0.01). Jejunal pouch reconstruction has been reported to have a beneficial effect on post-operative weight recovery; thus, it may be more beneficial in patients with low BMI than in those with normal BMI.\(^{[18]}\) Furthermore, as there were patients with BMI > 30 kg/m\(^2\) and patients with obesity often have many complications, the association between ASA-PS and high BMI group seems to be strong.

Clinical features and surgical outcomes of the study population after matching

Propensity score matching was used to reduce selection bias. To evaluate the impact of the abnormal BMI groups on the normal BMI group, matching was performed between the normal BMI group and low BMI group and between the normal BMI group and the high BMI group. Table 3 shows the comparisons of the clinical features among the three groups after matching (all P > 0.05).

The relationship between BMI and surgical outcomes after matching is shown in Table 4. Contrary to our expectation, in the comparison of the low BMI and normal BMI groups, there was no difference in operative time, estimated blood loss, post-operative complications and the length of post-operative hospital stay (all P > 0.05). Similarly, in the comparison of the normal BMI and high BMI groups, there was no difference in estimated blood loss, post-operative complications and length of post-operative hospital stay (all P > 0.05). However, the operative time was significantly longer in the high BMI group (P = 0.02). With respect to post-operative complications, a detailed analysis was performed for each complication: pancreatic fistula, anastomosis leakage, anastomosis stenosis, duodenal stump leakage, intra-abdominal abscess and abdominal

### Table 2: Comparison of the clinical features with body mass index before matching

| Variable                                      | Low-BMI (n=42) | Normal-BMI (n=290) | P       | Normal-BMI (n=290) | High-BMI (n=108) | P       |
|-----------------------------------------------|----------------|--------------------|---------|--------------------|------------------|---------|
| Age (years, mean±SD)                         | 66.9±11.0      | 66.5±11.3          | 0.82    | 66.5±11.3          | 65.6±10.9        | 0.50    |
| Gender (M/F)                                  | 24:18          | 202:88             | 0.10    | 202:88             | 79:29            | 0.46    |
| ASA-PS (II-III)                               | 29 (69.0%)     | 191 (65.9%)        | 0.68    | 191 (65.9%)        | 98 (90.7%)       | <0.01   |
| Clinical stage (II-III)                       | 17 (40.5%)     | 89 (30.7%)         | 0.20    | 89 (30.7%)         | 29 (26.8%)       | 0.46    |
| Method of surgery (LATG', TLTG')              | 17:25          | 82:208             | 0.10    | 82:208             | 31:77            | 0.93    |
| Combined resection of other organs            | 14 (33.3%)     | 96 (33.1%)         | 0.98    | 96 (33.1%)         | 31 (28.7%)       | 0.40    |
| Lymph node dissection (D2-3)                  | 8 (19.0%)      | 47 (16.2%)         | 0.64    | 47 (16.2%)         | 13 (12.0%)       | 0.30    |
| Method of anastomosis (Circular:Linear)       | 20:22          | 107:183            | 0.18    | 107:183            | 43:62            | 0.46    |
| Jejunal pouch reconstruction                  | 15 (35.7%)     | 38 (13.1%)         | <0.01   | 38 (13.1%)         | (Unknown=3)      | 0.36    |

*The American Society of Anaesthesiologist’s physical status, †According to the American Joint Committee on Cancer Cancer Staging, Manual 8th edition, ‡LATG, laparoscopic-assisted total gastrectomy, ‡TLTG, totally laparoscopic total gastrectomy

### Table 3: Comparison of the clinical features with body mass index after matching

| Variable                                      | Low-BMI (n=41) | Normal-BMI (n=41) | P       | Normal-BMI (n=104) | High-BMI (n=104) | P       |
|-----------------------------------------------|----------------|--------------------|---------|--------------------|------------------|---------|
| Age (years, mean±SD)                         | 66.9±11.2      | 68.0±11.8          | 0.68    | 65.9±9.8           | 65.7±10.9        | 0.88    |
| Gender (M/F)                                  | 24:17          | 23:18              | 0.82    | 76:28              | 77:27            | 0.87    |
| ASA-PS (II-III)                               | 28 (68.3%)     | 32 (78.0%)         | 0.32    | 95 (91.4%)         | 94 (90.4%)       | 0.81    |
| Clinical stage (II-III)                       | 16 (39.0%)     | 16 (39.0)          | 1.00    | 29 (27.9%)         | 29 (27.9%)       | 1.00    |
| Method of surgery (LATG', TLTG')              | 16:25          | 15:26              | 0.76    | 28:76              | 30:74            | 0.76    |
| Combined resection of other organs            | 14 (34.1%)     | 8 (19.5%)          | 0.14    | 30 (28.9%)         | 30 (28.9%)       | 1.00    |
| Lymph node dissection (D2-3)                  | 7 (17.1%)      | 8 (19.5%)          | 0.76    | 13 (12.5%)         | 13 (12.5%)       | 1.00    |
| Method of anastomosis (Circular:Linear)       | 19:22          | 15:26              | 0.37    | 39:65              | 42:62            | 0.67    |
| Jejunal pouch reconstruction                  | 14 (34.1%)     | 12 (29.3%)         | 0.64    | 16 (15.4%)         | 18 (17.3%)       | 0.71    |

*The American Society of Anaesthesiologist’s physical status, †According to the American Joint Committee on Cancer Cancer Staging, Manual 8th edition, ‡LATG, laparoscopic-assisted total gastrectomy, ‡TLTG, totally laparoscopic total gastrectomy

### Table 4: Comparison of the surgical outcomes with the body mass index after matching

| Variable                                      | Low-BMI (n=41) | Normal-BMI (n=104) | P       | Normal-BMI (n=104) | High-BMI (n=104) | P       |
|-----------------------------------------------|----------------|--------------------|---------|--------------------|------------------|---------|
| Operation time (min, mean±SD)                 | 330.4±88.6     | 323.2±76.3         | 0.69    | 328.5±75.6         | 354.8±89.0       | 0.02    |
| Blood loss (ml, mean±SD)                      | 129.9±217.6    | 75.1±104.0         | 0.15    | 95.9±174.2         | 116.3±157.8      | 0.38    |
| Postoperative complication (Cl-D, IIIa,c)     | 6 (14.6%)      | 7 (17.1%)          | 0.76    | 19 (18.3%)         | 13 (12.5%)       | 0.25    |
| Postoperative hospital stays (days, mean±SD)  | 18.0±17.5      | 17.3±14.2          | 0.73    | 17.3±14.2          | 18.0±17.5        | 0.73    |

Clavien-Dindo, classification
bleeding. No significant difference was observed in each post-operative complication.

DISCUSSION

While medical care is still developing, GC remains the third leading cause of cancer deaths worldwide. [1] Despite the development of endoscopy and drug therapies, surgical resection is still an important treatment for radical cure. LG was first reported in 1991 and has become increasingly popular in recent years. [19,20] Concerning laparoscopic distal gastrectomy (LDG), some reports have indicated its superiority over open gastrectomy. [21,22] In contrast, LTG has not been as widely used as LDG. As the localization of GC has gradually changed to the upper part of the stomach in recent years, it is considered that LTG will be the more commonly performed procedure in the future. Therefore, it is important to study the safety of LTG.

BMI is considered an index of obesity and emaciation because of the simplicity of its calculation. It has long been known that obesity makes surgery difficult. Several effects of obesity have also been reported in GC. [23,24] It has been reported that obesity increases the operative time, intraoperative blood loss and risk of post-operative pancreatic fistula formation. [8,23] Some reports have also indicated that emaciation increases the post-operative complications in GC. [7,23] Despite these reports, it remains controversial whether BMI affects the surgical outcomes of gastrectomy. Similarly, the impact of BMI on LG is still under discussion. [13,26,27] Due to its generality, LDG has been widely studied. However, there are few studies dedicated to LTG, as most studies included LTG only as a part of other LG procedures. [28] Thus, our study focused on the relationship between LTG and BMI. There was no significant difference in surgical outcomes, such as post-operative complications, between the low BMI group and the normal BMI group, and we observed no effect of low BMI on LTG in our study. In contrast with the existing reports, there was no significant difference in estimated blood loss, post-operative complications and length of post-operative hospital stay between the high BMI group and the normal BMI group (i.e., obese and non-obese patients). However, the operative time showed a significant difference. In a meta-analysis of the same Asian population as that in our study, although LDG was included, LG has been reported to have an effect on operative time and intraoperative blood loss but not on the short-term surgical outcomes. [29] Compared with this study, our study on LTG and BMI seems not to show markedly contradictory results.

The results of our study suggest that good visualization with a laparoscope may result in good surgical outcomes in LTG for both patients with obesity and those with emaciation. Especially in patients with obesity, there is also a benefit of avoiding fat from the surgical field through the rotation of the operation table and the creation of a pneumoperitoneum. The impact of BMI may be less, even in LTG. Although intraoperative blood loss, post-operative complications and length of post-operative hospital stay did not increase, it may be difficult to shorten the operative time through various intraoperative manipulations in the high BMI group. Most of the LTG procedures in our study were performed by experts in laparoscopic surgery. Conversely, improvements in the laparoscopic surgical technique may allow LTG to be performed safely regardless of the BMI of patients.

The limitation of our study is that data were collected retrospectively. Although propensity score matching was performed, selection bias, such as the above-mentioned operator bias, cannot be completely excluded. In addition, the results may differ if more patients and non-Asian patients were included. Furthermore, obesity and emaciation were simply assessed according to the BMI. The distribution of body fat tissue may potentially be different from BMI and may affect the surgical outcomes of LTG.

CONCLUSIONS

In the comparison of the low BMI group and the normal BMI group, there was no difference in the surgical outcomes of LTG. In the comparison of the normal BMI group and the high BMI group, only a difference in operative time was detected. Despite the general criteria of obesity and emaciation, our study showed that BMI has no significant effects on the surgical outcomes of LTG. LTG for GC might be performed safely regardless of BMI.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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