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# Robotic Gastrectomy as an Oncologically Sound Alternative to Laparoscopic Resections for the Treatment of Early-Stage Gastric Cancers

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**Objective:** To evaluate the comparative safety and efficacy of robotic vs laparoscopic gastrectomy for early-stage gastric cancer.

**Design:** Retrospective analysis.

**Setting:** Tertiary hospital.

**Patients:** Eight hundred twenty-seven patients with gastric cancer.

**Interventions:** Between July 2005 and April 2009, 827 patients with gastric cancer underwent 236 robotic and 591 laparoscopic radical gastrectomies with curative intent. The patients' data were prospectively collected and retrospectively analyzed.

**Main Outcome Measures:** We performed a comparative analysis between the robotic surgery group and laparoscopic surgery group for preoperative patient characteristics, intraoperative factors, and postoperative morbidity and mortality.

**Results:** The robotic group was younger than the laparoscopic group, but other preoperative patient characteristics did not differ. The mean operative time for the robotic group (219.5 minutes) was on average 49 minutes longer than the laparoscopic group (170.7 minutes) ($P < .001$), while mean blood loss was significantly less in the robotic group (91.6 mL vs 147.9 mL; $P = .002$). The robotic group had mortality of 0.4% and morbidity of 11.0%, comparable with those of the laparoscopic group ($P > .05$). The number of lymph nodes retrieved per level was adequate in both groups and did not differ significantly. Robotic D1+$\alpha$ (n=5), D1+$\beta$ (n=126), and D2 (n=105) dissections retrieved 27.2, 36.7, and 42.4 mean numbers of lymph nodes, respectively. Except for 3 cases in the laparoscopic group, all specimens had negative margins.

**Conclusions:** Our largest comparative study demonstrates robotic gastrectomy to have better short-term and comparable oncologic outcomes compared with laparoscopic gastrectomy. A robotic approach to gastric cancer is a promising alternative to laparoscopic surgery.

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GASTRIC CANCER IS THE fourth leading cancer and second leading cause of cancer death in the world.[1] Despite increased understanding of tumor biology and improved systemic therapy, the only chance for cure for patients with gastric cancer remains radical surgical resection. In Korea, a vigilant nationwide screening program that increases early diagnoses and locoregional control has consistently achieved 5-year survival rates of 90% for patients with early-stage disease.[2] While the goals for patients with early gastric cancer are undisputedly long-term survival and improved quality of life, the most effective surgical intervention to achieve curative resection is controversial. Several randomized trials and numerous retrospective studies have evaluated the advantages and limitations of the laparoscopic approach.[3-9]

*See Invited Critique at end of article*

The emerging paradigm of minimally invasive surgery promises clinically relevant benefits to the surgical patient including better pulmonary function, less blood loss, decreased postoperative pain, and earlier discharge from the hospital compared with the traditional open approach.[3-6] Currently, laparoscopic gastrectomy with lymph node dissection has become one of the preferred methods of treatment for patients with early gastric cancer in most experienced centers. This shift, which favors minimally invasive surgery, has prompted investigation into the role of robot assistance in the treatment of gastric malignancies because of technical difficulties of laparoscopic procedures for gastric cancer. The safety, feasibility, and oncologic efficacy of robotic gastrectomies and lymph node dissections are being evaluated, but the data are limited.[10-14] We offer the largest, to our knowledge, single-institution investigation on the comparative safety, feasibility, and oncologic efficacy of robotic vs laparoscopic gastrectomy, focusing on intraoperative factors, postoperative complications, and oncologic parameters.

## METHODS

Between May 2003 and April 2009, we performed a total of 922 laparoscopic and robotic radical resections for patients diagnosed with gastric cancer. The data from these patients were prospectively collected and retrospectively analyzed, comparing the laparoscopic with the robotic approach for preoperative patient characteristics, perioperative factors, and oncologic parameters. Excluding 84 of the laparoscopic and 11 of the robotic cases that involved concomitant operations, the study included 591 patients in the laparoscopic group and 236 patients in the robotic group.

All patients in the study were preoperatively diagnosed by upper endoscopy and staged with endoscopic ultrasonography and abdominopelvic computed tomography. The patients with clinical stage Ia or Ib disease (T1N0M0, T1N1M0, T2N0M0, and T2N1M0) were offered robotic or laparoscopic surgery. There was no difference in the indications between robotic and laparoscopic gastrectomies. Each patient was given detailed information about the instruments, size of incisions, the cost of surgery, and the expected postoperative course for both the robotic and laparoscopic approaches. The decision to receive laparoscopic vs robotic treatment was made by the patient after informed discussion about both approaches because the patient incurs extra expenses for robotic surgery in Korea. All the patients gave informed written consent for their operations.

An attending surgeon determined the extent of resection, whether total or subtotal distal gastrectomy and the level of lymph node dissection, to achieve R0 resection. The extent of lymph node dissection, either D1+α, D1+β, or D2, was performed according to the Japanese Classification of Gastric Carcinoma.[15] Reconstructions were made by either gastroduodenostomy or gastrojejunostomy for distal gastrectomy and Roux-en-Y esophagojejunostomy for total gastrectomy. Initially, most of the reconstructions were extracorporeal. With growing experience with both the laparoscopic and robotic operations, intracorporeal anastomoses were successfully accomplished. The da Vinci Surgical System (Intuitive Surgical, Inc, Sunnyvale, California) was used as the robotic tool in all patients in the robotic group. This retrospective study using a prospectively maintained database was approved by the institutional review board of Severance Hospital, Yonsei University College of Medicine.

### OPERATIVE TECHNIQUE

The operative technique for the robotic and laparoscopic gastrectomies with lymph node dissection was previously described in detail.[10,16,17] In brief, a total of 5 trocars were used. First, a 12-mm trocar was inserted through a vertical incision just below the umbilicus using the open method. After insufflation with carbon dioxide gas to an intraperitoneal pressure of 12 mm Hg, a dual-lens laparoscope (in robotic surgery) or single-lens laparoscope (during laparoscopy) was inserted. An additional 4 trocars were placed under direct visualization, including three 8-mm cannulas for the robotic arms and a 12-mm assistant's port for the robotic operation and two 12-mm trocars and 5-mm trocars for the laparoscopic gastrectomy. Then, the location of the tumor was identified by use of laparoscopic ultrasonography or portable plain radiography, as needed.[18]

In the case of robotic gastrectomy, docking of the robotic arms followed the localization of the tumor. The first arm of the da Vinci System held the Maryland bipolar forceps (Intuitive Surgical, Inc) at the patient's left side, the second arm held the ultrasonic shear, and the third arm held the Cadiere forceps (Intuitive Surgical, Inc) at the patient's right side. After the placement of EndoWrist instruments (Intuitive Surgical, Inc), the robot-assisted portion of the gastrectomy and dissection of the appropriate lymph node stations proceeded. Initially, the greater omentum was partially resected using ultrasonic shears. After division of the left gastroepiploic vessels at their roots, the gastrocolic ligament was divided toward the pylorus distally and the right gastroepiploic vessels were divided at their roots.

D2 lymph node dissection was performed by removing additional soft tissue at the root of the superior mesenteric vein for any suspicious distally located advanced lesion. The duodenum was transected 1 or 2 cm distal to the pylorus using an endoscopic stapling device by the assistant. The stapling by the assistant did not use robotic assistance and therefore was the same as during the laparoscopic resections. After division of the duodenum, the lesser omentum was then opened and divided up to the esophageal hiatus. The dissection proceeded to the right gastric artery, then to the left gastric vein and artery, which were ligated and transected. The lymph nodes containing soft tissue around the proper hepatic artery and medial side of the portal vein area at the upper margin of the common hepatic artery or pancreas were taken as well as those around the splenic vessels.

Perigastric lymph nodes were taken along the lesser curvature up to the esophagocardial junction. The extent of dissection along the lesser or greater curvature was determined to maintain at least a 2-cm length of the proximal resection margin from the lesion. After full mobilization of the stomach, the robotic arms were undocked in the robotic gastrectomy. After gastric resection, the appropriate reconstruction by gastroduodenostomy or gastrojejunostomy for distal gastrectomy and by esophagojejunostomy for total gastrectomy was performed.

### STATISTICAL ANALYSIS

All statistical analyses were performed using SPSS version 18.0 for Windows (SPSS, Inc, Chicago, Illinois). The variables for the laparoscopic vs robotic operations were compared with a *t* test or Fisher exact test as appropriate. A *P* value less than .05 was considered statistically significant.

## RESULTS

The patient characteristics are shown in **Table 1**. Patients in the robotic group were significantly younger (mean age, 54.0 years) than patients in the laparoscopic group (mean age, 58.3 years; $P < .001$). The range of ages was 25 to 88 years in the laparoscopic group and 24 to 89 years in the robotic group. No differences in sex or body mass index were found. Patients in the laparoscopic group showed more comorbidities (49%) than patients in the robotic group (42%), without statistical difference ($P = .08$). Hypertension, diabetes mellitus, and

**Table 1. Comparison of Patient Characteristics Between Laparoscopic and Robotic Gastrectomies**

| | No. (%) | | |
|---|---|---|---|
| | Laparoscopic | Robotic | *P* Value |
| Age, y, mean (SD) | 58.3 (11.6) | 54.0 (12.7) | <.001 |
| [range] | [25-88] | [24-89] | |
| Comorbidities | | | |
| None | 301 (51) | 136 (58) | .08 |
| Presence | 290 (49) | 100 (42) | |
| Hypertension | 168 (28) | 52 (22) | .06 |
| Diabetes mellitus | 65 (11) | 22 (9) | .48 |
| Pulmonary[a] | 60 (10) | 22 (9) | .72 |
| Cardiac[b] | 35 (6) | 13 (6) | .82 |
| Hepatic[c] | 29 (5) | 8 (3) | .34 |
| Renal[d] | 16 (3) | 4 (2) | .39 |
| Other[e] | 49 (8) | 24 (10) | .39 |
| Sex | | | .29 |
| M | 364 (62) | 136 (58) | |
| F | 227 (38) | 100 (42) | |
| BMI, mean (SD) | 23.5 (3.0) | 23.5 (3.0) | .94 |

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).
[a] Asthma, emphysema, chronic obstructive pulmonary disease.
[b] Ischemic heart disease, arrhythmias, congestive heart failure.
[c] Hepatitis, mild cirrhosis.
[d] Chronic kidney disease, end-stage renal disease, nephritis.
[e] Connective tissue disease, osteoporosis, severe rheumatoid arthritis, dementia, major depressive disorder, cataracts, glaucoma.

**Table 2. Comparison of Operative Factors Between Laparoscopic and Robotic Gastrectomies**

| | No. (%) | | |
|---|---|---|---|
| | Laparoscopic (n=591) | Robotic (n=236) | *P* Value |
| Open conversion | None | None | >.99 |
| Resection extent | | | .02 |
| Distal subtotal gastrectomy | 481 (81.4) | 172 (72.9) | |
| Total gastrectomy | 108 (18.3) | 62 (26.3) | |
| Completion total | 2 (0.3) | 2 (0.8) | |
| Type of reconstruction | | | <.001 |
| Billroth I | 319 (54.0) | 52 (22.0) | |
| Billroth II | 162 (27.4) | 120 (50.9) | |
| Roux-en-Y | 110 (18.6) | 64 (27.1) | |
| Extent of LN dissection | | | .74 |
| D1+α | 10 (1.7) | 5 (2.1) | |
| D1+β | 302 (51.1) | 126 (53.0) | |
| D2 | 279 (47.2) | 105 (45.0) | |
| Total operative time, min, mean (SD) | 170.7 (55.8) | 219.5 (46.8) | <.001 |
| Initial/docking | NA | 20.8 (8.9) | |
| Robotic | NA | 142.3 (35.6) | |
| Assistant | NA | 56.9 (23.3) | |
| Estimated blood loss, mL, mean (SD) | 147.9 (269.0) | 91.6 (152.6) | .002 |

Abbreviations: LN, lymph node; NA, not applicable.

pulmonary disease, including asthma, emphysema, and chronic obstructive pulmonary disease, were the most common comorbidities in both groups.

The operative factors such as open conversion rate, total operative time, estimated blood loss, extent of resection, and type of reconstruction were compared (**Table 2**). All patients successfully underwent their planned minimally invasive operations without open conversion. As expected, the mean (SD) total operative time for the robotic group was 219.5 (46.8) minutes (range, 140-439 minutes) and it was on average 49 minutes longer than that of laparoscopic group (170.7 [55.8] minutes; range, 75-420 minutes; $P<.001$) (**Figure 1**). The mean (SD) setup time for the da Vinci Surgical System, which included initial and docking time, was 20.7 (8.9) minutes. The initial time involved placement of the ports and the docking time included the placement of the robot arms onto the appropriate ports. The mean (SD) time for the robot-assisted portion of the operation was 142.3 (35.6) minutes. The mean (SD) patient-side operative time after undocking the robot was 46.9 (23.3) minutes. The intraoperative estimated blood loss for the robot-assisted cases was significantly less than the laparoscopic operations. The mean (SD) estimated blood loss for the laparoscopic group compared with the robotic group was 147.9 (269.0) mL vs 91.6 (152.6) mL, respectively ($P=.002$).

Distal subtotal gastrectomy was performed in the majority of cases in both groups. Notably, a significantly larger proportion of the patients received robotic total gastrectomies. This is consistent with the larger number of proximally located tumors in the patients who underwent robotic operations, as presented in Table 2. About 81% of the patients in the laparoscopic group and 72.9% of patients in the robotic group underwent subtotal gastrectomies and 18.3% of patients in the laparoscopic group and 26.3% in the robotic group had total gastrectomies for their proximal gastric cancer. The type of reconstruction for each group is also shown in Table 2.

The mean length of stay for all patients who underwent laparoscopic procedures was shorter than for robotic cases (7.0 days and 7.7 days, respectively) (**Table 3** and **Figure 2**). However, the median length of stay for patients in both groups was 5 days, with a larger percentage of patients in the robotic group being discharged by postoperative day 5 (48.8% of the laparoscopic group vs 61% of the robotic group). Closer analysis revealed the mean length of stay for the robotic group was skewed by 2 outliers. Two patients in the robotic group had complicated postoperative courses, one leading to death on day 175 and another patient who eventually recovered from multisystem organ failure after an anastomotic leak to be discharged on day 203. Neither the total nor specific postoperative complication rates differed between the 2 groups as shown inTable 3. Eighty-one complications (13.7%) were reported in the laparoscopic group and 26 (11.0%) were reported for the robotic group. The most common minor complication that did not prolong hospital stay was wound-related issues.

Pathologic parameters are shown in **Table 4**. All tumor margins were negative, except in 3 specimens from the laparoscopic group, with a mean proximal margin of 36.1 mm in the laparoscopic group compared


**Figure 1.** Robot gastrectomy mean operative times. The total mean operative time was 219.5 minutes. The initial and docking times of port placement and robot arm positioning averaged 20.7 minutes. The surgeon's console time as represented by robot time was 142.3 minutes and the patient-side assist time was 46.9 minutes.

with 37.2 mm in the robotic group, with no statistical difference. The distal margin was longer in the robotic group (72.1 mm) than in the laparoscopic group (60.8 mm) because more total gastrectomies were performed in the robotic group. The number of nodes retrieved in the laparoscopic group did not differ from those dissected in the robotic group. For D1+β and D2 dissection, a mean (SD) of 35.6 (13.4) and 36.7 (14.5) nodes ($P = .71$) and 40.1 (14.5) and 42.4 (15.5) nodes ($P = .18$) were retrieved with laparoscopic vs robotic dissection, respectively. Furthermore, proper lymph node staging was possible in more than 97% of the patients in both groups.

**Table 3. Short-Term Outcomes of Laparoscopic and Robotic Gastrectomies**

| | No. (%) | | |
|---|---|---|---|
| | Laparoscopic (n=591) | Robotic (n=236) | *P* Value |
| Length of hospital stay, d, mean (SD) | 7.0 (5.7) | 7.7 (17.2) | .004 |
| Complications | | | |
| None | 510 (86.3) | 210 (89.0) | .30 |
| Present | 81 (13.7) | 26 (11.0) | |
| Wound problems | 35 | 11 | |
| Fluid collection | 9 | 1 | |
| Intraabdominal bleeding | 7 | 0 | |
| Intraluminal bleeding | 5 | 4 | |
| Intestinal obstruction | 2 | 1 | |
| Stenosis | 4 | 0 | |
| Leakage | 9 | 4 | |
| Pancreatitis | 2 | 1 | |
| Pulmonary | 4 | 4 | |
| Urinary | 1 | 0 | |
| Hepatic | 1 | 1 | |
| Cardiac | 2 | 0 | |
| Other | 9 | 1 | |
| Mortality | 2 (0.3) | 1 (0.4) | .64 |

## COMMENT

In this study, we found robotic gastrectomy to be a sound oncologic surgical alternative for gastric cancer comparing favorably with the laparoscopic approach. The robotic gastrectomy group showed no margin involvement, with a mean number of 39.0 retrieved lymph nodes. Although the operative time for robotic gastrectomy was longer, a larger portion of robotic surgery patients were discharged by postoperative day 5, the median length of stay for both groups, and had less blood loss compared with the laparoscopic surgery group.

Following the first published experience with laparoscopic gastrectomy with lymph node dissection for early gastric cancer,[19] numerous studies comparing laparoscopic vs open procedures have demonstrated the benefits of laparoscopy to include better perioperative outcomes compared with the traditional open approach.[4-7,9,20,21] In patients with cancer, however, these advantages are weighed heavily against the concerns about surgeons' ability to maintain strict oncologic parameters using minimally invasive techniques. Encouraging evidence from several randomized control trials and retrospective reviews suggests no difference in the oncologic outcomes such as tumor recurrence and long-term survival between patients undergoing laparoscopic vs open surgery in patients with gastric cancer.[3,22,23] In combination, these results support not only the safety and feasibility of minimally invasive surgery for the treatment of cancer but suggest that the use of these techniques may provide an oncologically sound long-term outcome for patients with cancer.

Various subspecialties have successfully applied robot assistance in complex oncological operations, for example, in the treatment of prostate, endometrial, and ovarian cancers.[24-28] Studies suggest that robot assistance facilitates laparoscopic surgery and has great impact on improving minimally invasive surgical techniques.[24,28] Early evidence demonstrates that robot assistance may allow a surgeon to perform complicated minimally invasive procedures faster and more accurately than with laparoscopy.[29] Moreover, the growing application of preoperative simulator technology in surgical robotics may decrease the learning curve of robot-assisted operations.[30] The full potential of robotic surgery, however, still remains to be balanced against the high cost, the longer operation time, and, in the field of surgical oncology, the lack of oncologic superiority to its counterpart.[31,32]

In gastric cancer surgery, studies evaluating the value of robotic surgery are limited. Most are descriptive reports of technical feasibility and operative safety of robotic gastrectomy in a small number of patients.[13,14,33] In fact, even though our largest published series of 100 robotic gastrectomies for patients with gastric cancer pre-

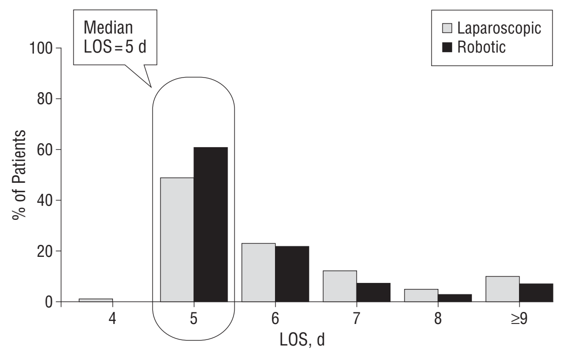


**Figure 2.** Comparison of postoperative hospital stays between robotic and laparoscopic gastrectomies. The median length of stay (LOS) for patients in both groups was 5 days. A significantly larger percentage of patients in the robotic group were discharged by postoperative day 5 (48.8% of the laparoscopic group vs 61.0% of the robotic group; *P*=.04).

viously demonstrated satisfactory perioperative outcomes with a 13% complication rate and 1% mortality, operative time of 231 minutes, and 7.8 days of postoperative hospital stay, we did not offer any comparison with laparoscopic surgery.[10] Overall, comparative studies are rare and the numbers of patients analyzed are too small to be generalized.[10,12]

Our larger-population comparative study demonstrates that robotic gastrectomy is safe and may offer the patient several advantages over laparoscopic gastrectomy. We confirmed that robotic surgery can result in less blood loss compared with the laparoscopic surgery group. The statistically significant difference in 56.3 mL of blood loss between the robotic and laparoscopic groups may not translate into much clinical benefit for every individual patient. However, the blood loss in the laparoscopic group had larger variability with an SD of 269.0 mL compared with the 152.6 mL in the robotic group. This suggests that robotic surgery can more consistently result in lower operative blood loss and become especially important for select patients with gastric cancer with severe anemia or cardiac comorbidities. The safety of robotic gastrectomy is further supported by our finding of similar complication rates between the 2 groups despite more cases of total gastrectomy in the robotic group.

As anticipated, the operative time and blood loss for robotic gastrectomy decreased as the surgeon performed more cases. When we compared the operative results of the current series with our previous 100-case series,[11] we found that the mean operative time was reduced from 231 minutes to 220 minutes and the mean blood loss decreased from 128 mL to 92 mL. Moreover, in-depth comparison of the initial 100 patients with the later 136 patients showed the improvement was more remarkable. The mean operation time of the later 136 cases was 208 minutes and the mean blood loss was 56 mL (data not shown). Thus, as in open and laparoscopic surgery and other surgical procedures, the accumulation of experience with robotic gastrectomy results in improved perioperative outcomes.

**Table 4. Pathologic Parameters Compared Between Laparoscopic and Robotic Gastrectomies**

| | No. (%) | | |
|---|---|---|---|
| | Laparoscopic (n=591) | Robotic (n=236) | *P* Value |
| Location | | | .24 |
| Upper | 65 (11.0) | 31 (13.1) | |
| Middle | 151 (25.6) | 72 (30.5) | |
| Lower | 373 (63.1) | 133 (56.4) | |
| Whole | 2 (0.3) | 0 | |
| Depth of invasion[a] | | | .26 |
| T1 | 467 (79.0) | 181 (76.7) | |
| T2 | 100 (16.9) | 39 (16.5) | |
| T3 | 24 (4.1) | 16 (6.8) | |
| Lymph node status[a] | | | .11 |
| N0 | 495 (83.8) | 184 (78.0) | |
| N1 | 81 (13.7) | 39 (32.5) | |
| N2 | 12 (2.0) | 11 (4.7) | |
| N3 | 3 (0.5) | 2 (0.8) | |
| Proximal margin, mm, mean (SD) | 36.1 (24.0) | 37.2 (25.3) | .56 |
| Distal margin, mm, mean (SD) | 60.8 (37.1) | 72.1 (43.3) | <.001 |
| No. of LN retrieved, mean (SD) | | | |
| All | 37.4 (14.2) | 39.0 (15.2) | .30 |
| D1+α | 21.2 (11.1) | 27.2 (10.7) | .33 |
| D1+β | 35.6 (13.4) | 36.7 (14.5) | .71 |
| D2 | 40.1 (14.5) | 42.4 (15.5) | .18 |

Abbreviation: LN, lymph node.
[a]Based on sixth American Joint Committee on Cancer classification.

In gastric cancer surgery, oncologic outcome is an equally important area of interest. Because the follow-up of the patients in the robotic group was less than 5 years, we cannot substantiate the long-term oncologic efficacy of robotic surgery in terms of recurrence and survival. However, we demonstrated that the robotic approach permits the experienced surgeon to follow oncologic parameters. None of the 236 specimens showed tumor involvement in the resection line in the robotic group while there were 3 of 591 margin involvements in the laparoscopic group. A greater percentage of the more technically challenging total gastrectomy were performed using the robotic approach. More importantly, the number of lymph nodes retrieved for each extent of dissection (D1+α, D1+β, or D2) was sufficient and did not differ by either method.

D2 lymph node dissections were safely performed in 105 of 236 patients, with an average of 42.4 nodes. D2 resection has not been recommended in the West because of higher morbidity and mortality when compared with the D1 procedure.

However, D2 lymph node dissection has been shown in several randomized prospective trials to have a long-term survival benefit over D1 lymph node dissection.[34-36] Thus, D2 lymph node dissection is essential for the treatment of gastric cancer, especially for those patients with advanced lesions. With 23.3% of the patients in the robotic group confirmed to have lesions deeper than T2, the results of this study seem promising for the future use of robotic assistance in treating advanced gastric cancer with D2 lymph node dissection. We can expand the indications of minimally invasive surgery by performing safe and acceptable oncologic surgery for patients with gastric cancer.

To our knowledge, this is the first and largest study assessing the safety and efficacy of robotic gastrectomy by comparing its perioperative outcomes and oncological adequacy with those of laparoscopic gastrectomy. In our study, robotic gastrectomy has resulted in better short-term and comparable oncologic outcomes compared with those of laparoscopic gastrectomy. However, the study is limited by the retrospective nature of analyses, single-surgeon experience, and lack of long-term oncological outcomes such as recurrence, survival, and quality of life. In the near future, we expect results from the continuing investigations of our institution and other experienced centers in the long-term follow-up of tumor recurrence, survival, and quality of life of these patients compared with those of laparoscopic surgery.

Last, our study lacks a cost analysis. Because of the retrospective nature of this study and uniqueness of the national insurance coverage in Korea, a cost comparison between robotic and laparoscopic gastrectomy could not be performed. The patients' financial burden for choosing to undergo their gastric cancer operation by the robotic approach is predetermined by each hospital, while the cost to the patient for laparoscopic surgery depends on the equipment used by the surgeon, including the number of staplers and type of heat devices. Currently, prospective multicenter studies comparing the cost-effectiveness of open vs laparoscopic gastrectomy and robotic vs laparoscopic gastrectomy for gastric cancer are planned as secondary outcomes of more comprehensive study designs.

In conclusion, our largest study of robotic gastrectomy for gastric cancer suggests that the robotic approach is a promising alternative to laparoscopic surgery, with sound oncologic operative outcomes. Some disadvantages of robotic surgery, such as longer operation time, may be overcome with accumulation of surgeon experience. Undoubtedly, continued critical evaluation of the emerging data is necessary as we judiciously expand the application of robotic technology in surgical oncology.

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**INVITED CRITIQUE**

# Robotic Gastrectomy Is Safe and Feasible, but Real Benefits Remain Elusive

The study by Woo et al,[1] while not randomized, provides a large cohort of robotic gastric dissections and lymphadenectomies (D1 and D2) for stage Ia and Ib gastric cancer. They have shown the ability to safely attain equivalent oncologic margins and lymph node harvest when compared with laparoscopic cases. While promising, the study lacks long-term outcomes to prove oncologic equivalency. Reconstructions were not performed robotically, limiting the scope of additional outcome comparisons such as leak. Overall morbidity and mortality appear similar, but it would be interesting to know if they experienced any robotic-specific complications such as iatrogenic injury out of the field of view.

The evolution from open to laparoscopic gastrectomy has been shown in randomized trials to provide equivalent oncologic outcomes with multiple benefits for patients including decreased postoperative pain, decreased hospitalization, and faster return to activity. It is not clear that the robotic approaches, requiring a similar number of abdominal trocars and longer operative times, can significantly improve these outcomes. While arguments for improved surgeon dexterity and training are interesting and could ultimately offer some benefit, they are unproven to date. The conclusion of Woo et al that robotic gastrectomy offers better short-term outcomes is based on what most surgeons would consider a negligible difference in blood loss. A more clinically relevant short-term outcome of hospital stay was on average longer for the robotic group, although median days to discharge were similar.

Finally, the question that plagues robotic approaches is of course increased cost. It is unfortunate that the self-pay health care system in Korea does not allow for a detailed analysis of cost. However, it would be reasonable to assume that the cost of the robotic approach is once again higher. Overall, it appears that robotic gastrectomy for early-stage cancer is feasible and safe, but clinically significant benefits are yet to be proven.

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