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Robotic versus laparoscopic gastrectomy for gastric cancer: comparison of short-term surgical outcomes

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Abstract

Background Robot-assisted gastrectomy (RAG) is a new minimally invasive surgical technique for gastric cancer. This study was designed to compare RAG with laparoscopy-assisted gastrectomy (LAG) in short-term surgical outcomes.

Methods Between October 2011 and August 2014, 423 patients underwent robotic or laparoscopic gastrectomy for gastric cancer: 93 RAG and 330 LAG. We performed a comparative analysis between RAG group and LAG group for clinicopathological characteristics and short-term surgical outcomes.

Results RAG was associated with a longer operative time ($P < 0.001$), lower blood loss ($P = 0.001$), and more harvested lymph nodes ($P = 0.047$). Only three patients in LAG group had positive margins, and R0 resection rate for RAG and LAG was similar ($P = 0.823$). The RAG group had postoperative complications of 9.8 %, comparable with those of the LAG group ($P = 0.927$). Proximal margin, distal margin, hospital stay, days of first flatus, and days of eating liquid diet for RAG and LAG were similar. In the subgroup of serosa-negative patients, RAG had a longer operation time ($P = 0.003$), less intraoperative blood loss ($P = 0.005$), and more harvested lymph nodes ($P = 0.04$). However, in the subgroup of serosa-positive patients, RAG had a longer operation time ($P = 0.001$), but no less intraoperative blood loss ($P = 0.139$) and no more harvested lymph nodes ($P = 0.139$). Similarly, in the subgroup of total gastrectomy patients, RAG had a longer operation time ($P = 0.018$), but no less intraoperative blood loss ($P = 0.173$).

Conclusions The comparative study demonstrates that RAG is as acceptable as LAG in terms of surgical and oncologic outcomes. With lower estimated blood loss, acceptable complications, and radical resection, RAG is a promising approach for the treatment of gastric cancer. However, the indication of patients for RAG is critical.

Keywords Gastric neoplasm · Robot-assisted gastrectomy · Laparoscopy-assisted gastrectomy

The development of laparoscopy-assisted gastrectomy (LAG) for gastric cancer has been ongoing since it was reported by Kitano et al. [1]. A large number of non-randomized trials, randomized controlled trials (RCTs), and meta-analyses comparing laparoscopic with open surgery have confirmed that minimally invasive laparoscopic surgery has obvious advantages [2–8]. Surgeons have accepted the use of laparoscopic techniques, and they are being used more and more frequently. It is not only gastrectomy that retains gastric function that is performed in patients with early gastric cancer. There are also many reports on laparoscopic surgery for advanced gastric cancer, with no difference in long-term outcomes between laparoscopic and open surgery [9–12].

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Robotic surgical system has opened up a new era of minimally invasive surgery, with minimally invasive surgery now elevated to a new stage. The da Vinci robotic surgery system has been widely used, for example, in urinary tract, hepatobiliary, cardiovascular, and gynecological surgery [13–16]. Hashizume [17] reported the first robot-assisted gastrectomy (RAG) in 2002, followed by similar reports from China, Korea, Japan, and Italy, among others. During the last 5 years, few studies have prompted investigation into the role of RAG in the treatment of gastric cancer [18–22], but only one study investigated the indications for RAG by subgroup analysis [21].

This study systematically compared clinical outcomes between RAG and LAG in order to be quantified for evaluating the advantages of RAG. In addition, we conducted subgroup comparisons, to analyze the indication of gastric cancer patients for RAG.

Materials and methods

Patients

Between October 2011 and August 2014, 423 patients underwent robotic or laparoscopic gastrectomy for gastric cancer: 93 RAG and 330 LAG. A retrospective data of patients were collected comparing the laparoscopic with the robotic approach for preoperative patient characteristics, perioperative factors, and oncologic parameters. All patients in the study should be preoperatively diagnosed by upper endoscopy and confirmed by biopsy, and then, they were staged by preoperative endoscopic ultrasonography, abdominopelvic computed tomography, and abdominal ultrasound. Additionally, all patients successfully underwent their planned minimally invasive operations without conversion (robotic to conventional laparoscopic, robot to open, conventional laparoscopic to open). The patients with recurrent gastric cancer, gastrointestinal stromal tumors, benign gastric diseases, or synchronous malignancy in other organs were excluded. Besides, patients diagnosed with clinical stage IV based on the third version of the pathologic classification of the Japanese classification of gastric carcinoma [23] should not be included. After exclusion of patients that were out of the scope of our study criteria, a total of 423 patients (93 RAG and 330 LAG) were included in our study.

Procedure

There was no difference in the indications between robotic and laparoscopic gastrectomies. The attending surgeon determined the extent of resection, whether total or subtotal distal gastrectomy and the extent of lymph node dissection, to achieve R0 resection. The extent of gastrectomy and lymph node dissection was performed according to the Japanese gastric cancer treatment guidelines [24]. Reconstructions were made by either gastroduodenostomy or gastrojejunostomy for distal gastrectomy, Roux-en-Y esophagojejunostomy for total gastrectomy, and esophagogastric anastomosis for proximal gastrectomy. Most of the reconstructions were extracorporeal.

Statistical analysis

SPSS version 19.0 (Chicago, IL, USA) was used for statistical analysis. The Mann–Whitney test or independent sample t test was used for continuous variable, and the Pearson χ^2 test was used for categorical variables. Data for continuous variable were presented as mean $\pm$ standard deviation (SD). A value of $P < 0.05$ was considered statistically significant, and all P values were two-sided.

Results

Clinicopathologic characteristics

The patient characteristics are given in Table 1. There was no significant differences in age, body mass index (BMI), tumor location, TNM stage, and medical comorbidities ($P > 0.05$). The common comorbidities were diabetes, hypertension, pulmonary disease, cardiac disease, and hepatic disease.

Operative factors

All minimally invasive operations were completed successfully without open conversion. The operative factors such as operative time, estimated blood loss, and extent of resection were compared (Table 2). Operating time was longer for RAG than for LAG (257.1 ± 74.5 vs. 226.2 ± 61.3 min, $P < 0.001$). However, RAG was associated with less intraoperative blood loss than LAG (176.6 ± 217.2 vs. 212.5 ± 198.8 ml, $P = 0.001$). And, no significant difference was found between the two groups in terms of resection type ($P = 0.686$).

Pathological parameters

Pathological parameters are given in Table 2. The proximal margin was not significantly different in the RAG and LAG groups (5.8 ± 1.6 vs. 5.4 ± 1.8, $P = 0.092$). Also, there was no statistical difference for distal margin between the RAG and LAG groups (5.1 ± 2.3 vs. 5.6 ± 1.6, $P = 0.486$). All tumor margins were negative, except in three specimens from the laparoscopic group. The R0 resection rates were comparable between the two groups

Table 1 Comparison of patients' characteristics between RAG and LAG

	RAG ($n = 93$)	LAG ($n = 330$)	P value
Age	56.8 ± 10.5	57.9 ± 11.5	0.299
BMI	24.3 ± 3.3	23.8 ± 3.6	0.133
Sex			0.296
Male	75	249	
Female	18	81	
Tumor location			0.924
Upper third	18	70	
Middle third	21	74	
Lower third	54	186	
Stage			0.078
Ia	29	59	
Ib	14	41	
IIa	8	51	
IIb	8	40	
IIIa	7	41	
IIIb	14	49	
IIIc	13	49	
Comorbidity	25 (27 %)	111 (33.7 %)	0.218
Hypertension	8	50	
Diabetes	4	17	
Pulmonary disease	3	15	
Cardiac disease	6	14	
Hepatic disease	4	15	

RAG robot-assisted gastrectomy, *LAG* laparoscopy-assisted gastrectomy

($P = 0.823$). The number of lymph nodes retrieved in the RAG group was more than those dissected in the LAG group (33 ± 8.5 vs. 31.3 ± 9.5, $P = 0.047$).

Short-term outcomes

The time of first flatus and days of eating liquid diet for all patients who underwent robotic gastrectomy were similar with laparoscopic group (both $P > 0.05$) (Table 2). Postoperative complication rates did not differ between the two groups. As shown in Table 2, nine complications (9.8 %) were reported for the robotic group and 33 complications (10 %) were reported in the laparoscopic group. The incidence of postoperative complications was not significantly different between the two groups ($P = 0.927$). Also, there was no significant differences in length of postoperative hospital stay (9.4 ± 7.5 vs. 10.6 ± 10.9, $P = 0.41$).

Subgroup comparison in resection type

In this study, we investigated gastric cancer patients by grouping the patients according to resection type. As shown in Table 3, there was no significant difference in age, BMI, TNM stage, and medical comorbidities ($P > 0.05$). We could find that proximal margin, distal margin, number of lymph nodes retrieved, days of eating liquid diet, days of postoperative hospital stay, and postoperative complications were not significantly different between RAG and LAG groups in both subtotal and total subgroups. However, in the subgroup of subtotal gastrectomy patients, RAG had a longer operation time (251.8 ± 78.8 vs. 219.4 ± 59.5, $P = 0.001$) and less intraoperative blood loss (146.7 ± 132 vs. 193.9 ± 179.1, $P = 0.001$). In contrast, in the subgroup of total gastrectomy patients, RAG had a longer operation time (274.5 ± 55.5 vs. 249.2 ± 62.2, $P = 0.018$), but no less intraoperative blood loss (207.1 ± 157.4 vs. 275.3 ± 245.3, $P = 0.173$).

Subgroup comparison in depth of invasion

Because the depth of invasion has an important effect on the short-term outcomes, we analyzed the impact of T stage on gastric cancer patients. As shown in Table 4, there was no significant difference in age, BMI, tumor location, and medical comorbidities ($P > 0.05$). The proximal margin, distal margin, days of eating liquid diet, days of postoperative hospital stay, and postoperative complications were not significantly different between RAG and LAG groups in both serosa-negative and serosa-positive subgroups (Table 4). And, in the subgroup of serosa-negative patients, RAG had a longer operation time (255.6 ± 84.1 vs. 219.6 ± 59.2, $P = 0.003$), less intraoperative blood loss (151.6 ± 146.1 vs. 202.9 ± 209.1, $P = 0.005$), and more lymph nodes retrieved (31.8 ± 7.7 vs. 29.3 ± 9.5, $P = 0.04$) than those who underwent LAG. However, in the subgroup of serosa-positive patients, RAG had a longer operation time (258.7 ± 62.9 vs. 230.4 ± 62.4, $P = 0.001$), but no less intraoperative blood loss (204.1 ± 274 vs. 218.6 ± 192.3, $P = 0.139$), and no more lymph nodes retrieved (34.4 ± 9.1 vs. 32.5 ± 9.3, $P = 0.139$).

Discussion

The clinical efficacy and advantages of laparoscopic radical gastrectomy have now been recognized, but there are also deficiencies, such as the surgeon's postural discomfort, performing a reverse operation, and the possibility of tremor. These factors hinder the use of laparoscopy for complex surgery. Robotic surgery is superior to laparoscopic surgery in that it has wristed instruments, tremor filtration, the ability to scale motion, and stereoscopic vision. These characteristics improve a surgeon's dexterity and allow precise dissection and anastomoses [25–27].

Table 2 Comparison of operative factors, pathological parameters, and short-term outcomes between RAG and LAG

	RAG ($n = 93$)	LAG ($n = 330$)	P value
Operative factors			
Operative time	257.1 ± 74.5	226.2 ± 61.3	<0.001
Blood loss	176.6 ± 217.2	212.5 ± 198.8	0.001
Resection type			0.686
Subtotal	70	255	
Total	23	75	
Pathological parameters			
T			0.024
1	31	65	
2	18	56	
3	23	101	
4	21	108	
N			0.609
0	42	150	
1	11	50	
2	14	57	
3	26	73	
Proximal margin	5.8 ± 1.6	5.4 ± 1.8	0.092
Distal margin	5.1 ± 2.3	5.6 ± 1.6	0.486
R0 resection rates	93	327	0.823
Harvested lymph nodes	33 ± 8.5	31.3 ± 9.5	0.047
Short-term outcomes			
Days of first flatus	3.1 ± 3.4	2.8 ± 2.2	0.309
Days of eating diet	3.8 ± 3.5	3.4 ± 2.4	0.218
Complication	9 (9.8 %)	33 (10 %)	0.927
Wound infection	3	12	
Anastomotic fistula	3	11	
Delayed gastric emptying	1	2	
Intestinal obstruction	1	3	
Pulmonary infection	0	1	
Fluid collection	1	2	
Intraabdominal bleeding	0	1	
Intraluminal bleeding	0	1	
Hospital stay	9.4 ± 7.5	10.6 ± 10.9	0.41

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The results in our study indicated that RAG requires a longer operative time, because RAG requires “setting and docking” time for the robotic arms, which results in a longer operative time. However, Woo et al. [28], whose study contained the largest number of robotic cases, found that the mean operative time was reduced from 233 to 219 min when compared with the previous 100 cases in their study [29]. Therefore, with the development of the da Vinci robotic surgery system, more experience, and a shortened learning curve, the operative time could be mostly shortened. The study indicated that there was less blood loss in the RAG group than in the LAG group. With tremor filtration and stereoscopic vision supplied by the robotic system, a surgeon not only can precisely dissect primary gastric carcinoma and lymph nodes, but he or she can also reduce blood loss during the surgery.

As a pathological parameter, the proximal margin and distal margin were similar for RAG and LAG. The R0 resection rates were comparable between the two groups. But RAG group had more lymph nodes removed than the LAG groups. Curative resection for gastric cancer requires adequate extent of lymphadenectomy. RAG has the advantages of dexterity and accuracy over LAG because of a tremor filter, three-dimensional imaging, and an internal articulated EndoWrist with seven degrees of freedom. These features contribute to precise dissection and

Table 3 Comparison of the two surgery methods in different resection types

	Subtotal gastrectomy			Total gastrectomy		
	RAG ($n = 70$)	LAG ($n = 255$)	*P* value	RAG ($n = 23$)	LAG ($n = 75$)	*P* value
Age	54.9 ± 10.4	56.8 ± 10.9	0.193	57.3 ± 10.5	58.6 ± 11.6	0.632
BMI	23.8 ± 3.2	23.2 ± 3.3	0.176	24.6 ± 3.5	24.4 ± 3.7	0.819
Sex (male/female)	56/14	191/64	0.376	18/5	57/18	0.823
Stage (Ia, Ib, IIa, IIb, IIIa, IIIb, IIIc)	21/10/7/8/6/10/8	44/32/39/33/32/37/38	0.322	6/4/2/2/4/2/3	13/10/12/9/9/11/11	0.855
Comorbidity	19 (27.1 %)	87 (34.1 %)	0.270	6 (26.1 %)	24 (32 %)	0.590
Operative time	251.8 ± 78.8	219.4 ± 59.5	0.001	274.5 ± 55.5	249.2 ± 62.2	0.018
Blood loss	146.7 ± 132	193.9 ± 179.1	0.001	207.1 ± 157.4	275.3 ± 245.3	0.173
Proximal margin	5.6 ± 1.6	5.3 ± 1.5	0.204	6.2 ± 1.7	5.9 ± 2.2	0.384
Distal margin	5.4 ± 1.5	5.4 ± 1.4	0.769	9 ± 3.1	7 ± 1.6	0.034
Harvested lymph nodes	32.1 ± 8.1	30.5 ± 9.3	0.085	36.3 ± 9.1	34 ± 9.5	0.286
Days of eating diet	3.8 ± 3.9	3.4 ± 2.5	0.568	3.8 ± 1.7	3.4 ± 2.1	0.098
Hospital stay	9.3 ± 7.7	10.2 ± 10.4	0.51	9.9 ± 6.9	12.2 ± 12.3	0.625
Complication	5 (7.1 %)	20 (7.8 %)	0.846	4 (17.4 %)	13 (17.3 %)	0.995

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Table 4 Comparison of the two surgery methods in depth of invasion

	Serosa-negative			Serosa-positive		
	RAG ($n = 49$)	LAG ($n = 121$)	*P* value	RAG ($n = 44$)	LAG ($n = 209$)	*P* value
Age	55.3 ± 10.1	56.8 ± 10.3	0.388	57.1 ± 10.6	58.2 ± 11.3	0.553
BMI	23.6 ± 3.1	23.5 ± 3.4	0.858	24.9 ± 3.4	24.3 ± 3.7	0.323
Sex (male/female)	39/10	90/31	0.472	36/8	157/52	0.342
Tumor location (upper/middle/lower)	9/11/29	26/27/68	0.896	9/10/25	44/42/123	0.926
Comorbidity	13 (26.5 %)	43 (35.5 %)	0.258	12 (27.3 %)	68 (32.5 %)	0.495
Operative time	255.6 ± 84.1	219.6 ± 59.2	0.003	258.7 ± 62.9	230.4 ± 62.4	0.001
Blood loss	151.6 ± 146.1	202.9 ± 209.1	0.005	204.1 ± 274	218.6 ± 192.3	0.139
Proximal margin	5.8 ± 1.6	6 ± 1.9	0.957	5.7 ± 1.7	5.2 ± 1.6	0.122
Distal margin	5.8 ± 2.6	5.7 ± 1.6	0.104	5.3 ± 1.7	5.6 ± 1.7	0.463
Harvested lymph nodes	31.8 ± 7.7	29.3 ± 9.5	0.04	34.4 ± 9.1	32.5 ± 9.3	0.139
Days of eating diet	3.7 ± 3.5	3.4 ± 2.8	0.282	3.9 ± 3.5	3.4 ± 2.1	0.413
Hospital stay	8.8 ± 7	10.4 ± 13.2	0.722	11.1 ± 8	10.7 ± 9.2	0.374
Complication	4 (8.2 %)	9 (7.4 %)	0.872	5 (11.4 %)	24 (11.5 %)	0.982

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lymphadenectomy. With adequate margins and harvested lymph nodes, both RAG and LAG meet the criteria for performing radical gastrectomy.

As observed in the study, hospital stay was not significantly different in the RAG and LAG groups. Postoperative recovery time (the time of first flatus and days of eating liquid diet) was also similar in the RAG and LAG groups. The postoperative complication rate is an important indicator of the short-term outcome, with which RAG is acceptable according to our finding of similar complication rates for the two groups. Based on these results, both RAG and LAG were able to achieve their purpose with minimal invasiveness, thereby benefiting the patients.

In this study, we performed an analysis by grouping the patients according to resection type. There were no significant differences between the two groups in terms of proximal margin, distal margin, number of lymph nodes retrieved, days of eating liquid diet, days of postoperative hospital stay, and postoperative complications in both subtotal and total subgroups. In the subgroup of subtotal gastrectomy patients, RAG had a longer operation time and less intraoperative blood loss. In contrast, in the subgroup of total gastrectomy patients, RAG had a longer operation time, but no less intraoperative blood loss. Compared to total gastrectomy, RAG was more suitable for subtotal gastrectomy.

The depth of invasion could be a factor associated with the short-term outcomes. In the study, we performed an analysis by grouping the patients according to T stage. The proximal margin, distal margin, days of eating liquid diet, days of postoperative hospital stay, and postoperative complications were not significantly different between RAG and LAG groups in both serosa-negative and serosa-positive subgroups. RAG was feasible but provided no benefit to justify the longer operation time in the subgroup of serosa-positive patients. However, in the subgroup of serosa-negative patients, RAG was provided benefit to justify less intraoperative blood loss and more lymph nodes retrieved. Although robotic technology may be the most ideal for patients with locally advanced gastric cancer that require D2 lymphadenectomy, robotic surgery provides the advantages of increased dexterity of movement for more precise dissection along the vessels during retrieval of perivascular soft tissues containing lymph nodes [30]. With limited training opportunities and experience, it is difficult to do RAG in patients with serosa-positive patients due to the adhesion and wide range of resection. The indication of patients for RAG should be critical at the present stage. Besides, eight high-quality clinical trials were eligible in our meta-analysis. And, the indication for RAG is a gastric cancer at the depth of invasion lower than T2 in seven clinical trials [31]. Nowadays, RAG was more suitable for serosa-negative gastric cancer based on these results.

This study has some limitations. Our study was limited by the retrospective nature of analyses, so there would be some selection bias. Due to the limited experience, the surgeon may choose patients in good condition for robotic gastrectomy. In pathological parameters, there was significant difference between two groups in T stage, and LAG group had more serosa-positive patients. Thus, the results of the comparison could be influenced. Because of this, we performed comparison between RAG and LAG by grouping the patients according to T stage. Long-term outcomes were not obtained, because the follow-up period was too short. So, a prospective, randomized, controlled study is necessary for a comparison between RAG and LAG.

In general, the da Vinci robotic system overcomes the technical limitations of laparoscopy. The comparative study demonstrates that RAG is as acceptable as LAG in terms of surgical and oncologic outcomes. With lower estimated blood loss, more lymph nodes retrieved, acceptable complications, and radical resection, RAG is a promising approach for the treatment of gastric cancer. However, the indication of patients for RAG is critical.

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Compliance with Ethical Standards

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