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Laparoscopic Resection of Gastric Submucosal Tumors: Outcomes of 141 Consecutive Cases in a Single Center

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Purpose: The treatment of choice for gastric submucosal tumors (SMT) is surgical resection. Recent advanced techniques has facilitated more extensive application of laparoscopic surgery to most types of resectable gastric SMTs. The aim of this study was to verify the efficacy of laparoscopic resection for treatment of gastric SMT through analysis of outcomes obtained at a single center.

Methods: A total of 141 patients who underwent laparoscopic resection for treatment of gastric SMT were enrolled between April 2003 and June 2011. Analysis of the demographics, tumor characteristics, and surgical or oncological outcomes of these patients was performed.

Results: Gastrointestinal stromal tumors (GIST) were the most common pathologic findings (90 cases), and the upper third of the stomach was the most common location (70 cases). Wedge resections were performed in 128 patients and major gastrectomies were performed in 13 patients. The mean surgical time was 102 minutes, which was reduced to a stable 70 minutes after the 30th case. The surgical time for tumors located on the posterior or lesser portion of the upper third of the stomach was longer than that for other lesions. Twelve postoperative complications, including two cases of intra-abdominal bleeding, one case of marginal ulcer bleeding, and one case of leakage occurred. However, there was no occurrence of complications after the 70th case. During the follow-up period, two patients suffered recurrent GIST.

Conclusion: Laparoscopic surgery for treatment of gastric SMT is safe and feasible, particularly as the surgeon develops greater skill with increased experience. Laparoscopic resection is useful for treatment of any type of gastric SMT.

Key words: Submucosal tumor, Laparoscopy, Gastric neoplasm

INTRODUCTION

A submucosal tumor (SMT) in the gastrointestinal tract describes an epithelial or non-epithelial mesenchymal tumor, accounting for 1% or less of all gastrointestinal tumors.[1] The stomach is the most common site for SMTs. The rate of detection of asymptomatic gastric SMTs has increased in Asian countries including Japan and Korea because of the increasing use of screening gastrofiberscopy for detection of gastric cancer.[2]

The first option for management of a gastric SMT is surgical resection, due to the limited preoperative pathologic diagnosis and the high possibility of malignancy.[3] Although the pathologic result is malignant gastrointestinal stromal tumor (GIST), lymphadenectomy is not usually required because of the low frequency of lymph node involvement.[4] Therefore, wedge resection of the stomach is possible and often results in complete resection of the gastric SMT without subtotal or total gastrectomy. This is fortunate as the latter procedures have a significant impact on the patient's postoperative quality of life.[5]

In recent years, laparoscopic resection of gastric SMTs has been regarded as the most appropriate curative approach. Previously, several reports had suggested limiting the indications for the laparoscopic approach to gastric SMTs of 2 cm in diameter, or smaller.[6,7] Since several comparative studies have described the efficacy of laparoscopic surgery compared to open surgery for gastric SMTs,[4,8,9] the laparoscopic approach has been applied to most types of resectable gastric SMTs.[10,11] However, in these reports, the number of enrolled patients was too small to be conclusive. In addition, they did not consider the features of SMTs requiring subtotal or total gastrectomy. Therefore, a clinical study involving a large series of patients undergoing laparoscopic surgery for gastric SMT can be of significant value and aid in the determination of the safety and effectiveness of the procedure across a broad array of SMTs.

Here, we analyzed prospectively collected data concerning laparoscopic resections of gastric SMTs within a single center. We aimed to evaluate the feasibility of this procedure through the analysis of surgical and oncologic outcome.

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MATERIALS AND METHODS

Between April 2003 and June 2011, 141 consecutive patients with gastric SMTs underwent laparoscopic surgery in our institution. Indications for surgical treatment of gastric SMTs included, a tumor with a diameter greater than 2 cm; a fine needle aspiration-confirmed gastrointestinal stromal tumor (GIST) of any size; and a clinical GIST suggested by computed tomography (CT) or endoscopic ultrasonography. Also we resected the mass which cause symptoms or patients want resection unless the tumor is smaller than 2 cm.

Initially, we applied laparoscopic surgery to gastric SMT of below 5 cm size. However, indication for laparoscopic surgery was extended to 8cm size after surgeon performed the 70th laparoscopic surgery for gastric SMT.

Data concerning patient clinicopathologic features, surgical procedures, pathology reports, and follow-up results were retrospectively collected from the medical records of all patients. In addition, data regarding surgical parameters, including operation times and postoperative complications, were reviewed.

1) Surgical procedures

Two surgeons who had a combined experience of more than 100 laparoscopic surgeries for gastric tumors, including adenocarcinomas, performed all of the surgical procedures. Laparoscopic surgery was performed under general endotracheal anesthesia. A 10-mm trocar for the laparoscope was inserted into the infra-umbilical area, and a 12 mm trocar for a flexible linear stapler was inserted, along with 2 or 3 additional trocars, into the upper abdomen after CO_2 pneumoperitoneum was established. Intra-abdominal pressure was maintained at 10～12 mmHg.

Each abdominal cavity was fully explored and the location of the exophytic tumors was easily identified. For exophytic tumors located in posterior wall or lesser curvature of the stomach, the lesser or greater omental fat was dissected to expose the mass. Small endophytic tumors (<2 cm in size) were located using intraoperative sonography or gastrofiberscopy. To avoid gastric deformity after resection, six endophytic tumors of intermediate size (2～5 cm) which was not detected at the serosa surface of the stomach were resected by eversion, as suggested by Hyung et al.[12] For resection of tumors located in the posterior wall of the stomach, anterior gastrotomy was performed (Fig. 1A). After tumors were identified, a flexible linear stapler was inserted through the gastrostomy site and the stapling was performed. Most tumors were resected by wedge resection using 2 or 3 staplers (Fig. 1B). Several intracorporeal sutures were made to reinforce the resection lines to reduce the risk of postoperative bleeding. Laparoscopic gastrectomy was performed for several SMTs located at the gastroesophageal junction or the prepyloric area which can cause narrowing or obstruction of stomach after resection. Anastomoses were performed extracorporeally through a 4～5 cm incision into the epigastric area. Most of the tumors were removed through the trocar site, using a laparoscopic bag. For large tumors (>5 cm), the trocar site was extended 3～4 cm to extract the tumor from the abdominal cavity.

During operation, tumors were carefully manipulated in order to prevent the tumor rupture. To extract from abdominal cavity, resected specimen was inserted into the laparoscopic bag, and the pull it out without contact of tumor with wound.

2) Perioperative management and outcome measurement

All patients who underwent gastric wedge resection were managed with common clinical pathway. They started sips of water on the second postoperative day, and began on a soft diet on the fourth postoperative day, if they were available. In case of patients who underwent gastrectomy, sips of water was supplied on the third postoperative day, and a soft diet on the fifths postoperative day. All patients were discharged once they exhibited at least 2 days without specific complaints and had nor-

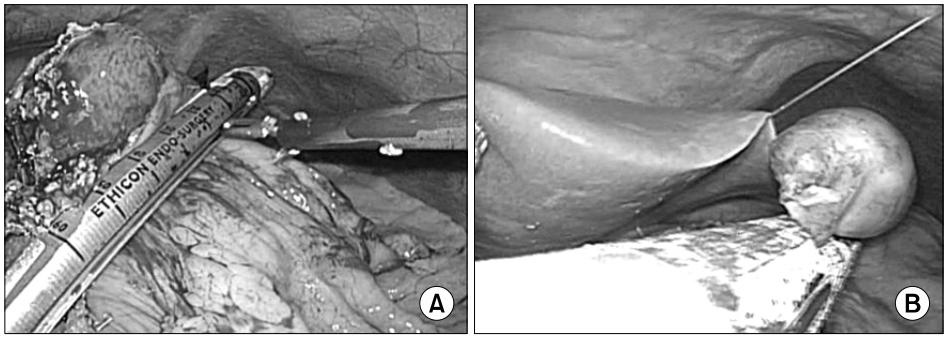

Fig. 1. (A) Laparoscopic resection for endophytic submucosal resection using eversion technique. (B) Laparoscopic resection for exophytic submucosal tumor using endoscopic linear staplers.

mal clinical status and physical examination after starting soft diet. We decided that postoperative morbidity was occurred when the patient required additional management due to unusual events.

3) Patient follow-up

Only patients diagnosed with GIST were recommended for follow-up every 6 months to 1 year. Abdominal CT and gastrofiberscope examinations were performed to evaluate tumor recurrence. Recurrence was diagnosed by further imaging studies or explorative laparotomy.

4) Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences version 15.0 (SPSS, IBM Corporation, Armonk, NY, USA). Differences in the numbers of major gastrectomies and complication rates were evaluated relative to clinicosurgical features using the chi-squared test. Operation time, according to the tumor location, was compared using a one-way analysis of variance (ANOVA) test, and a post-hoc test using the Duncan method was performed to make specific comparisons between locations. A p value of less than 0.05 was considered to be statistically significant.

RESULTS

Laparoscopic surgeries for SMT resections were performed on 141 patients without open conversion. Mean age and body mass index of the patients was 53.9±12.4 years old and 24.5±4.3 kg/m^2 (mean±S.D.), respectively. Other clinicopathologic factors are listed in Table 1. The most common location of the tumors was the upper third of the stomach (70 cases) followed by the middle (41 cases) and lower thirds (30 cases). More than 90% of masses were larger than 2 cm in diameter, and 41 patients (29.1%) had tumors larger than 5 cm in diameter. Maximum size of tumors was 9 cm and it was re-

Table 1. Clinicopathologic and surgical results of 141 enrolled patients

Clinical variables	N	Percentage
Age (years old)		
<65	111	78.7
≥65	30	21.3
Gender		
Male	63	55.3
Female	78	44.7
Body mass index (kg/m^2)		
<25	88	62.4
≥25	53	37.6
Location		
Upper	70	49.6
Middle	41	29.1
Lower	30	21.3
Circular location		
Lesser/Posterior	72	51.1
Greater/Anterior	69	48.9
Type		
Endophytic	61	43.3
Mixed	35	24.8
Exophytic	45	31.9
Size		
<2 cm	11	7.8
≥2 cm, <5 cm	89	63.1
≥5 cm	41	29.1
Surgical procedure		
Wedge resection	129	90.8
Distal gastrectomy	9	7.1
Proximal gastrectomy	1	0.7
Total gastrectomy	2	1.4

Table 2. Comparison of gastrectomy according to the clinicopathologic features

		Wedge resection (%) (129)	Gastrectomy (%) (12)	p value
Age (years old)				0.719
<65	111	102 (91.9)	9 (8.1)	
≥65	30	27 (90.0)	3 (10.0)	
Gender				0.408
Male	63	59 (93.7)	4 (6.3)	
Female	78	70 (89.7)	8 (10.3)	
BMI* (kg/m^2)				0.353
<25	88	82 (93.2)	6 (6.8)	
≥25	53	47 (88.7)	6 (11.3)	
Location				0.034
Upper	70	67 (95.7)	3 (4.3)	
Middle	41	38 (92.7)	3 (7.3)	
Lower	30	24 (80.0)	6 (20.0)	
Circular location				0.598
Lesser/Posterior	72	64 (92.8)	5 (7.2)	
Greater/Anterior	69	65 (90.3)	7 (9.7)	
Type				0.139
Endophytic	61	53 (86.9)	8 (13.1)	
Mixed	35	32 (91.4)	3 (8.6)	
Exophytic	45	44 (97.8)	1 (2.2)	
Size				0.499
<2 cm	11	11 (100.0)	0 (0.0)	
≥2 cm, <5 cm	89	80 (89.9)	9 (10.1)	
≥5 cm	41	38 (92.7)	3 (7.3)	

*Body mass index.

Table 3. Clinical features of patients who were undergone laparoscopic gastrectmy for gastric submucosal tumor

		Gender/Age	Location		Type	Size (cm)	Pathology
1	Distal gastrectomy	F/39	Lower	Lesser	Endophytic	3.7	Leiomyoma
2	Distal gastrectomy	F/75	Lower	Greater	Mixed	6	Schwannoma
3	Distal gastrectomy	F/45	Lower	Posterior	Endophytic	2	Polyp
4	Distal gastrectomy	F/66	Lower	Anterior/Greater	Endophytic	2.8	GIST
5	Distal gastrectomy	F/32	Lower	Posterior	Endophytic	5.5	Ectopic pancreas
6	Distal gastrectomy	F/54	Middle	Lesser	Endophytic	4.8	GIST
7	Distal gastrectomy	M/69	Middle	Lesser	Endophytic	3	Plasmacytoma
8	Distal gastrectomy	F/42	Middle	Greater	Exophytic	4.5	Schwannoma
9	Distal gastrectomy	M/55	Lower	Greater	Mixed	2.2	Polyp
10	Proximal gastrectomy	M/45	Upper	Greater	Endophytic	7	Leiomyoma
11	Total gastrectomy	F/45	Upper	Lesser/Posterior	Endophytic	4	GIST
12	Total gastrectomy	M/27	Upper	Lesser/Posterior	Mixed	3.7	Leiomyoma

GIST = gastrointestinal stromal tumor.

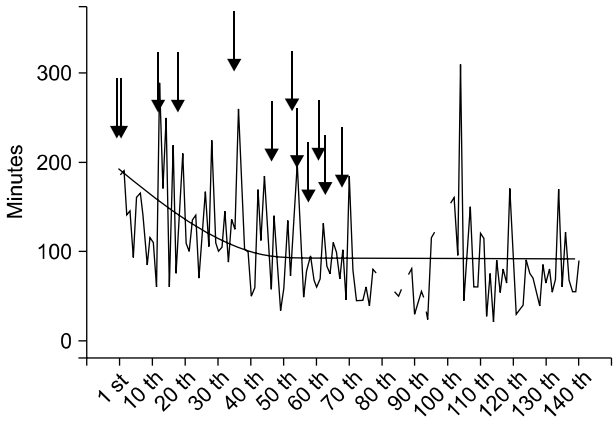

Fig. 2. Change in operation time, according to the surgeon's experience in laparoscopic surgery for gastric submucosal tumors. Arrow shows the occurrence of postoperative complications.

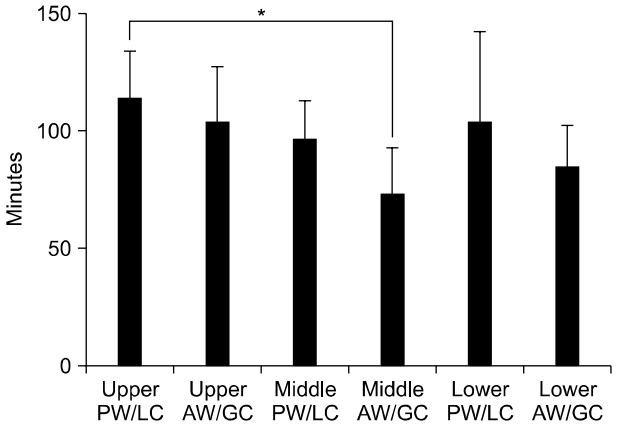

Fig. 3. Operation time according to tumor locations. There was no significant difference in operation time among the locations, by one-way ANOVA test. However, operation times for gastric submucosal tumor located in the posterior wall or lesser curvature of upper portion of the stomach was significantly longer than it was for those in the anterior wall or greater curvature of the stomach. *Means $p<0.05$ in post-hoc test (Duncan method). PW = posterior wall; LC = lesser curvature; AW = anterior wall; GC = greater curvature.

sected by wedge resection. Endophytic masses were found in 61 cases and exophytic masses in 45 cases. GIST was the most common pathologic finding (63.8%); other diagnoses included leiomyoma (14.2%), schwannoma (11%), ectopic pancreas (7%), and polyps (7%).

Among the 141 patients, 129 underwent laparoscopic wedge resections and 12 underwent laparoscopic major gastrectomy. Nine SMTs, located in the prepyloric antrum, were treated by distal gastrectomy, and 3 gastroesophageal junction tumors were treated by either proximal gastrectomy or total gastrectomy. The characteristics of the tumors resected by wedge resection were compared to those resected by major gastrectomy, by age, sex, body mass index, and tumor size; statistically significant correlations were not observed, but gastric SMTs located in the lower third of the stomach were more likely to be removed by major gastrectomy (p=0.034) (Table 2). Tumor rupture or spillage did not occur during any of the procedures. The pathological and surgical features associated with each type of surgery are listed in Table 3.

The mean operation time was 102 minutes, and it was gradually reduced to about 70 minutes, after 30 cases, where it stabilized. However, the surgical time did vary on a case-by-case basis (Fig. 2). A one-way ANOVA test indicated that the oper-

Table 4. Characteristics of patients who had complications

No	Gender/ Age	Resection	Location	Approach	Type	Size	Complication	Treatment
1	F/45	Distal gastrectomy	Lower	Posterior	Endophytic	1.8	Ulcer bleeding	
2	M/52	Wedge resection	Middle	Lesser	Endophytic	4.3	Tonsilitis	
3	M/68	Wedge resection	Upper	Greater	Endophytic	3	Bleeding	
4	F/40	Wedge resection	Upper	Greater	Endophytic	3	Bleeding	Reoperation
5	F/39	Distal gastrectomy	Lower	Lesser	Endophytic	3.5	Gastric stasis	
6	M/45	Proximal gastrectomy	Upper	Greater	Endophytic	3	Gastric stasis	
7	M/65	Wedge resection	Upper	Lesser/Posterior	Exophytic	5	Leakage	Reoperation
8	F/71	Wedge resection	Upper	Anterior	Endophytic	2.2	Effusion	
9	F/50	Wedge resection	Upper	Lesser	Exophytic	3.2	Effusion	
10	M/67	Wedge resection	Upper	Greater	Exophytic	1.7	Wound hematoma	
11	M/71	Distal gastrectomy	Middle	Greater	Endophytic	2	Intraabdominal abscess	
12	M/44	Wedge resection	Middle	Lesser	Mixed	1.5	Wound hematoma	

ation times did not differ significantly relative to the tumor location (p=0.116). The surgical time for resection of gastric SMTs located in the posterior wall of the lesser curvature of the stomach were relatively longer than they were for tumors of the anterior wall or greater curvature of the stomach (Fig. 3).

The mean time to gas out after surgery was 3.3±2.3 days, and the mean length of hospital stay was 7.1±3.4 days. The discharge of forty seven patients (33.3%) who should be managed for postoperative complications and want it to be postponed was behind the planned schedule.

Operative morbidity was 8.5% (12/141), including 2 cases of intra-abdominal bleeding, 1 case of marginal ulcer bleeding, and 1 case of leakage of resection line. Re-operation was necessary only in the 2 cases of bleeding and leakage. There were no mortality cases (Table 4). None among age gender, BMI, location, growth type, size, and type of resection were found to have significant influence on post-gastrectomy complications. (Table 5), and there were no complications observed after the 70th patient was operated on.

Of the 90 patients diagnosed with GIST, we selected 52 patients who were followed up more than 12 months. At a mean follow-up of 31 months (range, 12.3 to 56.5 months, median: 17.6 months), recurrence was observed in 2 (1.4%) patients, and no local recurrence was observed. Both of these patients had high-risk GIST; 1 had a tumor that was 5.4 cm in diameter and more than 10 mitoses per 50 high-powered fields were observed; the other case involved a tumor of 7.5 cm in diameter and more than 15 mitoses per 50 high-powered fields. One case was detected liver metastasis at postoperative 16 months, and the other case peritoneal seeding at postoperative 18 months.

Table 5. Comparison of risk of postoperative complications according to the clinicopathologic features

		Complication (%)	p value
Age (years old)			0.071
<65	111	7 (6.3)	
≥65	30	5 (16.7)	
Gender			0.320
Male	63	7 (11.1)	
Female	78	5 (6.4)	
BMI* (kg/m^2)			0.760
<25	88	7 (8.0)	
≥25	53	5 (9.4)	
Location			0.451
Upper	70	8 (11.4)	
Middle	41	2 (4.9)	
Lower	30	2 (6.7)	
Circular location			0.939
Lesser/Posterior	72	6 (8.7)	
Greater/Anterior	69	6 (8.3)	
Type			0.193
Endophytic	61	8 (13.1)	
Mixed	35	1 (2.9)	
Exophytic	45	3 (6.7)	
Size			0.568
<2 cm	11	0 (0.0)	
≥2 cm, <5 cm	89	8 (9.0)	
≥5 cm	41	4 (9.8)	
Resection			0.067
Wedge	129	9 (7.0)	
Gastrectomy	12	3 (25.0)	

*body mass index.

DISCUSSION

To date, many researchers have reported the efficacy of laparoscopic surgery compared to open surgery for gastric SMTs.[4,8,9,13] Laparoscopic surgery for gastric SMTs has been shown to yield patient benefits, including enhancing their postoperative recovery.[14,15] This study reports the evaluation of the largest number of patients who underwent laparoscopic surgery for gastric SMTs at a single center. Most of tumors were resected by laparoscopic wedge resection. However, tumors located at the prepyloric junction showed the highest proportion of distal gastrectomies compared to tumors at other locations. The surgical time was variable in spite of sufficient surgeon's experience, but there were no complications after 70 cases. Results of the long-term follow-up showed that laparoscopic surgery is feasible for gastric SMTs.

Although laparoscopic resection has become the treatment of choice for gastric SMTs, not all SMTs are resected using this technique. Some authors have limited the indication of laparoscopic surgery to only those patients who have a gastric SMT that is less than 5 cm in diameter.[13,15,16] This tumor size limitation might reflect the technical difficulty of laparoscopic minimal resection. In the current series, laparoscopic surgery was applied to all tumors below 5 cm in size, but the limitation was increased to 8 cm after the 70th surgery in our institution. As a result, 41 cases (29.0%) involved tumors $\geq$5 cm in diameter. All of these laparoscopic surgeries were successfully performed, without open conversion, presumably because of proficiency of the surgeon in the laparoscopic technique. It is possible for surgeons to perform total or subtotal laparoscopic gastrectomy for SMTs that are impossible to resect by wedge resection. Therefore, the indication for laparoscopic surgery of gastric SMTs below 8 cm might have no limitations with respect to tumor location.

Although the surgical procedures can vary according to tumor size and location, most tumors can be resected by wedge resection. It is important to resect gastric SMTs by wedge resection, if possible. Major gastrectomy and reconstruction leads to a defect in gastrointestinal function, such as dumping syndrome and stasis, and can negatively affect the patient's quality of life. Because resection of gastric SMTs does not require lymph node dissection, it is possible to resect the tumor while preserving most of the stomach. However, stapler resection of endophytic SMTs can lead to stomach deformities because an excessive amount of normal stomach around the tumor needs to be removed due to the extra-luminal approach. Through the use of the eversion method suggested by Hyung et al.,[12] most endophytic SMTs located even in the lower and upper portions of the stomach can be treated by wedge resection. However, the rate of gastrectomy for SMTs in the lower portion of the stomach increased to 20% in this study.

Previous reports have not documented the development of strictures after wedge resection of the stomach near the pylorus, but several authors have reported strictures after endosopic resection.[17,18] Such strictures can occur after surgical resection of SMTs near the pyloric ring. Therefore, distal gastrectomy was employed if the resection margin was too close to the pylorus, in order to avoid the possible formation of a postoperative stricture around the pyloric ring.

Several reports have described the tail-road approach for resection of SMTs near the esophagogastric (EG) junction.[19,20] Proximal or total gastrectomies of these SMTs are associated with increased postoperative complications, including reflux esophagitis. Most surgeons consider that minimal resection, avoiding major gastrectomy, is required for the removal of SMTs near the EG junction. Several approaches to such tumors can be applied to allow minimal resection. For endophytic lesions in the posterior stomach wall, transgastric resection is the treatment of choice. In this method, the surgeon can visualize the exact location of the tumor and confirm its margins.[21,22] Exophytic SMTs located on the lesser curvature of the stomach or on its posterior wall can be removed completely after dissection of the gastrocolic or gastrohepatic ligaments to identify the tumor margin. For this reason, the surgical time for SMTs in this region were longer than for those conducted on tumors located in other regions of the stomach, in the present case series. However, most SMTs in this region were resected by wedge resection, except for 3 cases of large tumors where malignancy was expected in the preoperative study. In these instances, major gastrectomy was inevitable. One of these cases was later diagnosed as having a 3.7 cm leiomyoma. If an exact diagnosis, by fine needle biopsy, had been available earlier, a minimal resection, like enucleation, could have been performed. Therefore, thorough preoperative investigations are required to obtain a correct diagnosis and for the selection of appropriate techniques.

Present study showed fair results with regard to the safety of the procedure. There were no mortalities, and no complications were observed after the 70th case. Laparoscopic surgery for gastric cancer has become popular in Korea, because of the high proportion of early gastric cancers. First laparoscopic surgery for gastric SMTs was started after they performed the first laparoscopic gastrectomy for early gastric cancers. Now, they

performed over 100 laparoscopic surgeries for gastric cancers a year. Because the laparoscopic gastrectomy for gastric cancer requires the complicated procedure, laparoscopic resection for SMTs is assumed to have become a safe method. The variation of operative time should be considered according to complexity of procedures for tumors that are located in the lesser curvature and posterior wall of the stomach or closed to esophagogastric junction or pylorus.

Two of the 52 patients diagnosed with GIST demonstrated a recurrence of their cancer within 12 months of surgery. In both these cases, the tumors were greater than 5 cm in diameter. Although the number of cases is insufficient to be conclusive, large tumors ($\geq$5 cm) appeared to be more likely to recur than did the smaller ones ($<$5 cm). Previous clinical studies on patients who underwent open laparotomy for GIST also indicated that tumor sizes greater than 5 cm in diameter were prognostic of poor survival.[23-25] We assumed that the laparoscopic surgery for tumors with greater than 5cm did not affect on the recurrence of them. However, prospective clinical study will be required for confirmative results about it.

CONCLUSION

In conclusion, we confirmed that laparoscopic surgery for gastric SMTs is technically safe and oncologically feasible. Laparoscopic resection could be a useful and promising procedure for any kind of gastric SMT if size is below 8 cm. However, wedge resection was considered according to the location and characteristics of tumor.

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