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Safety and feasibility of laparoscopy-assisted surgery for gastrointestinal stromal tumors larger than 5 cm: Results of a retrospective, single-center series of 1,802 consecutive patients

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ABSTRACT

Background: The role of laparoscopy-assisted resection for treating gastrointestinal stromal tumors >5 cm is still disputed. We aimed to assess the advantages of laparoscopy-assisted resection for treating gastrointestinal stromal tumors >5 cm.

Methods: In total, 1,802 patients with primary gastrointestinal stromal tumors who underwent laparoscopy-assisted surgery or open surgery were retrospectively evaluated. Propensity score matching was performed to reduce confounders.

Results: In total, 518 patients with tumor size >5 cm were enrolled in this study (males: 292, 56.4%; females: 226, 43.6%; median age: 58 years, range: 23–85 years). One hundred and twenty-three (23.7%) patients underwent laparoscopy-assisted resection, and 395 (76.3%) patients underwent open resection. After propensity score matching, 190 patients were included (95 in each group). The laparoscopy-assisted surgery group was superior to the open surgery group considering the blood loss (>200 mL: 6.3% vs 22.1%, $P = .005$), length of midline incision (6.0 ± 0.9 cm vs 9.6 ± 2.1 cm, $P < .001$), time to first flatus (49.7 ± 10.5 hours vs 63.9 ± 7.4 hours, $P < .001$), and shorter hospital stay (10.3 ± 3.2 days vs 11.9 ± 2.9 days, $P < .001$). The difference in relapse-free survival or overall survival between the laparoscopy-assisted surgery and open surgery groups after matching was not significant (all $P > .05$). On subgroup analysis, the relapse-free survival and overall survival of the laparoscopy-assisted surgery group were comparable to those of the open surgery group, irrespective of tumor location (gastric or nongastric locations) (all $P > .05$).

Conclusion: When performed by experienced surgeons, laparoscopy-assisted resection is feasible and safe for gastrointestinal stromal tumors >5 cm, which showed improved short-term outcomes and comparable oncological outcomes, regardless of whether the tumor had a gastric or nongastric location.

Introduction

Complete resection remains the main treatment for primary localized gastrointestinal stromal tumors (GISTs). Since treatment via laparoscopy for GISTs was first reported by Lukaszczry in 1992, laparoscopy has rapidly become an accepted approach.[1] In response to the increasing literature regarding this approach, the 2007 update of the National Comprehensive Cancer Network (NCCN) guidelines recommended that gastric GISTs ≤5 cm in diameter were acceptable for laparoscopic resection, and tumors larger than 5 cm might benefit from a laparoscopy-assisted technique.[2] According to the NCCN guidelines (2021, v.1), a laparoscopic

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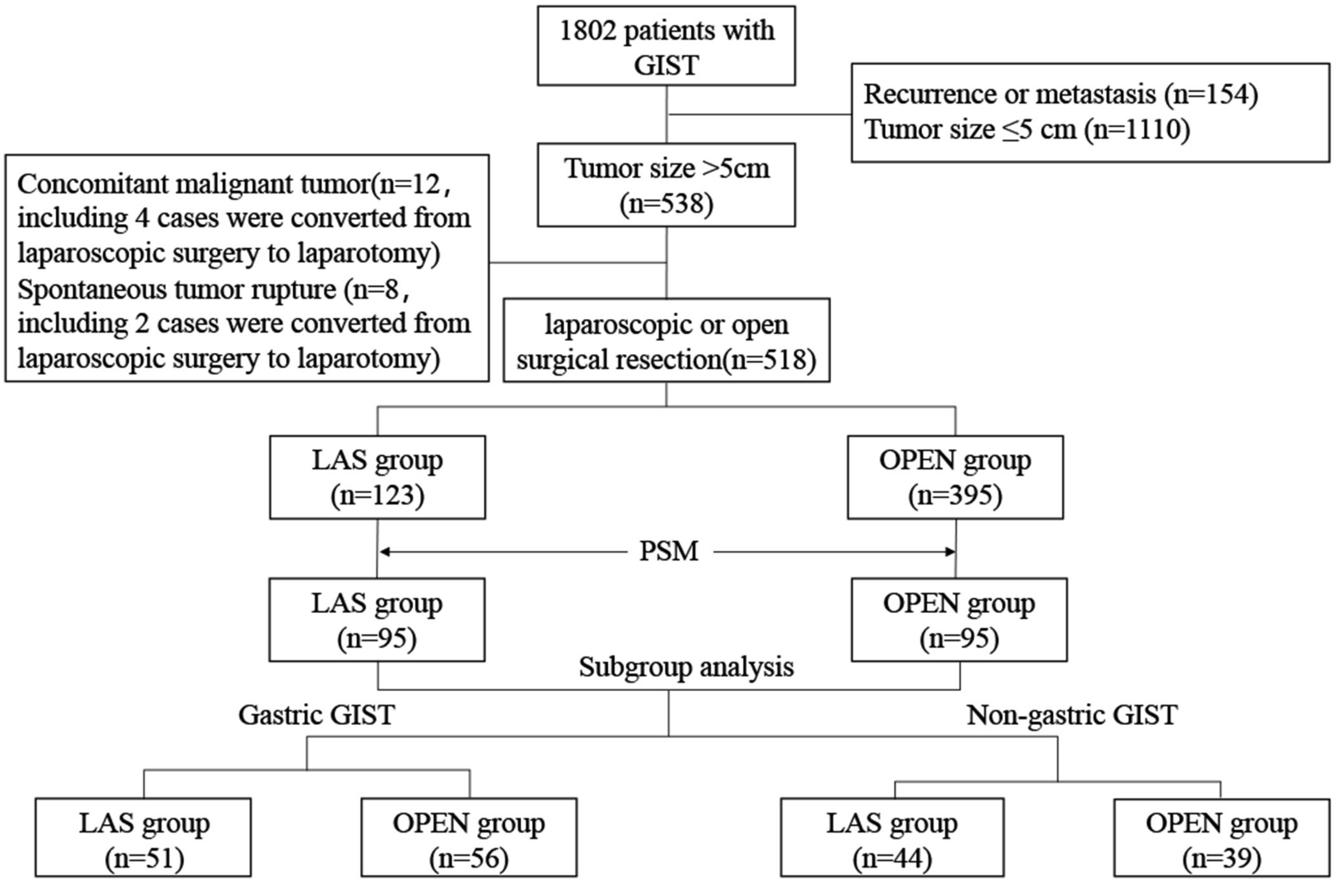

Figure 1. Flow diagram for extracting eligible cases for comparison. *GIST*, gastrointestinal stromal tumors; *LAS*, laparoscopic assisted surgery.

approach may be considered for selected GISTs in favorable anatomic locations.[3] At present, studies have proven that laparoscopic surgery is safe and feasible for GISTs smaller than 5 cm.[4,5] However, because of the difficulty of tumor extraction through enlarged laparoscopic ports, fragile texture, and abundant blood vessel intersections of GIST, the implementation of laparoscopy-assisted surgery (LAS) for GISTs larger than 5 cm is still controversial.

Several studies have shown that the long-term prognosis of gastric GISTs larger than 5 cm after laparoscopic surgery is equivalent to that after open surgery.[6,7] There are fewer studies related to GIST LAS compared to open surgery for nongastric GIST >5 cm. Therefore, whether laparoscopy-assisted treatment of nongastric GIST >5 cm is safe and feasible remains to be determined. In this study, we used data from a large database of a tertiary hospital in China to compare the postoperative and oncologic results of patients with GIST >5 cm after open surgery or LAS, and propensity score matching (PSM) was used to adjust for confounding variables. Moreover, subgroup analysis based on tumor location (gastric or nongastric) was conducted to further explore the outcomes in the 2 groups.

Methods

Patients

Between January 2000 and December 2020, 1,802 patients were diagnosed with GISTs at the Union Hospital, Tongji Medical College, Huazhong University of Science and Technology. All the patients provided consent to have their data used for the study. The inclusion criteria were as follows: (1) primary GIST confirmed by pathology, (2) laparoscopy-assisted or open surgical resection, and (3) tumor size >5 cm. The exclusion criteria were as follows: (1) the presence of other malignant tumors, (2) spontaneous tumor rupture, (3) synchronous metastatic diseases, and (4) conversion to laparotomy. Patients were classified into 2 groups: those who underwent LAS (LAS group) and those who underwent open surgery (open group). Standard demographic and clinicopathological data, including sex, age, tumor location and size, and pathological results and prognosis, were collected. The modified National Institutes of Health (NIH) risk classification scheme was used for tumor risk stratification and matching.[8] Surgical details were assessed, including the year of surgery, R0 resection, tumor rupture, operating time, multivisceral resection, estimated blood loss, length of hospital stay, and postoperative complications. Complications were classified according to the Clavien-Dindo classification scheme.[9] R0 resection is defined as removal of the whole tumor with no macroscopic or microscopic disease at the margins of the specimen.[10]

The flow diagram showing study subject screening and grouping is shown in Figure 1. This study was reviewed and approved by the Institutional Review Board of Tongji Medical College, Huazhong University of Science and Technology (2020S004).

Surgical procedure

All patients were placed in a supine position and underwent conventional endotracheal intubation anesthesia. Open resection

Table I
Patient baseline clinicopathological characteristics before and after propensity score-matching

Characteristics	Overall Population (*n* = 518[%])	Before matching				After matching			
		LAS (*n* = 123[%])	OPEN (n = 395[%])	χ2 /t	P	LAS (*n* = 95{%}]	OPEN [*n* = 95[%])	χ2 /t	*P*
Year of surgery				39.43	<.001			-	1.000*
2001–2010	121 (23.4)	3 (2.4)	118 (29.9)			3 (3.1)	2 (2.1)		
2011–2020	397 (66.6)	120 (97.6)	277 (70.1)			92 (96.9)	93 (97.9)		
Sex				0.02	.890			0.02	.885
Male	292 (56.4)	70 (56.9)	222 (56.2)			49 (51.6)	48 (50.5)		
Female	226 (43.6)	53 (43.1)	173 (43.8)			46 (48.4)	47 (49.5)		
Age (year)				1.40	.237			0.09	.766
≤60	310 (59.8)	68 (55.3)	242 (61.3)			57 (60.0)	59 (62.1)		
>60	208 (40.2)	55 (44.7)	153 (38.7)			38 (40.0)	36 (37.9)		
BMI (kg/m2)	22.1 ± 3.1	24.1 ± 3.6	22.6 ± 2.8	4.85	<.001	24.4 ± 3.4	23.3 ± 3.4	1.13	.260
Tumor location				15.55	<.001			0.54	.465
Gastric	244 (47.1)	77 (62.6)	167 (42.3)			51 (53.7)	56 (58.9)		
Nongastric	274 (52.9)	46 (37.4)	228 (57.7)			44 (46.3)	39 (41.1)		
Tumor size (cm)				42.25	<.001			0.05	.824
5~10	347 (67.0)	112 (91.1)	235 (59.5)			84 (88.4)	83 (87.4)		
>10	171 (33.0)	11 (8.9)	160 (40.5)			11 (11.6)	12 (12.6)		
Mitotic rates (mitoses/50 HPFs)				7.37	.025			0.47	.800
≤5	315 (60.8)	86 (69.9)	229 (58.0)			61 (64.2)	59 (62.1)		
5~10	121 (23.4)	26 (21.2)	95 (24.0)			24 (25.3)	23 (24.2)		
>10	82 (15.8)	11 (8.9)	71 (18.0)			10 (10.5)	13 (13.7)		
NIH Recurrence risk				52.15	<.001			0.02	.878
Intermediate	120 (23.2)	58 (47.2)	62 (15.7)			32 (33.7)	31 (32.6)		
High	398 (76.8)	65 (52.8)	333 (84.3)			63 (66.3)	64 (67.4)		
Adjuvant TKI				0.44	.506			0.78	.376
Yes	224 (43.2)	50 (40.7)	174 (44.1)			36 (37.9)	42 (44.2)		
No	294 (56.8)	73 (59.3)	221 (55.9)			59 (62.1)	53 (55.8)		

BMI, body mass index; *HPF*, high-powered field; *LAS*, laparoscopy-assisted surgery; *OPEN*, open surgery; *NIH*, National Institutes of Health; *TKI*, tyrosine kinase inhibitor.
* Fisher exact test.

Table II
Short-term preoperative outcomes between the LAS and OPEN groups with GISTs >5 cm

Characteristics	Overall Population (*N* = 518[%])	Before matching				After matching			
		LAS (*n* = 123[%])	OPEN (*n* = 395[%])	χ2 /t	*P*	LAS (*n* = 95[%])	OPEN (n = 95[%])	χ2 /t	*P*
R0 resection				0.07	.797			0.12	.733
No	32 (6.2)	7 (5.7)	25 (6.3)			5 (5.3)	4 (4.2)		
Yes	486 (93.8)	116 (94.3)	370 (93.7)			90 (94.7)	91 (95.8)		
Tumor rupture				-	.318*			2.75	.097
No	505 (97.5)	122 (99.2)	383 (97.0)			94 (98.9)	90 (94.7)		
Yes	13 (2.5)	1 (0.8)	12 (3.0)			1 (1.1)	5 (5.3)		
Operative duration	168.2 ± 70.2	148.3 ± 51.7	174.5 ± 74.0	-3.37	<.001	148.8 ± 52.9	150.3 ± 64.0	-0.17	.862
Blood loss (mL)				13.58	.001			10.49	.005
≤200	433 (83.6)	116 (94.3)	317 (80.3)			89 (93.7)	74 (77.9)		
200~500	66 (12.7)	5 (4.1)	61 (15.4)			4 (4.2)	18 (18.9)		
>500	19 (3.7)	2 (1.6)	17 (4.3)			2 (2.1)	3 (3.2)		
Multivisceral resection				0.01	.919			0	1.000
Yes	39 (7.5)	9 (7.3)	30 (7.6)			7 (7.4)	7 (7.4)		
No	479 (92.5)	114 (92.7)	365 (92.4)			88 (92.6)	88 (92.6)		
Length of midline incision (cm, mean ± SD)	10.3 ± 4.2	5.8 ± 0.7	11.7 ± 3.9	-28.10	<.001	6.0 ± 0.9	9.6 ± 2.1	-15.54	<.001
Time to first flatus (hours, mean ± SD)	61.0 ± 10.5	49.2 ± 10.1	64.6 ± 7.5	-18.35	<.001	49.7 ± 10.5	63.9 ± 7.4	-10.76	<.001
Hospital stay (days, mean ± SD)	11.8 ± 3.2	10.1 ± 3.1	12.3 ± 3.1	-6.95	<.001	10.3 ± 3.2	11.9 ± 2.9	-3.57	<.001
Grade ≥3 complications				0.71	.399			-	1.000
Yes	14 (2.7)	2 (1.6)	12 (3.0)			2 (2.1)	2 (2.1)		
No	504 (97.3)	121 (98.4)	383 (97.0)			93 (97.9)	93 (97.9)		

GIST, gastrointestinal stromal tumor; *LAS*, laparoscopy-assisted surgery; *OPEN*, open surgery; *SD*, standard deviation.
* Fisher exact test.

was typically performed through a midline incision. For the laparoscopy-assisted procedure, after pneumoperitoneum was established to an insufflation pressure of 10–15 mm Hg, a 10-mm trocar for the laparoscope was inserted below the umbilicus. Then other trocars were inserted depending on the patients' treatment. In laparoscopy-assisted operation for gastric, rectal, and extragastrointestinal GISTs, abdominal exploration, mobilization, tumor resection, and reconstruction procedures were completed under laparoscopy, and a vertical incision was made in the infraumbilical port for specimen delivery. In laparoscopy-assisted operation for small intestinal GIST, abdominal exploration, tumor localization, and tumor mobilization were completed under laparoscopy, and a vertical incision was made in the infraumbilical port for the reconstruction procedures and specimen removal.

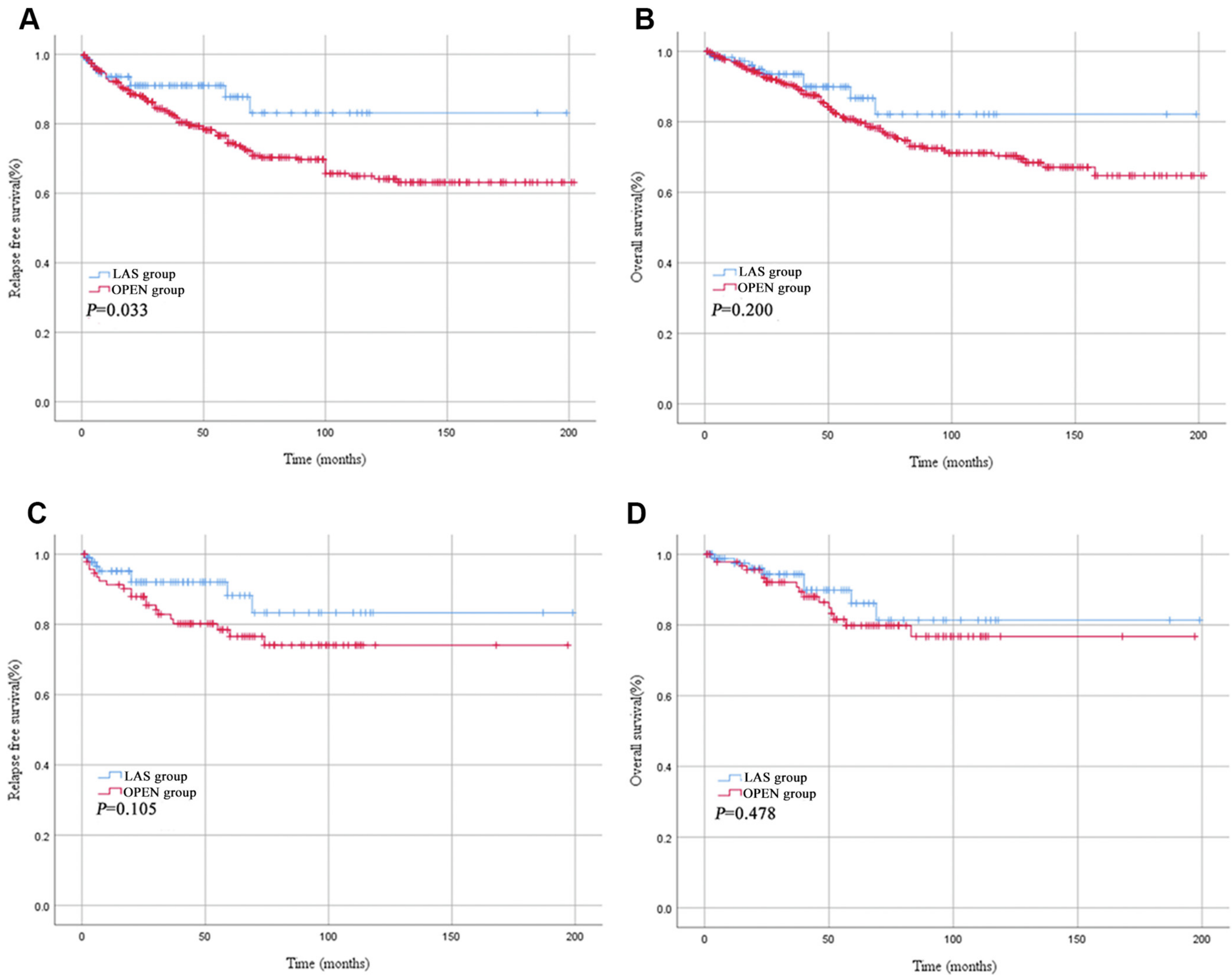

Figure 2. Comparison of relapse-free survival between the LAS and OPEN groups before (A) and after (C) propensity score matching. Comparison of overall survival between the LAS and OPEN groups before (B) and after (D) propensity score matching. *LAS*, laparoscopy-assisted surgery group; *OPEN group*, open surgery group.

The tumor diameter of every patient in this study was large, and the specimen was generally taken out through an auxiliary incision >5 cm; therefore, we defined it as laparoscopic-assisted surgery. During laparoscopic-assisted multivisceral resection, abdominal exploration, mobilization, and tissue and organ resection were also completed under laparoscopy, and the reconstruction procedures depended on the tumor location. In both laparoscopy-assisted and open resections, all tumors were removed with extraction bags, while all cuts were covered using a protective sleeve.

Follow-up

After surgery, patients were routinely followed up (3–6 months) by specially trained researchers. The follow-up information gathered included adjuvant therapy, survival time, recurrence, and death. The latest follow-up date for the study was June 2021. Relapse-free survival (RFS) was defined as the time from surgery to the first event of recurrent disease, and overall survival (OS) was calculated as the time from surgery to the date of death. The median follow-up was 50 months (range, 6–202 months) in the entire cohort.

Statistical analysis

Quantitative data were expressed as the mean ± standard deviation, and the differences between the groups were compared using the independent *t* test. Categorical data from different groups were compared using the χ^2 test or Fisher exact test. Eight covariates (age, sex, body mass index, year of surgery, tumor location, tumor size, mitotic rate, and adjuvant TKI) that may have affected patients' allocation to undergoing different techniques or the outcomes were selected to calculate the propensity score. We chose 2010 as the cut-off point for the year of surgery because that was when imatinib was approved in China for use in adjuvant therapy for primary GISTs after complete resection. One-to-one nearest neighbor matching was used to match patients based on the logic of the propensity score within a caliper of 0.05. The standardized difference was used to assess the balance of covariates after matching, and a standardized difference of less than 10% was considered acceptable. Data management and statistical analyses were performed using the Statistical Package for the Social Sciences statistical program (SPSS 20.0, Chicago, IL). PSM was performed using Stata 14.0 (StataCorp, College Station, TX). $P < .05$ was considered statistically significant, and all tests were 2-sided.

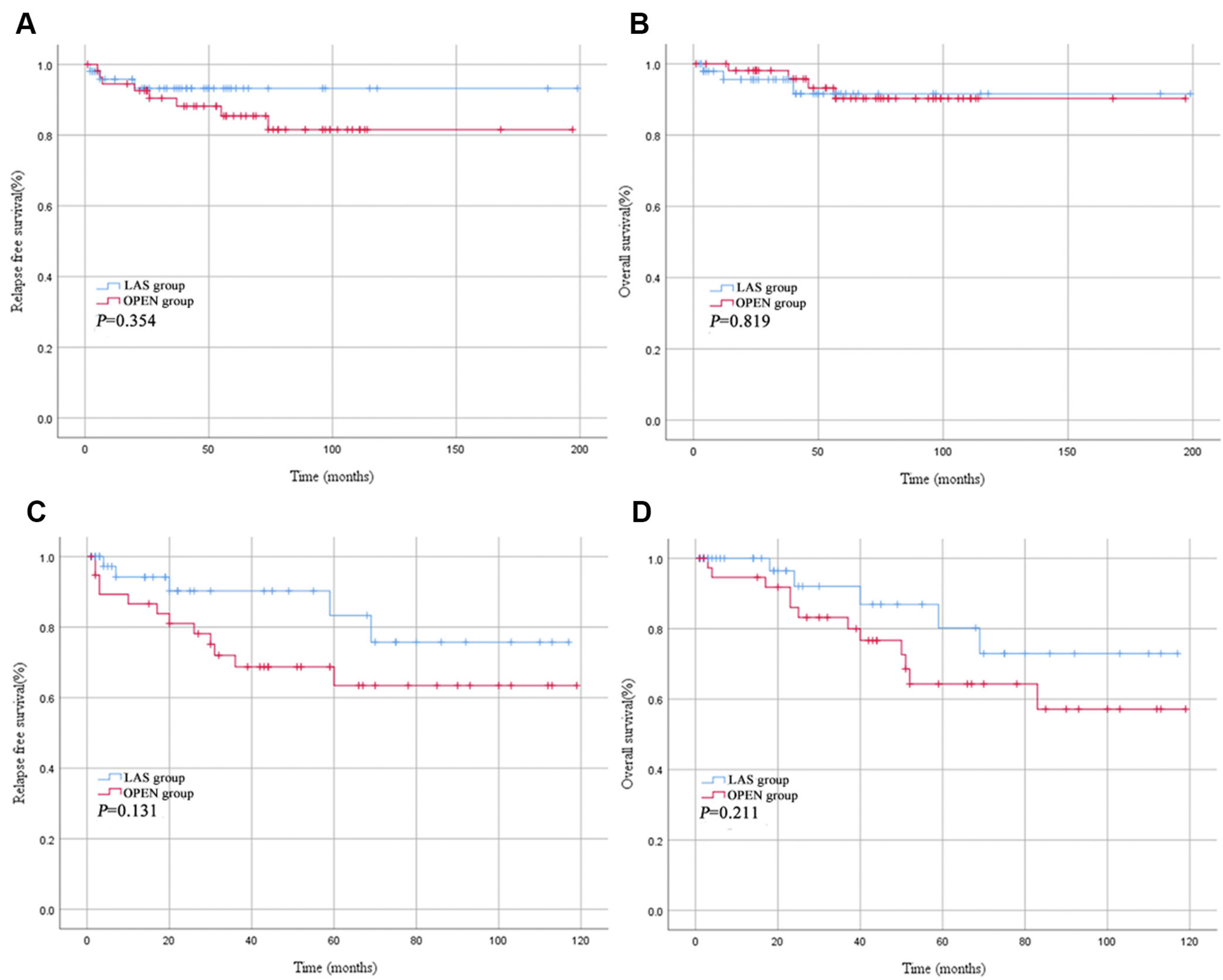

Figure 3. Comparison of relapse-free survival between the LAS group and OPEN group with gastric GIST (A) after propensity score matching. Comparison of overall survival between the LAS group and OPEN group with gastric GIST (B) after propensity score matching. Comparison of relapse-free survival between the LAS group and OPEN group with nongastric GIST (C) after propensity score matching. Comparison of overall survival between the LAS group and OPEN group with nongastric GIST (D) after propensity score matching. *LAS*, laparoscopy-assisted surgery group; *OPEN group*, open surgery group.

Results

Demographic data and clinicopathological characteristics

The characteristics of the 518 patients who underwent surgery for GIST >5 cm are shown in Table I. For the entire cohort, the median age was 58 years (range: 23–85 years); 56.4% of patients were male and 43.6% were female. Before PSM was performed, 395 (76.3%) patients treated with conventional open surgery were included in the open group. A total of 6 (4.7%) patients underwent conversion from laparoscopic surgery to laparotomy, all because of technical difficulty in mobilization or visualization of the tumor, which precluded safe oncological resection. The remaining 123 (23.7%) patients treated with LAS were included in the LAS group. As expected, there were significant differences in the baseline characteristics between the 2 groups. Patients in the LAS group had a higher number of tumor sites in the stomach (62.6% vs 42.3% in the open group), smaller tumor diameters (>10 cm: 8.9% vs 40.5% in the open group), smaller mitotic figures (>10 mitoses/50 HPFs: 8.9% vs 18.0% in the open group), and lower NIH risk grades (high risk: 52.8% vs 84.3% in the open group).

After PSM was performed, 190 patients were compared (95 in the LAS group vs 95 in the open group), and the tumor size was 5.1 to 12.0 cm and 5.2 to 12.5 cm in the LAS and the open groups, respectively. After PSM, the LAS group in this study included 2 (2.1%) GISTs at the gastroesophageal junction, 16 (16.8%) GISTs at the gastric fundus, and 9 (9.5%) GISTs at the lesser curvature of the gastric body; GISTs at the anterior wall and greater curvature of gastric body in 16 (16.8%) cases, posterior gastric wall in 5 (5.3%) cases, gastric antrum and pylorus in 3 (3.2%) cases; and small intestine GIST in 33 (34.7%) cases, rectal GIST in 8 (8.4%) cases, and extra-gastrointestinal GIST in 3 (3.2%) cases. The open group included 1 (1.1%) case of GIST at the gastroesophageal junction, 17 (17.9%) cases of gastric fundus GIST, 8 (8.4%) cases of GIST at the lesser curvature of the gastric body, 16 (16.8%) cases of GIST in the anterior wall and greater curvature of gastric body, 7 (7.4%) cases in the posterior wall of the gastric body, 7 (7.4%) cases in the gastric antrum and pylorus, 35 (36.7%) cases in the small intestine GIST, 3 (3.2%) cases of rectal GIST, and 1 (1.1%) case of extra-gastrointestinal GIST, and there was no significant difference in tumor specific location between the 2 groups after matching ($P = .713$). The demographic and clinicopathological characteristics for the open and

Table III
Short-term preoperative outcomes of GISTs >5 cm between the LAS and open groups considering the presence of gastric and nongastric GISTs

Characteristics	Gastric GIST				Nongastric GIST			
	LAS (n = 51[%])	OPEN (n = 56[%])	χ2 /t	P	LAS (n = 44[%])	OPEN (n = 39[%])	χ2 /t	P
R0 resection			-	.572			-	1.000*
No	3 (5.9)	2 (3.6)			2 (4.5)	2 (5.1)		
Yes	48 (94.1)	54 (96.4)			42 (95.5)	37 (94.9)		
Tumor rupture			-	.245*			-	.598
No	51 (100)	53 (94.6)			43 (97.7)	37 (94.9)		
Yes	0 (0)	3 (5.4)			1 (2.3)	2 (5.1)		
Operative duration	145.2 ± 60.2	151.1 ± 49.7	0.54	.588	146.2 ± 56.8	157.5 ± 69.2	-0.82	.414
Blood loss (mL)			13.51	.001			1.49	.476
≤200	49 (96.1)	41 (73.2)			40 (90.9)	33 (84.6)		
200~500	0 (0)	13 (23.2)			4 (9.1)	5 (12.8)		
>500	2 (3.9)	2 (3.6)			0 (0)	1 (2.6)		
Multivisceral resection			-	1.000*			-	1.000*
Yes	3 (5.9)	3 (5.4)			4 (9.1)	4 (10.3)		
No	48 (94.1)	53 (94.6)			40 (90.9)	35 (89.7)		
Length of midline incision (cm, mean ± SD)	5.7 ± 0.6	9.6 ± 2.3	-11.99	<.001	6.1 ± 1.0	9.7 ± 1.9	-10.17	<.001
Time to first flatus (hours)	46.9 ± 7.1	63,.6 ± 7.8	-11.46	<.001	53.0 ± 13.0	64.4 ± 6.9	-5.01	<.001
Hospital stay (days)	10.6 ± 3.5	11.9 ± 2.8	-2.16	.033	10.0 ± 2.8	11.9 ± 3.0	-2.93	.004
Grade ≥3 complications			-	.225			-	.218
Yes	2 (3.9)	0 (0)			0 (0)	2 (5.1)		
No	49 (96.1)	56 (100)			44 (100)	37 (94.9)		

GIST, gastrointestinal stromal tumor; *LAS*, laparoscopy-assisted surgery; *OPEN*, open surgery.
* Fisher exact test.

LAS groups were much more comparable, and all these differences became insignificant ($P > .05$) in the 95 matched pairs (Table I).

Short-term preoperative outcomes for >5 cm GISTs

There were differences in the short-term perioperative outcomes between patients in the LAS group and those in the open group before and after PSM. After PSM, the patients in the LAS group had lesser blood loss (>200 mL: 6.3% vs 22.1% in the open group, $P = .005$), shorter length of midline incision (6.0 ± 0.9 cm vs 9.6 ± 2.1 cm in the open group, $P < .001$), significantly shorter time to first flatus (49.7 ± 10.5 hours vs 63.9 ± 7.4 hours in the open group, $P < .001$), and shorter hospital stay (10.3 ± 3.2 days vs 11.9 ± 2.9 days in the open group, $P < .001$). There were no significant differences in the R0 resection, tumor rupture, operative duration, multivisceral resection, and ≥grade 3 complications (Table II).

Long-term outcomes for >5 cm GISTs

The median follow-up time was 50.0 months in the full cohort and 43.5 months in the propensity-matched group. Before PSM, the 1-, 3-, and 5-year RFS rates in the LAS and open groups were 93.5%, 81.0%, and 87.7% and 92.2%, 83.1%, and 74.5%, respectively. The LAS group had a superior RFS ($P = .033$). The 1-, 3-, and 5-year OS rates in the LAS and open groups were 97.2%, 93.5%, and 86.7% and 96.9%, 90.2%, and 80.8%, respectively. There was no significant difference in OS between the LAS and open groups ($P = .200$). In the PSM cohort, no differences were observed in the RFS ($P = .105$) or OS ($P = .478$) between the LAS and open groups (Figure 2).

Subgroup analysis based on tumor location

After PSM, 107 patients had large gastric tumors, whereas 83 had nongastric tumors. The demographic and clinicopathological characteristics between the LAS and open groups remained well balanced among patients with GISTs in gastric and nongastric locations (all $P > .05$; Supplementary Table S1). The LAS group showed lesser blood loss (>200 mL: 3.9% vs 26.8% in the open group, $P = .001$) than the open group in gastric GISTs (Table III). Furthermore, the LAS group had a shorter length of midline incision ($P < .001$), shorter time to first flatus ($P < .001$), and shorter postoperative hospital stay ($P < .05$) than the OPEN group, but comparable long-term outcomes with the open group considering the RFS and OS (both $P > .05$) irrespective of the tumor location (Figure 3).

Discussion

With advances in surgical techniques, laparoscopy is being used with increasing frequency for primary GISTs. However, most studies on laparoscopy for GISTs >5 cm have been focused on gastric GISTs.[11,12] Therefore, the current study is of importance because we used the largest cohort of patients who underwent surgery for primary GISTs with a tumor larger than 5 cm to assess both the short-term and long-term outcomes of LAS. Specifically, we demonstrated that the laparoscopy-assisted resection was safe for GISTs >5 cm, with oncological outcomes comparable to those of the open method. In addition, the same outcomes were verified for both gastric and nongastric GISTs through subgroup analysis. Hence, the laparoscopy-assisted approach can be considered a feasible surgical approach for patients with GISTs >5 cm.

Several retrospective studies have demonstrated that the laparoscopic approach is associated with low morbidity and mortality and good oncologic outcomes.[13,14] As tumor size is among the dominant variables that determine the surgical approach, the benefits of the laparoscopic approach may be attributed to selection bias because larger tumors tend to be approached via open resection. Totally laparoscopic surgery is more minimally invasive. However, concerns such as the difficulty of removing tumors through a mini wound have prevented the use of totally laparoscopic surgery for treating large GISTs. In the current study, the tumor diameter was large, and the length of the auxiliary incision was all >5 cm in the LAS group. Certain baseline characteristics of patients in the LAS group were more favorable compared to those of patients in the open group; therefore, we performed PSM between the LAS and open groups in an effort to mitigate this potential bias. After PSM, we found that LAS was associated with lesser blood loss, shorter length of midline incision, shorter time to first flatus, and shorter hospital stay compared to the open approach. However, it should be noted that inherent selection bias between the patients in the laparoscopic-assisted group and the open group may also affect the results. Lin et al[11] reported similar findings for the time to first flatus in a size-matched comparison of 46 patients with primary gastric GISTs >5 cm. Hsiao et al[15] compared 18 cases of gastric GISTs (5–8 cm) treated via laparoscopy resection with 21 cases treated via open surgery; the mean hospital stay was 8.4 days in the LAS group versus 9.6 days in the open group. In addition, our study showed that there was no significant difference in the R0 resection rate, tumor rupture, and postoperative complications between the LAS and open groups. Overall, these data suggested that favorable perioperative outcomes are associated with being eligible and selected for the LAS approach for GIST >5 cm.

Similar to published information regarding the long-term oncologic results of laparoscopic resection of primary GISTs, there were no differences in the oncologic outcomes between the surgical approaches in the current study.[16,17] Piessen et al[6] performed a size-matched comparison of laparoscopic resection ($n = 90$) and open resection ($n = 93$) for gastric GISTs with tumor larger than 5 cm. The 5-year RFS and OS were similar between the groups during a median follow-up of 45.4 months. In our study, LAS for gastric GISTs >5 cm achieved a survival similar to open surgery.

Known factors associated with recurrence risk in primary GISTs are tumor site, tumor size, mitotic rate, and intraoperative tumor rupture.[8] In addition to size, tumor's location is essential in selecting patients for laparoscopic surgery. The role of laparoscopy in treating localized gastric GISTs has been discussed recently; however, there are few studies on nongastric GIST laparoscopic resection, and most of them are case reports.[18,19] Importantly, through subgroup analysis, we evaluated the safety and feasibility of LAS for GISTs >5 cm irrespective of their location in the stomach. We found that laparoscopic-assisted resection could achieve better short-term outcomes than laparotomy for nongastric GIST >5 cm, and the oncological outcomes of the 2 groups were comparable. The need to prevent tumor rupture remains a barrier for the use of LAS for treating large GISTs. In fact, there are more difficulties in laparoscopy-assisted resection for nongastric tumors. In our experience, GIST rupture could be prevented by the effective use of laparoscopic instruments, such as the incision protection sleeve and specimen retrieval bag. To avoid tumor rupture and preserve the advantage of minimally invasive surgery, we propose that laparoscopy-assisted resection for nongastric GISTs larger than 5 cm should be performed only by experienced surgeons after a complete preoperative evaluation.

This study has several limitations. First, the study was retrospective in nature, and there was an inherent selection bias between the patients in the laparoscopic-assisted group and the open group. Second, even with covariates included in the PSM to eliminate selection bias, other potential factors may exist that would influence the allocation of patients to receive the different techniques and outcomes. Finally, the clinical data were collected over a long period, and uneven distribution of the proportion of laparoscopic-assisted surgery in different years may affect the outcomes in our study.

In conclusion, laparoscopy-assisted resection is a safe and feasible approach for GISTs >5 cm when performed by experienced surgeons. Laparoscopy-assisted resection for GIST >5 cm has a better short-term outcome than open surgery and had a long-term prognosis comparable to open surgery, irrespective of whether they were located in the stomach.

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Conflict of interest/Disclosure

The authors have no related conflicts of interest to declare.

Supplementary materials

Supplementary materials associated with this article can be found in the online version, at [https://doi.org/10.1016/j.surg.2022.04.049].

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