

Cost-Effectiveness of Robotic Surgery for Rectal Cancer Focusing on Short-Term Outcomes

A Propensity Score-Matching Analysis

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Abstract: Although the total cost of robotic surgery (RS) is known to be higher than that of laparoscopic surgery (LS), the cost-effectiveness of RS has not yet been verified. The aim of the study is to clarify the cost-effectiveness of RS compared with LS for rectal cancer.

From January 2007 through December 2011, 311 and 560 patients underwent totally RS and conventional LS for rectal cancer, respectively. A propensity score-matching analysis was performed with a ratio of 1:1 to reduce the possibility of selection bias. Costs and perioperative short-term outcomes in both the groups were compared. Additional costs due to readmission were also analyzed.

The characteristics of the patients were not different between the 2 groups. Most perioperative outcomes were not different between the groups except for the operation time. Complications within 30 days of surgery were not significantly different. Total hospital charges and patients' bill were higher in RS than in LS. The total hospital charges for patients who recovered with or without complications were higher in RS than in LS, although their short-term outcomes were similar. In patients with complications, the postoperative course after RS appeared to be milder than that of LS. Total hospital charges for patients who were readmitted due to complications were similar between the groups.

RS showed similar short-term outcomes with higher costs than LS. Therefore, cost-effectiveness focusing on short-term perioperative outcomes of RS was not demonstrated.

(*Medicine* 94(22):e823)

Abbreviations: ASA = American Society of Anesthesiologists, BMI = body mass index, IC = insured charge, LOS = length of stay, LS = laparoscopic surgery, NHIC = National Health Insurance Corporation, NIC = noninsured charge, OS = open surgery, OT = operation time, POD = postoperative day, RS = robotic surgery.

Editor: Lalit Banswal.

Received: January 14, 2015; revised: February 10, 2015; accepted: April 7, 2015.

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The authors have no funding and conflicts of interest to disclose.

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ISSN: 0025-7974

DOI: 10.1097/MD.0000000000000823

INTRODUCTION

Previous studies have demonstrated that laparoscopic surgery (LS) for colorectal cancer is comparable to open surgery (OS) in terms of long-term oncologic outcomes and short-term perioperative outcomes.¹⁻³ Moreover, although robotic surgery (RS), which was introduced only a decade ago, has not been fully regarded as an alternative surgical option for colorectal cancer, it has shown not only acceptable short-term outcomes and pathologic results but also long-term oncologic outcomes similar to LS and OS.⁴⁻⁷ Additionally, in attempting to prove the theoretical advantages of robotic rectal resection (ie, better preservation of sexual and urinary function), we found evidence supporting the benefits of this technique in a previous study.⁸ Based on these outcomes, robotic rectal surgery is increasing in East Asia and Western countries. However, the most well-known drawback of RS is its high cost. Most surgeons in the fields of urology, gynecology, cardiac surgery, and others have noted higher costs of RS compared with LS or OS.⁹⁻¹³ Similar data have been reported by colorectal surgeons, with all investigators who analyzed the cost of RS for colorectal diseases showing higher costs of RS compared with LS or OS.¹⁴⁻²⁰ In Korea, patients who receive RS pay much higher medical fees than patients who receive OS or LS, due to the unique Korean health care system. By contrast, there are few studies that have analyzed cost-effectiveness of RS for colorectal diseases.²¹ Thus, we analyzed the cost-effectiveness of RS for rectal cancer focusing on short-term outcomes within 30 days of surgery compared with LS from a single large-volume institution in Korea.

METHODS

Patients

From January 2007 through December 2011, a total of 2614 patients underwent low anterior resection for rectal cancer within 15 cm of the anal verge at Severance Hospital, Yonsei University College of Medicine, Seoul, Korea. Among these patients, 234 who underwent RS were compared with 234 who underwent LS after propensity score-matching. In this study, the evaluation of cost-effectiveness was based on the relative correlations between cost and short-term outcomes. Whether the cost is high or low and whether the short-term outcomes of RS were good or poor were rated by relative comparison with LS.

With respect to baseline characteristics, sex, age, body mass index (BMI), alcohol intake, smoking status, American Society of Anesthesiologists (ASA) classification, previous abdominal surgery, neoadjuvant therapy, histology, and tumor location from the anal verge were evaluated. To evaluate perioperative short-term outcomes, operation type, operation time (OT), estimated blood loss, combined resection, ileostomy formation, conversion to OS, pain score on the day of surgery,

postoperative day (POD) number 1, and POD number 2, time to first flatus, time to liquid and soft diet, total and postoperative length of stay (LOS), morbidity and mortality within 30 days of surgery, Clavien-Dindo classification of complications,²² and readmission rates due to complications were evaluated and compared between the groups. Both robotic and laparoscopic surgical procedures followed oncologic principles in rectal cancer surgery. Patients who underwent RS with a hybrid technique (use of both robotic and laparoscopic instruments) were excluded. Details of the surgical procedure are described in our previous studies.^{5,23} The study was approved by the institutional review board of Severance Hospital.

Costs

Total hospital charges were classified into 2 categories: total insured charge (IC) and total noninsured charge (NIC). In Korea, the Korean National Health Insurance Corporation (NHIC), a government organization, pays 90% of the IC from September 2005 to November 2009, and has paid 95% from December 2009 to the present for patients with cancer for a total of 5 years from the date of diagnosis. Therefore, the patient's bill was the sum of 5% or 10% of IC and 100% of NIC in this study. Most treatment modalities for various diseases are composed of both IC and NIC, which are decided by the NHIC in Korea. When the NHIC accepts a certain treatment or medicine as IC, it also determines the cost. Conversely, when the NHIC names a certain treatment or medicine as NIC such as additional fee for physician experience >10 years, private room fees, special diet fees, cost of the new technology that has not been proven safe with level-1 evidence, and so on, the cost are set by each hospital.

All costs accumulated during admission for RS or LS were analyzed. Additional costs for readmission due to complications

within 30 days of surgery were also evaluated. Total hospital charges were categorized into 5 groups; fees for the operation, anesthesia, preoperative diagnosis, postoperative management, and other.

Fees for the operation included surgery and treatment fees plus the cost of instruments and supplies. Surgery and treatment fees were composed of the cost of surgery and other treatment needs including urinary catheter insertion, aseptic dressings, nasogastric tube insertion, suture removal, and so on. The surgery fee included the cost for use of the operating room and compensation for the doctors and nurses who participated in the surgery. The RS fee was NIC and set at \$9756.10, with consideration of the initial purchasing, maintenance, and depreciation costs of the robotic system. Additionally, the RS fee included disposable and reusable supplies. On the contrary, the LS fee was IC and did not include the cost of disposable and reusable supplies. The LS fee gradually increased from \$1145.30 in January 2007 to \$1724.80 in December 2011.

Anesthesia fees were proportional to OT. Fees for preoperative diagnosis were composed of the outpatient physician's fee, laboratory studies, and imaging study fees. Fees for postoperative management included cost of the hospital room, diet, medication, postoperative laboratory studies, imaging studies, transfusion, consultation fees, and other medical management. Other costs included fees for rehabilitation, medical documents, and so on.

Statistical Analysis

To reduce the possibility of selection bias, the authors performed propensity score-matching with a ratio of 1:1 according to the following 10 variables: year of operation, sex, age, BMI, alcohol intake, smoking status, ASA classification,

TABLE 1. Baseline Characteristics of the Patients

Variable	Overall Cohort			After Matching		
	Robot (n = 311)	Laparoscopy (n = 560)	P	Robot (n = 251)	Laparoscopy (n = 251)	P
Male	198 (63.9%)	352 (62.9%)	0.770	156 (62.2%)	159 (63.8%)	0.782
Age, y	57.0 ± 11.5	62.4 ± 10.4	<0.001	59.0 ± 11.0	59.1 ± 10.9	0.925
BMI, kg/m ²	23.5 ± 2.9	23.3 ± 3.1	0.502	23.4 ± 2.9	23.5 ± 3.2	0.740
Alcohol intake	172 (55.5%)	273 (48.8%)	0.066	133 (53.0%)	126 (50.2%)	0.532
Smoking	145 (46.8%)	256 (45.7%)	0.764	119 (47.4%)	114 (45.4%)	0.655
ASA grade			<0.001			0.929
I	84 (27.1%)	98 (17.5%)		58 (23.1%)	63 (25.1%)	
II	197 (63.5%)	351 (62.7%)		164 (65.3%)	158 (63.0%)	
III	28 (9.0%)	102 (18.2%)		28 (11.2%)	29 (11.6%)	
IV	1 (0.3%)	9 (1.6%)		1 (0.4%)	1 (0.4%)	
Previous abdominal surgery	52 (16.8%)	114 (20.4%)	0.208	47 (18.7%)	46 (18.3%)	0.909
Neoadjuvant therapy			0.001			>0.999
Chemotherapy only	8 (2.6%)	7 (1.2%)		6 (2.4%)	6 (2.4%)	
Chemoradiotherapy	90 (29.0%)	113 (20.2%)		69 (27.5%)	69 (27.5%)	
Tumor location from AV, cm	8.0 ± 3.1	9.3 ± 3.2	<0.001	8.4 ± 3.2	8.3 ± 3.0	0.885
Operation year			<0.001			0.451
2007	1 (0.3%)	41 (7.3%)		1 (0.4%)	11 (4.4%)	
2008	22 (7.1%)	92 (16.4%)		20 (8.0%)	38 (15.1%)	
2009	79 (25.4%)	120 (21.4%)		70 (27.9%)	48 (19.1%)	
2010	126 (40.5%)	126 (22.5%)		103 (41.0%)	57 (22.7%)	
2011	83 (26.7%)	181 (32.3%)		57 (22.7%)	97 (38.6%)	

All values are expressed as means ± SDs. ASA = American Society of Anesthesiologists; AV = anal verge; BMI = body mass index.

previous abdominal surgery, neoadjuvant therapy, and tumor location. Continuous variables were compared using Student *t* tests or Mann–Whitney *U* test, and categorical variables were compared using χ^2 or Fisher exact tests. *P* values <0.05 were considered to be statistically significant. All analyses were performed using Statistical Package for the Social Sciences (version 20.0, Chicago, IL). All charges were converted to US dollars according to the May 2014 exchange rate (\$1 = 1025 won).

RESULTS

A total of 871 patients were eligible for participation in this study. As a result of the propensity score-matching, both groups included 251 patients, and all variables were balanced. The baseline characteristics of the patients before and after case-matching are shown in Table 1.

Most perioperative outcomes were similar between the groups except for the OT (Table 2). The OT was longer in RS

than in LS, and the time to soft diet was earlier in RS than in LS. Complications and readmission rates within 30 days of surgery were not different between the 2 groups.

Total hospital charges were higher in RS than in LS (Table 2). Operation fees and anesthesia fees were higher in RS than in LS. Fees for preoperative diagnosis were similar between the 2 groups. Fees for postoperative management were not different between the groups.

Comparisons of short-term outcomes and costs between RS and LS in cases without complications are listed in Table 3. The RS group had longer OT and higher total hospital charges than the LS group. Fees for postoperative management were higher in RS than in LS.

Longer OT and higher total hospital charges in the RS group than in the LS group were also found in patients with complications (Table 4). However, the RS group had a shorter OT during the second operation compared with LS, and a higher portion of second operations with a borderline *P* value (0.065). Anesthesia fees were not different between groups, and fees for

TABLE 2. Perioperative Outcomes and Overall Costs During Admission (\$)

Variable	Robot (n = 251)	Laparoscopy (n = 251)	<i>P</i>
Operation type			0.199
Low anterior resection	210 (83.7%)	218 (86.9%)	
Ultra low anterior resection	34 (13.5%)	31 (12.4%)	
Intersphincteric resection	7 (2.8%)	2 (0.8%)	
Operation time, min	353.1 ± 86.9	266.6 ± 81.8	<0.001
Histology			0.145
Adenocarcinoma	249 (99.2%)	243 (96.8%)	
Tubulovillous adenoma	1 (0.4%)	3 (1.2%)	
Carcinoid tumor	0 (0%)	4 (1.6%)	
GIST	1 (0.4%)	1 (0.4%)	
Estimated blood loss, mL*	100 (0–1230)	50 (0–3500)	0.817
Combined resection	22 (8.8%)	31 (12.4%)	0.245
Ileostomy formation	91 (36.3%)	79 (31.5%)	0.300
Conversion	0 (0%)	0 (0%)	>0.999
NPIS at			
Operation day	4.4 ± 1.6	4.4 ± 1.4	0.929
POD No. 1	3.7 ± 1.3	3.6 ± 1.2	0.281
POD No. 2	3.5 ± 1.3	3.5 ± 1.3	0.918
Time to the first flatus, d	2.8 ± 1.6	3.0 ± 1.7	0.232
Time to liquid diet, d	3.6 ± 2.4	3.8 ± 2.1	0.293
Time to soft diet, d	4.6 ± 2.9	4.9 ± 2.9	0.266
Total length of stay, d	14.2 ± 7.4	14.3 ± 9.4	0.853
Postoperative length of stay, d	10.8 ± 6.0	11.3 ± 8.7	0.457
Morbidity within 30 days of surgery	61 (24.3%)	57 (22.7%)	0.752
Readmission within 30 days of surgery	7 (2.8%)	10 (4.0%)	0.623
Mortality within 30 days of surgery	0 (0%)	0 (0%)	>0.999
Total hospital charges	15965.10 ± 3512.10	11933.00 ± 4593.00	<0.001
Government's bill	3352.00 ± 2167.90	6829.00 ± 3095.20	<0.001
Patient's bill	12613.10 ± 2002.70	5104.00 ± 1903.90	<0.001
Operation	10375.40 ± 916.20	6796.30 ± 1347.90	<0.001
Anesthesia	1028.50 ± 257.90	875.30 ± 323.40	<0.001
Preoperative diagnosis	1175.70 ± 1012.90	1184.80 ± 1160.90	0.926
Postoperative management	3317.00 ± 2132.70	3010.20 ± 2342.50	0.126
Other	56.40 ± 137.20	66.50 ± 111.00	0.366

All values are expressed as means ± SDs. Preoperative diagnosis: doctor's fee, preoperative laboratory examination and imaging studies; Postoperative management: room, diet, medication, postoperative laboratory examination and imaging studies, transfusion, consultation fees, and so on; Other: rehabilitation, psychiatry, documents, and so on. GIST = gastrointestinal submucosal tumor, NPIS = numerical pain intensity scale, POD = postoperative day.

TABLE 3. Comparison of Short-Term Outcomes and Costs Between RS and LS in Cases Without Complications

	Robot (n = 190)	Laparoscopy (n = 194)	P
Male	114 (60.0%)	114 (58.8%)	0.836
Age, y	58.5 ± 10.9	59.4 ± 11.2	0.396
BMI, kg/m ²	23.5 ± 2.8	23.5 ± 3.1	0.833
ASA grade			0.584
I	44 (23.2%)	56 (28.9%)	
II	127 (66.8%)	115 (59.3%)	
III	19 (10.0%)	22 (11.3%)	
IV	0 (0%)	1 (0.5%)	
Tumor location from AV, cm	8.3 ± 3.2	8.6 ± 3.1	0.505
Operation time, min	350.6 ± 85.6	256.6 ± 80.1	<0.001
Estimated blood loss, mL*	50 (0–1230)	50 (0–3500)	0.975
Combined resection	17 (8.9%)	24 (12.4%)	0.323
Ileostomy formation	65 (34.2%)	60 (30.9%)	0.515
Postoperative length of stay, d	8.7 ± 2.9	8.8 ± 3.2	0.672
Total hospital charges	15138.50 ± 2586.10	10693.00 ± 1815.60	<0.001
Government's bill	2671.70 ± 1193.00	5982.80 ± 1085.10	<0.001
Patient's bill	12466.80 ± 1933.10	4710.20 ± 1062.70	<0.001
Operation	10200.20 ± 525.90	6506.10 ± 827.90	<0.001
Anesthesia	974.50 ± 174.70	786.00 ± 152.10	<0.001
Postoperative management	2963.30 ± 1911.90	2416.60 ± 1077.80	0.001

ASA = American Society of Anesthesiologists, AV = anal verge, BMI = body mass index, LS = laparoscopic surgery, RS = robotic surgery.
* All values are expressed as means ± SDs except for median (range).

postoperative management were not different between groups. Total hospital charges for patients who were readmitted due to complications within 30 days of surgery were similar between the 2 groups.

DISCUSSION

Although the short- and long-term outcomes of RS for rectal cancer are acceptable, the cost of RS is significantly higher than that of LS or OS. This raises the questions of whether RS is worthwhile due to its financial burden. In this study, cost-effectiveness was evaluated focusing on the potential advantages in short-term outcomes such as early recovery, lower morbidity during the hospital stay, and adverse events after discharge for RS compared with LS. Most of the short-term outcomes were not different except for longer OT in RS. In terms of complications, the patients who underwent RS appeared to experience a milder complication, which requires conservative management than patients who underwent LS. However, this might be due to the year when the operation was performed and the increasing use of “critical pathway,” which is a kind of enhanced recovery after surgery program. Although propensity score-matching was applied so as to include the year of each operation, LS may have been performed earlier than RS. Moreover, the operations included in this study were performed by 4 surgeons. The learning curves of these surgeons probably varied, and the effects of this variation were not assessed. These results show that the high cost of RS was not compensated for by definitely better perioperative outcomes, making it difficult to conclude that RS is cost-effective.

Cost-effectiveness is determined by comparing the relative costs related to outcomes. Because it is difficult to assign a monetary value to measured outcomes or effects on a cost-effectiveness analysis, there can be various conclusions, which might be influenced by the investigator's concerns. Keller

et al²¹ concluded that robotic colorectal resection has higher costs and longer OT than LS without a measurable benefit focusing on the perioperative outcomes. Baek et al¹⁴ also showed higher cost of robotic rectal cancer surgery with longer OT. In other fields, Hohwu et al¹³ reported that higher costs of robotic prostatectomy might not be compensated for because there is no gain in quality-adjusted life-years and the incremental cost-effectiveness ratio using a questionnaire to assess sexual and voiding functions. However, another urologist group who used a similar method concluded differently, showing a gain in quality-adjusted life-years.¹¹ Waters et al¹² suggested that robotic distal pancreatectomy was cost-effective in selected cases because of comparable direct hospital costs with a shorter LOS. However, fewer malignancies and greater spleen preservation were observed in their RS than in the LS group, suggesting that simple cases were selected for RS, and this selection bias likely resulted in a conclusion favoring RS. In our study, we defined cost-effectiveness as better short-term outcomes per similar costs or similar outcomes per lower costs. In addition, we selected a homogeneous indication and applied a propensity score-matching analysis to reduce the possibility of selection bias.

Operation fees resulted in higher total hospital charges in the RS group compared with the LS group (Table 2). Because the RS fee was NIC and the LS fee was IC, patients undergoing RS paid 2.4 times more. Anesthesia fees were higher in the RS group due to the longer OT compared with that in the LS group.

Fees for preoperative diagnosis were similar because the diagnostic studies preceding RS and LS were the same. Fees for postoperative management, however, may reflect the quality of postoperative outcomes. These costs increased with longer LOS due to the fees associated with the hospital room, diet, and medications. Among such fees, the use of private rooms, special diets, and other patient-specific preferences and needs were all NIC and thus paid by patients. Fees for postoperative

TABLE 4. Comparison of Short-Term Outcomes and Costs Between RS and LS in Cases With Complications

	Robot (n = 61)	Laparoscopy (n = 57)	P
Male	42 (68.9%)	45 (78.9%)	0.295
Age, y	60.6 ± 11.2	57.9 ± 10.2	0.176
BMI, kg/m ²	23.3 ± 3.1	23.5 ± 3.5	0.780
ASA grade			0.652
I	14 (23.0%)	7 (12.3%)	
II	37 (60.7%)	43 (75.4%)	
III	9 (14.8%)	7 (12.3%)	
IV	1 (1.6%)	0 (0%)	
Tumor location from AV, cm	8.5 ± 3.3	7.6 ± 2.1	0.079
First operation time, min	360.9 ± 91.4	300.8 ± 78.6	<0.001
Estimated blood loss, mL*	180 (0–850)	100 (0–1400)	0.629
Combined resection	5 (8.2%)	7 (12.3%)	0.550
Ileostomy formation	26 (42.6%)	19 (33.3%)	0.346
Postoperative length of stay	17.3 ± 8.3	19.7 ± 14.6	0.287
Clavien–Dindo classification			0.103
I/II/IIIa	38 (62.3%)	27 (47.4%)	
IIIb/IV	23 (37.7%)	30 (52.6%)	
Treatment for complications			0.065
Conservative management	37 (60.7%)	26 (45.6%)	
Second operation during first admission	21 (34.4%)	24 (42.1%)	
Second operation during readmission	3 (4.9%)	7 (12.3%)	
Second operation time, min	124.0 ± 65.8	198.6 ± 124.7	0.006
Length of stay during readmission	14.7 ± 18.0	12.5 ± 7.1	0.601
Total hospital charges (first operation)	18539.70 ± 4628.80	16153.40 ± 7704.60	0.046
Government's bill	5874.20 ± 3147.20	10254.10 ± 5213.00	<0.001
Patient's bill	12946.00 ± 2872.00	6760.00 ± 3273.40	<0.001
Operation	10921.00 ± 1492.20	7783.80 ± 2112.80	<0.001
Anesthesia	1196.80 ± 378.00	1179.10 ± 515.40	0.831
Postoperative management	4418.80 ± 2409.70	5030.50 ± 3888.20	0.311
Total hospital charge (readmission alone)	4974.90 ± 4571.20	4905.90 ± 4116.80	>0.999 [†]
Government's bill	3502.50 ± 3361.70	3107.30 ± 2772.00	0.922 [†]
Patient's bill	1472.40 ± 1291.50	1798.60 ± 1518.70	0.536 [†]

ASA = American Society of Anesthesiologists, AV = anal verge, BMI = body mass index, LS = laparoscopic surgery, RS = robotic surgery.

* All values are expressed as means ± SDs except for median (range).

[†] Mann–Whitney *U* test.

management in RS were higher by only \$307 ($P = 0.126$) for all patients. In detail, however, the gap became wider in patients without complications (\$573, $P = 0.001$), and RS resulted in lower fees for postoperative management in patients with complications (\$612, $P = 0.311$).

Patients without complications, that is, those who had ideal postoperative courses, had longer OTs and higher costs for RS than for LS. Higher fees for postoperative management without any difference of LOS for RS suggested that patients who underwent RS may have used private rooms or had special diets. In patients with complications, total hospital charges were also higher for RS than for LS; however, the gap between them was reduced to \$2386.3, which was less than the overall cost difference for all patients (Tables 2 and 4). Patients who underwent LS required a second operation more often than patients who underwent RS (54.3% vs 39.3%, $P = 0.065$). As a result, the gap in operation fees between the 2 groups was reduced to \$3137.20 (\$10921.00 vs \$7783.80, $P < 0.001$). The RS group had a shorter OT during the second operation than the LS group, whereas the OT for the first operation was longer, which explains why anesthesia fees were similar for both the groups. Fees for postoperative management were lower in the RS than in the LS group due to a shorter LOS (17.3 vs 19.7 days,

$P = 0.287$). These results suggest that the postoperative course of the patients who underwent RS might be milder than after LS in cases in which complications developed, whereas the postoperative course of the patients who recovered without complications after RS was not different from LS in terms of short-term outcomes, though with higher associated costs. The fact that only patients with complications after RS had potential advantages during recovery is not sufficient to demonstrate the cost-effectiveness of RS.

Additionally, RS has never been performed as the second operation in patients with complications after RS or LS as the first operation. Although RS utilizes advanced techniques that allow for meticulous dissection and magnified vision, it is not an appropriate option for use in an emergent situation due to its longer OT, lack of tactile sense, and higher costs. In patients who were readmitted due to complications, all second operations were OS or LS, which is why total hospital charges during the readmission period were similar between both the groups (Table 4).

In this study, RS for rectal cancer did not exhibit remarkable advantages with the exception of the postoperative course in patients with complications. Therefore, the cost-effectiveness of RS compared with LS focusing on the short-term outcomes

within 30 days of surgery was not evident. However, these data are not enough to make a clear conclusion about the cost-effectiveness of RS because this study only evaluated short-term outcomes and did not assess postoperative functional outcomes including sexual and voiding functions. These functional outcomes are important in preserving the quality of life of the patient. To date, there has been no definitive evidence that RS results in better functional outcomes than LS.⁸ Another limitation of this study is due to the Korean health care system; thus, the results could not be generalized for the patients in other countries.

Because the robotic system is a surgical instrument, which is continuously evolving into future robotic systems may yield different results. If we consider future clinical trials on the functional outcomes of RS using more advanced robotic systems, it is reasonable that the conclusion of this study should be limited to the current generation robotic system.

Many colorectal surgeons have no experience with RS because costs for investment and maintenance of the system are significant, and are arithmetically offset only after approximately 300 RS cases in Korea. Opportunities for use of RS are limited to only a few high-volume institutions. If the costs associated with robotic systems were more reasonable, a larger pool of data from a larger number of surgeons would be more widely available.

CONCLUSIONS

The costs of RS were significantly higher than those of LS for rectal surgery, and short-term outcomes were similar between RS and LS. Thus, the cost-effectiveness of RS in rectal surgery was not clear in terms of short-term outcomes. However, a well-designed future prospective randomized trial that investigates the cost-effectiveness of RS in terms of functional outcomes and more advanced robotic systems may yield different results.

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