INTRODUCTION

Recent developments in screening programs and endoscopic techniques have allowed the diagnosis of gastric cancer (GC) at an early stage[1]. Early GC (EGC) makes up 50% of the diagnosed cases and the five-year survival rate of EGC treated with surgery is over 90% in Japan[2]. Due to the low incidence of lymph node metastasis and the favorable prognosis of EGC, areas of gastric resection and lymph node dissection areas could be reduced to preserve postoperative gastric function. Although the Japanese GC treatment guidelines advocate resection of at least two-thirds of the stomach with D2 node dissection as the standard treatment for most stages of advanced GC, the guidelines also describe less invasive procedures such as pylorus-preserving gastrectomy (PPG), proximal gastrectomy (PG), and other minimally invasive procedures as investigational treatments (Figure 1)[3].

Here we review PPG and PG as function-preserving procedures for GC.

PPG

PPG was initially used to treat peptic ulcers[4]. Starting in the late 1980s, some surgeons performed PPG in selected patients with EGC to improve postoperative gastric function and maintain patient quality of life[5]. PPG is generally thought to offer several advantages over conventional distal gastrectomy (DG) with Billroth I reconstruction in terms of the incidence of dumping syndrome, bile reflux gastritis, and the frequency of flatus, although the operative duration of PPG is longer than that of DG.

During the procedure, the distal part of the stomach is resected, but a pyloric cuff 2-3 cm wide is preserved[6,7]. The right gastric artery and the infrapyloric artery are preserved to maintain the blood supply to the pyloric cuff. In addition, the hepatic and pyloric branches of the vagal nerves are preserved to maintain pyloric function. The celiac branch of the posterior vagal trunk is sometimes preserved. All regional nodes except the suprapyloric nodes (No. 5) should be dissected as in the standard D2 procedure. However, there are technical challenges associated with completing all of these procedures. Shibata *et al*[8] conducted a questionnaire survey on the PPG procedure in Japanese institutions. According to their report, the vagus nerve was preserved at 73.5% of the institutions, the infrapyloric artery was preserved in 49.4%, and partial dissection of the suprapyloric lymph nodes was performed in 56.2%. These differences in the procedure may affect postoperative gastric function after PPG, leading to postoperative symptoms.

INDICATIONS AND ONCOLOGIC SAFETY OF PPG

Since function-preserving surgeries such as PPG are usually less extensive, patient selection for these procedures should be carefully considered in terms of oncologic safety. In particular, in order to maintain pyloric cuff function with PPG, lymph nodes at the suprapyloric and infrapyloric stations may be incompletely dissected due to preservation of the right gastric artery, the infrapyloric artery, and the hepatic and pyloric branches of the vagus nerves[9-11].

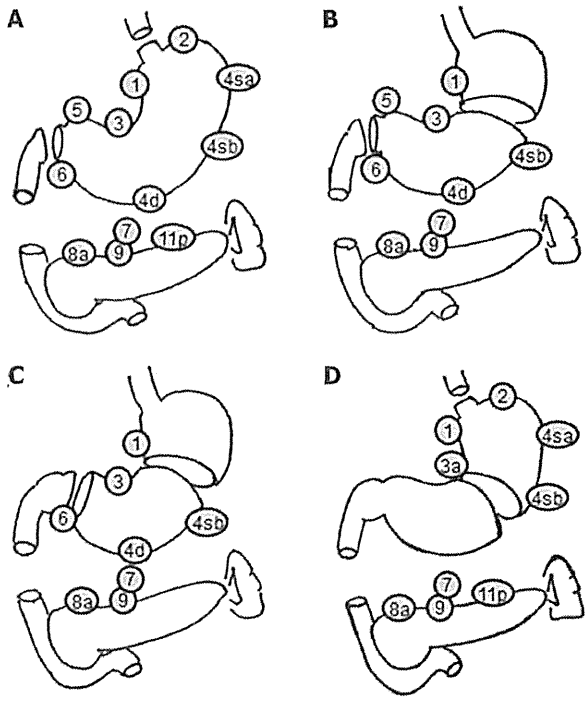

Figure 1 Extent of D1+ lymph node dissection in pylorus-preserving gastrectomy and proximal gastrectomy. A: Total gastrectomy; B: Distal gastrectomy; C: Pylorus-preserving gastrectomy; D: Proximal gastrectomy. The number of lymph node stations is according to the classification of the Japanese Gastric Cancer Association.

In general, PPG is performed in patients who are preoperatively diagnosed with cT1N0M0 primary GC in the middle third of the stomach when the distal border of the tumor is approximately 4-5 cm away from the pylorus[9-12]. This indication is based on the incidence of lymph node metastasis in patients who have undergone conventional gastrectomy[13-16].

Kim *et al*[17] reported that the incidence of lymph node metastasis at the suprapyloric and infrapyloric stations in EGC located in the middle third of the stomach after PPG and conventional DG was 0.45% (1/220) and 0.45% (1/220), respectively. In addition, Kong *et al*[18] showed that the incidence of lymph node metastasis at the suprapyloric and infrapyloric stations in EGC located ≥ 5 cm from the pylorus was 0.46% (1/219) and 0.90% (2/221), respectively. Both studies also found that the mean number of suprapyloric lymph nodes dissected was significantly lower after PPG than that with conventional DG, but no significant difference was found for infrapyloric lymph nodes. However, incomplete dissection of lymph nodes at the suprapyloric station is considered acceptable because of the low incidence of metastasis. Therefore, patients who are clinically diagnosed with T1N0 disease

Table 1 Postoperative symptomatic outcomes after pylorus-preserving surgery

Ref.	Procedure	No. of patients	Endoscopic findings (%)				Symptom (%)			Change of body weight (%)
			Esophagitis	Food residue	Bile reflux	Gastritis	Reflux	Fullness	Dumping	
Matsuki *et al*[21], 2012	PPG	433	11	19	3	11	6	2		94
Morita *et al*[24], 2013	PPG	408	6	28	12	10	6	9	4	92
Ikeguchi *et al*[25], 2010	PPG	24	35	71			0	4	0	97
	DG-B1	30	26	16			3	10	10	90
Park do *et al*[26], 2008	PPG	22			0	0	32	32		
	DG-B1	17			25	17	46	40		
Nunobe *et al*[27], 2007	PPG	194	6	22	7	12	7	10		93.9
	DG-B1	203	2	13	8	8	6	13		90.2
Tomita *et al*[28], 2003	PPG	10	0	60		10	0	40	0	94.3
	DG-B1	22	23	18		64	68	18	23	91.3
Yamaguchi *et al*[29], 2004	PPG	28		61		28	20	44	12	94.6
	DG-B1	58		33		57	27	36	36	91.3
Nakane *et al*[30], 2000	PPG	25	4	56	4	8	4	35	0	90
	DG-B1	25	8	36	40	68	0	0	4	93

PPG: Pylorus-preserving surgery; DG: Distal gastrectomy; B1: Billroth-I reconstruction.

could be candidates for PPG without suprapyloric lymph node dissection.

The five-year survival rate after PPG with modified D2 lymph node dissection ranges from 95% to 98%[10,11,19-21]. This rate is comparable to the five-year survival rate after gastric resection for EGC, which ranges from 90% to 98%[2,22,23]. In terms of oncologic safety, PPG seems reasonably safe for EGC when the accuracy of preoperative diagnosis can be assured.

POSTOPERATIVE SYMPTOMATIC OUTCOMES AFTER PPG

The advantage of PPG is the prevention of post-gastrectomy symptoms such as dumping syndrome and bile reflux gastritis, as well as reduced frequency of flatus. As shown in Table 1, the ratio of dumping syndrome and bile reflux gastritis was quite low in PPG compared to DG. However, delayed gastric emptying (DGE) after PPG resulting in patient-reported gastric fullness could be a disadvantage of PPG[21,24-30], which make PPG inappropriate in elderly patients and those with hiatus hernia or esophagitis[29,30]. The incidence of gastric stasis after PPG based on endoscopic studies ranges from 19% to 70%, compared to 13% to 36% after DG. Michiura *et al*[31] showed that food intake along with DGE was improved with time. Moreover, the reservoir function of the remnant stomach may promote better body weight (BW) recovery after PPG than after DG with Billroth I reconstruction[21,24,25,27,28].

Preserving the vagal nerve and the infrapyloric artery is thought to prevent gastric stasis[10,32,33], although these techniques have not been evaluated in randomized clinical trials. The length of the pyloric cuff is another important factor with regards to preservation of pyloric function. Nakane *et al*[34] reported that retaining a pyloric cuff of 2.5 cm results in a lower incidence of postoperative stasis compared to retaining a pyloric cuff of 1.5 cm as severe postoperative edema of the pyloric cuff might affect gastric wall motility after PPG. Morita *et al*[24] showed that retaining a pyloric cuff over 3 cm did not affect the incidence of postoperative stasis compared to retaining a pyloric cuff of less than 3 cm. At Japanese institutions, the retained pyloric cuff is usually between 2 and 4 cm[8,35]. Moreover, Hiki *et al*[6] argued that the infrapyloric and right gastric veins should be preserved to maintain blood flow in order to prevent postoperative edema of the pyloric cuff. Complete dissection of both veins could induce severe edema of the pyloric cuff, resulting in long-term postoperative retention of food in the residual stomach.

PG

The incidence of proximal GC has increased in recent years[36]. Total gastrectomy (TG) and PG with lymph node dissection are both performed for EGC located in the upper third of the stomach (U-EGC). In a retrospective study of Japanese institutions, Takiguchi *et al*[37] found that a quarter of the 586 patients with U-EGC underwent PG.

PG is generally thought to offer advantages over conventional TG with Roux-en-Y reconstruction in terms of retention of food in the remnant stomach. On the other hand, heartburn or gastric fullness due to esophageal reflux or gastric stasis is a potential disadvantage. However, these advantages and disadvantages depend on the reconstruction method used.

During the procedure, all regional nodes except the splenic hilar nodes (No. 10), the distal splenic nodes (No. 11d), the suprapyloric nodes (No. 5), and the infrapyloric nodes (No. 6) are dissected, although the dissection of the distal lesser curvature nodes (No. 3) and the right gastroepiploic artery (No. 4d) is incomplete. The hepatic and pyloric branches of the vagal nerve are preserved to

Table 2 Postoperative symptomatic outcomes after proximal gastrectomy

Ref.	Procedure	No. of patients	Endoscopic findings (%)			Symptom (%)			Change of body weight (%)
			Esophagitis	Stenosis	Food residue	Reflux	Fullness	Dumping	
Masuzawa *et al*[41], 2014	PG-EG	49				18	16	0	87
	PG-JI	32				16	0	0	86
	TG-RY	122				12	3	8	85
Nozaki *et al*[42], 2013	PG-JI	102	3		32				88
	TG-RY	49	2						86
Katai *et al*[43], 2010	PG-JI	128	2		9	6		3	88.9
Katai *et al*[44], 2003	PG-JI	45	0			4		9	88.5
Tokunaga *et al*[45], 2008	PG-EG	36	30						
	short-PG-JI	18	9						
	long-PG-JI	22	0						
Ahn *et al*[46], 2013	LAPG-EG	50	32	12					
	LATG-RY	81	4	5					
An *et al*[47], 2008	PG-EG	89	29	38					86.4
	TG-RY	334	2	7					87.4
Yoo *et al*[48], 2004	PG-EG	74	16	35					
	TG-RY	185	1	8					
Tokunaga *et al*[50], 2009	PG-EG	38				8	3		86
	PG-JI	45				9	22		86
Ahn *et al*[52], 2013	LAPG-EG	50		8		32			94
	LAPG-DT	43		5	49	5		12	96.3
Nomura *et al*[53], 2014	PG-JI	10	10			0	30		91.2
	PG-DT	10	10			10	20		87.1

LAPG: Laparoscopy-assisted proximal gastrectomy; LATG: Laparoscopy-assisted total gastrectomy; PG: Proximal gastrectomy; TG: Total gastrectomy; EG: Esophagogastrostomy reconstruction; RY: Roux-en-Y reconstruction; JI: Jejunal interposition reconstruction; DT: Double tract reconstruction.

maintain the function of the remnant stomach and pylorus as in PPG[7].

INDICATIONS AND ONCOLOGIC SAFETY OF PG

In general, to maintain both curability and functional capacity of the remnant stomach, PG is performed in patients who are preoperatively diagnosed with cT1N0M0 primary GC in the upper third of the stomach when at least half of the stomach can be preserved[38].

In patients undergoing PG, the lymph nodes in the lesser curvature (No. 3) and near the right gastroepiploic artery (No. 4d) are incompletely dissected. Thus, the surgical curability of GC may be lower with PG than with TG. However, Ooki *et al*[39] reported that proximal GC confined to the muscularis propria (mp) is not associated with lymph node metastasis at the right gastroepiploic artery (No. 4d), suprapyloric (No. 5), or infrapyloric (No. 6) stations. Sasako *et al*[40] reported that after curative gastrectomy, lymph node metastasis occurs at the suprapyloric and infrapyloric stations in patients with GC located in the upper third of the stomach in approximately 3% and 7% of cases, respectively. Although these percentages seem high, approximately half of the patients had T2 or more advanced GC and the incidence of metastasis may be lower in patients with EGC. Therefore, patients who are clinically diagnosed with T1N0 disease could be candidates for PG without dissection of the right gastroepiploic artery, suprapyloric, and infrapyloric lymph nodes.

The five-year survival rate after PG ranges from 90.5% to 98.5%[41-47]. Some studies have demonstrated that PG confers a survival benefit comparable to that of TG, the standard procedure for GC located in the upper third of the stomach[41,46-48]. Therefore, PG seems oncologically safe for EGC.

POSTOPERATIVE SYMPTOMATIC OUTCOMES AFTER PG

PG is generally thought to offer several advantages over conventional TG with Roux-en-Y reconstruction (Table 2). Ichikawa *et al*[49] reported that reduced food intake volume occurred less often in patients who underwent PG compared to TG. Masuzawa *et al*[41] reported that postoperative nutritional status as analyzed by blood tests such as serum albumin and hemoglobin was better after PG than TG. However, no studies have shown a superior outcome with PG as compared to TG in terms of postoperative BW, with the exception of one study which compared PG with jejunal interposition (JI) for reconstruction and TG at one year after surgery[41,42,47]. Moreover, compared to TG, PG was associated with a much higher rate of complications such as heartburn and anastomotic stenosis, which led An *et al*[47] to conclude that PG is not a better option for U-EGC than TG[46]. However, the reconstruction method was limited to esophagogastrostomy (EG) in these reports which did not demonstrate that PG was better. Therefore, the evaluation of other reconstruction methods is necessary.

Currently, three procedures, TG with Roux-en-Y reconstruction (TG-RY), PG-EG, and PG-JI, are widely

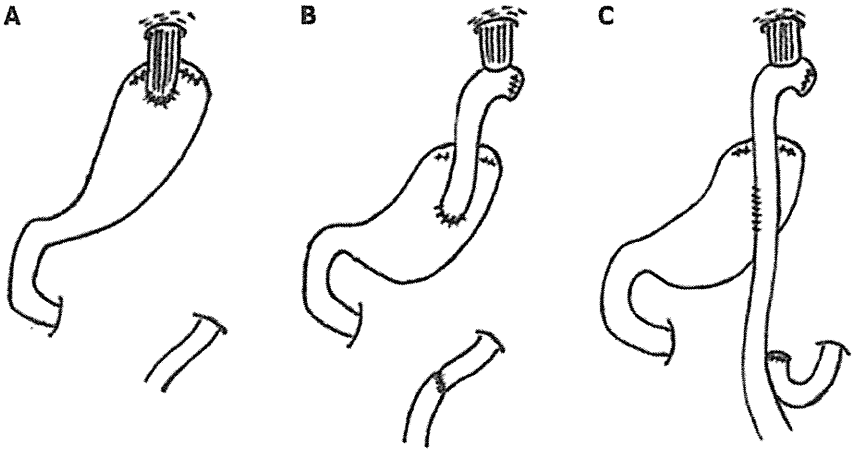

Figure 2 Reconstruction methods after proximal gastrectomy. A: Esophagogastrostomy; B: Jejunum interposition; C: Double tract.

Table 3 Comparison of the reconstruction methods after proximal gastrectomy

	PG-EG	PG-JI	PG-DT
Advantage	Short operation time	Low incidence of reflux esophagitis	Low incidence of reflux esophagitis Low incidence of DGE
Disadvantage	High incidence of reflux esophagitis High incidence of anastomotic stenosis	Long operation time High incidence of DGE	Long operation time Sometimes difficult for endoscopic evaluation of remnant stomach

PG: Proximal gastrectomy; EG: Esophagogastrostomy reconstruction; JI: Jejunal interposition reconstruction; DT: Double tract reconstruction; DGE: Delayed gastric emptying.

used to treat U-EGC in Japan (Figure 2, Table 3)[37]. Double tract (DT) reconstruction and jejunal pouch reconstruction have also been used in a small number of patients. A survey of Japanese institutions regarding reconstruction methods after PG showed that the most frequently used method was EG (48%), followed by JI (28%), DT (13%), and pouch reconstruction (7%)[35].

PG-EG is the simplest procedure since there is a single anastomotic site, but it is associated with a high incidence of reflux esophagitis[46,47]. PG-JI may prevent regurgitation of the gastric contents, resulting in a lower incidence of reflux esophagitis, but the procedure is slightly complicated. Several studies have compared the postoperative outcomes of PG-EG and PG-JI. The incidence of esophageal reflux as evaluated by endoscopic findings and symptoms was reported to be lower after PG-JI compared to PG-EG[41,45]. However, the questionnaire conducted by Tokunaga *et al*[50] showed that abdominal fullness was more frequently observed after PG-JI than after PG-EG, because the interposed jejunum may prevent the smooth passage of food. The length of interposed jejunum is important in preventing esophageal reflux, but a longer length may induce abdominal fullness.

The other important problem after PG is remnant GC (RGC). Ohyama *et al*[51] reported that RGC was observed in 5% of 316 patients after PG. They also showed that advanced RGC was more likely in patients after PG-JI with a longer length of interposed jejunum (> 15 cm) or PG-DT, and cancer-related death was only observed in patients who underwent these reconstruction methods. Tokunaga *et al*[45] reported that endoscopic evaluation of the remnant stomach could not be performed in 50% of patients after PG-JI with interposed jejunum > 10 cm, compared to 22% in patients after PG-JI with interposed jejunum ≤ 10 cm. They concluded that a length of 10 cm or shorter is preferable for endoscopic evaluation of the remnant stomach. The type of reconstruction chosen after PG should facilitate postoperative endoscopic examinations for early detection and treatment of RGC.

PG-DT has been attempted to improve postoperative outcomes after PG. PG-DT has three anastomotic sites; esophagojejunostomy, jejunogastrostomy and jejunojejunostomy. The length of interposed jejunum is from 10 to 20 cm between esophagojejunostomy and jejunogastrostomy, and about 20 cm between jejunogastrostomy and jejunojejunostomy. Food passes through the remnant stomach or the jejunum by two routes in PG-DT. PG-DT is thought to offer the same advantages as PG-JI, including the prevention of esophageal reflux, but it is expected to be better than PG-JI with regards to DGE, because an alternative route for food exists if DGE occurs. Only a few studies have analyzed postoperative outcomes after PG-DT. Ahn *et al*[52] evaluated postoperative complications after PG-DT compared to PG-EG; they concluded that PG-DT is a feasible, simple, and novel method. They showed that the incidence of anastomotic stenosis and reflux symptoms was lower after PG-DT than PG-EG and BW was better maintained. Nomura *et al*[53] evaluated

postoperative outcomes after PG-DT *vs* PG-JI. Although their study had a small sample size, they showed that the BW ratio was significantly higher in the PG-JI group than in the PG-DT group. The incidence of esophageal reflux was 10% in both groups. Further studies are needed to assess the clinical utility of PG-DT.

CONCLUSION

Function-preserving surgery has already been performed in some of the high volume institutions in Japan and South Korea, and it seems to be useful in terms of postoperative quality of life and oncologic safety. However, indications should be carefully considered, because function-preserving surgery usually involves less extensive procedures, resulting in the possibility of inadequate treatment for more deeply invasive tumors. Preoperative evaluation is very important in selecting the appropriate candidates for function-preserving surgery.

Laparoscopy-assisted PPG and PG has several advantages over conventional PPG and PG in terms of reduced intraoperative blood loss, postoperative pain and fast recovery from invasive surgery[54,55]. Since some studies reported that the oncological curability was assured[33,56,57], laparoscopic function-preserving gastrectomy is considered to be feasible by surgeons with sufficient experience in laparoscopic gastrectomy.

Many retrospective studies have shown the usefulness of function-preserving surgery, but there has been no consensus to adopt function-preserving surgery as the standard of surgery. To establish function-preserving surgery as the gold standard for patients with EGC, prospective randomized controlled trials that compare PPG or PG with conventional gastrectomy and evaluate survival and postoperative quality of life are necessary.

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ORIGINAL ARTICLE

Feasibility of laparoscopy-assisted total gastrectomy in patients with clinical stage I gastric cancer

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Abstract
Background Laparoscopy-assisted total gastrectomy (LATG) for gastric cancer is not yet widespread because of the technical difficulty of reconstruction. We have performed LATG on 100 patients with clinical stage I gastric cancer. This study investigated the short-term outcomes of LATG.
Methods Between September 2001 and September 2012, 100 patients with clinical stage I gastric cancer underwent LATG with D1 plus beta or D2 lymphadenectomy. Roux-en-Y esophagojejunostomy was performed intracorporeally using end-to-side anastomosis with a circular stapler (the purse-string suture method). The primary endpoint was the proportion of postoperative complications during hospitalization.
Results Mean operation time was 249 min; mean blood loss was 182 ml. There were no conversions to open surgery. According to the Clavien–Dindo classification, there were 8 grade II (8 %) and 10 grade IIIa/b (10 %) complications. There were no treatment-related deaths or grade IV complications. The most frequent complication was anastomotic or stump leakage (6 %), followed by pancreatic fistula (5 %). Reoperations were required in two patients with leakage.
Conclusions The short-term outcomes of LATG in our study involving 100 patients were outlined. LATG for gastric cancer patients should be attempted preferably in a clinical trial setting by surgeons with sufficient experience in laparoscopic gastrectomy.

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Keywords LATG · LTG · Laparoscopic · Purse-string suture

Introduction

The feasibility of laparoscopy-assisted distal gastrectomy (LADG) has been assessed in many studies [1–3]. A multicenter phase II study has demonstrated that LADG can be performed safely by surgeons with sufficient experience [4]. Large-scale phase III trials of LADG versus open distal gastrectomy for clinical stage I gastric cancer are now ongoing in Japan and Korea. Although long-term outcomes have not yet been evaluated, LADG has recently become a common surgical procedure in both countries.

Nevertheless, laparoscopy-assisted total gastrectomy (LATG) is not yet widespread. The reconstruction required in LATG is technically much more difficult than that in LADG. Only a few Korean studies have evaluated the feasibility of LATG with more than 100 patients [5, 6], so the safety of LATG is still controversial. We have performed LATG with the purse-string suture anastomosis on 100 patients with clinical stage I gastric cancer. This is the first Japanese study involving 100 patients to evaluate short-term outcomes after LATG.

Methods

Patients

Between September 2001 and September 2012, 110 consecutive patients with clinical stage I (T1N0M0, T1N1M0,

and T2N0M0) gastric cancer underwent LATG at the Osaka University Hospital. Cases of stump carcinoma were excluded from this study. Because 10 of 110 cases underwent the OrVil method or the overlap method (side-to-side anastomosis with a linear stapler) anastomosis, we analyzed only 100 cases with the purse-string suture anastomosis in this study. Clinical evaluation of tumor depth (cT) and lymph node metastasis (cN) were determined by preoperative evaluations with both endoscopy and computed tomography. The details of the methods for preoperative T staging have been reported elsewhere [7]. All tumors were histologically diagnosed as adenocarcinoma of the stomach. Clinical stage was classified according to the Japanese Classification of Gastric Carcinoma, second English edition [8]. Informed consent for LATG was obtained from all patients before surgery.

Surgery

Surgeons performed LATG and lymph node dissection according to the Japanese Gastric Cancer Treatment Guidelines in principle [9]. Patients with cT1 carcinoma underwent D1 plus beta dissection, including station nos. 7, 8a, and 9. Patients with cT2 disease underwent D2 or D2 minus splenic hilum node (station no. 10). D2 minus station no. 10 was treated as D1 plus beta in this study.

For reconstruction, Roux-en-Y esophagojejunostomy was performed with the purse-string suture method as previously reported [10]. In brief, the esophageal stump was sewn over with interrupted sutures laparoscopically or by using a device called the Endostich, and the anvil of a circular stapler was inserted into the esophageal stump. The purse-string suture was tied and reinforced with a monofilament pre-tied loop. A circular stapler inserted into the distal side of the jejunum was introduced into the abdominal cavity through the minilaparotomy site, and esophagojejunostomy was performed. Anastomotic leaks were evaluated using air insufflation.

All operations were performed or supervised by surgeons with sufficient experience with laparoscopic gastrectomies and who were certified by the Japan Society for Endoscopic Surgery.

Statistical analysis

The primary endpoint of this study was the incidence of postoperative complications during hospitalization. The grading of complications was based on the Clavien–Dindo classification system [11]. All statistical analyses were performed using SPSS Statistics software, version 20 (Chicago, IL, USA).

Results

The background characteristics of the 100 patients in this study are shown in Table 1. Ninety percent of patients were diagnosed as cT1. Only 6 patients (6 %) had clinically positive lymph nodes.

Surgical results are shown in Table 2. D1 plus beta dissection was performed in 95 cases (95 %) and D2 in 5 cases (5 %). All patients received Roux-en-Y reconstruction. Mean operation time was 249 min and mean blood loss was 182 ml. No patients required conversion to open surgery. Two of 7 patients who received splenectomy did so because of either preoperative comorbidity of thrombocytopenia or intraoperative bleeding from the splenic vein.

Table 3 lists the postoperative complications that occurred during hospitalization. Clavien–Dindo grade II complications occurred in eight patients (8 %) whereas those of grade IIIa/b occurred in ten patients (10 %). There were no treatment-related deaths or grade IV complications. The most frequent complication was anastomotic or stump leakage (6 %), followed by pancreatic fistula (5 %). Among the six leakage cases, four occurred in the esophagojejunal anastomosis, one in the duodenum stump, and one in the duodenum stump and the distal side of the jejunum stump. No patients suffered from anastomotic stricture. Reoperations were required in two patients with leakage.

Table 1 Clinical characteristics

	$n = 100$
Age (years)	
Median	63
Range	29–85
Gender	
Male	75 (75 %)
Female	25 (25 %)
Body mass index (kg/m^2)	
Median	22.5
Range	16.2–28.0
Clinical T	
T1	90 (90 %)
T2	10 (10 %)
Clinical N	
N0	94 (94 %)
N1	6 (6 %)
Clinical stage	
IA	84 (84 %)
IB	16 (16 %)

Clinical TNM stages were classified according to the Japanese Classification of Gastric Carcinoma, second English edition

Table 2 Surgical results

	$n = 100$
Lymph node dissection	
D1 plus beta[a]	95 (95 %)
D2	5 (5 %)
Combined resection	
Spleen	7 (7 %)
Gallbladder	6 (6 %)
Operation time (min)	
Mean ± SD	249 ± 47
Blood loss (ml)	
Mean ± SD	182 ± 183
Number of dissected lymph nodes	
Mean ± SD	38 ± 16

[a] D2 minus station no. 10 was treated as D1 plus beta in this study

Table 3 Postoperative complications

	$n = 100$
Any complications	
Grade II	8 (8 %)
Grade IIIa/b	10 (10 %)
Leakage	
Grade II	0
Grade IIIa/b	6 (6 %)
Pancreatic fistula	
Grade II	1 (1 %)
Grade IIIa/b	5 (5 %)
Bleeding	
Grade II	4 (4 %)
Grade IIIa/b	0
Pneumonia	
Grade II	4 (4 %)
Grade IIIa/b	0
Bowel obstruction	
Grade II	2 (2 %)
Grade IIIa/b	0
Reoperation	2 (2 %)

Grading of complications was based on the Clavien–Dindo classification

Discussion

Laparoscopy-assisted total gastrectomy is still not widespread because of the technical difficulty of the reconstruction. Several reports have been issued on the feasibility of LATG, but only a few Korean studies have evaluated the feasibility of LATG in populations of more than 100 patients [5, 6]. We have performed LATG with the purse-string suture anastomosis in 100 patients with clinical stage I gastric cancer. Compared with the previous Korean studies and a small-scale Japanese study evaluating the safety of LATG [5, 6, 12, 13], we were able to perform LATG with more favorable surgical results in terms of operation time. Regarding the incidence of postoperative complications, our study showed better or similar results compared to previous studies of LATG. The incidence of anastomotic leakage in our study was 6 % (6/100), including 1 case of duodenum stump leakage and 1 case of leakage of the duodenum stump and the distal side of the jejunum stump. Previous randomized controlled studies have reported that incidence rates of anastomotic leakage after open total gastrectomy ranged from 3.8 % to 6.8 % [14–16]. Nomura et al. [17] reported the result of a retrospective large-scale study of open total gastrectomy. Although they reported the esophagojejunal leakage rate after stapled anastomosis as 1.0 % using only the data of the recent 6 years, the overall incidence of esophagojejunal anastomosis leakage was 2.9 % (27/943). Indeed, our result of the incidence of esophagojejunal anastomosis leakage (4.0 %) was slightly higher than their result, so we think we should continue to make efforts for reducing the complication rate.

In this study we used only the purse-string suture anastomosis method. The purse-string suture method is simple and is similar to the anastomosis method in open total gastrectomy. The safety of this method has been already reported by other institutions [18, 19]. It requires fewer devices and costs less, and has the advantage of only rarely causing stenosis. Besides the purse-string suture method, two anastomosis methods (the OrVil method and the overlap method) have been reported as useful anastomosis procedures in LATG [20–23]. Although we have performed LATG with the OrVil method or the overlap method for ten cases outside this study, the incidence of anastomotic leakage of grade IIIa/b was 30 % (3/10). The reason for this high incidence was considered to be the inexperience of the surgeons with these methods. These methods might be safer if they were performed more frequently, thus increasing our overall level of expertise.

The risk of postoperative complications is affected by the skill of each individual surgeon. In our case series, six surgeons performed LATG. There was no clear difference among them in the incidence of postoperative complications. Furthermore, all operations were performed or supervised by surgeons with sufficient experience with laparoscopic gastrectomy and who were certified by the Japan Society for Endoscopic Surgery. Also, all surgeons had abundant experience with open gastrectomy. With regard to the learning curve, the incidence of postoperative complications did not show a clear decrease despite the surgeons' increasing expertise. However, in the recent 2 years (after January 2011), there was only one pancreatic

fistula and no anastomotic leakage. During this period, a fixed team of two surgeons (S.T. and Y.K.) have performed LATG in most cases. Even if the learning curves of individual surgeons do not affect the incidence of complications, a fixed team consisting of the same surgeons could perform LATG more safely.

At this point there are insufficient data concerning long-term outcomes after LATG. Several ongoing randomized control trials are comparing long-term survival between laparoscopic and open distal gastrectomy. Long-term outcomes after LATG should be also evaluated by randomized control trials to establish the possibility of a new standard for the surgical treatment of clinical stage I gastric cancer.

In conclusion, the short-term outcomes of LATG in our study involving 100 patients have been outlined. LATG for gastric cancer patients should be attempted preferably in the clinical trial setting by surgeons with sufficient experience in laparoscopic gastrectomy.

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Efficacy of Endoscopic Gastroduodenal Stenting for Gastric Outlet Obstruction due to Unresectable Advanced Gastric Cancer: A Prospective Multicenter Study

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Background and Objectives: Gastroduodenal stents for gastric outlet obstruction due to unresectable advanced gastric cancer are increasingly used; however, their effects have not been fully evaluated.
Methods: A multicenter prospective observational study was performed. Patients were eligible if they had stage IV gastric cancer with a gastric outlet obstruction scoring system (GOOSS) score of 0 (no oral intake) or 1 (liquids only). Self-expandable metallic stents were delivered endoscopically. The effects of stents were evaluated.
Results: Twenty patients were enrolled and 18 were eligible (15 men, three women; median age, 70 years). Stent placement was successfully performed in all patients, with no complications. After stenting, a GOOSS score of 2 (soft solids only) or 3 (low-residue or full diet) was achieved in 13 (72%) patients. An improvement in the GOOSS score by one or more points was obtained in 16 (94%) patients. The median duration of fasting and hospital stay was 3 (range, 0–9) days and 18 (6–168) days, respectively. Chemotherapy was performed after stenting in 13 (72%) patients.
Conclusions: Gastroduodenal stents are thought to be feasible, safe, and effective for gastric outlet obstruction due to unresectable advanced gastric cancer, with rapid clinical relief and a short hospital stay.
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KEY WORDS: **gastric outlet obstruction; stomach neoplasms; stent**

INTRODUCTION

Gastric cancer is one of the most common cancers worldwide and leads to a poor prognosis. In Japan, early detection has increased the number of curative resections and diminished the number of cancer deaths. However, many cases are still detected in the unresectable advanced stage. Advanced gastric cancer often results in gastric outlet obstruction (GOO). GOO causes vomiting, nausea, weight loss, and intolerance to oral feeding, and diminishes the quality of life in these patients who have limited life expectancies. Chemotherapy is indicated for patients with unresectable advanced gastric cancer. However, it is difficult for patients with GOO to orally take S-1, which is included in the first-line regimen for unresectable gastric cancer recommended in Japanese gastric cancer treatment guidelines 2010 [1].

The treatment for GOO has traditionally been surgical gastrojejunostomy. Previously, we have reported the clinical outcome for palliative gastrojejunostomy in unresectable advanced gastric cancer, resulting in good improvement of oral food intake with acceptable morbidity and mortality [2]. However, invasiveness of surgery with general anesthesia is problematic because most of those with GOO have a poor general condition.

Currently, endoscopic placement of self-expandable metallic stents (SEMSs) is increasingly used as a less invasive method for palliative treatment of GOO caused by biliary-pancreatic malignancies. The efficacy and safety of SEMSs have been reported with an early food intake, short hospital stay, and low total hospital costs [3,4]. However, the effects of SEMSs for GOO with gastric cancer have not been fully evaluated.

In Japan, SEMSs were not common because this procedure was not included in the Japanese health insurance system. In April 2010, the Japanese payment system for medical services was revised, and endoscopic gastroduodenal stent placement for GOO due to malignancies was approved by the Japanese health insurance system.

Abbreviations: GOO, gastric outlet obstruction; SEMS, self-expandable metallic stent; OS, overall survival; UICC, the International Union Against Cancer; PS, Eastern Cooperative Oncology Group Performance Status; GOOSS, gastric outlet obstruction scoring system; BW, body weight; T, depth of tumor invasion; N, lymph node metastasis; M, distant metastasis; MST, median survival time.

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In this study, we aimed to prospectively evaluate the effect of SEMSs on the rate of improvement of clinical symptoms in patients with GOO due to unresectable advanced gastric cancer. Additional aims were to study the feasibility, complications, duration of fasting after stenting, duration of the hospital stay, feasibility of chemotherapy after stenting, need for re-intervention, and overall survival (OS). This is the first prospective multicenter study to evaluate the effects of SEMSs for GOO due to advanced gastric cancer.

MATERIALS AND METHODS

Patients and Data Retrieval

This prospective multicenter clinical trial was carried out at 11 institutions belonging to the Clinical Study Group of Osaka University, Upper GI Group between February 2011 and January 2013. Eligibility criteria for participation included the following: non-surgically treated patients with histologically diagnosed primary gastric adenocarcinoma, which was not estimated to be curatively resectable by clinical examinations, with clinical cancer stage IV according to the International Union Against Cancer (UICC) TNM classification (7th edition) [5]; aged equal to or older than 20 years; aged equal to or younger than 90 years; with an Eastern Cooperative Oncology Group Performance Status (PS) score of 0–2 [6]; with a GOO scoring system (GOOSS) score of 0 or 1 [7]; and considered to be alive for more than 3 months. Patients with GOO due to recurrent cancer, with active bleeding from the tumor, who could not receive an endoscopic examination, with additional obstruction of the oral side of the stomach, with additional obstruction of the small or large intestine, who had already undergone SEMS placement, who could not answer the questionnaire about quality of life, or who were considered inappropriate for participants, were excluded. The presence of duodenal invasion was not excluded.

The institutional review board of each hospital approved the protocol. All participants provided written informed consent. This study was performed by the Clinical Study Group of Osaka University, Upper GI Group, which conducted investigator-initiated trials and was composed of hospitals affiliated from the Department of Gastroenterological Surgery, Osaka University Graduate School of Medicine. The data center, located at the Multicenter Clinical Study Group at the Department of Gastroenterological Surgery, Osaka University Graduate School of Medicine, was responsible for central monitoring and statistical analyses under supervision of the statistician in charge.

Procedures

Endoscopic stent placement was performed using the Wallflex™ duodenal stent (Boston Scientific, Natick, MA) under conscious sedation. It is an uncovered-SEMS with a diameter of 22 mm at the mid-body, and 60, 90, or 120 mm long depending on the case. After a guidewire was correctly positioned distal to the stricture, a stent catheter was advanced over the wire through the working channel of a therapeutic endoscope and the stent was released under fluoroscopic control.

Outcomes and Definitions

The primary outcome was an improvement in the ability to tolerate an oral solid diet after stenting as assessed by the GOOSS score. Secondary outcomes included the technical success rate, complications, the duration of post-interventional fasting, the duration of the post-interventional hospital stay, the feasibility of chemotherapy after stenting, the need for re-intervention, and OS.

Food intake was assessed by the standardized GOOSS score as follows: 0 = no oral intake, 1 = liquids only, 2 = soft solids, and 3 = almost complete or full diet [7]. The ability to take a solid diet was indicated by a GOOSS score of 2 or 3. Technical success was defined as deployment of the SEMS across the stricture, with patency visualized both fluoroscopically and endoscopically. Complications were defined as any adverse event related to SEMS placement, such as bleeding, perforation, and jaundice.

Sample Size and Data Analysis

A sample size of 20 patients had been planned when the trial was designed, considering that the number of GOO cases due to gastric cancer in the institutions of the Clinical Study Group of Osaka University, Upper GI Group was approximately 60 per year. The projected accrual period was 2 years.

The following parameters were collected and analyzed: sex, age, GOOSS score, body weight (BW), height, PS, albumin levels, total lymphocyte count, hemoglobin levels, previous chemotherapy, tumor location, macroscopic tumor type, depth of tumor invasion (T), lymph node metastasis (N), and distant metastasis (M) according to the Japanese classification of gastric carcinoma (3rd English edition) [8]. Interventional outcomes and complications were collected. GOOSS scores, BW, PS, albumin levels, lymphocyte count, and hemoglobin levels, at 1, 2, and 4 weeks, and every other 4 weeks after stenting, were recorded until the 24th week. The date of the start of oral intake, the date of hospital discharge, post-interventional therapy, including re-stenting, surgery, and chemotherapy, and the date and causes of death were also recorded. The survival time was defined as the duration from the date of stenting to death.

Statistical Analysis

Differences in parameters after stenting were compared with baseline (pre-interventional) values by the Wilcoxon signed-ranks test. P values were derived from two-tailed tests, and differences were considered significant at $P < 0.05$. Analyses were performed using StatView® software (version 5.0 for Macintosh; SAS Institute Inc., Cary, NC).

RESULTS

Patients' Characteristics

Twenty patients from six institutions were enrolled between March 2011 and July 2012. One patient with a GOOSS score of 2 and one patient with cancer stage IIIB were excluded. Therefore, the clinical data of 18 patients were retrieved and analyzed in this study. The clinical characteristics of the 18 patients are summarized in Table I.

Outcome of Stent Placement

SEMS placement was technically successful in all cases, and no complications were encountered. The ability to take solid food orally was achieved by 13 (72%) patients, in whom six had a GOO score of 2 and seven had a GOOSS score of 3. The remaining five patients who could not take solid food included three patients whose GOOSS score improved from 0 to 1, one patient whose GOOSS score remained as 0, and one patient who died within 1 week after stenting. A total of 16 (94%) out of 17 patients showed an improvement of the GOOSS score. The mean GOOSS scores were 1.7, 1.9, 1.8, 1.8, 1.8, 2.1, 2.3, and 2.2, at 1, 2, 4, 8, 12, 16, 20, and 24 weeks after stenting, respectively. The change in GOOSS scores by the post-stenting week is shown in Figure 1. The median duration of post-stenting fasting was 3 (range, 0–9 days) days. The median duration of hospitalization was 18 (6–168 days) days

TABLE I. Clinical Features of Patients Who Underwent Endoscopic Gastroduodenal Stent Placement for Gastric Outlet Obstruction Due to Unresectable Advanced Gastric Cancer

Variables		
Sex	Male/female	15/3
Age	(Year)	70 (48–90)*
GOOSS score	0/1	10/8
Body weight	(kg)	48 (29–71)*
Body mass index	(kg/m^2)	18.8 (13.1–22.9)*
PS	0/1/2	5/6/7
Albumin	(g/dl)	2.7 (1.7–3.8)*
Lymphocyte	(/mm^3)	1068 (602–1,657)*
Hemoglobin	(g/dl)	9.1 (6.6–13.5)*
Pre-interventional chemotherapy	+/−	8/10
Tumor location	L/ML/UML	14/3/1
Tumor type	2/3/4	4/8/6
Depth of tumor invasion (T)	3/4a/4b	3/10/5
Lymph node metastasis (N)	1/2/3a/3b/X	3/4/9/1/1

PS, Eastern Cooperative Oncology Group Performance Status score; GOOSS, gastric outlet obstruction scoring system; Tumor location, Tumor type, T, and N are written according to the Japanese Classification of Gastric Carcinoma the 3rd English edition; *, median (range).

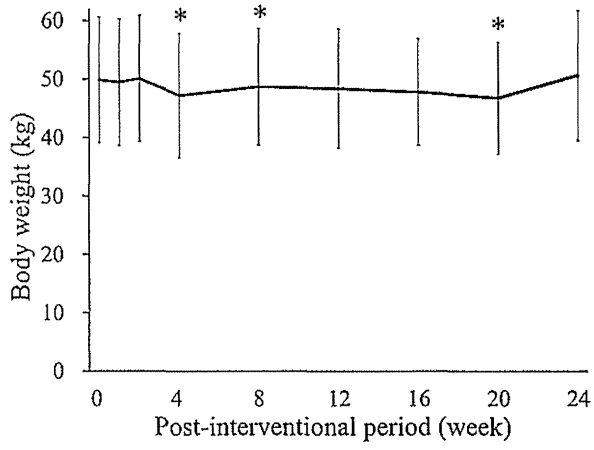

Fig. 2. Changes in the mean body weight at baseline (0) and during follow-up after stenting. Body weight after re-intervention was not included. Bars represent the standard deviation. Asterisks represent significant differences ($P < 0.05$) compared with baseline values using the Wilcoxon signed-ranks tests.

after stenting. Post-stenting chemotherapy was provided to 13 (72%) patients, including 10 patients with an S-1-containing regimen.

Additional therapy included re-stenting in two patients, surgical gastrojejunostomy in three patients, and gastrectomy in one patient. Two patients who could eat solid food after stenting, but then returned to no oral intake because of re-obstruction, received additional SEMS placement on the 105th and 126th post-stenting day, which resulted in good oral intake of solid food. One patient with development of re-obstruction after stenting could take solid food after gastrojejunostomy on the 69th post-stenting day. One patient with inadequate improvement of GOO after stenting could not eat solid food after gastrojejunostomy on the 45th post-stenting day. The other patient who could take solid food after stenting and developed tumor perforation after chemotherapy underwent surgery for peritonitis and gastrojejunostomy on the 165th postoperative day. A patient who had GOO and peritoneal metastasis due to gastric cancer underwent SEMS placement and received chemotherapy with S-1, cisplatin, and trastuzumab. Curative gastrectomy could be performed on the 76th post-stenting day because the peritoneal metastasis disappeared after two cycles of the regimen. The cancer stage was ypT4aN3bM0 stage IIIB.

Changes in Nutritional Values and Performance Status

BW, PS, albumin levels, total lymphocyte count, and hemoglobin levels, at 1, 2, and 4 weeks, and every other 4 weeks after stenting, were recorded until the 24th week and compared with baseline values. BW was significantly decreased at 4, 8, and 20 weeks after stenting compared with baseline, however, no significant increase in BW compared with the baseline value was observed during follow-up (Fig. 2). There were no significant changes in PS (Fig. 3), albumin levels (Fig. 4), lymphocyte count, and hemoglobin levels during the follow-up.

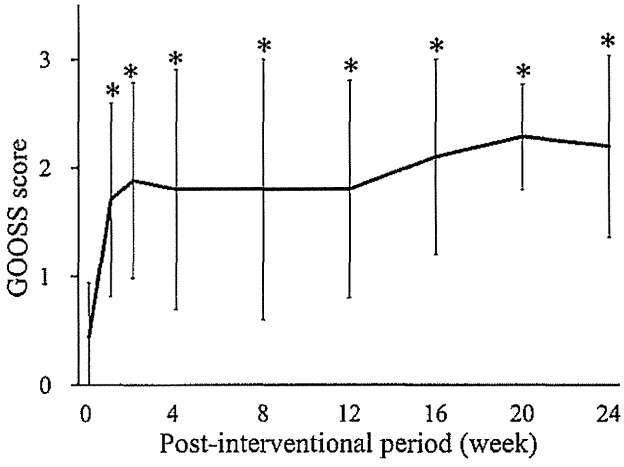

Fig. 1. Changes in the mean gastric outlet obstruction scoring system (GOOSS) score at baseline (0) and during follow-up after stenting. GOOSS scores after re-intervention were not included. Bars represent the standard deviation. Asterisks represent significant differences ($P < 0.05$) compared with baseline values using the Wilcoxon signed-ranks tests.

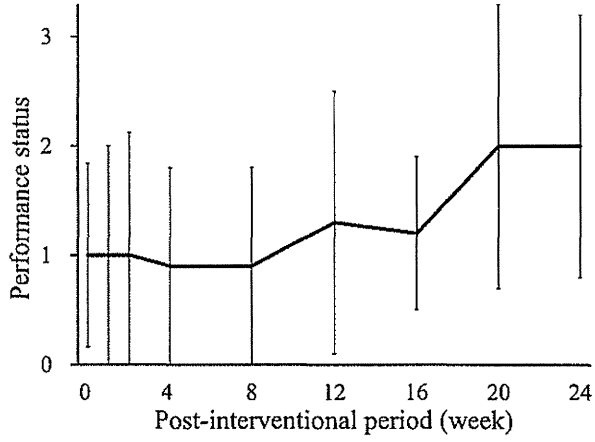

Fig. 3. Changes in the mean Eastern Cooperative Oncology Group Performance Status (PS) score at baseline (0) and during follow-up after stenting. PS scores after re-intervention were not included. Bars represent the standard deviation. There were no significant differences between baseline and post-interventional values by the Wilcoxon signed-ranks tests.

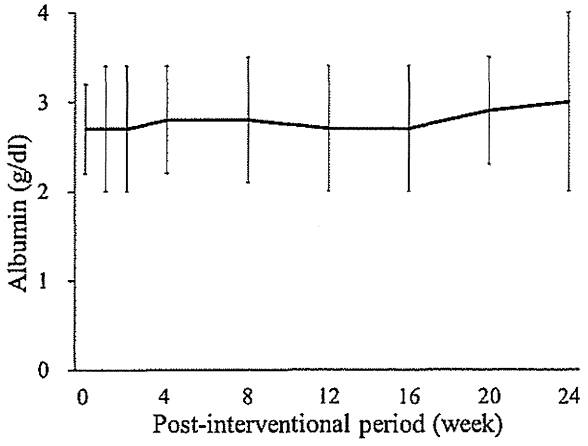

Fig. 4. Changes in the mean albumin levels at baseline (0) and during follow-up after stenting. Albumin levels after re-intervention were not included. Bars represent the standard deviation. There were no significant differences between baseline and post-interventional values by the Wilcoxon signed-ranks tests.

Overall Survival

At the time of analysis, 17 patients had died. The cause of death was gastric cancer in every case. The median survival time (MST) was 186 days and the 1-year survival rate was 11%.

DISCUSSION

The SEMS has been increasingly used for the palliation of malignant GOO, mainly due to biliary-pancreatic cancer. Some studies have reported the effects of SEMSs for GOO [3,4,9–11]. However, for the first time, we evaluated the effects of SEMSs for GOO due to advanced gastric cancer by a prospective multicenter study. We found that SEMSs in gastric cancer resulted in an acceptable improvement in oral intake with excellent technical success, without any complications.

Previous retrospective analyses concerning the effects of SEMSs for malignant GOO have reported similar clinical outcomes. Chandrasegaram et al. [4] reported that 69% and 77% patients could eat solids or puree on the 5th and 10th post-stenting days, respectively. Canena et al. [9] also reported that solid food intake (GOOSS score of 2–3) was achieved by 72% of patients within 5 days after stenting, which is similar to our study. They reported that the mean GOOSS score was 1.76 at 5 days after stenting, and 1.64 during the follow-up. Compared with these data, our patients maintained a good GOOSS score, ranging from 1.7 to 2.3 during follow-up. Although some other reports have mentioned a remarkably higher rate of clinical success with GOO, the definition of improvement of GOO differs [10–12]. An improvement of the GOOSS score by one or more points was obtained in 94% of patients in our series. However, this improvement in GOO failed to lead to improvement in nutritional parameters and general condition, including BW, PS, albumin levels, lymphocytes, and hemoglobin levels.

In the current study, five patients could not eat solid food after SEMS placement. All of them had a GOOSS score of 0 and a PS of 2. One patient died on the 6th day after stenting, and one died on the 17th day after stenting. One patient needed gastrojejunostomy, one needed central venous port placement, and the other patient did not receive any additional intervention because of a poor general condition. However, among 13 patients who could eat solid food after stenting, only two patients had a PS of 2 and the other 11 patients had a PS of 0 or 1. Considering these data, the ability to take solid food after stenting might partially depend on PS. Sasaki et al. [10] also showed that a poor PS was a poor predictive factor of solid intake. Patients with a PS of 2 would be more likely to be lying in bed, which makes oral intake difficult because advanced cancer in the stomach results in lost migration activity and patients require the assistance of gravity to let food pass through the stent. In fact, the patient with a PS of 2 who could not eat solid food after stenting could also not eat solid food after gastrojejunostomy.

The change in the GOOSS showed that GOOSS scores were maintained at approximately 2 from the 1st week to the 24th week after stenting. In Figure 1, GOOSS scores after re-intervention were not included. Four patients maintained GOOSS scores of 2–3 for 24 weeks after stenting without re-intervention, while three patients required re-intervention due to re-obstruction on the 69th, 105th, and 126th days. No et al. [12] reported that the median duration between SEMS placement for gastric cancer and the recurrence of obstructive symptoms was 125 days. Some studies, including those on gastric cancer and biliary-pancreatic malignancies, found that stent patency lasted for 4–17 months [4,9,11], although the duration of stent patency is thought to be difficult to evaluate objectively. Recurrent obstruction is caused by tumor ingrowth or overgrowth, and remains an important problem of SEMSs. Additional SEMS placement was performed for two cases in our series with good results. Recent reports have also described the effectiveness of additional SEMS insertion using a stent-in-stent procedure [4,11,12]. Additional SEMS placement may be a feasible choice for recurrent obstruction after stenting.

Chemotherapy is also expected to improve maintenance of stent patency, mainly as a result of reducing tumor ingrowth or overgrowth. In our series, chemotherapy was administered in most patients soon after stenting. Ability of oral intake of S-1 is important for treating patients with unresectable advanced gastric cancer because S-1 is a key drug for unresectable advanced gastric cancer [13]. Notably, one patient in our series with peritoneal metastasis underwent curative resection after SEMS placement and chemotherapy. Less invasiveness of endoscopic SEMS placement enabled the patient to start chemotherapy as soon as the 8th day after stenting. Furthermore, if this patient had undergone surgical gastrojejunostomy instead of SEMS placement, the next surgery of gastrectomy would have been difficult and complicated. In this patient, gastrectomy was performed without difficulty by fully mobilizing the duodenal bulbus and resecting the duodenum just distal to the SEMS. This patient showed the advantages of SEMS placement in terms of early administration of chemotherapy and the technical ease of gastrectomy when chemotherapy was effective. This patient is doing well with good oral intake for 16 months after stenting and 13 months after gastrectomy.

The MST after stenting was 186 days, which is compatible with that in a recent Korean report after stenting for gastric cancer (189 days) [12]. For patients who underwent chemotherapy including the S-1 regimen, the MST was 9.1 months, which is similar to the reported MST of patients with advanced gastric cancer who underwent S-1 chemotherapy (11.0 months) [13]. Therefore, the ability of chemotherapy with S-1 after stenting leads to a survival benefit.

CONCLUSIONS

We prospectively analyzed the effectiveness of endoscopic gastroduodenal SEMS placement for GOO due to unresectable advanced gastric cancer. This procedure was technically successful in every patient, and 72% of patients could eat solid food. The duration of post-interventional fasting and hospitalization was short. Gastroduodenal SEMSs are thought to be feasible, safe, and effective for GOO due to unresectable advanced gastric cancer. This palliative treatment might become the choice of treatment for GOO. A further study is being planned to compare SEMSs and gastrojejunostomy by a randomized controlled trial in our multicenter group.

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ORIGINAL ARTICLE

Postoperative gastrectomy outcomes in octogenarians with gastric cancer

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Abstract
Purpose It is controversial whether the treatment strategy for gastric cancer should be different for elderly patients. We herein evaluated the feasibility of gastrectomy and the risk factors for postoperative complications in octogenarians with gastric cancer.
Methods We retrospectively collected data on 441 consecutive patients who underwent total or subtotal gastrectomy for gastric cancer. We divided all of the patients into two groups: the octogenarian group ($n = 47$), consisting of patients aged 80–89 years, and the younger group ($n = 394$), consisting of patients under 80 years of age.
Results The postoperative complication rate was 23.1 % (91/394) in the younger group and 36.2 % (17/47) in the octogenarian group ($P = 0.049$). Octogenarian patients had significantly lower preoperative serum albumin levels ($P < 0.001$) and higher ASA scores ($P < 0.001$). Although the rate of each major complication was similar between the two groups, there was a trend toward a higher rate of other miscellaneous complications, mostly non-surgical complications, in the octogenarian group ($P = 0.077$). A multivariate analysis of the patients in the octogenarian group revealed that only total gastrectomy was a significant risk factor for postoperative complications ($P = 0.035$).
Conclusion Octogenarian patients with gastric cancer experienced more complications than younger patients. Therefore, closer monitoring is needed for octogenarian patients who will receive total gastrectomy.

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Keywords Gastric cancer · Gastrectomy · Elderly patient · Older persons · Oldest-old persons

Introduction

Gastric cancer is the second most common cancer worldwide [1]. Recent increases in the average human lifespan have resulted in an increased number of elderly patients with gastric cancer, including those who undergo surgery [2]. Surgeons need to minimize the occurrence of severe and potentially fatal complications, especially among elderly patients, most of whom are fragile due to multiple comorbidities. Some studies have reported that elderly cancer patients might not have the same opportunity for curative treatment as younger patients [3, 4]. However, the living conditions and medical care have recently been dramatically improved in many countries [5]. These changes may make it possible to perform invasive surgery safely, even in elderly patients with comorbidities [6]. Therefore, it is necessary to re-evaluate the optimal treatment strategy in elderly patients after considering their medical history and general health status.

Several studies have reported that aging is associated with the occurrence of postoperative complications after gastric cancer surgery [7–9], while other studies have reported that elderly patients can safely undergo gastrectomy [6, 10]. Thus, it is controversial whether the treatment strategy for elderly patients should be the same as that for younger patients. The risk factors for postoperative complications in elderly patients with gastric cancer remain unknown. In this study, we evaluated the feasibility of gastrectomy in octogenarians, and investigated the risk factors for postoperative complications in octogenarians with gastric cancer.

Patients and methods

We retrospectively collected data on 441 consecutive patients who underwent total or subtotal gastrectomy for gastric cancer between January 2008 and December 2011. Patients who were over 90 years old and patients who underwent concurrent surgery for synchronous malignant tumors were excluded. All tumors were histologically diagnosed as adenocarcinoma of the stomach. In principle, all patients were treated according to the Japanese Gastric Cancer Treatment Guidelines [11]. We used the 14th edition of the Japanese classification of gastric carcinoma to determine the pathological stage [12]. Postoperative complications were evaluated according to the Clavien–Dindo classification [13]. We considered complications of Grade II or higher to be postoperative complications in this study.

We divided the patients into two groups: the octogenarian group, consisting of patients aged 80–89 years, and the younger group, consisting of patients under 80 years of age. We compared the clinicopathological factors in the two groups using the Chi-squared test for categorical variables and the Mann–Whitney U test for continuous variables. Yates' correction was used for the Chi-squared test when at least one cell of the table was smaller than 5. We also evaluated which clinicopathological factors were associated with postoperative complications in the octogenarian group using a multivariate logistic regression analysis. A value of $P < 0.05$ was considered to be statistically significant. All statistical analyses were performed using the SPSS Statistics software program, version 20 (IBM Corp., Armonk, NY, USA).

Results

Of the 441 patients, 47 (10.7 %) were in the octogenarian group (Table 1). The median age was 66 years old in the younger group and 82 years old in the octogenarian group. The male to female ratio was similar between the two groups. Although the body mass index (BMI) was similar between the two groups, the octogenarian group had a significantly lower preoperative serum albumin level (median 3.5 g/dl) than the younger group (median 4.0 g/dl) ($P < 0.001$). The preoperative American Society of Anesthesiologists (ASA) score was also significantly different between the two groups ($P < 0.001$). The laparoscopic approach was used frequently in both groups, and nearly 30 % of patients underwent total gastrectomy in both groups. Regarding the distribution of the pStage, there were significantly more patients with advanced tumors in the octogenarian group ($P = 0.046$).

Table 2 compares the surgical outcomes in the younger and octogenarian groups. The volume of blood loss and the length of the operation were similar between the two groups. The proportion of patients who experienced postoperative complications was 23.1 % (91/394) in the younger group and 36.2 % (17/47) in the octogenarian group ($P = 0.049$). The most frequent complication was pancreatic fistula formation, followed by anastomotic leakage and abdominal abscess, and the rate of each major complication was similar between the two groups. Other miscellaneous complications included enterocolitis (younger 0.3 %, octogenarian 2.1 %), cholecystitis (octogenarian 2.1 %), liver dysfunction (younger 0.3 %), urinary tract infection (younger 0.3 %), massive ascites (younger 0.3 %), bacteremia (younger 0.5 %, octogenarian 2.1 %), colon perforation (younger 0.5 %), pancreatitis (younger 0.3 %), pulmonary

Table 1 Patient characteristics of the younger and octogenarian groups

Factors	Younger group ($n = 394$)	Octogenarian group ($n = 47$)	P value
Age (years)			
Median (range)	66 (29–79)	82 (80–89)	<0.001
Sex			
Male	290 (73.6 %)	34 (72.3 %)	0.85
Female	104 (26.4 %)	13 (27.7 %)	
Body mass index (kg/m^2)			
Median (range)	22.1 (12.9–31.3)	21.6 (13.3–27.4)	0.44
Serum albumin level (g/dl)			
Median (range)	4.0 (2.1–4.9)	3.5 (1.9–4.4)	<0.001
ASA score			
1	130 (33.0 %)	2 (4.3 %)	<0.001
2	237 (60.2 %)	33 (70.2 %)	
3 or 4	27 (6.9 %)	12 (25.5 %)	
Approach			
Open	119 (30.2 %)	18 (38.3 %)	0.26
Laparoscopic	275 (69.8 %)	29 (61.7 %)	
Gastrectomy			
Total	119 (30.2 %)	15 (31.9 %)	0.81
Subtotal	275 (69.8 %)	32 (68.1 %)	
Lymph node dissection			
<D2	253 (64.2 %)	29 (61.7 %)	0.74
≥D2	141 (35.8 %)	18 (38.3 %)	
pStage[a]			
I	266 (67.5 %)	24 (51.1 %)	0.046
II	70 (17.8 %)	9 (19.1 %)	
III	45 (11.4 %)	10 (21.3 %)	
IV	13 (3.3 %)	4 (8.5 %)	

ASA American Society of Anesthesiologists

[a] Pathological stage was according to the 14th edition of Japanese classification of gastric carcinoma

Table 2 Surgical outcomes of the younger and octogenarian groups

Outcomes	Younger group ($n = 394$)	Octogenarian group ($n = 47$)	P value
Blood loss (ml), median (range)	150 (10–2700)	232 (20–1650)	0.18
Operation time (min), median (range)	215 (105–570)	210 (120–346)	0.27
Postoperative complications[a]	91 (23.1 %)	17 (36.2 %)	0.049
Pancreatic fistula	23 (5.8 %)	4 (8.5 %)	0.69
Anastomotic leakage	16 (4.1 %)	3 (6.4 %)	0.72
Abdominal abscess	17 (4.3 %)	2 (4.3 %)	1.00
Bowel obstruction or ileus	13 (3.3 %)	2 (4.3 %)	1.00
Bleeding	8 (2.0 %)	1 (2.1 %)	1.00
Delayed gastric empty	7 (1.8 %)	1 (2.1 %)	1.00
Pneumonia	6 (1.5 %)	1 (2.1 %)	1.00
Other	10 (2.5 %)	4 (8.5 %)	0.077
Hospital death	1 (0.3 %)	0 (0.0 %)	1.00

[a] Postoperative complications included Grade II or higher according to the Clavien–Dindo classification. Some complications were duplicated in same patient

infarction (younger 0.3 %) and cerebral infarction (octogenarian 2.1 %). The rate of hospital death was 0.3 % (1/394) in the younger group and 0.0 % (0/47) in the octogenarian group. Among the patients who experienced a postoperative complication, the duration of the postoperative hospital stay was similar in the two groups ($P = 0.96$).

A multivariate analysis of the octogenarian group revealed that only total gastrectomy was a significant risk factor for postoperative complications (odds ratio 5.43; 95 % confidence interval 1.12–26.3; $P = 0.035$) (Table 3). There were 15 patients who underwent total gastrectomy in the octogenarian group, with eight (53.3 %) of them experiencing a complication. On the other hand, nine (28.1 %) of the 32 patients who underwent subtotal gastrectomy developed a complication.

Table 3 Multivariate logistic analysis of risk factors for postoperative complications in the octogenarian group

	Multivariate	
	Odds ratio(95 % CI)	P value
Male	1.03 (0.21–5.19)	0.97
Body mass index ≥25 kg/m^2	3.65 (0.42–31.8)	0.24
Serum albumin level <3 g/dl	3.56 (0.55–23.3)	0.18
ASA score ≥3	1.56 (0.30–8.13)	0.60
Laparoscopic approach	4.04 (0.60–27.0)	0.15
Total gastrectomy	5.43 (1.12–26.3)	0.035
Lymph node dissection ≥D2	1.46 (0.27–7.87)	0.66
pStage II–IV[a]	1.71 (0.27–11.0)	0.57

CI confidential interval, *ASA* American Society of Anesthesiologists

[a] Pathological stage was according to the 14th edition of Japanese classification of gastric carcinoma

Discussion

In this study, the proportion of patients who experienced postoperative complications in the octogenarian group was significantly higher compared to that in the younger group. The significant difference in the overall complication rate between the two groups was due to the difference in the rates of miscellaneous complications, such as enterocolitis, cholecystitis, pulmonary infarction and cerebral infarction. Indeed, octogenarian patients usually have some comorbidities and a worse nutritional status, which was consistent with the significantly lower preoperative serum albumin levels and higher ASA scores in the octogenarian group in the present study. These high-risk conditions probably contributed to some non-surgical complications after gastrectomy in the octogenarian group.

Total gastrectomy was the only significant risk factor for postoperative complications in the octogenarian group. All of the other clinicopathological factors, including the serum albumin level, extent of lymph node dissection and tumor stage did not significantly affect the occurrence of postoperative complications. More than half of the octogenarian patients who underwent total gastrectomy experienced a postoperative complication. Although there were no hospital deaths in the octogenarian group, closer monitoring is needed for octogenarian patients who will undergo total gastrectomy compared to younger patients.

There has been no standard definition of elderly patients in clinical studies involving surgery. In previous studies that have included elderly patients with gastric cancer, various definitions of "elderly" were used [14–17]. The United Nations defines persons aged 80 years or over as the oldest-old [18]. However, patients over 90 years old are extremely rare even in Japan. Indeed, there was only one patient in our institution who was over 90 and treated during the study period. We therefore classified the study patients into two groups, the octogenarian group (80–89 years) and the younger group (under 80 years). Park et al. [8] reported that aging was associated with a higher frequency of surgical