Comparison of Robotic Gastrectomy with D2 Lymphadenectomy with Laparoscopic Gastrectomy with D2 Lymphadenectomy for Patients with High Body Mass Index

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ABSTRACT

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Background: Minimally invasive surgery (MIS) has become one of the treatments of choice for gastric cancer. However, applying MIS to patients with high body mass index is technically challenging, especially when performing D2 lymphadenectomy. We hypothesized that robot surgery would affect the results of gastrectomy with D2 lymphadenectomy in high body mass index(BMI) patients. To assess the impact of surgical methods and BMI, we compared surgical outcomes of robotic distal gastrectomy (RDG) and laparoscopic distal gastrectomy (LDG) for patients with different BMIs.

Methods: Between 2003 and 2010, 400 gastric cancer patients underwent radical distal gastrectomy with D2 lymphadenectomy. Patients were categorized by surgical approaches and their BMIs. We compared surgical outcomes between each group.

Results: Regardless of BMI, RDG required significantly longer operation time

than LDG (p=0.001). Among high BMI patients, the RDG group showed significantly less blood loss than the LDG group (66.8±61.3mL vs. 157.2±338.4mL, p=0.018). The radicality of each surgical approach for high BMI group was considered similar, evidenced by comparable numbers of retrieved lymph nodes. In high BMI patients, the frequency of complications did not differ significantly between surgical approaches. However, although statistically not significant, the RDG group showed decreased incidences of moderate to severe complications(3.2%) compared to the LDG group(9.0%).

Conclusions: In gastric cancer, the effects of robotic application were more evident for high BMI patients than normal BMI patients, based on blood loss and complication severity. Gastric cancer patients with high BMI could therefore be good candidates for robotic surgery when surgeons select surgical methods for treatment.

Key words: stomach neoplasms, laparoscopy, robotics, body mass index

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I. INTRODUCTION

In spite of decreasing incidence and mortality of gastric cancer, it remains the fourth most common cancer, as well as the second leading cause of cancer-related death worldwide.[1] In Korea, it is still the most prevalent cancer and the second leading cause of cancer-related death.[2] Nationwide screening for early detection in prevalent areas, like Korea and Japan, has resulted in early detection and led to improved prognosis.[3-5] Considering the excellent prognosis of early gastric cancer (EGC), emphasis has been directed towards improving quality of life after surgery. Following this trend, with its benefit of minimal invasiveness, laparoscopic surgery has emerged as an alternative therapy for early stage cancer.[3]

Laparoscopic gastrectomy with lymph node dissection is beneficial in terms of postoperative pain, hospital stay, gastrointestinal function recovery, and

return to normal activity.[6-8] However, the adoption of laparoscopic gastrectomy was limited by the complexity of lymphadenectomy and its innate technical limitations. The limitations of conventional laparoscopic systems are 2-dimensional visualization, restricted range of motion, physiologic tremor, and a decreased sense of touch.[9] Furthermore, high BMI is an important constraint in laparoscopic procedures due to excessive intra-abdominal fat, thick abdominal walls, and reduced surgical dexterity.

In an effort to overcome these drawbacks, the robotic system was introduced.[10,11] Robotic surgery proved to be a better surgical approach, especially when performing complex procedures and treating high BMI patients in various surgical fields.[12,13] In gastric cancer surgery, because D2 lymphadenectomy requires dissection around deep seated vessels, stable exposure and a wristed instrument may help to efficiently perform this complex procedure.

The safety and feasibility of laparoscopic surgery for gastric cancer patients with high BMIs are currently being evaluated, but the data are limited.[14,15] Moreover, no study regarding robotic application based on BMI has been reported. To the best of our knowledge, this study is the first study to compare LDG and RDG with D2 lymphadenectomy as a function of BMI.

We hypothesized that robot surgery would affect the results of gastrectomy

with D2 lymphadenectomy in high BMI patients. To assess the impact of surgical methods and BMI, we compared surgical outcomes of RDG and LDG for patients with different BMIs.

II. MATERIALS AND METHODS

1. Patients and Methods

A retrospective review of a prospectively collected database of gastric cancer patients at Severance Hospital, Yonsei University Health System, revealed 1192 patients who underwent radical distal subtotal gastrectomy with lymphadenectomy by a minimally invasive technique for gastric cancer between 2003 and 2010. Among these1192 patients, we excluded 792 patients who received D1+ lymphadenectomy or a combined operation for another primary disease. Finally, 400 patients who underwent radical distal subtotal gastrectomy with D2 lymphadenectomy either by laparoscopy or robot were included for analyses.

For preoperative diagnosis and evaluation, all patients received upper endoscopy, endoscopic ultrasonography, and abdomino-pelvic computed tomography. Tumor staging was described according to the 7th tumor node metastasis (TNM) classification of the American Joint Committee in Cancer/International Union Against Cancer (AJCC/IUAC).[16] Patients who were confirmed by preoperative evaluation to have serosa-exposed gastric cancer underwent open surgery, because the oncologic safety of minimally invasive surgery in advanced gastric cancer is still in debate.[17] We performed laparoscopic and robotic distal gastrectomy with D2 lymphadenectomy based on the treatment guidelines of the Japanese Gastric Cancer Association.[18] The

operative technique of each approach was previously described in detail.[19,20]

The degree of obesity was determined using the body mass index (BMI). According to the definition of obesity in Asian and Pacific Islander populations,[21] patients were categorized as the normal BMI group (<25 kg/m2) and the high BMI group (≥25 kg/m2). Operation time, estimated blood loss, retrieved lymph nodes (LNs) number, length of stay, and postoperative complications were evaluated to compare surgical outcomes. Frequency and severity of complications were reviewed according to the Clavien-Dindo classification of surgical complications.[22] Postoperative death of a patient was classified as a severe complication.

All patients selected their own type of surgery after receiving a complete explanation of cost, risk, and possible alternative treatments in accordance with the clinical stage of their disease at the time of surgery. All procedures were performed after informed consent had been obtained, including consent for the extra cost of robotic surgery. This retrospective study was approved by the Institutional Review Board of Severance Hospital, Yonsei University Health System (2011-1062-001).

2. Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Science (SPSS) version 19.0 for Microsoft Windows (IBM, Armonk, NY, USA). Student's t-test was used to analyze the mean differences of numerical variables between the high BMI and normal BMI groups. The chi-square test with Fisher's exact test was used in other comparisons. All p values less than 0.05 were considered statistically significant.

III. RESULTS

Among 400 patients who underwent radical distal subtotal gastrectomy with D2 lymphadenectomy by minimally invasive surgery, 267 patients underwent laparoscopic distal gastrectomy and 133 patients underwent robotic distal gastrectomy. Among them, 120 patients (31, RDG; 89, LDG) with BMIs greater than 25 kg/m2 were assigned to the high BMI group [mean±standard deviation (SD), 26.8±1.8 kg/m2] and 280 patients to the normal BMI group (22.1±1.8 kg/m2).

1. Comparison of the Laparoscopic Group with the Robotic Group

Patient characteristics and surgical outcome comparisons between the LDG and RDG groups are shown in Table 1. The LDG group patients were significantly older than robotic group patients (mean age, 59.2±11.7 vs. 53.6±13.2, respectively, $p<0.001$). BMI and gender were not significantly different between surgical methods. No significant differences were found between LDG and RDG in terms of comorbidities, with the exception of hypertension. Pathological stages showed no significant differences between the LDG and RDG groups. Mean operation time for the RDG group was 217.5±37.8 minutes, which was on average 46 minutes longer than that of the LDG group (171.0±52.5 minutes, $p<0.001$). The intraoperative estimated blood loss of the RDG group was significantly less than that of the LDG group

(p=0.005). The number of retrieved LNs showed no significant difference

Table 1. Clinical Characteristics and Surgical Outcomes of Surgical Approaches

Variable	LDG (n = 267)	RDG (n = 133)	*P*
BMI (kg/m^2, range)	23.7±2.8 (16.2 ~ 37.1)	23.2±2.7 (16.8 ~ 33.3)	0.117
Gender(male/female)	154/113	85/48	0.231
Age (years, range)	59.2±11.7 (27~ 82)	53.6±13.2 (26 ~ 84)	<0.001
Comorbidities			
Absent	125 (46.8%)	76 (57.1%)	0.052
Present	142 (53.2%)	57 (42.9%)	
Hypertension	81 (30.3%)	26 (19.5%)	0.022
Diabetes mellitus	27 (10.1%)	19 (7.5%)	0.399
Pulmonary	7 (2.6%)	3 (2.3%)	0.825
Cardiac	21 (7.9%)	9 (6.8%)	0.694
Renal	11(4.1%)	4(3.0%)	0.581
Liver	14(5.2%)	9 (6.8%)	0.537
CVA	5 (1.9%)	6 (4.5%)	0.191
Tuberculosis	22 (8.2%)	10 (7.5%)	0.802
Other	3 (1.1%)	2(1.5%)	0.020
Operation time (minutes)	171.0±52.4	217.5±37.8	<0.001
EBL (mL)	87.1±216.9	47.0±57.9	0.005
Retrieved LNs	39.9±13.3	41.2±13.1	0.358
LN≥16 (patients No.)	263 (98.5%)	130 (97.7%)	0.690
LN≤15 (patients No.)	4 (1.5%)	3 (2.3%)	
Length of hospital stay (days)	7.0±6.4	6.2±3.8	0.151
Complications†			0.296
Absent	233 (87.3%)	119 (89.5%)	
Mild	19 (7.1%)	11 (8.3%)	
Moderate to severe	15 (5.6%)	3 (2.2%)	

BMI = body mass index; LDG = laparoscopic distal gastrectomy; RDG = robotic distal gastrectomy; CVA = cerebrovascular accident; EBL = estimated blood loss; LN = lymph node.

Values are expressed as mean ± standard deviation or number (percentage).

†Based on the Clavien-Dindo classification of surgical complications.

between the LDG and RDG groups. Percentage of patients with less than 16 retrieved LNs were 1.5% for the LDG group and 2.3% for the RDG group.

Complication rate and severity were not significantly different (p=0.296).

Table 2. Clinical Characteristics and Surgical Outcomes for each Surgical Method according to BMI

Variable	LDG (n = 267)			RDG (n = 133)		
	Normal BMI (178)	High BMI (89)	*P*	Normal BMI (102)	High BMI (31)	*P*
BMI (kg/m^2, range)	22.1±1.7 (16.2 ~ 24.9)	26.8±1.9 (25.0 ~ 37.1)	<0.001	22.1±1.9 (16.8 ~ 24.9)	26.9±1.8 (25.0 ~ 33.3)	<0.001
Gender (male/female)	98 / 80	56 / 33	0.220	59 / 43	26 / 5	0.008
Age (years, range)	57.8±12.2 (27 ~ 82)	62.0±10.2 (36 ~ 79)	0.005	52.3±13.4 (26 ~ 84)	58.1±11.4 (38 ~ 79)	0.032
Comorbidities						
Absent	88 (49.4%)	37 (41.6%)	0.225	61 (59.8%)	15 (48.4%)	0.261
Present	90 (50.6%)	52 (58.4%)		41 (40.2%)	16 (51.6%)	
Hypertension	44 (24.7%)	37 (41.6%)	<0.001	16 (15.7%)	10 (32.3%)	0.042
DM	18 (10.1%)	9 (10.1%)	>0.999	6 (5.9%)	4 (12.9%)	0.241
Pulmonary	5 (2.8%)	2 (2.2%)	>0.999	1 (1.0%)	2 (6.5%)	0.135
Cardiac	13 (7.3%)	8 (9.0%)	0.630	4 (3.9%)	5 (16.1%)	0.032
Renal	9 (5.1%)	2 (2.2%)	0.346	4 (3.9%)	0	0.573
Liver	9 (5.1%)	5 (5.6%)	>0.999	8 (7.8%)	1 (3.2%)	0.684
CVA	4 (2.2%)	1 (1.1%)	0.668	4 (3.9%)	2 (6.5%)	0.623
Tuberculosis	17 (9.6%)	5 (5.6%)	0.271	9 (8.8%)	1 (3.2%)	0.452
Other	15 (8.4%)	6 (6.7%)	0.630	10 (9.8%)	5 (16.1%)	0.340
Operation time (minutes)	162.8±46.2	187.2±59.9	0.001	210.8±36.6	239.7±33.6	<0.001
EBL (mL)	52.1±100.4	157.2±338.4	0.005	40.9±55.8	66.8±61.3	0.029
Retrieved LNs	41.3±12.9	37.1±13.7	0.013	42.5±13.4	36.9±11.1	0.036
LN≥16 (patients No.)	177 (99.4%)	86 (96.6%)	0.109	101 (99%)	29 (93.5%)	0.135
LN≤15 (patients No.)	1 (0.6%)	3 (3.4%)		1 (1%)	2 (6.5%)	
LOS (days)	7.3±7.5	6.5±3.2	0.337	6.1±3.8	6.5±3.8	0.567
Complications†			0.151			0.029
Absent	160 (89.9%)	73 (82.0%)		95 (93.1%)	24 (77.4%)	
Mild	11 (6.2%)	8 (9.0%)		5 (4.9%)	6 (19.4%)	
Moderate to severe	7 (3.9%)	8 (9.0%)		2 (2.0%)	1 (3.2%)	

BMI = body mass index; LDG = laparoscopic distal gastrectomy; RDG = robotic distal gastrectomy; DM = diabetes mellitus; CVA = cerebrovascular accident; EBL = estimated blood loss; LN = lymph node; LOS = length of stay.
Values are expressed as mean ± standard deviation or number (percentage).
†Based on the Clavien-Dindo classification of surgical complications.

2. Comparison of Surgical Outcomes According to BMI

In each surgical method, patient characteristics and surgical outcomes according to BMI are shown in Table 2. High BMI group patients were significantly older than normal BMI group patients for both the LDG and RDG groups. For the RDG group, the gender ratio was significantly different between BMI groups (p=0.008).

Table 3. Pathological Characteristics of Patients according to BMI

	LDG (n = 267)			RDG (n = 133)		
Variable	Normal BMI (178)	High BMI (89)	*p*	Normal BMI (102)	High BMI (31)	*p*
Location			0.267			0.948
Middle	47 (26.4%)	18 (20.2%)		29 (28.4%)	9 (29.0%)	
Lower	131 (73.6%)	71 (79.8%)		73 (71.6%)	22 (71.0%)	
Depth of invasion†			0.256			0.832
T1	134 (75.3%)	67 (75.3%)		72 (70.6%)	23 (74.2%)	
T2	20 (11.2%)	15 (16.9%)		12 (11.8%)	3 (9.7%)	
T3	10 (5.6%)	6 (6.7%)		9 (8.8%)	2 (6.5%)	
T4	14 (7.9%)	1 (1.1%)		9 (8.8%)	3 (9.7%)	
Lymph node status†			0.697			0.528
N0	146 (82.0%)	73 (82%)		74 (72.5%)	23 (74.2%)	
N1	11 (6.2%)	8 (9.0%)		15 (14.7%)	3 (9.7%)	
N2	13 (7.3%)	5 (5.6%)		7 (6.9%)	0 (0%)	
N3	8 (4.5%)	3 (3.4%)		6 (5.9%)	5 (16.1%)	
TNM stage†			0.355			0.524
I	144 (80.9%)	74 (83.1%)		77 (75.5%)	24 (77.4%)	
II	20 (11.2%)	12 (13.5%)		12 (11.8%)	3 (9.7%)	
III	14 (7.9%)	3 (3.4%)		13 (12.7%)	4 (12.9%)	

BMI = body mass index; LDG = laparoscopic distal gastrectomy; RDG = robotic distal gastrectomy.

†Based on the Seventh American Joint Committee on Cancer classification.

Analysis of comorbidities showed that hypertension was more common in high BMI patients than in normal BMI patients, regardless of surgical methods. Cardiac dysfunction was more prevalent in the high BMI group than in the normal BMI group of RDG patients (p=0.032). Pathological characteristics of patients showed no significant differences between the BMI groups for both LDG and RDG groups (Table 3).

High BMI patients showed significantly longer operation time than normal BMI patients for both LDG and RDG. Estimated blood loss was significantly greater in the high BMI group than in the normal BMI group, regardless of surgical approaches (LDG, 157.2±338.4 mL vs. 52.1±100.4 mL, respectively, p=0.005; RDG, 66.8±61.3 mL vs. 40.9±55.9 mL, respectively, p=0.029). Differences in blood loss according to BMI were significantly greater for the LDG group (105.1 mL) than for the RDG group (25.9 mL). Retrieved LN number of high BMI groups was significantly less than normal BMI groups. Length of stay was not significantly different between BMI groups. For the LDG group, complications were not affected by BMI. However, the complication rate of the high BMI group was greater than that of the normal BMI group for the RDG group (p=0.029), although 6 out of 7 had minor complications, including wound complications.

3. Comparison of LDG and RDG for Normal BMI patients (Table 4)

Laparoscopic group patients were significantly older than robotic group patients. Operation time was significantly longer for LDG than for RDG groups ($p<0.001$). Estimated blood loss, retrieved LN number, length of stay, and complications were not significantly different between laparoscopic and robotic surgery in normal BMI patients.

Table 4. Comparison of Distal Gastrectomy according to Operation Methods in Normal BMI

Variable	LDG (n = 178)	RDG (n = 102)	*p*
BMI (kg/m2, range)	22.1±1.7 (16.2 ~ 24.9)	22.1±1.9 (16.8 ~ 24.9)	0.959
Gender(male/female)	98 / 80	59 / 43	0.708
Age (years, range)	57.8±12.2 (27 ~ 82)	52.3±13.4 (26 ~ 84)	0.001
Operation time (minutes)	162.8±46.2	210.8±36.6	<0.001
EBL (mL)	52.1±100.4	40.9±55.8	0.232
Retrieved LNs	41.3±12.9	42.5±13.4	0.466
LN ≥ 16 (patients No.)	177 (99.4%)	101 (99%)	>0.999
LN ≤ 15 (patients No.)	1 (0.6%)	1 (1%)	
Length of hospital stay (days)	7.3±7.5	6.1±3.8	0.069
Complications†			0.668
Absent	160 (89.9%)	95 (93.1%)	
Mild	11 (6.2%)	5 (4.9%)	
Moderate to severe	7 (3.9%)	2 (2.0%)	

LDG = laparoscopic distal gastrectomy; RDG = robotic distal gastrectomy; EBL = estimated blood loss; LN = lymph node.
Values are expressed as mean ± standard deviation or number (percentage).
†Based on the Clavien-Dindo classification of surgical complications.

4. Comparison of LDG and RDG for High BMI patients (Table 5)

Gender ratio was significantly different between the LDG and RDG groups ($p=0.043$). More male patients were included for the RDG group than for the LDG group. The RDG group showed significantly longer operation time than the LDG group ($p<0.001$). In high BMI patients, in contrast to normal BMI patients, estimated blood loss was significantly greater for the LDG group than for the RDG group ($p=0.018$). Retrieved LN number and length of stay were not significantly different between laparoscopic and robotic surgery for high BMI patients. Complications did not differ significantly between surgical approaches ($p=0.270$). Although not statistically significant, the RDG group showed fewer complications graded as moderate to severe (3.2%) compared to the LDG group (9.0%).

Table 5. Comparison of Distal Gastrectomy according to Operation Methods in High BMI

Variable	LDG (n = 89)	RDG (n = 31)	*p*
BMI (kg/m2, range)	26.8±1.9 (25.0 ~ 37.1)	26.9±1.8 (25.0 ~ 33.3)	0.886
Gender(male/female)	56 / 33	26 / 5	0.043
Age (years, range)	62.0±10.2 (36 ~ 79)	58.1±11.4 (38 ~ 79)	0.074
Operation time (minutes)	187.2±59.9	239.7±33.6	<0.001
EBL (mL)	157.2±338.4	66.8±61.3	0.018
Retrieved LN	37.1±13.7	36.9±11.1	0.946
LN ≥ 16 (patients No.)	86 (96.6%)	29 (93.5%)	0.603
LN ≤ 15 (patients No.)	3 (3.4%)	2 (6.5%)	
Length of hospital stay (days)	6.5±3.2	6.5±3.8	0.988
Complications†			0.270
Absent	73 (82.0%)	24 (77.4%)	
Mild	8 (9.0%)	6 (19.4%)	
Moderate to severe	8 (9.0%)	1 (3.2%)	

LDG = laparoscopic distal gastrectomy; RDG = robotic distal gastrectomy; EBL = estimated blood loss; LN = lymph node.
Values are expressed as mean ± standard deviation or number (percentage).
†Based on the Clavien-Dindo classification of surgical complications.

IV. DISCUSSION

The results of the present study showed that the benefits of robotic application were more evident in gastric cancer with high BMI patients. Patients who underwent RDG showed significantly longer operation time than those who underwent LDG, regardless of BMI. In the high BMI group, patients who underwent RDG experienced significantly less blood loss than those who underwent LDG. In high BMI patients, complications were not significantly different between surgical methods. Although not statistically significant, the RDG group showed fewer complications graded as moderate to severe compared to the LDG group.

Recent studies have shown that laparoscopic gastrectomy is a safe and feasible technique when performed by experienced surgeons.[6-8,23] However, high BMI patients present further challenges using the laparoscopic technique, because the excessive fat of high BMI patients impairs adequate exposure of the surgical field and physiologic adhesion makes it difficult to perform precise lymph node dissection around major vessels.[15,24,25]

Regarding minimally invasive techniques, the robotic approach takes advantage of excellent stereoscopic visualization, improved dexterity with tremor filter, and superior movement of the robotic arm.[9-11] These features allow surgeons to safely perform robotic gastrectomy.[20,26-28] We assumed that these

advantages would be reflected in surgical outcomes, especially technically challenging procedures, such as D2 lymphadenectomy for high BMI patients.

To test our hypothesis, we compared short term and oncologic outcomes of gastrectomy according to surgical approaches and BMIs. In this study, the amount of blood loss for the high BMI group was significantly affected by surgical methods. Not only amount but also variability of blood loss showed a large difference between the RDG and LDG groups. Comparing the standard deviation of blood loss, the variability of the LDG group was significantly greater than that of the RDG group (over fivefold). Thus a robotic system can facilitate high quality surgery with more consistent outcomes for high BMI patients. Because blood loss during lymphadenectomy can obscure the surgical field, it impairs precise dissection.[29] In addition, for some high risk patients such as those with cardiac disease, bleeding might be critical. Furthermore, spillage of free cancer cells from the lymphovascular channels[30] and perioperative transfusion might negatively impact oncologic outcomes.[31]

Complications are another important concern in postoperative outcomes. Overall complication rate of high BMI patients for RDG was significantly higher than in normal BMI patients for RDG. However, only one complication was graded as moderate to severe for the high BMI patients. Most complications for high BMI patients for the RDG group were minor, especially

wound complications. Consistent with previous studies,[32, 33] the long operation times of robotic surgery for high BMI patients may be associated with wound complications. However, operation time shortens with experience, as shown in our previous study.[26] Hence, wound complications would be expected to be reduced as surgeons obtain more experience.

In cancer surgery, oncologic outcome is as important as short term outcome. For satisfactory oncologic outcomes for gastric cancer surgery, D2 lymphadenectomy is crucial. It can increase long-term survival and has become a standard surgical procedure for curative treatment of gastric cancer.[34-36] Both anatomical location and number of retrieved LNs are important in D2 lymphadenectomy. The increased number of retrieved LNs improves the accuracy of staging and the regional disease control.[37,38]. In spite of technical advancement, D2 lymphadenectomy in high BMI patients is still difficult.[39] In this study, for the high BMI group, numbers of retrieved LNs were significantly less than for the normal BMI group using both surgical approaches. However, the numbers exceeded the recommended number of retrieved LNs for a D2 lymphadenectomy, thus the radicality of the operation for the high BMI group can be considered clinically acceptable.[18,40]

The demand for minimally invasive surgery for gastric cancer treatment is increasing. At the same time, using this technique for high BMI patients is still

technically challenging. Robotic surgery makes it possible to perform higher quality surgery for high BMI patients. A previous study reported that robotic surgery can reduce the learning curve for gastric cancer surgery,[41] suggesting that high quality surgery is possible with less experience than required for laparoscopic surgery. These advantages could be more helpful for Western countries or lower volume centers, where high BMI patients are more common and where there is a lower incidence of gastric cancer, which minimizes the number of gastric cancer surgeries compared to Eastern countries. With time, it is probable that the use of robotic system in gastrectomy will increase globally, due to the difficulty of laparoscopic training and increase of patients' BMI worldwide.[42]

As obesity continues to increase, surgeons may treat increasing numbers of gastric cancer patients with high BMIs. A study of gastrectomy for high BMI patients is therefore essential. Prior studies have compared a limited number of open and laparoscopic gastrectomies with D1+ or D2 lymphadenectomy. Our study is the first to compare robotic gastrectomy and laparoscopic gastrectomy with D2 lymphadenectomy as a function of BMI. Moreover, our study is strengthened with its large scale and the homogenous extent of the lymph node dissection.

This study has several limitations. First, it was a single institutional study

with a retrospective design. However, this made it possible to maintain homogeneity in the extent of D2 lymphadenectomy, despite different surgical approaches. Second, the proportion of extremely high BMI patients (BMI>35 kg/m2) was small. We could not fully evaluate the safety and benefits of RDG in extremely high BMI patients. However, this was due to demographical characteristics of Eastern compared to Western populations. Third, we did not include an analysis of cost effectiveness. Finally, our study lacked long-term outcomes, but we are planning further investigations to obtain long-term results.

V. CONCLUSION

In conclusion, our results showed that the effects of robotic surgery were more evident for high BMI patients than for normal BMI patients. Robotic application leads to less blood loss, fewer incidences of severe complications, and acceptable numbers of retrieved LNs for high BMI patients. Patient with high BMI could therefore be good candidates for robotic surgery when surgeons select the surgical methods for treatment of gastric cancer.

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< ABSTRACT(IN KOREAN)>

높은 체질량지수의 위암환자에서 로봇 위절제술 및 D2 림프절절제술과 복강경 위절제술 및 D2 림프절절제술의 비교

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최소침습수술은 위암 치료에서 최선의 치료방법 중 하나로 받아들여지고 있다. 그러나, 높은 체질량지수의 위암 환자에서 최소침습수술 적용은 기술적으로 어렵고, 특히 D2 림프절절제술에서 어려움이 크다. 저자는 난이도 높은 수술 즉, 높은 체질량지수의 위암환자 위절제술 및 D2림프절절제술에서 로봇 수술의 강점이 보통 체질량지수 환자에서보다 뚜렷하다는 가설을 세웠다. 따라서 수술 방법과 체질량지수가 결과에 미치는 영향을 알아보기 위해 본 연구를 진행하였다. 2003년에서 2010년까지, 최소침습수술을 이용하여 근치적 위아전절제술 및 D2 림프절절제술을 시행 받은 400명의 위암환자를 대상으로 수술방법과 체질량지수에 따라 집단을 나누고, 각 집단의 수술결과를 비교하였다. 체질량지수에 관계없이, 로봇수술은 복강경수술에 비해 수술시간이 오래 걸렸다(p=0.001).

반면에 높은 체질량지수 환자에서, 로봇수술은 복강경수술에 비해 출혈량이 적었다(66.8±61.3mL vs. 157.2±338.4mL, p=0.018). 높은 체질량지수 환자에서 각 수술방법의 근치도는 유사하였으며, 이는 획득림프절의 수가 통계적인 차이가 없음으로 확인할 수 있었다. 높은 체질량지수 환자군에서 합병증의 발생빈도는 수술방법간의 차이는 없었다. 통계적으로 유의하지는 않았으나, 로봇수술에서 중등도 이상의 합병증(3.2%)은 복강경수술(9.0%)에 비해 적은 것으로 나타났다.

결론적으로 출혈량과 합병증 중증도를 살펴보았을 때, 위암에서 로봇수술의 장점은 높은 체질량지수 환자에서 특히 뚜렷하다. 수술방법을 결정할 때 높은 체질량지수의 위암환자는 로봇수술의 좋은 적응증이 될 수 있다.

핵심되는 말 : 위암, 복강경, 로봇, 체질량지수