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Original Article

Advantages of Function-Preserving Gastrectomy for Older Patients With Upper-Third Early Gastric Cancer: Maintenance of Nutritional Status and Favorable Survival

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ABSTRACT

Purpose: The incidence of early gastric cancer is increasing in older patients alongside life expectancy. For early gastric cancer of the upper third of the stomach, laparoscopic function-preserving gastrectomy (LFPG), including laparoscopic proximal gastrectomy (LPG) and laparoscopic subtotal gastrectomy (LSTG), is expected to be an alternative to laparoscopic total gastrectomy (LTG). However, whether LFPG has advantages over LTG in older patients remains unknown.
Materials and Methods: We retrospectively analyzed data of consecutive patients aged ≥75 years who underwent LTG, LPG, or LSTG for cT1N0M0 gastric cancer between 2005 and 2019. Surgical and nutritional outcomes, including blood parameters, percentage body weight (%BW) and percentage skeletal muscle index (%SMI) were compared between LTG and LPG or LSTG. Survival outcomes were also compared between LTG and LFPG groups.
Results: A total of 111 patients who underwent LTG (n=39), LPG (n=48), and LSTG (n=24) were enrolled in this study. To match the surgical indications, LTG was further categorized into "LTG for LPG" (LTG-P) and "LTG for LSTG" (LTG-S). No significant differences were identified in the incidence of postoperative complications among the procedures. Postoperative nutritional parameters, %BW and %SMI were better after LPG and LSTG than after LTG-P and LTG-S, respectively. The survival outcomes of LFPG were better than those of LTG.
Conclusions: LFPG is safe for older patients and has advantages over LTG in terms of postoperative nutritional parameters, body weight, skeletal muscle-sparing, and survival. Therefore, LFPG for upper early gastric cancer should be considered in older patients.

Keywords: Stomach neoplasms; Laparoscopy; Aged; Nutrition assessment; Skeletal muscle

INTRODUCTION

With improvements in endoscopic diagnostic accuracy, the incidence of early gastric cancer (EGC) has increased [1,2]. Because EGC has a low incidence of lymph node metastasis, long survival time after surgery is expected, and function-preserving gastrectomy (FPG)

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has been introduced to maintain gastric function and postoperative quality of life of patients. For upper-third EGC, 2 types of FPG, including proximal gastrectomy (PG) and distal gastrectomy with a small remnant proximal stomach, subtotal gastrectomy (STG), have replaced total gastrectomy (TG). Recently, PG and STG have become more likely to be performed with a laparoscopic approach (laparoscopic proximal gastrectomy [LPG] and laparoscopic subtotal gastrectomy [LSTG]) as minimally invasive surgery.

The number of older patients with EGC has been increasing alongside life expectancy, and the feasibility of laparoscopic gastrectomy in older patients has been reported [3-5]. In this case, laparoscopic function-preserving gastrectomy (LFPG) may be beneficial in vulnerable older patients compared with laparoscopic total gastrectomy (LTG). LFPG, which reduces the extent of lymphadenectomy and gastric resection, may be less invasive than LTG. Gastric remnant preservation is reported to be much more important in terms of nutritional absorption [6].

However, many surgeons hesitate to perform LFPG in older patients for 2 reasons. First, it is unclear whether LFPG is safe in older patients. LFPG requires complicated surgical procedures and longer surgery time, which may be associated with a high incidence of postoperative complications. In LSTG, determination of the gastric transection line is technically demanding [7]. In LPG, anti-reflux devices are necessary [8,9]. Second, whether LFPG provides older patients with some advantages over LTG is unclear. Older patients have a shorter lifespan, and their gastrointestinal functions are impaired. We have no data indicating how preserved impaired stomach function influences shorter life.

This study aimed to clarify whether LFPG, LPG, and LSTG are advantageous for older patients with upper-third EGC. We evaluated the safety and nutritional and oncological outcomes of LTG and LFPG in older patients. The findings of this study will help determine whether LFPG should be performed among older patients in daily practice.

MATERIALS AND METHODS

Patients

Data of patients aged ≥75 years who underwent LTG, LPG, or LSTG for cT1N0M0 gastric cancer in the upper third of the stomach at the Cancer Institute Hospital, Tokyo, Japan between January 2005 and December 2019 were retrospectively collected from our prospectively developed database. We also included patients who underwent an additional gastrectomy after endoscopic submucosal dissection. Because the method of reconstruction after LPG may influence some surgical outcomes, patients who underwent LPG with double-flap technique reconstruction (LPG-DFT) were limited in this study. For LTG, we created subgroups, such as “LTG for LPG” (LTG-P) and “LTG for LSTG” (LTG-S), to match surgical indications between LPG or LSTG and LTG. Exclusion criteria were as follows: tumors involving the esophagus, synchronous cancer, or converted open surgery. Clinical and pathological stages were classified according to the 14th edition of the Japanese Classification of Gastric Carcinoma (3rd English edition) [10]. In pathological diagnosis, tubular and papillary adenocarcinomas were classified into differentiated and poorly differentiated types of adenocarcinomas, and signet ring cell carcinoma and mucinous adenocarcinoma were classified as undifferentiated type of adenocarcinoma.

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Surgical procedure

LTG

We performed D1 + lymphadenectomy using the usual approach according to the Gastric Cancer Treatment Guidelines [11]. Roux-en-Y reconstruction was performed via the antecolic route. An esophagojejunostomy was created using a linear or circular stapler with an anvil head of 25 mm in diameter. A jejunojejunostomy was extracorporeally created approximately 40 cm from the esophagojejunostomy in a side-to-side fashion.

Selection of LFPG

In this study, LFPG denotes the LPG-DFT and LSTG. Both procedures were performed for cT1N0M0 gastric cancer in the upper third of the stomach. LSTG was mainly applied to the upper EGC as an LFPG between 2005 and 2012. Since 2013, LPG-DFT has been applied to such diseases. Generally, LSTG is first considered for tumors, the proximal boundary of which is more than 2–3 cm distal to the esophagogastric junction [12]. If tumors were not eligible for LSTG because of their location, LPG-DFT was performed. When neither LSTG nor LPG-DFT is used, LTG is performed [13,14].

LPG

Patients whose distal remnant stomach was one-half to two-third of the original size of the stomach after gastrectomy underwent LPG. After D1 + lymphadenectomy, the stomach was transected with a linear stapler according to the marking clips. During DFT, esophagogastrostomy was performed according to Kamikawa's open surgical methods [15].

LSTG

In the LSTG, D1 + lymphadenectomy was performed in the usual manner. The stomach was transected using a linear stapler according to the marking clips under intraoperative endoscopy guidance. As previously reported, intraoperative gastroscopy was useful for confirming an adequate surgical margin [16,17]. Marking clips were placed preoperatively on the pathologically intact mucosa proximal to the tumor boundary. Roux-en-Y reconstruction was performed via the antecolic route. Intracorporeal gastrojejunostomy was performed using a linear or circular stapler. A side-to-side jejunojejunostomy was extracorporeally created, approximately 40 cm from the gastrojejunostomy site.

Evaluation of outcomes

In this study, we performed 3 comparisons to identify the advantages of LPG or LSTG over LTG in older patients. First, surgical data and postoperative outcomes were compared between LTG-P and LPG or LTG-S and LSTG groups. Postoperative morbidities were evaluated according to the Clavien–Dindo classification, and patients with grade II or higher within 30 days after surgery were recorded. Endoscopic findings were evaluated one year after surgery. Esophagitis reflux severity was classified according to the Los Angeles classification. Second, nutritional parameters, such as trends in the levels of total protein, albumin, and hemoglobin at 6, 12, and 24 months after surgery were retrospectively evaluated. The percentage body weight (percentage postoperative bodyweight/preoperative body weight [%BW]) and percentage skeletal muscle index (percentage postoperative skeletal muscle index/preoperative skeletal muscle index [%SMI]), which represents the skeletal muscle mass, were also compared between the LTG-P and LPG or LTG-S and LSTG groups. The SMI was evaluated, including the psoas, paraspinal, and abdominal wall muscles measured at the level of the third lumbar vertebra using a SYNAPSE VINCENT Volume Analyzer (Fujifilm Medical Co., Tokyo, Japan). The tissue Hounsfield unit (HU) was −29 to 150 HU for the

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skeletal muscle. The SMI was calculated as follows [18]: SMI = Cross-sectional Area of the Skeletal Muscle (cm^2)/Height (m^2). Third, overall survival (OS) between the LTG (LTG-P + LTG-S) and LFPG (LPG + LSTG) groups were compared. The LPG and LSTG patients were grouped together because our previous study showed that oncological outcomes were comparable between the 2 groups [14].

Statistical analysis

Categorical variables were analyzed using the Fisher's exact test, and continuous variables were analyzed using the Mann–Whitney U test. Changes in nutritional indices, BW, and SMI were compared between the LTG-P and LPG groups or LTG-S and LSTG groups using the Student's t-test. The OS was estimated using the Kaplan–Meier method and compared using the log-rank test in both groups. Statistical significance was defined as $P<0.05$. All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (R Foundation for Statistical Computing, Vienna, Austria).

Ethics statements

The protocol for this study was approved by a suitably constituted ethics committee (committee of the Institutional Review Board of the Cancer Institute Hospital, approval No. 2021-GB-023), and it conforms to the provisions of the Declaration of Helsinki. Informed consent was obtained from all the participants.

RESULTS

Patient characteristics

A total of 140 patients were included in this study. After exclusion, LTG was performed in 39 patients, LPG in 48, and LSTG in 24. Regarding LTG, in comparison to LPG, 9 patients were further excluded because their tumors extended distally to the lower body of the stomach and could not be resected with LPG. Similarly, in comparison to LSTG, 7 patients were further excluded because their tumors were located within 2 cm of the esophagogastric junction and could not be resected with LSTG (**Fig. 1**). Clinicopathological features of the patients according to the procedure are shown in **Table 1**. No significant differences were identified in the comparison of the procedures.

Surgical outcomes

Table 2 presents surgical outcomes between the LTG-P and LPG or LTG-S and LSTG groups. Surgery time was significantly longer in the LPG group than in the LTG-P group (P=0.003). Intraoperative blood loss in the LSTG group was significantly lower than that in the LTG-S group (P=0.009). Overall incidence of postoperative complications did not differ between the LTG-P and LPG or the LTG-S and LSTG groups.

Postoperative nutritional outcomes

Nutritional parameters

Fig. 2 shows the postoperative trends in nutritional parameters. Three parameters were significantly higher after the LPG than after the LTG-P at 6, 12, and 24 months. In comparison with LSTG, total protein levels at 24 months and serum albumin and hemoglobin levels at 6 months were significantly higher than those in the LTG-S group, although after the LSTG, the 3 parameters were consistently higher than those after the LTG-S.

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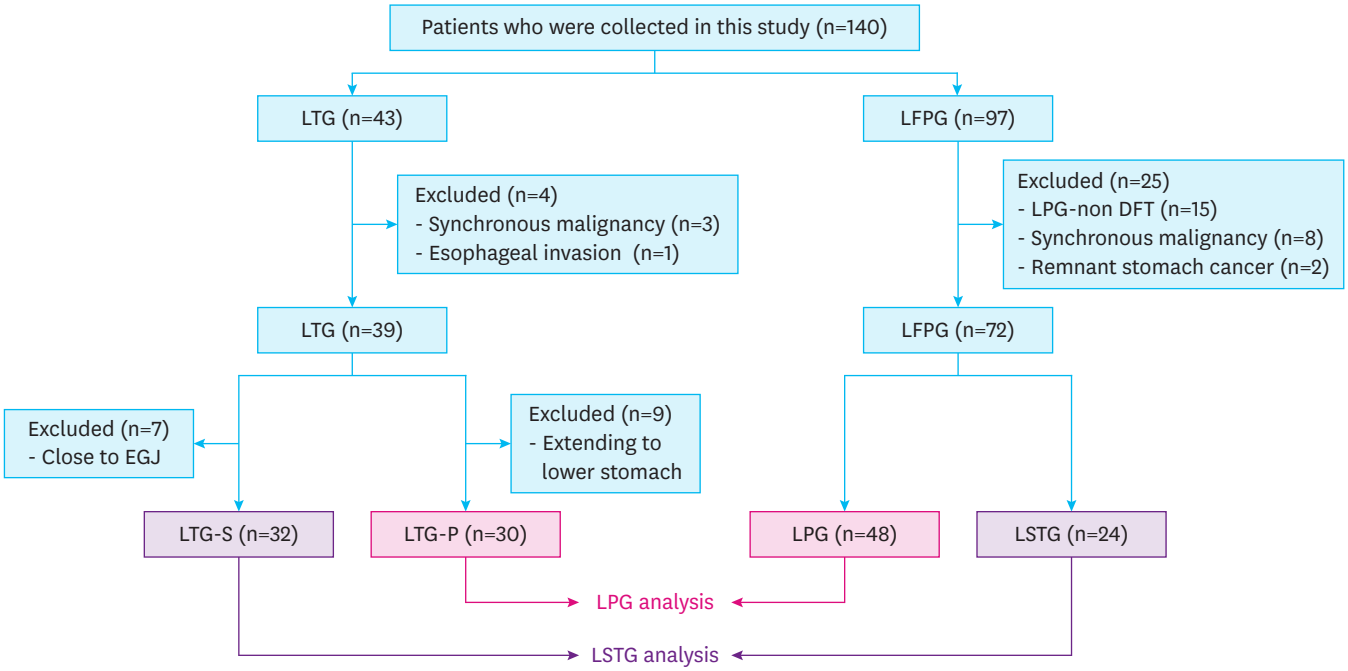

Fig. 1. Flowchart of patient selection in this study.
LTG = laparoscopic total gastrectomy; LFPG = laparoscopic function-preserving gastrectomy; LPG = laparoscopic proximal gastrectomy; LSTG = laparoscopic subtotal gastrectomy; EGJ = esophagogastric junction; LTG-P = LTG for LPG; LTG-S = LTG for LSTG.

Trends of %BW and %SMI

Fig. 3 shows the postoperative %BW and %SMI over 2 years. In the first 6 months, the %BW after LPG was significantly higher than that after LTG-P. Similarly, the %BW after LSTG was significantly larger than that after LTG-S in the first 6 months. For the subsequent 2 years, the %BW after LPG was also significantly larger than that after LTG-P.

The %SMI after LPG and LSTG was significantly larger than that after LTG-P and LTG-S in the first year. The %SMI after LPG and LSTG remained unchanged for subsequent years. Similarly, the %SMI after LTG-P and LTG-S remained flat and was consequently smaller than that after LPG and LSTG for 2 postoperative years.

Oncological outcomes

Overall survival curves stratified according to the procedures are shown in **Fig. 4**. The 5-year OS rate of the LFPG group was significantly higher than that of the LTG group. Among the 7 patients who underwent LTG, 1 died of postoperative pancreatic fistula, 1 died of cancer relapse, and the remaining 5 died of other diseases. Among 3 patients who underwent LFPG, 1 died of cancer relapse and 2 died of other diseases.

DISCUSSION

In this retrospective study, we assessed the advantages of LFPG, including LPG and LSTG, over LTG in older patients with cT1N0M0 gastric cancer of the upper third of the stomach. Three critical findings were obtained in this study. First, the incidence of postoperative complications in the LFPG was comparable to that in the LTG. Second, the LFPG had greater advantages than the LTG in terms of postoperative nutritional parameters. Additionally,

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Table 1. Patients' characteristics

Variables	LTG-P (n=30)	LPG (n=48)	P-value (LTG-P vs. LPG)	LTG-S (n=32)	LSTG (n=24)	P-value (LTG-S vs. LSTG)
Age (yr)	77 (76–80)	79 (76–81)	0.508	77 (76–79)	78 (76–81)	0.366
Sex			0.772			0.146
Male	25 (83.3)	38 (79.2)		25 (78.1)	14 (58.3)	
Female	5 (16.7)	10 (20.8)		7 (21.9)	10 (41.7)	
BMI (kg/m^2)	23.8 (21.7–25.7)	22.2 (20.5–24.6)	0.079	22.9 (21.1–25.8)	22.4 (20.9–23.5)	0.513
ASA-PS			0.353			0.421
1	17 (56.7)	21 (43.8)		16 (50.0)	15 (62.5)	
2	13 (43.3)	27 (56.3)		16 (50.0)	9 (37.5)	
PS	23/7	35/13	0.794	22/10	11/13	0.207
0	23 (76.7)	35 (72.9)		22 (68.8)	11 (45.8)	
1	7 (23.3)	13 (27.1)		10 (31.3)	13 (54.2)	
Tumor size (mm)	32.0 (18–40)	25 (18–35)	0.216	40 (22–50)	25 (20–34)	0.054
Comorbidity	17 (56.6)	26 (54.1)	1.000	15 (46.9)	11 (45.8)	1.000
Hypertension	12 (40.0)	14 (29.2)	0.337	10 (31.3)	6 (25.0)	0.767
Cardiovascular	2 (6.6)	4 (8.3)	1.000	2 (6.3)	1 (4.2)	1.000
Respiratory	3 (9.9)	3 (6.3)	0.670	4 (12.6)	0 (0)	0.127
Cerebrovascular	1 (3.3)	1 (2.1)	1.000	1 (3.2)	2 (8.3)	0.571
Diabetes mellitus	0 (0)	3 (6.3)	0.281	0 (0)	2 (8.3)	0.179
Liver disease	0 (0)	1 (2.1)	1.000	0 (0)	0 (0)	1.000
Histological type			0.110			0.171
Differentiated	19 (63.3)	39 (81.3)		18 (56.2)	18 (75.0)	
Undifferentiated	11 (36.7)	9 (18.7)		14 (43.7)	6 (25.0)	
pT			0.322			0.743
1	24 (80.0)	44 (91.7)		25 (78.1)	21 (87.5)	
2	3 (10.0)	3 (6.3)		4 (12.5)	2 (8.3)	
3	2 (6.7)	1 (2.1)		2 (6.3)	0 (0.0)	
4	1 (3.3)	0 (0.0)		1 (3.1)	1 (4.2)	
pN			0.157			1.000
0	28 (93.3)	42 (87.5)		30 (93.8)	23 (95.8)	
1	1 (3.3)	6 (12.5)		1 (3.1)	1 (4.2)	
2	1 (3.3)	0 (0.0)		1 (3.1)	0 (0.0)	
pStage			0.574			1.000
IA	22 (73.3)	40 (83.3)		23 (71.9)	20 (83.3)	
IB	5 (16.7)	5 (10.4)		6 (18.8)	3 (12.5)	
IIA	3 (10.0)	3 (6.3)		2 (6.3)	0 (0.0)	
IIB	0 (0.0)	0 (0.0)		1 (3.1)	1 (4.2)	

Values are presented as number or median (interquartile range).
LTG = laparoscopic total gastrectomy; LPG = laparoscopic proximal gastrectomy; LSTG = laparoscopic subtotal gastrectomy; BMI = body mass index; ASA-PS = American Society of Anesthesiologist Physical Status; PS = performance status; IQR = interquartile range; LTG-P = LTG for LPG; LTG-S = LTG for LSTG.

Table 2. Surgical outcomes of the procedures

Variables	LTG-P (n=30)	LPG (n=48)	P-value (LTG-P vs. LPG)	LTG-S (n=32)	LSTG (n=24)	P-value (LTG-S vs. LSTG)
Surgery time (min)	316 (222–536)	367 (265–639)	0.003	326 (222–549)	296 (175–451)	0.053
Blood loss (mL)	67.5 (10–680)	57.5 (20–280)	0.183	95 (10–700)	35 (20–300)	0.009
Postoperative morbidity	9 (30.0)	12 (25.0)	0.794	8 (25.0)	4 (16.7)	0.525
Anastomotic leakage	5 (16.7)	3 (6.3)	0.248	6 (18.7)	0 (0)	0.031
Anastomotic structure	0 (0)	0 (0)	1.000	0 (0)	0 (0)	1.000
Anastomotic hemorrhage	0 (0)	0 (0)	1.000	0 (0)	1 (4.1)	0.429
Delayed gastric emptying	0 (0)	4 (8.3)	0.156	0 (0)	1 (4.1)	0.429
Bowel obstruction	1 (3.3)	1 (2.1)	1.000	0 (0)	0 (0)	1.000
Pneumoniae	1 (3.3)	1 (2.1)	1.000	1 (3.1)	0 (0)	1.000
Pancreatic fistula	1 (3.3)	2 (4.2)	1.000	1 (3.1)	1 (4.1)	1.000
Intraabdominal abscess	1 (3.3)	1 (2.1)	1.000	0 (0)	0 (0)	1.000
Surgical site infection	0 (0)	0 (0)	1.000	0 (0)	1 (4.1)	0.429
Endoscopic findings						
Reflux esophagitis	2 (6.6)	3 (6.2)	1.000	2 (6.2)	0 (0)	0.501
Mortality	1 (3.3)	0 (0)	0.385	1 (3.1)	0 (0)	1.000

Values are presented as number or median (range).
LTG = laparoscopic total gastrectomy; LPG = laparoscopic proximal gastrectomy; LSTG = laparoscopic subtotal gastrectomy; LTG-P = LTG for LPG; LTG-S = LTG for LSTG.

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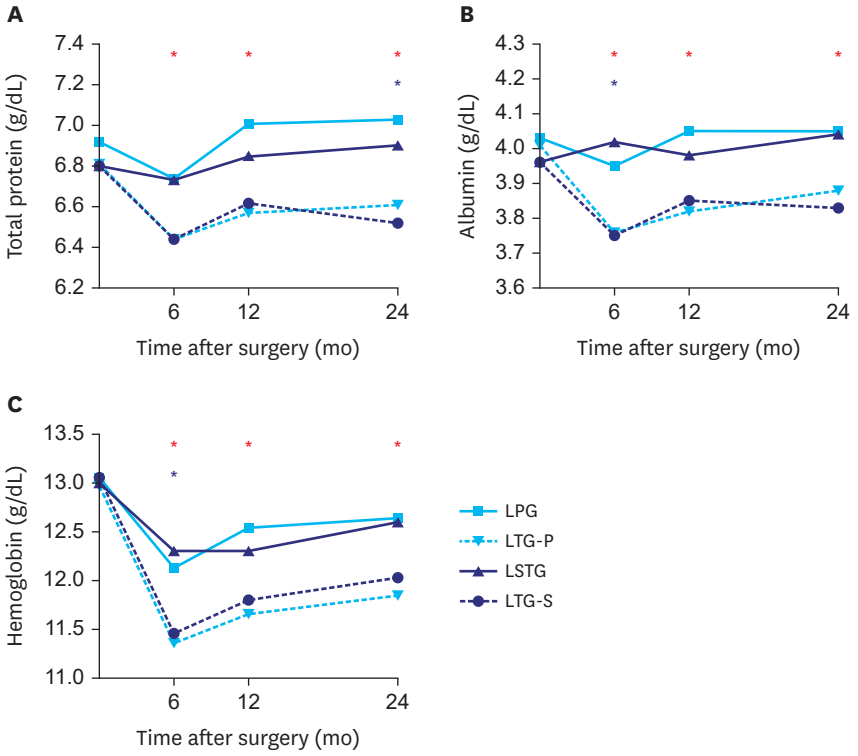

Fig. 2. Postoperative trends of (A) total protein, (B) albumin, and (C) hemoglobin levels in LTG-P, LTG-S, LPG, and LSTG.
These 3 parameters were significantly higher after LPG than after LTG-P at 6, 12, and 24 months. Statistical significance was observed at 6 (P=0.02), 12 (P<0.001), and 24 (P<0.001) postoperative months for total protein levels; at 6 (P=0.03), 12 (P=0.005), and 24 (P=0.04) postoperative months for serum albumin levels; and at 6 (P=0.005), 12 (P=0.002), and 24 (P=0.007) postoperative months for hemoglobin levels. In comparison to LSTG, total protein (P=0.04) levels at 24 months and serum albumin (P=0.01) and hemoglobin (P=0.02) levels at 6 months were significantly higher than those after LTG-S, although the 3 parameters after LSTG were consistently higher than those after LTG-S. Statistical significance is represented by the red asterisks between LTG-P and LPG, and by the blue asterisks between LTG-S and LSTG.
LTG = laparoscopic total gastrectomy; LPG = laparoscopic proximal gastrectomy; LSTG = laparoscopic subtotal gastrectomy; LTG-P = LTG for LPG; LTG-S = LTG for LSTG.

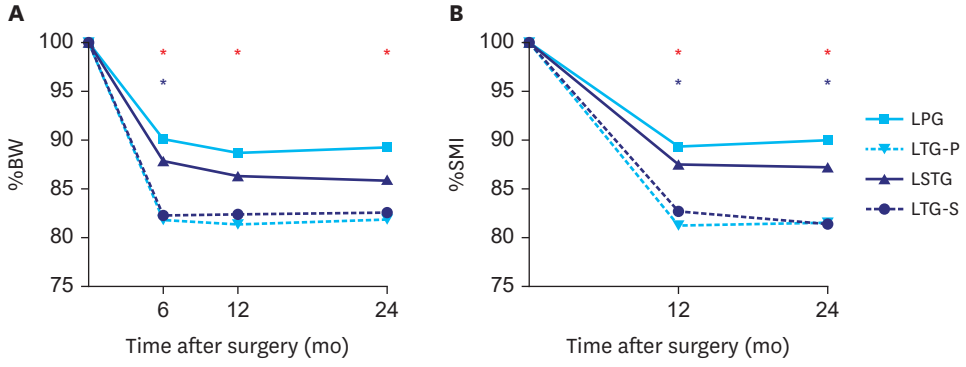

Fig. 3. Comparison for trends of (A) %BW and (B) %SMI in LTG-P, LTG-S, LPG, and LSTG.
(A) During the first 6 months, the %BW after LPG and LSTG was significantly larger than that after LTG (LTG-P vs. LPG: 81.8% vs. 90.2%, P<0.001; LTG-S vs. LSTG: 82.3% vs 87.8%, P=0.03). For the subsequent 2 years, the %BW after LPG were also significantly larger than that after LTG (LTG-P vs. LPG at 12 months; 81.4% vs. 88.7%, P=0.002, at 24 months; 81.9% vs. 89.2%, P<0.001). (B) The %SMI after LPG and LSTG was significantly larger than that after LTG during the first year (LTG-P vs. LPG; 81.2% vs 89.3%, P<0.001; LTG-S vs. LSTG; 82.9% vs 87.4%, P=0.04). The %SMI after LPG and LSTG remained unchanged for one subsequent year. Similarly, the %SMI after LTG-P and LTG-S remained flat and was consequently smaller than that after LPG and LSTG, respectively, for 2 postoperative years (LTG-P vs. LPG: 81.5% vs. 89.9%, P<0.0001; LTG-S vs. LSTG; 81.3% vs. 87.2%, P=0.03). Statistical significances are represented by the red asterisks between LTG-P and LPG, and by the blue asterisks between LTG-S and LSTG.
%BW = percentage bodyweight; %SMI = percentage skeletal muscle index; LTG = laparoscopic total gastrectomy; LPG = laparoscopic proximal gastrectomy; LSTG = laparoscopic subtotal gastrectomy; LTG-P = LTG for LPG; LTG-S = LTG for LSTG.

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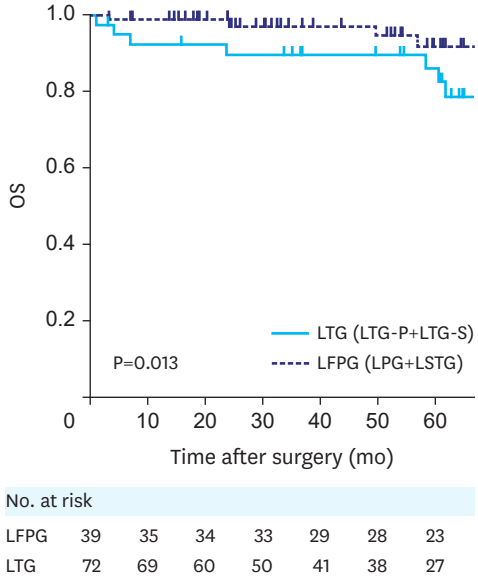

Fig. 4. Comparison of OS between LTG and LFPG.
The 5-year OS rate of patients undergoing LFPG (91.7%) was significantly better than that of those undergoing LTG (82.6%) (P=0.013). Seven patients who underwent LTG and 3 who underwent LFPG died within 5 years after gastrectomy.
OS = overall survival; LTG = laparoscopic total gastrectomy; LFPG = laparoscopic function-preserving gastrectomy.

%BW and %SMI were larger in the LFPG group than in the LTG group. Finally, the survival outcomes of the LFPG group were better than those of the LTG group. These findings suggest that in older patients, LFPG is a feasible and advantageous procedure compared with LTG in terms of postoperative nutritional parameters, %BW and %SMI, and survival.

Therefore, the safety of LFPG in older patients is a major concern. These patients are often not only malnourished but also functionally compromised, which makes them difficult to tolerate surgical invasiveness [19,20]. The surgical techniques of LPG are more complicated than those of LTG, especially regarding reconstruction, which requires more surgical skills and longer surgery time. Although recent advances in surgical techniques regarding reconstruction following LPG have exhibited better perioperative outcomes than LTG [21], considering that older patients have a lower capacity to recover from postoperative complications, these technical procedures may not be suitable for older patients. However, we revealed that LFPG could be safely performed compared to LTG with minimal surgical invasiveness in older patients. Thus, in patients for whom LFPG and LTG can be selected according to tumor size and location, our data may be sufficient to convince us to recommend LFPG for older patients.

In the older patients, LFPG maintained nutritional parameters, such as total protein, albumin, and hemoglobin better than the LTG. Post-total gastrectomy is known to be a risk factor for postoperative malnutrition [22]. Although several studies have discussed the significance of preserving the stomach and nutritional advantages of LFPG over LTG [23-26], a detailed evaluation stratified by age is needed in this aging era. From this point of view, what is important in our study is the nutritional advantages of LFPG over LTG, even though the objective of this study was limited to older patients. This information clearly confirmed that LFPG should be considered in older patients, despite their population having insufficient gastrointestinal function and being prone to malnutrition after surgery.

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Maintenance of %BW is another preferred benefit of LFPG because %BW is a prevalent problem after gastrectomy [27]. All 3 procedures showed a similar pattern of %BW, predominantly in the first 6 months during the 2 postoperative years, but %BW at 6 months after gastrectomy was smaller in the LTG group than in the LFPG group. These findings are consistent with previous studies [28,29]. Davis et al. [30] attributed this to the fact that %BW depends on the extent of gastric resection. Park et al. [31] focused on postoperative changes in body composition after gastrectomy; they implied that loss of skeletal muscle mass was associated with %BW. From this point of view, we also showed the advantages of LFPG over LTG in preventing severe loss of skeletal muscle mass. The discrepancies between these procedures may be attributed to the severity of post-gastrectomy syndrome (PGS), such as body weight loss, diarrhea, dumping, and the necessity for additional meals. The frequency of PGS was significantly lower after LFPG than after LTG [32,33]. Patients who undergo TG often suffer from PGS and experience decreased food intake and malabsorption, which subsequently results in loss of skeletal muscle mass [34]. Although reflux esophagitis is also a problem after LPG, our results showed no significant differences between LPG and LTG-P, probably because of DFT in reconstruction [35]. The findings of skeletal muscle mass maintenance after LFPG are valuable because the recovery of skeletal muscle mass is difficult, especially for older patients. This is because oral nutritional supplements after TG cannot offset the loss of skeletal muscle mass, and interventions, such as progressive exercise cannot be expected in older patients [36]. Based on these considerations, sparing of body weight and skeletal muscle mass after gastrectomy might be sufficient for surgeons to select LFPG over LTG in older patients.

Generally, the worse survival outcome of patients who underwent LFPG is concerning because lymph node dissection and extension of the resected stomach are reduced in LFPG. However, our survival analyses of older patients showed better survival outcomes with LFPG than with LTG. We suggest that one of the reasons for this is the better nutritional status and maintenance of body weight and skeletal muscle mass after LFPG. Previous reports have indicated that the maintenance of nutritional parameters and body weight after gastrectomy significantly influences long-term outcomes [37,38]. Therefore, >70% of the deaths in the LTG group were associated with other diseases, which might have been caused by postoperative malnutrition. Because improvements in long-term outcomes are as important in older patients as they are in younger patients in the aging population, we suggest that LFPG is more beneficial for older patients with respect to not only better nutritional outcomes but also better survival outcomes.

This study has several limitations. First, this was a single-institutional, retrospective study. Each group became smaller after grouping. Second, symptoms or a validated questionnaire was not assessed in this study, which may have introduced underestimation. Third, in this study, LTG, LPG, and LSTG had different indications, although we matched the indications as much as possible. The findings of this study cannot be extrapolated to all older patients with upper-third EGC. Fourth, differences in surgical skills among surgeons might be associated with the outcomes. However, all the operations were performed by surgeons who were technically certified or equivalent to operators or instructive assistants. No differentiation was made in the selection of surgeons among the procedures (LPG, LSTG, and LTG); therefore, we considered that there might be less possibility of differences in surgical skills among surgeons affecting the results. Although this study had inevitable limitations, these results may be useful because there is little evidence regarding LFPG in older patients.

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In conclusion, LFPG may be advantageous in older patients with upper-third EGC. LFPG is safe and maintains not only nutritional status but also shows favorable survival in older patients. Therefore, surgeons should not hesitate to perform LFPG, even if it is technically complicated.

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