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Short-term outcomes and prognosis of laparoscopy-assisted total gastrectomy in elderly patients with stomach cancer

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Abstract

Background The aim of this study was to evaluate the short-term outcomes and prognosis of laparoscopy-assisted total gastrectomy (LTG) in elderly patients with gastric cancer.

Methods The clinical data of 275 patients aged over 65 years undergoing open total gastrectomy (OTG, $n=184$) or laparoscopy-assisted total gastrectomy (LTG, $n=91$) were reviewed from January 2015 to August 2017 at the First Affiliated Hospital of the University of Science and Technology of China. Short-term outcomes were compared between the two groups, and risk factors for postoperative complications were explored. In addition, the 2-year overall survival (OS) and disease-free survival (DFS) were investigated for both groups.

Results Except for the ASA score ($P=0.01$), there was no significant difference regarding patient baselines between the two groups. Patients in the LTG group had a longer operative time ($P<0.001$), less intraoperative blood loss ($P=0.004$), a shorter time of resumption to a semi-liquid diet ($P<0.001$) and a shorter postoperative hospital stay ($P=0.001$). The incidence of pulmonary complications was significantly lower in the LTG group than in the OTG group (4.4% vs. 13%, $P=0.026$). The number of lymph nodes harvested in the LTG group was higher than that in the OTG group (20.7 ± 7.4 vs. 17.5 ± 6.9, $P=0.001$), and the proportion of patients with TNM stage III gastric cancer was higher in the LTG group than in the OTG group ($P=0.035$). There was no significant difference in the 2-year OS rate or 2-year DFS rate between the two groups ($P=0.057$ and $P=0.344$). Sex, age, preoperative comorbidity, intraoperative blood loss, and TNM stage were identified as independent prognostic factors for postoperative survival.

Conclusion Comparing with OTG, LTG is feasible and contributes to less surgical trauma and a faster recovery after total gastrectomy. In addition, LTG contributes to a lower risk of postoperative pulmonary complications. Regarding oncological results, LTG is more effective for lymph node dissection and has a comparable long-term prognosis as OTG.

Keywords Elderly patients · Laparoscopy-assisted surgery · Open surgery · Total gastrectomy · Gastric cancer

Gastric cancer is one of the most common malignant tumors in the world [1–3]. An epidemiological study showed that gastric cancer is the third most common malignancy in the Chinese population [4]. The prevalence of gastric cancer is significantly increasing for elderly individuals, and the risk of gastric cancer occurrence remains higher for elderly populations than for young people [5].

Surgery is a curative approach for the treatment of gastric cancer. In 1994, Kitano and Iso reported the first case of laparoscopy-assisted gastrectomy for the treatment of gastric cancer [6]. With the rapid development of laparoscopic instruments and techniques in the past decade, laparoscopic surgery has been widely used for the treatment of early and advanced gastric cancer [7]. The advantages of laparoscopic surgery, such as less surgical trauma, faster postoperative recovery, and less stress response to surgery, have been acknowledged in many published studies [8–10]. Elderly

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patients are a special group with decreased organ function and reduced surgical tolerance, and whether laparoscopic surgery is safe and provides enough benefits to elderly patients remains uncertain [11, 12]. Some studies reported that laparoscopy-assisted distal gastrectomy was safe and advantageous in elderly patients when compared to open distal gastrectomy [10, 13–15]. In contrast, total gastrectomy leads to more surgical trauma than distal gastrectomy in elderly patients, and whether laparoscopy-assisted total gastrectomy (LTG) remains beneficial to elderly patients remains unclear and needs more clinical evidence because few studies are currently available [16–18]. The study by Jung et al. [16] compared the clinical outcomes of LTG in elderly patients and nonelderly patients, and the results suggested that elderly patients encountered a higher risk of anastomosis leakage than nonelderly patients. Another study by Sheng et al. [18] suggested that elderly patients with LTG had a higher risk of pulmonary infection and a comparable risk of surgical complications with nonelderly patients. Lu et al. compared LTG with open total gastrectomy (OTG) for elderly patients older than 65 years and reported that elderly patients undergoing LTG had a comparable risk of postoperative complications and similar 3-year overall survival.

The aim of this study was to evaluate the short-term outcomes and prognosis of LTG for the treatment of gastric cancer in patients over 65 years in comparison to OTG, to explore risk factors for postoperative complications and to investigate predictors for postoperative survival.

Materials and methods

Patient selection

The inclusion criteria for patients were as follows. (1) Patients were over 65 years old and newly diagnosed with gastric cancer at the Department of General Surgery, The First Affiliated Hospital of the University of Science and Technology of China from January 2015 to August 2017; all patients were preoperatively diagnosed with gastric cancer by gastroscopy and biopsy. (2) Patients received curative LTG or OTG. (3) Patients did not have malignant tumors previously. (4) Medical records and follow-up information were complete and available. The exclusion criteria included emergency surgery due to massive bleeding and gastric perforation. In addition, patients with combined organ resection or who received preoperative chemoradiotherapy were also excluded. Finally, a total of 275 elderly patients were included (LTG, $n=91$; OTG, $n=184$). The study was conducted in compliance with the Helsinki Declaration and was approved by our Ethics Committee. All patients in this study provided informed consent.

Perioperative management

Abdominal CT scans were routinely conducted to assess the gastric cancer lesions; a chest X-ray or CT scan was used to assess whether there was distant metastasis. Cardiac and pulmonary functions were evaluated before surgery. A PET–CT scan was conducted if necessary. After all examinations were completed, patients were assessed to determine whether they could undergo total gastrectomy. The surgeon would have a discussion with the patients or their relatives to determine the final surgical approaches, LTG or OTG.

Solid food and liquid diet were prohibited 6 h and 4 h before surgery, respectively. After the success of general anesthesia, a gastric tube and urinary catheter were inserted and removed within 48 h after surgery. Prophylactic antibiotics were administered within 30 min before surgery and stopped within 48 h after surgery. A liquid diet was initiated 2–3 days postoperatively when patients did not have abdominal distention, and a semi-liquid diet was given dependent on the patient's recovery. Total gastrectomy with D2 lymph node dissection was conducted for all patients. Roux-en-Y reconstruction was used after total gastrectomy. In addition, esophagojejunostomy was performed using a stapler, and subsequently, anastomosis was reinforced with suturing.

Data collection

The data collected in this study included the following: (1) patient characteristics (age, sex, body mass index (BMI), preoperative comorbidity, etc.); (2) short-term outcomes within 30 days after surgery, including postoperative complications and recovery; (3) pathological results; and (4) long-term outcomes, including 2-year disease-free survival (DFS) and 2-year overall survival (OS). Postoperative complications were classified according to the Clavien–Dindo scoring system [19], by which the severity of postoperative complications was ranked into five grades. Pathological results included tumor diameter, TNM stage (according to the 8th edition of the AJCC cancer staging system) and lymph node harvested.

Follow-up

Follow-up was conducted via outpatient visits or telephone interviews with patients or their family members. Patients were followed up every 3 months for the first two years after surgery and every 6 months thereafter. Physical examination, laboratory tests, and CT or MRI were

conducted. Gastroscopy was performed annually. The last follow-up was November 30, 2018. OS was defined as the period from the date of surgery to the last follow-up or death due to any cause, and DFS was the period from the date of surgery to cancer recurrence or death due to any cause.

Statistics

Continuous variables are presented as the mean with standard deviation (mean ± SD); categorical variables are presented as counts and percentages. Student's *t* test was used to compare differences in continuous variables between groups if the variables followed a normal distribution; otherwise, the Mann–Whitney *U* test was used. The Chi-square test or Fisher's exact test was used for categorical variables. Univariate analysis was conducted to explore potential risk factors for postoperative complications, and the variables with a P value < 0.10 were included in multivariate logistic regression analysis; $P < 0.05$ indicated statistical significance. The Kaplan–Meier method with the log-rank test was used to analyze the survival rate between the two groups. A multivariate Cox proportional hazards regression model, including sex (male vs. female), BMI, preoperative comorbidities (yes vs. no), previous abdominal surgery (yes vs. no), ASA score (III vs. I/II), surgical approach (LTG or OTG), operative time, intraoperative blood loss, postoperative complications (yes vs. no), tumor diameter, tumor differentiation (well vs. moderate and poor) and TNM stage (III vs. I and II), was used to explore prognostic factors for 2-year OS and 2-year DFS, and adjusted hazard ratios (HRs) along with the corresponding 95% confidence intervals (CIs) were calculated. All data were statistically analyzed using SPSS 20.0 software, and a P value < 0.05 indicated statistical significance.

Results

Patient characteristics

A total of 275 patients were included. The detailed information of these patients is shown in Table 1. Among these elderly patients, the proportions of males were 80.4% and 80.2% for the OTG and LTG groups, respectively. Seventy-one patients (38.6%) in the OTG group and thirty-four patients (37.4%) in the LTG group had comorbidities, including hypertension, diabetes, etc. The proportions of patients with ASA III were 31% in the OTG group and 49.5% in the LTG group, and the difference between the two groups was statistically significant ($P = 0.01$).

Table 1 Characteristics of two groups

	OTG group ($n = 184$)	LTG group ($n = 91$)	P value
Gender (n, %)			0.966
Male	148 (80.4)	73 (80.2)	
Female	36 (19.6)	18 (19.8)	
Age (years, n, %)			0.110
65–75	149 (81.0)	66 (72.5)	
≥ 75	35 (19.0)	25 (27.5)	
BMI(kg/m^2)	22.19 ± 3.06	21.99 ± 3.08	0.620
Preoperative comorbidity (n, %)	71 (38.6)	34 (37.4)	0.844
Hypertension	53 (28.8)	31 (34.1)	0.373
Diabetes	10 (5.4)	5 (5.5)	0.984
Pulmonary dysfunctions	5 (2.7)	2 (2.2)	0.797
Cardiology diseases	22 (12.0)	4 (4.4)	0.196
Neurological dysfunctions	10 (5.4)	4 (4.4)	0.712
Other comorbidities	3 (1.6)	0 (0)	0.221
Preoperative blood transfusion (n, %)	16 (8.7)	6 (6.6)	0.545
Previous abdominal surgery (n, %)	31 (16.8)	14 (15.4)	0.758
ASA score (n,%)			0.010
I	1 (0.5)	0 (0)	
II	126 (68.5)	46 (50.5)	
III	57 (31.0)	45 (49.5)	
IV	0 (0)	0 (0)	

OTG open total gastrectomy, *LTG* laparoscopy-assisted total gastrectomy

Table 2 Short-term outcomes of two groups

	OTG group ($n=184$)	LTG group ($n=91$)	P value
Operation time (min)	200.4 ± 46.0	242.2 ± 55.2	0.000
Intraoperative blood loss (ml)	163.2 ± 158.2	124.5 ± 58.5	0.004
Postoperative semi-liquid diet (d)	8.0 ± 2.6	6.5 ± 1.7	0.000
Hospital stay after surgery (d)	11.2 ± 4.3	9.7 ± 2.6	0.001

OTG open total gastrectomy, *LTG* laparoscopy-assisted total gastrectomy

Table 3 Postoperative complications of two groups

	Total ($n=275$)	OTG ($n=184$)	LTG ($n=91$)	P value
Incision complication	4 (1.5)	3 (1.6)	1 (1.1)	0.729
Abdominal infection	5 (1.8)	4 (2.2)	1 (1.1)	0.530
Postoperative bleeding	2 (0.7)	2 (1.1)	0 (0)	0.318
Anastomotic leak	8 (2.9)	5 (2.7)	3 (3.3)	0.788
Intestinal obstruction	5 (1.8)	3 (1.6)	2 (2.2)	0.740
Cardiologic complication	2 (0.7)	2 (1.1)	0 (0)	0.318
Pulmonary complication[a]	28 (10.2)	24 (13.0)	4 (4.4)	0.026
Clavien–Dindo II	45 (16.4)	35 (19.0)	10 (11.0)	0.090
Clavien–Dindo III/IV	4 (1.5)	3 (1.6)	1 (1.1)	0.729
Overall postoperative complications	49 (17.8)	38 (20.7)	11 (12.1)	0.081
Reoperation	3 (1.1)	2 (1.1)	1 (1.1)	0.993

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[a]Pulmonary complication included infection, pleural effusion, pulmonary edema and atelectasis

Short-term outcomes

Table 2 shows the short-term outcomes of both groups. The operative time was significantly longer for the LTG group than for the OTG group ($P<0.01$). In contrast, intraoperative blood loss was significantly less in the LTG group than in the OTG group ($P=0.004$). The time of resumption to a semi-liquid diet after surgery was 8 days for the OTG group and 6.5 days for the LTG group ($P<0.01$). Moreover, the postoperative hospital stay was significantly shorter for patients in the LTG group than for those in the OTG group (9.7 vs. 11.2 days, $P=0.001$).

Table 3 shows detailed information on the postoperative complications occurring within 30 days after surgery in both groups. There were no significant differences in surgery-related complications, such as incisional and abdominal infection, postoperative bleeding, anastomotic leak and intestinal obstruction. Similarly, the risks of cardiologic dysfunction and overall postoperative complications were also not statistically significant in either group. However, the risk of pulmonary complications was significantly lower in the LTG group than in the OTG group ($P=0.026$). Serious complications (Clavien–Dindo III & IV) occurred in 4 patients (3 patients in the OTG group and 1 patient in the LTG group), three of which were admitted to the ICU for treatment. Three patients (2 patients in the OTG group and 1 patient in the LTG group) underwent reoperation due to postoperative bleeding and intestinal obstruction. No deaths occurred in either group.

Table 4 Multivariable logistic regression analysis for risk factors associated with postoperative complications

	OR	95% CI	P value
Serum albumin(g/L)	0.909	0.833–0.992	0.032
Intraoperative blood loss (ml)	1.002	1.000–1.003	0.027
Surgical approach (LTG vs. OTG)	0.511	0.243–1.077	0.077

OTG open total gastrectomy, *LTG* laparoscopy-assisted total gastrectomy

By univariable analysis, preoperative serum albumin, type of surgery (OTG or LTG) and intraoperative blood loss were identified as potential risk factors for postoperative complications with $P<0.10$ (Supplementary Table 1). Multivariable analysis based on these factors showed that low serum albumin and massive intraoperative blood loss, rather than types of surgery, were independent risk factors for postoperative complications (Table 4).

Pathological results

Table 5, 6 and 7 shows the pathological outcomes of both groups. The mean number of lymph nodes harvested was significantly higher in the LTG group than in the OG group

Table 5 Pathological results of two groups

	OTG group ($n=184$)	LTG group ($n=91$)	P value
T stage			0.155
T1	24 (13.0)	11 (12.1)	
T2	28 (15.2)	11 (12.1)	
T3	14 (7.6)	15 (16.5)	
T4	118 (64.1)	54 (59.3)	
N stage			0.020
N0	92 (50.0)	28 (30.8)	
N1	29 (14.9)	23 (25.3)	
N2	33 (17.9)	19 (20.9)	
N3	30 (16.3)	21 (23.1)	
TNM stage			0.035
IA	23 (12.5)	10 (11.0)	
IB	23 (12.5)	5 (5.5)	
IIA	6 (3.3)	10 (11.0)	
IIB	45 (24.5)	13 (14.3)	
IIIA	30 (16.3)	17 (18.7)	
IIIB	34 (18.5)	21 (23.1)	
IIIC	25 (13.6)	15 (16.5)	
Tumor diameter(cm)			0.888
≤5	134 (72.8)	67 (73.6)	
>5	50 (27.2)	24 (26.4)	
Pathological stage			0.640
Early stage	26 (14.1)	11 (12.1)	
Progressive stage	158 (85.9)	80 (87.9)	
Lymph node harvest	17.5 ± 6.9	20.7 ± 7.4	0.001

OTG open total gastrectomy, *LTG* laparoscopy-assisted total gastrectomy

(20.7 vs. 17.5, $P=0.001$). In addition, the proportion of patients with TNM stage III was 58.3% in the LTG group and 48.4% in the OG group, and the difference reached statistical significance ($P=0.035$).

Prognosis

A total of 230 patients finished the follow-up, including 152 patients in the OTG group and 78 patients in the LTG group. The median follow-up time was 24 months for the OTG group and 19.5 months for the LTG group. The median OS time was 20.9 months in the LTG group and 24.7 months in the OTG group. The 2-year OS rate was 55.6% in the OTG group and 42.3% in the LTG group. The Kaplan–Meier analysis for OS indicated that there was no significant difference between the two groups ($P=0.057$) (Fig. 1). Multivariable Cox regression analysis showed that sex, age, intraoperative blood loss and TNM stage (III vs. I/II) were prognostic factors for 2-year OS.

During the follow-up period, postoperative recurrence was observed in 18 patients (23.1%) in the LTG group and 43 patients (28.1%) in the OTG group, with no statistical significance ($P=0.412$). The median DFS time was 20.2 months in the LTG group and 23.2 months in the OTG group. The 2-year DFS rate was 41.3% in the OTG group and 34.1% in the LTG group. The Kaplan–Meier analysis for DFS indicated that there was no significant difference ($P=0.344$) (Figs. 2, 3, 4). Multivariable Cox regression analysis showed that age, intraoperative blood loss and TNM stage (III vs. I/II) were prognostic factors for 2-year DFS.

Stratified analysis for DFS and OS was conducted for patients with advanced gastric cancer (158 patients and 80 patients in the OTG group and LTG group, respectively). Similarly, DFS and OS were not significantly different

Table 6 COX regression model for prognostic factors of 2-year overall survival

	B	Wald	P value	HR	95% CI
Gender (male vs. female)	−0.566	3.942	0.047	0.568	0.325–0.993
Age	0.062	6.472	0.011	1.064	1.014–1.116
BMI (kg/m^2)	0.031	0.546	0.460	1.031	0.951–1.118
Preoperative comorbidity (Yes vs. No)	−0.426	2.727	0.099	0.653	0.394–1.083
Previous abdominal surgery (Yes vs. No)	0.281	0.803	0.370	1.325	0.716–2.450
ASA (III vs. I/II)	−0.035	0.019	0.892	0.966	0.585–1.595
Surgical approach (LTG vs. OG)	0.176	0.371	0.542	1.192	0.678–2.096
Operation time(min)	−0.002	0.551	0.458	0.998	0.993–1.003
Intraoperative blood loss(ml)	0.003	13.015	0.000	1.003	1.001–1.004
Postoperative complications (Yes vs. No)	−0.056	0.028	0.866	0.946	0.493–1.815
Tumor diameter(> 5 cm vs. ≤ 5)	0.340	1.794	0.180	1.405	0.854–2.311
Tumor differentiation (Poor vs. Well and Moderate)	0.442	2.913	0.088	1.556	0.936–2.587
TNM stage (III vs. I/II)	0.685	5.968	0.015	1.983	1.145–3.436

*Use the last one as a reference category

Table 7 COX regression model for prognostic factors of 2-year disease-free survival

	B	Wald	*P* value	Exp (B)	95% CI
Gender (male vs. female)	−0.548	3.702	0.054	0.578	0.331–1.010
Age	0.062	6.406	0.011	1.064	1.014–1.116
BMI(kg/m^2)	0.030	0.535	0.465	1.030	0.951–1.116
Preoperative comorbidity (Yes vs. No)	−0.444	2.989	0.084	0.642	0.338–1.061
Previous abdominal surgery (Yes vs. No)	0.227	0.518	0.472	1.254	0.677–2.324
ASA (III vs. I/II)	−0.027	0.012	0.915	0.973	0.589–1.607
Surgical approach (LTG vs. OG)	0.041	0.021	0.885	1.042	0.598–1.815
Operation time(min)	−0.002	0.521	0.470	0.998	0.994–1.003
Intraoperative blood loss(ml)	0.002	12.066	0.001	1.002	1.001–1.004
Postoperative complications (Yes vs. No)	−0.122	0.131	0.717	0.885	0.458–1.713
Tumor diameter(> 5 cm vs. ≤ 5)	0.340	1.820	0.177	1.405	0.857–2.302
Tumor differentiation (Poor vs. Well and Moderate)	0.459	3.161	0.075	1.582	0.954–2.623
TNM stage (III vs. I/II)	0.676	5.792	0.016	1.967	1.134–3.412

*Use the last one as a reference category

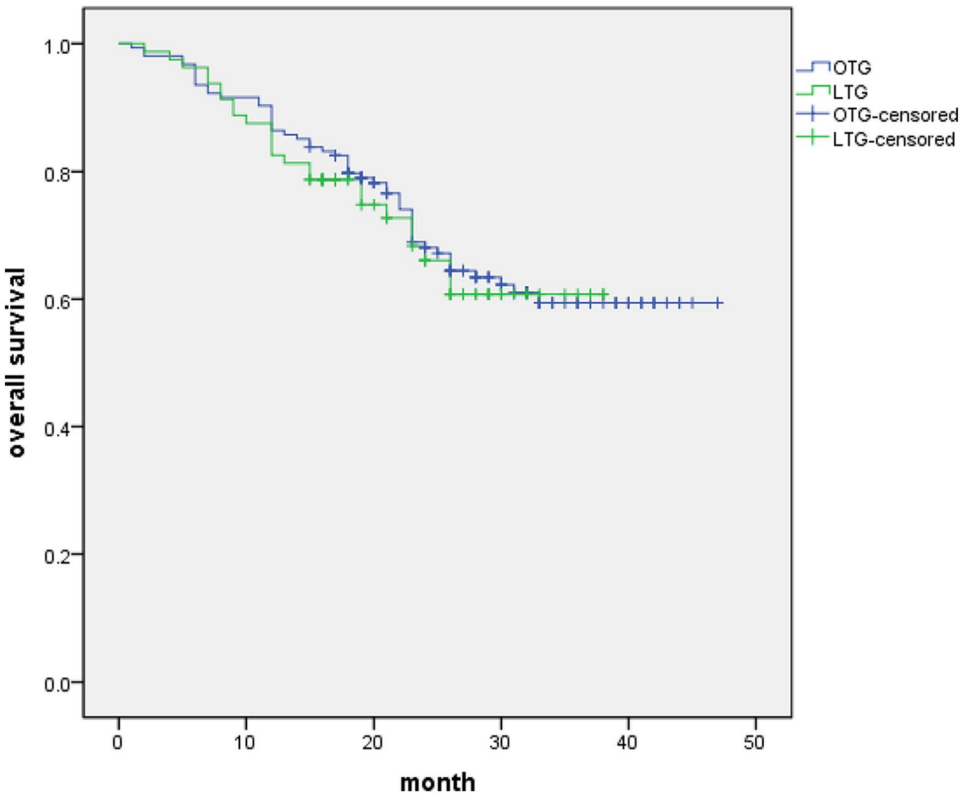

Fig. 1 Kaplan–Meier analysis showing the overall survival times between the laparoscopy-assisted total gastrectomy group and the open total gastrectomy group

between the two groups ($P = 0.882$ for DFS and $P = 0.646$ for OS).

Discussion

Approximately 60% of cancer incidence and 70% of cancer-related mortality occurs in people over 65 years old [20]. Elderly patients have a high risk of preoperative comorbidities and poor surgical tolerance. With increasing age, decreased physiological reserve and organ function affect the life expectancy of patients and reduce the tolerance to surgical treatment [21–24]. Published studies have demonstrated that pneumoperitoneum during laparoscopic surgery might have an adverse effect on lung function in elderly patients [25, 26]. Despite high-quality preoperative care, the surgical risk for elderly patients with gastric cancer remains significantly high. Some studies have proven the safety and

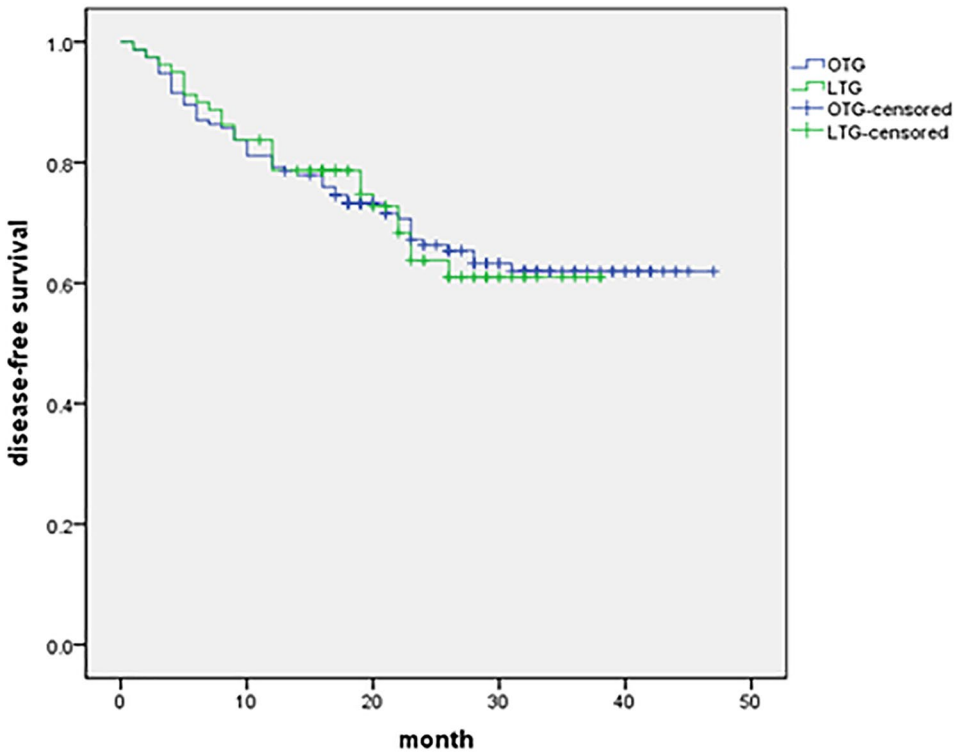

Fig. 2 Kaplan–Meier analysis showing the disease-free survival times between the laparoscopy-assisted total gastrectomy group and the open total gastrectomy group

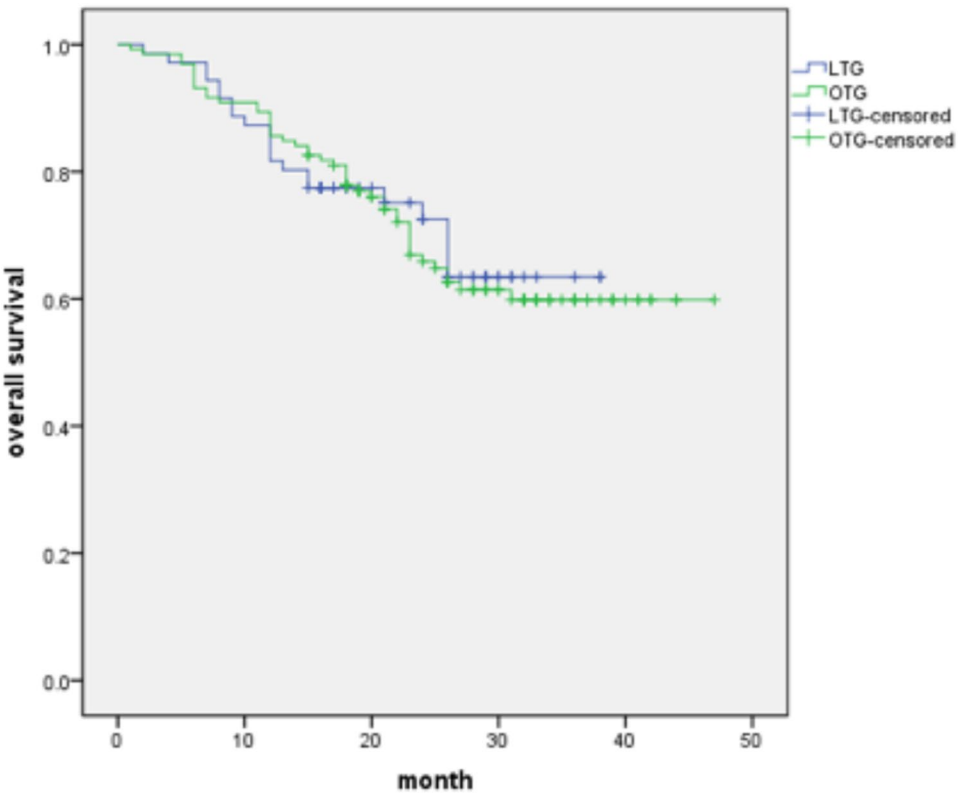

Fig. 3 Kaplan–Meier analysis showing the overall survival times between the laparoscopy-assisted total gastrectomy group and the open total gastrectomy group in patients with advanced gastric cancer

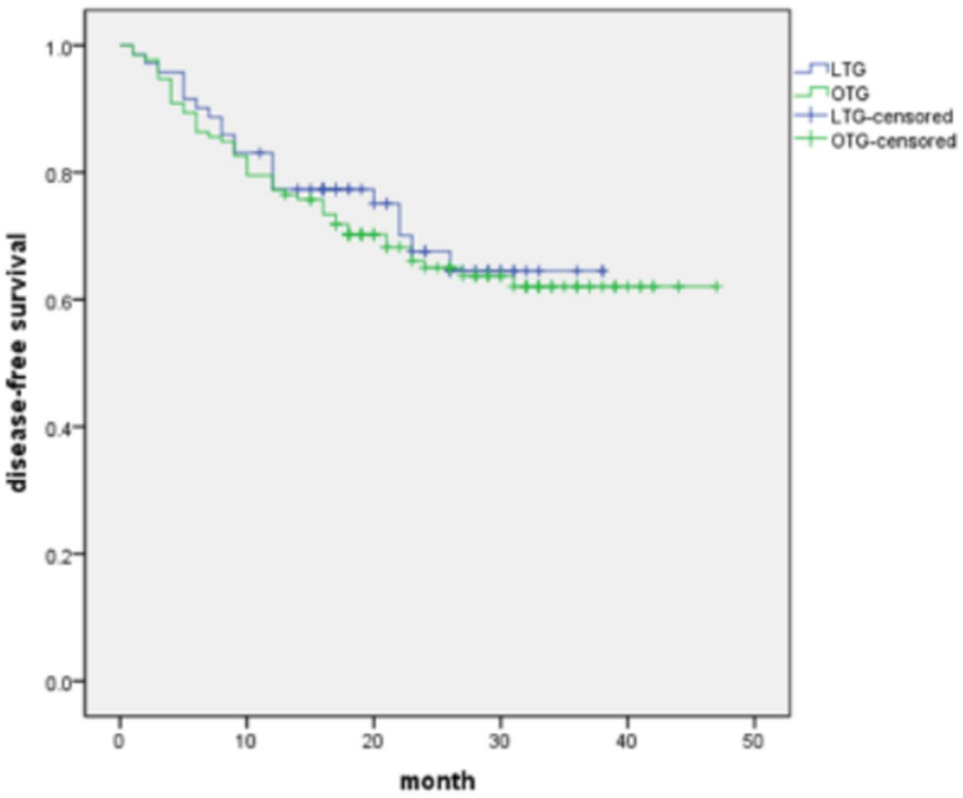

Fig. 4 Kaplan–Meier analysis showing the disease-free survival times between the laparoscopy-assisted total gastrectomy group and the open total gastrectomy group in patients with advanced gastric cancer

feasibility of laparoscopy-assisted distal gastrectomy for elderly patients when compared to open distal gastrectomy [10, 27–30]. In contrast, few studies were available to evaluate the safety and potential benefit of laparoscopy-assisted total gastrectomy for elderly patients [16–18]. Therefore, this study aimed to explore the safety and potential benefit of LTG for elderly patients.

First, we found that compared to patients in the OTG group, patients in the LTG group had less surgical trauma and faster postoperative recovery, reflected by less intraoperative blood loss (124.5 vs. 163.2 ml, $P=0.004$), a shorter initial feeding time (6.5 vs. 8.0 days, $P<0.001$) and a significantly shorter hospital stay (9.7 vs. 11.2 days, $P=0.001$). The results indicated that LTG had a significant advantage in postoperative recovery for elderly patients, despite longer operation times (242.2 min in the LTG group vs. 200.4 min in the OTG group, $P<0.001$). A study reported by Lu J found that LTG decreased intraoperative blood loss and shortened the hospital stay, which were consistent with our findings [17]. Another study demonstrated that laparoscopic surgery for gastric cancer was associated with a significantly shorter length of postoperative stay than open surgery, while laparoscopic surgery was not associated with a risk of severe complications [31].

Second, a low incidence of postoperative complications is an important indicator of surgical safety. In this study, postoperative complications were slightly higher in the OTG group (38, 20.7%) than in the LTG group (11, 12.1%), although there was no significant difference between the two groups ($P=0.081$). Sheng S et al. reported that compared to patients < 70 years, patients ≥ 70 years had a significantly higher risk of pulmonary infection when undergoing LTG [18]. In our study, subgroup analyses according to different types of complications suggested that LTG contributed to a decreased incidence of pulmonary complications compared with OTG in elderly patients. In contrast, there was no significant difference in surgery-related and severe complications between the two groups. This finding may be ascribed to the minimal trauma and rapid recovery after laparoscopic surgery. Evans et al. [32] reported that laparoscopic surgery had little impact on human immune function and induced a slight inflammatory reaction in elderly patients, which could effectively reduce the occurrence of cardiopulmonary complications. Yoshida et al. reported that compared to patients ≤ 65 years, patients over 80 years old undergoing laparoscopy-assisted distal gastrectomy had significantly higher incidences of pneumonia and delirium; however, other complications were not statistically significant [33]. This evidence suggested that elderly patients had a higher risk of pneumonia than young patients, and LTG contributed to a lower risk of lung infection than OTG in elderly patients.

In view of the reduced organ function and poor surgical tolerance of elderly patients, some studies suggested that

high-pressure CO_2 pneumoperitoneum during laparoscopic surgery might have an adverse impact on lung function [34, 35]. Laparoscopic surgery requires the establishment of artificial pneumoperitoneum, and pneumoperitoneum pressure can uplift the diaphragm, leading to a reduction in chest volume and lung compliance. In addition, CO_2 can be absorbed into human blood through the peritoneum. When elderly patients have cardiopulmonary complications, CO_2 pneumoperitoneum can cause hypercarbia and induce postoperative complications [36]. Therefore, controlling the abdominal pressure of CO_2 pneumoperitoneum during surgery can effectively prevent the occurrence of complications in elderly patients. During our laparoscopic surgery, the pneumoperitoneum pressure was usually maintained at 12–14 mm Hg.

The short-term advantages of LTG have been recognized, but it remains uncertain whether LTG can achieve a radical effect as open total gastrectomy for stomach cancer in elderly patients. Simth et al. [37] confirmed that the prognosis of gastric cancer was closely related to the number of lymph node dissections during surgery. Etoh et al. [38] pointed out that laparoscopic surgery could be used as an effective treatment for gastric cancer only if the number of lymph node dissections and long-term efficacy were guaranteed. In this study, all patients were successfully treated with D2 lymph node dissection, and the pathological examination confirmed that the resection margin was negative, which suggested that both the LTG group and the OTG group met the requirement of radical resection. Lymph node dissection is the most objective index to reflect whether radical gastrectomy is complete. In this study, the average detection number in the LTG group was significantly higher than that in the OG group (20.7 ± 7.4 vs. 17.5 ± 6.9, $P = 0.001$), which confirmed the curative effectiveness of LTG. Compared to OTG, laparoscopy has an amplifying effect and can clearly show the lymph nodes of the vascular root or relatively small lymph nodes, which facilitates the implementation of thorough lymph node dissection [39, 40].

Regarding the long-term oncological results, the 2-year OS rate and DFS rate were comparable between laparoscopic and open total gastrectomy in meta-analysis studies [41, 42]. A case-matched controlled prospective analysis demonstrated similar and acceptable cumulative incidences of recurrence and disease-free or overall survival rates between laparoscopic and open total gastrectomy [43]. Kim et al. [44] found that the long-term oncologic outcomes of 238 gastric cancer patients undergoing laparoscopic surgery were consistent with those of open gastrectomy in a case-controlled and case-matched study. Our study showed that the survival curves for the LTG and OTG groups were not significantly different ($P > 0.05$). These results demonstrated that the surgical method did not affect long-term survival rates. Male sex was a prognostic factor in Cox regression analysis, probably because a large proportion of male patients (approximately 80%) were enrolled in this study.

Some limitations should be acknowledged in this study. The main limitation of this study was its retrospective design, and treatment strategies were not based on random allocation. Moreover, the retrospective design might introduce some selection bias and performance bias, and the propensity score-matching method might be useful for reducing the bias. Third, the median follow-up time might be short, and the survival differences might be underestimated between the two groups.

In conclusion, this study demonstrated that LTG reduced surgical trauma, enhanced postoperative recovery and shortened the length of postoperative stay for elderly patients with gastric cancer in comparison to OTG. In addition, LTG reduced postoperative pulmonary complications and had a comparable survival with OTG. This study provided evidence for the clinical application of LTG in elderly patients.

Author contributions DLL, LL and ZQZ were involved in the study conception and design. DLL, LL and XW performed the data acquisition. DLL, LCL and SJL performed the analysis and interpretation of the data. DLL, LH, and YRH drafted the manuscript. DLL, YF and ZQZ critically revised the manuscript.

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Compliance with ethical standards

Disclosure Dongliang LIU, Lichuan LIANG, Liu LIU, Zhiqiang ZHU, Shaojun LIU, Lei HU, Yiren HE, Yu FANY, Xiao WAN have no conflicts of interest or financial ties to disclose.

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