

REVIEW ARTICLE

The current status and future perspectives of laparoscopic surgery for gastric cancer

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Gastric cancer is most common cancer in Korea. Surgery is still the main axis of treatment. Due to early detection of gastric cancer, the innovation of surgical instruments and technological advances, gastric cancer treatment is now shifting to a new era. One of the most astonishing changes is that minimally invasive surgery (MIS) is becoming more dominant treatment for early gastric cancer. These MIS are represented by endoscopic resection, laparoscopic surgery, robotic surgery, single-port surgery and natural orifice transluminal endoscopic surgery. Among them, laparoscopic gastrectomy is most actively performed in the field of surgery. Laparoscopy-assisted distal gastrectomy (LADG) for early gastric cancer (EGC) has already gained popularity in terms of the short-term outcomes including patient's quality of life. We only have to wait for the long-term oncologic results of Korean Laparoscopic Gastrointestinal Surgery Study Group. Upcoming top issues following oncologic safety of LADG are function-preserving surgery for EGC, application of laparoscopy to advanced gastric cancer and sentinel lymph node navigation surgery. In the aspect of technique, laparoscopic surgery at present could reproduce almost the whole open procedures. However, the other fields mentioned above need more evidences and experiences. All these new ideas and attempts provide technical advances, which will minimize surgical insults and maximize the surgical outcomes and the quality of life of patients.

Key Words: Gastric cancer, Future perspective, Laparoscopy, Sentinel lymph node navigation surgery, Minimally invasive surgery

INTRODUCTION

Gastric cancer is still a major health problem and leading cause of cancer death in spite of decreasing worldwide incidence. About one million new cases of stomach cancer were estimated to have occurred in 2008 (988,000 cases, 7.8% of the total cancer), making it the fourth most com-

mon malignancy in the world. Moreover, stomach cancer is the second leading cause of cancer death in both sexes worldwide (736,000 deaths a year, 9.7% of the total) [1]. Gastric cancer is also the most common cancer and annually affects over 25,000 patients in Korea, where the incidence is stationary or slightly decreased. In addition, it is the second leading cause of cancer death after lung cancer,

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and is up to over 10,000 deaths a year [2,3]. There are notable changes over the past 20 years. The proportion of early gastric cancer (EGC) and proximal gastric cancer has increased continuously from 24.8 to nearly 50% and from 5.3 to 14.0%, respectively. Proximal EGC consisted of 30.3% of total proximal gastric cancer while distal EGC consisted of 51.5% of total distal gastric cancer [4,5]. There is also increasing trend of older gastric cancer patients due to increased average life expectancy. Owing to early detection of the disease, the results of treatment for gastric cancer have improved in Korea. The survival rate of gastric cancer has been increased from 64.0% in the late 1980s to 73.2% in the early 2000s [4].

As the proportion of EGC and the age of gastric cancer patients have increased, accordingly, more and more surgeons are interested in minimally invasive surgery represented by endoscopic resection, laparoscopic gastrectomy. Among them, laparoscopic gastrectomy is most actively performed in the field of surgery. Laparoscopy-assisted gastrectomy in distal EGC has already gained an acceptance with respect to minimal invasiveness and a suitable alternative method to open surgery. Recently, experienced surgeons are trying to extend the application of this laparoscopic approach to certain advanced gastric cancer (AGC) using more aggressive laparoscopic techniques. On the contrary, there is a larger trend of adopting these techniques to sentinel lymph node navigation surgery (SNNS) for more minimizing surgical extent. On the other side, robotic surgery, single port surgery and natural orifice transluminal endoscopic surgery (NOTES) is gradually being applied to clinical fields for investigational purposes. The purpose of this article is to review these top issues and the current status with literature review to propose the future of laparoscopic gastric surgery.

LAPAROSCOPIC GASTRECTOMY IN DISTAL EGC

Considering the excellent prognosis of EGC, the quality of life after operation has been focused on these patients. For the better quality of life, laparoscopic gastrectomy has emerged as an alternative treatment option for EGC

patients. Since Kitano first performed laparoscopy-assisted distal gastrectomy (LADG) for EGC in 1991, it has been performed worldwide, especially in Korea and Japan. According to the Korean Laparoscopic Gastrointestinal Surgery Study Group (KLASS) survey, 3,783 laparoscopic gastric cancer surgeries (25.8% of total gastric cancer operations) were performed during 2009. The number of surgeries in 2009 is almost five times more than that of 2004. The cumulative number from 1995 to 2009 was about 14,731. Laparoscopic procedures for gastric cancer were widely adopted in Korea since 2006 because laparoscopic procedures could be reimbursed by health insurance [5].

The purposes of laparoscopic surgery for gastric cancer are to minimize surgical insults and to maximize patient's quality of life, while not influencing radicality. A number of reports have presented the excellent short term outcomes; less postoperative pain, improved cosmetics, less inflammatory reaction, a good preserved immune function, a rapid recovery of bowel function, shorter hospital stay, and a rapid return to normal social activity [6-9]. Most reports on laparoscopic distal gastrectomy were retrospective studies, and many retrospective multicenter studies about laparoscopic gastric surgery were conducted in Korea [10-13] (Table 1). According to Korean a retrospective multicenter study, morbidity and mortality were 13.1% and 0.7% [10]. Of course, there are 6 available prospective randomized controlled trials (RCT) for preliminary results worldwide (Table 2). But even these studies have many limitations (e.g. limited trial numbers, non-multicenter, small sample size, conflicting results etc.). In Korea, two small sized RCTs comparing LADG and open distal gastrectomy (ODG) already has been reported [9,14] and KLASS trial, which is the first multicenter, large-scale, prospective, randomized controlled study is going on briskly. According to the interim analysis of KLASS trial including 179 LADG and 163 ODG patients, there was no significant difference between two groups in terms of age, gender, and comorbidity. Postoperative complication rates of LADG and ODG groups were 10.5% (17/179) and 14.7% (24/163), respectively ($P = 0.137$). Postoperative mortality was 1.1% (2/179) in LADG and 0% (0/163) in ODG patients ($P = 0.497$). There was no significant difference of morbidity and mortality between

Table 1. Recurrences and survival after laparoscopic gastrectomy for gastric cancer (mean or median follow-up period > 20 months)

	No. of patients/follow-up periods (mo)		Indication	LND	Recurrence		P-value	Survival
	Laparoscopy	Open			Laparoscopy	Open		
Randomized controlled trial								
Kitano et al. [51]	2002	14/24.3 ± 9.6	14/18.8 ± 12.4	cT1	D1 + α	0	0	NS
Hayashi et al. [52]	2005	14/39 (5-49)	14/45 (34-53)	cT1	D1 + α	0	0	NS
Huscher et al. [7]	2005	30/52.2 ± 26.5	29/49.7 ± 5.2	T1-4	D1, 2			5-yr OS = 58.9% 5-yr OS = 55.7% NS
Retrospective case controlled study								
Hwang et al. [40]	2009	45/23 (9-40)	83/23.5 (8-41)	T1b-4a	D1 + α, β, D2	6 (13.3%)	17 (20.4%)	
Lee et al. [53]	2009	106/58.2 ± 22.3	105/58.2 ± 22.3	T1	D2	1 (0.9%)	1 (0.9%)	5-yr OS = 95.9% 5-yr OS = 94.9% 0.371
Retrospective case series								
Kitano et al. [54]	2002	116/45 (2-120)		cT1	D1 + α	0		
Yasuda et al. [55]	2004	99/48		T1	D1	0		
Sakuramoto et al. [56]	2006	111/36		T1	D1 + α, β	1 (0.9%)		
Kitano et al. [57]	2007	1,294/36 (13-113)		T1	D1 + α, β, D2	6 (0.6%)		5-yr DFS (LADG) = 99.4% 5-yr OS = 90% 3-yr DFS = 96.9% 5-yr OS = 81.4%
Fujiwara et al. [58]	2008	94/60		cT1	D1, D2			
Hwang et al. [8]	2009	197/45 (1-113)		cT1, 2	D1 + β, D2	7 (3.6%)		
Lee and Kim [41]	2009	106/21.5 (2-60)		T2-4a	D2	17 (16.0%)		
Song et al. [59]	2010	1,417/41 (2-109)		cT1, 2	D1 + β, D2	50 (3.5%)		

LND, lymph node dissection; OS, overall survival; DFS, disease free survival; LADG, laparoscopy-assisted distal gastrectomy; NS, not significant.

Table 2. Six prospective randomized controlled trials about laparoscopy-assisted distal gastrectomy for gastric cancer

	Year	No. of patients/follow-up periods (mo)		Indication	LND	No. of retrieved LNs		Recurrence or 5-yr overall survival		P-value
		LADG	ODG			LADG	ODG	LADG	ODG	
Kitano et al. [51]	2002	14/24.3 ± 9.6	14/18.8 ± 12.4	cT1	D1 + α	20.2	24.9	No recurrence	No recurrence	NS
Lee et al. [14]	2005	24/median 14	23/median 14	cT1	D2	31.8	38.1	No recurrence	No recurrence	NS
Hayashi et al. [52]	2005	14/39 (5-49)	14/45 (34-53)	cT1	D1 + α	28.0	27.0	No recurrence	No recurrence	NS
Huscher et al. [7]	2005	30/52.2 ± 26.5	29/49.7 ± 5.2	T1-4	D1, 2	30.0	33.4	58.9%	55.7%	NS
Kim et al. [9]	2008	82/≥12	82/≥12	cT1	D1 + β; D2	39.0	45.1	No recurrence	One recurrence	NS
Kim et al. [6]	2010	179	163	≤cT2N0	D1 + β; D2	-	-	-	-	-

LADG, laparoscopy-assisted distal gastrectomy; ODG, open distal gastrectomy; LND, lymph node dissection; LNs, lymph nodes; NS, not significant.

LADG and ODG patients [6].

However, despite of the favorable results of all of the above studies, there is little evidence of long-term oncological outcome of laparoscopic gastrectomy as a treatment modality for gastric cancer. Even in a revised 2011 English version of the Japanese gastric cancer treatment guideline 3rd edition, to be published 15 years after the first case of laparoscopic gastrectomy, laparoscopic gastrectomy is still classified as an investigational treatment eligible for EGC [15]. In the early 2000s, phase III evidence began to emerge in Western countries for colon cancer demonstrating that the oncologic outcomes of laparoscopic colon operation are similar to those of open colon operation and the new procedure is associated with less pain and shorter hospital stay. Undoubtedly, most surgeons have now accepted laparoscopic surgery for colon cancer. In contrast, the long-term results of multi-center randomized controlled trials of laparoscopic versus open gastrectomy are needed to establish the future role of laparoscopic surgery in the treatment of patients with gastric cancer. The KLASS trial completed the enrollment of patients in 2010. We now have to wait for the long-term results of KLASS study in 2015. Another RCT to compare long-term survival after open and laparoscopic gastrectomy for EGC are currently ongoing in Japan (JCOG 0912 trial). If the result of these two trials will be positive, the laparoscopic gastrectomy will be a standard method for distally located EGC like the clinical outcomes of surgical therapy (COST) study group trial did in colon cancer [16].

In the view of laparoscopic techniques for distal gastric cancer, there are some trends of moving from extra-corporeal anastomosis to an intra-corporeal fashion to get rid of mini-laparotomy for improving the quality of life of patients. Totally laparoscopic distal gastrectomy (TLDG) with delta-shape anastomosis is a representative procedure. In one retrospective study, it was suggested that TLDG contributes to the improvement of early surgical outcomes, more interestingly, TLDG in obese patients could be the best way to improve early surgical outcomes, including the bowel movement, pain score, overall complication rate [17]. In another study which was prospective, non-randomized with small numbers of cases, no significant difference was found in mean operative

time, estimated blood loss, or immunologic or inflammatory markers between TLDG and LADG. However, time to first meal was significantly shorter in the TLDG group than either LADG or ODG but TLDG needed more cost [18]. Intra-corporeal anastomosis without mini-laparotomy is gaining more popularity. However, to prove superiority of this procedure over LADG, phase III trials are required.

In the aspect of reconstruction methods, the Billroth I procedure was most frequently performed after distal gastrectomy (63.4%), followed by Billroth II (33.1%) in Korea in 2009. Roux-en-Y gastrojejunostomy was only performed in 3.3% [5]. When we choose the reconstruction methods, we should consider whether the patient suffers from type 2 diabetes or not. Recently, in the management of type 2 diabetes, bariatric surgery (Roux-en-Y Gastric Bypass Procedure [RYGBP] and Laparoscopic Adjustable Gastric Banding) was added to the treatment guidelines of International Diabetes Federation for type 2 diabetes [19]. The proposed mechanism is that by bypassing duodenum and proximal jejunum, loss of the signals causing insulin resistance is achieved (foregut hypothesis) and fast reach to hindgut cause early signal for glucose control (hindgut hypothesis) [20]. In the patients of gastric cancer with type 2 diabetes and high body mass index, Roux-en-Y gastrojejunostomy method is expected to be better than Billroth I methods to resolve type 2 diabetes and obesity [21]. In one study from Japan, they reported that Roux-en-Y reconstruction after distal gastrectomy seems superior to Billroth-I reconstruction for preventing both bile reflux into the gastric remnant and postoperative complications. They concluded R-Y reconstruction was a feasible and safe method for LADG [22].

LAPAROSCOPIC FUNCTION PRESERVING GASTRECTOMY

Pylorus-preserving gastrectomy (PPG) has not been widely performed in Korea. In the Korean national survey 2009, PPG was only performed in 86 cases (0.6%), which was less than PG [5]. There has been no consensus about PPG in Korea mainly because of extremely rare operations

in Korea. It is originally treatment option in gastric ulcer surgery, which has several benefits compared to distal gastrectomy like the lower incidence of dumping syndrome, bile reflux, gall stone, and the significant decrease in postoperative weight loss [23]. But these benefits have not yet been proven by prospective randomized trials. Park et al. [24] reported PPG has many advantages than Billroth I such as the gastric emptying, bile reflux and gall stone, which was mostly due to the preservation of hepatic branch of vagus nerve and pylorus. PPG patients also had fewer subjective postprandial symptoms than Billroth I patients. Another report on laparoscopy-assisted pylorus-preserving gastrectomy (LAPPG) concluded that LAPPG is a safe operation with minimized complications based on Clavien-Dindo classification for the middle third EGC. But surgeons need to ensure an extra learning curve for LAPPG [25]. In Korea, cases of PPG are so very rare that the data of PPG is not available to some conclusions. In the laparoscopic gastric surgery era, PPG could be another fascinating treatment option for middle third EGC. But we need a greater level of evidence. It is necessary to give more regards to LAPPG and organize multicenter prospective RCTs in Korea.

For proximal EGC, total gastrectomy is regarded as a standard method in Korea. But even laparoscopy-assisted total gastrectomy has not been performed widely due to technical difficulty. It's only recent that laparoscopy-assisted total gastrectomy has increased in the number of cases in Korea (20 cases in 2003, 112 cases in 2004 and 231 cases in 2008). By comparison, laparoscopy-assisted proximal gastrectomy (LAPG) has been performed rarely to this day. Even including the cases of open gastrectomy, proximal gastrectomy were performed only in 141 (1.0%) patients in Korea [5]. In the concept of minimally invasive surgery and function-preserving procedure, LAPG is theoretically ideal. A lot of functional benefits have been reported in the several reports; improved postoperative fat absorption, improved nutrition, preventing anemia, releasing of gut hormones and reducing postoperative complaints [26,27]. Oncologic concerns have also been solved to some degree by several reports in proximal gastrectomy, showing the similar long-term oncologic outcomes even in AGC [28]. But most

gastric surgeons are afraid of performing proximal gastrectomy because of the infamous complications such as anastomotic stricture and reflux esophagitis [29-31]. To overcome these complications, various reconstruction methods have been developed so far. These methods were mainly classified into two categories (esophago-gastrostomy versus esophago-jejunostomy). The incidence of anastomotic stricture was mainly higher in gastro-esophagostomy methods than in esophago-jejunostomy, especially in end-to-end esophago-gastrostomy. The mechanisms of anastomotic strictures are not known. Proposed mechanisms are causation by reflux esophagitis and the discrepancy of wall thickness between esophagus and stomach. In the case of reflux esophagitis, rates were reported in a wide range from 7 to 50% mainly because of the different diagnostic criteria of reflux esophagitis and the selection bias of retrospective studies. Actually, there are no prospective reports analyzing the incidence and pathophysiology of reflux esophagitis after proximal gastrectomy.

Our recent data showed a feasibility and acceptability of LAPG by retrospective analysis in LAPG of 52 cases comparing with LATG of 82 cases. In this study, early complication rates after LAPG and LATG were 23.1% and 17.1%, respectively, which was insignificant. The overall incidence of reflux esophagitis were about 30.8% in the overall LAPG group and about 3.7% in the LATG group ($P < 0.001$). But the clinical outcomes of late phase of LAPG ($n = 13$) were superior to LATG (shorter operative time, 198.0 vs. 242.2 minutes $P < 0.001$; similar early complication rate, 15.4% vs. 17.1% $P = 0.880$; similar reflux symptoms, 7.7% vs. 3.7% $P = 0.083$; less body weight loss, -3.4 vs. -6.3 kg $P = 0.026$). Recently, esophago-jejunostomy with a double tract reconstruction or jejunal interposition after proximal gastrectomy showed acceptable rates of anastomotic stricture and reflux esophagitis comparing with total gastrectomy [32].

LAPAROSCOPY-ASSISTED TOTAL GASTRECTOMY

LATG remains challenging under the laparoscopic ap-

proach and the technique has not been standardized. The incidence of complications is reported to be higher comparing with LADG, and a reliable method of esophago-jejunostomy is still key issues [33]. So, some gastric surgeons prefer open total gastrectomy to laparoscopic methods. This preference mainly comes from the difficulty of esophago-jejunostomy (E-Jstomy) in laparoscopy settings. There are several methods for reconstruction after LATG. Reconstruction methods for bowel continuity are largely two kinds. One is extracorporeal method using conventional open purse-string clamp and circular stapler through mini-laparotomy at epigastrium, which is similar to conventional open surgery and has been commonly performed after LATG [34]. But, in this method it is quite difficult to apply conventional purse-string clamp and to obtain enough proximal resection margin due to poor visualization of fields, especially in obese patients. The other is the intracorporeal method, which means the transection of esophagus is performed under laparoscopy vision. The esophagus transection is made by linear stapler or laparoscopic purse-string clamp (Endo-PSI, Hope Electronics, Chiba, Japan; Lap-Jack, Eterne, Seongnam, Korea) or semi-automatic suturing device (Endostitch, Covidien, Mansfield, MA, USA). In the case of linear stapler transection, the E-Jstomy is done by linear stapler in side to side fashion or by OrVil (Covidien) and circular stapler. In the case of using laparoscopic purse-string clamp, the E-Jstomy is done by circular stapler. Transoral introduction of the anvil head of the circular stapler seems to be a recent innovation that is promising [35]. Another group reported the initial experience of application of the delta-shaped anastomosis to E-Jstomy, which is intracorporeal anastomosis, without mini-laparotomy. [36].

In our retrospective study, which was a relatively large number of cases, comparative analysis of short-term outcomes between extracorporeal end-to-side E-Jstomy and intracorporeal side-to-side E-Jstomy was done. We concluded by this study that end-to-side E-Jstomy using circular stapler could be recommended after LATG because E-Jstomy leakage rates (14.3% vs. 2.2%, $P = 0.043$) after side-to-side E-Jstomy by linear stapler & intracorporeal suture was higher than end-to-side E-Jstomy [37]. Based on these results, we changed the anastomosis methods to

intracorporeal end-to-side E-Jstomy using by laparoscopic purse-string clamp (LapJack, Eterne) and circular stapler. After the application of LapJack, there has been no anastomotic problems, including leakage, in the consecutive 50 cases, which is very promising.

However, the optimal procedures for reconstruction methods after LATG have yet to be established [36]. And there have been a few reports on this subject. We need more advanced, novel instruments such as deployable stapler and techniques for the application for LATG or totally laparoscopic total gastrectomy.

LAPAROSCOPIC SURGERY FOR AGC

Open surgery has been the standard method for AGC for over 100 years. There are no evidences of the application of laparoscopic approach in AGC at present. Technical feasibility of laparoscopy gastrectomy for AGC largely depends on the applicability and safety of D2 lymph node dissection, which is regarded as a standard for AGC in Korea and Japan. Recently, several experienced surgeons have tried to extend the application of laparoscopy-assisted gastrectomy for AGC. In some studies, the short-term and the long-term outcomes after laparoscopy-assisted gastrectomy for AGC were non-inferior to open surgery. But these were small size, retrospective studies with many biases [38,39]. One RCT and one retrospective case controlled study including advanced gastric cancer showed that there was no significant difference between two groups in terms of the number of resected lymph nodes, recurrence and survival [7,40]. One retrospective single center study demonstrated that five-year overall survival rate was 81.4% [41]. These retrospective data has selection bias that preoperative stage was cT2 or less than cT2 but final pathologic stage was T2 or more than T2.

If the same extents of resection and lymph node dissection (LND) comparing with open surgery could be performed, the oncological results theoretically would be the equivalent to open surgery. In the aspect of technique, laparoscopic surgery could reproduce almost the whole of open procedures. Although laparoscopic gastrectomy with D2 LND is being performed for patients with locally

advanced gastric cancer, the completeness of the D2 LND during laparoscopic surgery has not been evaluate and no standardized procedure exists. Soon, a multicenter, prospective randomized study about LADG for AGC in Korea (KLASS-02 study) is to start. To conduct a clinical trial comparing laparoscopic D2 LND to the open approach, quality control of D2 LND is necessary. Only experienced laparoscopic gastric surgeons will have been invited to participate in KLASS-02 trial. They must be validated by peer reviewer's evaluation of unedited video recording of three open gastrectomies and three laparoscopic gastrectomies to predetermined criteria, which is finally approved by review committee. This trial was registered as KLASS-02-QC trial at www.clinicaltrials.gov (NCT00452751). After the confirmation of the results of this study, main KLASS-02 study of LADG for AGC can be started without the criticism of appropriacy of D2 LND.

SNNS IN LAPAROSCOPIC ERA

Stage I gastric cancer accounts for approximately 50% of all surgically resected cases in Korea [4]. Because lymph node metastases occur in only 5 to 20% of patients with early gastric cancer, reduction of the extent of lymph node dissection and gastric resection would be beneficial if it were possible to predict the direction of lymph node metastasis. SNNS is now widely available as reduction surgery for breast cancer. But SNNS is still in its infancy in gastric cancer area. A sentinel node (SN) is defined as the lymph node that is first to receive the flow of lymphatic fluid from the area containing the primary tumor of an organ. According to the SN hypothesis, lymph node dissection can be omitted when no metastasis are detected in SNs. Sentinel basin represent all the lymphatic stations to which SNs belong. Sentinel node identification is usually performed with radioactive tin colloid and/or indocyanine green (ICG). To use SNNS in clinical practice, skip metastases and false negative rate are crucial points. In gastrointestinal malignancies, the appearance of lymph node metastasis is not constant mainly because of the existence of multiple and complex lymphatic routes. There is a report in which skip metastases is occurred in 20 to 30%

of gastric cancer [42]. In one large prospective multicenter trial of sentinel node mapping for gastric cancer, Kitagawa et al [43], reported at ASCO in 2009 that the detection rates was 97.5% (387/397), the mean numbers of SNs 5.6 and the sensitivity and the accuracy was 93% (53/57) and 99% (383/387), respectively. There were 4 cases of false-negative cases; among them, 2 cases were T2 and 3 cases were on same basin. Their eligible criteria were that patients had clinically T1-2N0M0 single tumor with diameter of primary lesion less than 4 cm without any previous treatment. They used radioactive tin colloid and isosulfan blue for dual traces.

In our series, we initially used indocyanine green and ^{99m}Tc-tin colloid (separate injections in the first phase, n = 16) and later indocyanine green and ^{99m}Tc-ASC (simultaneous injections in the second phase, n = 52) (Fig. 1). The SNs were identified in 62 of the 68 patients (91.2%; mean 3.3 per patient) with gastric cancer, and the sensitivity and specificity of SNNS was elevated to 100% by using the dual dye methods and basin dissection. If there are no metastasis in SNs in basins, no further dissection is necessary, which means that the hepatic and celiac branch of vagus nerve and parasympathetic nerve to small bowel can be saved, so it guarantee gastric and small bowel motility

function [44]. In the near future, most of EGC patients will be treated by one-stop intraoperative endoscopic submucosal dissection plus SNNS rather than the extensive resection and lymph node dissection in the way modified radical mastectomy with axillary lymph node dissection has migrated to the lumpectomy with SNNS in breast cancer [44].

ROBOTIC SURGERY IN GASTRIC CANCER

Robotic surgery has recently emerged as a newer minimally invasive technique that may offer surgeons technical solution to the limitations of conventional laparoscopy surgery. These solutions consist of a steady camera platform with 3D imaging, surgical instrument with high degree of angulation, filtration of resting tremor and an ergonomically comfortable surgeon's position. Another most important aspect of robotic surgery is that it enables performances of so called "telesurgery" or "remote surgery". It promises to allow the expertise of specialized surgeons to be available to patients worldwide, without the need for patients to relocate.

Robotic surgery was applied to the fields of gastric cancer in Korea earlier than in other country. There have been installed about 50 da Vinci systems in 20 institutions until now. Robotic gastrectomy's greatest advantages are in fine manipulations as in D2 lymph node dissection and intracorporeal anastomosis. But there are many disadvantages. Not only the lack of tactile sense, but also its macroscopic manipulation speeds and shift of scene are not quick enough. Experienced surgeons accustomed to laparoscopy speeds, dexterity, and tactile sense may feel that robot gastrectomy have no advantages over laparoscopy gastrectomy.

Currently, there are little evidences supportive of robotic gastrectomy. Some retrospective studies with early experiences in Korea have been reported gradually. There were no significant differences in the complication rate amongst the open, laparoscopic, or robotic group. However, while the estimated blood loss and post-operative hospital stay were significantly less than in the robotic group, the operative time was significantly longer. Furthermore,

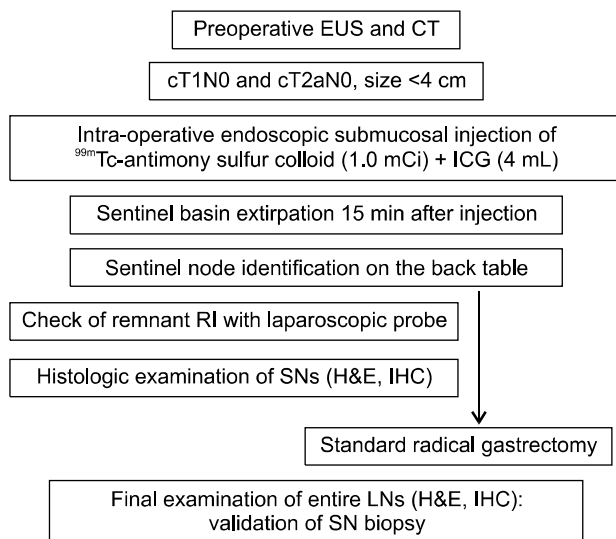


Fig. 1. Protocol of sentinel lymph node navigation surgery in Seoul National University Bundang Hospital. EUS, endoscopic ultrasonography; CT, computed tomography; RI, radioisotope; H&E, hematoxylin & eosin; IHC, immunohistochemistry.

with respect to performing D2 lymphadenectomy, surgeons found the dissection around major vessels to be easier robotically due to the stability of the camera, the articulation of the operating arms, and the 3-D, magnified view [45].

We must try to identify the beneficial aspects of patients but its cost is too high to study large number of patients. So, to begin with, we should focus on cost-cutting of current robotic surgery, such as localization of laparoscopic robot to abolish the monopoly of da Vinci. We must lead in the field of robotic gastrectomy and make the evidences of robot gastrectomy by balancing costs with its effectiveness, as there are a few cases of robotic gastrectomy outside Korea. The Multi-institutional prospective study on the assessment of robotic surgery for gastric cancer in Korea is now proceeding according to plan. It is certain that robotic surgery will become an additional option in minimally invasive surgery.

NEW EMERGING TECHNIQUES

Single incision laparoscopic surgery (SILS) was developed to reduce the minimal invasiveness of laparoscopy to an ultra-minimal invasiveness and to achieve excellent cosmesis. The SILS has been performed in various surgeries such as cholecystectomy, appendectomy, colectomy, sleeve gastrectomy for morbid obesity [46,47]. Very recently, there was the first report on successful single-incision laparoscopic gastrectomy for EGC [48]. They used a vertical 2.5-cm intraumbilical incision with two 2-mm mini-loop retractor. All seven cases with single-incision laparoscopic distal gastrectomies (SIDG) were performed without conversion to LADG or open gastrectomy. The median operative time was 344 minutes (range, 282 to 385 minutes). They showed that SIDG was a feasible and safe procedure for EGC and gives a favorable cosmetic result. Further research is warranted to evaluate the safety and feasibility of SIDG. Our team also had the experiences of two SIDG cases followed by experimental study "SIDG vs. LADG in a porcine model" which is going to be published soon. Eventually, after further development of smart instruments with 5-mm flexible scopes, which could possi-

bly be used in single port, for example, it will be the time that SILS become the optional treatment for gastric cancer. It currently remains in experimental stages.

Natural Orifice Transluminal Endoscopic Surgery has increasingly been reported as the future new technique to laparoscopic surgery. A few reports have emerged reporting a hybrid approach using transvaginal NOTES technique with laparoscopic assistance in the partial gastrectomy of submucosal tumor, with removal of the specimen through the vagina [49]. Several proposals for transgastric resection or lymph node biopsy or dissection have also been proposed via NOTES technique [50]. But there are many criticisms of this proposal for which oncologic safety needs to be considered. There is no role for NOTES for gastric cancer yet.

CONCLUSION

Gastric cancer treatment is now moving on to a new era. This is a major evolution since Billroth performed the first successful gastrectomy in 1881. Present data indicate that the treatment of gastric cancer has more and more individualized with various tailored therapies. As laparoscopic experience has been accumulated, the indications for laparoscopic gastrectomy have been greatly broadened. Advanced laparoscopic techniques for gastric cancer, such as laparoscopy-assisted total gastrectomy, laparoscopy-assisted proximal gastrectomy, laparoscopic SNNS, and laparoscopic D2 lymph node dissection for AGC will have been more broadly performed in the near future. Additionally, robotic surgery, single port surgery and natural orifice transluminal endoscopic surgery (NOTES) will become additional options in minimally invasive surgery much as the validation needs to be used in clinical fields.

Another important thing is education. As the number of laparoscopic gastric surgeries has increased rapidly, the importance of education for laparoscopic skills became higher. Because many active domestic training workshops have been actively held in Korea, novices can easily and quickly overcome the learning curve in laparoscopic gastric surgery. More refined domestic training workshops

and international collaborations including animal or cadaveric surgical models will promise to progress advanced laparoscopic gastric surgery. All these efforts and technical advancements will finally improve the survival and the quality of life of patients suffering from gastric cancer.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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