REVIEW ARTICLE

Robotic Versus Laparoscopic Surgery for Rectal Cancer: A Comprehensive Review of Oncological Outcomes

Jessica Lam, MD[1]; Michael S Tam, MD[1]; R. Luke Retting, MD[2]; Elisabeth C McLemore, MD[2]

Perm J 2021;00:21.050

E-pub: 00/00/0000

https://doi.org/10.7812/TPP/21.050

ABSTRACT

The treatment of rectal cancer is complex and involves specialized multidisciplinary care, although the tenet is still rooted in a high-quality total mesorectal excision. The robotic platform is one of many tools in the arsenal to assist dissection in the low pelvis. This article is a comprehensive review of the oncological outcome comparing robotic vs laparoscopic rectal cancer resection, with a particular focus on total mesorectal excision. There is no statistical difference in total mesorectal grade, circumferential margin, distal margin, and lymph node harvest. Survival data are less mature, but there is also no difference in disease-free or overall survival between the two techniques. Although additional randomized trials are still needed to validate these findings, both techniques are currently acceptable in the minimally invasive treatment of rectal cancer, and surgeon preference is paramount to safe and optimal resection.

INTRODUCTION

The treatment of rectal cancer involves a multidisciplinary approach including some combination of operative resection, radiation therapy, and systemic therapy for locally advanced disease.[1] The order in which these modalities are delivered continues to evolve as total neoadjuvant therapy gains momentum in the literature.[2] However, surgical resection—and particularly a total mesorectal resection (TME)—continues to be the mainstay therapy for cure.[3]

Laparoscopic surgery has been adopted during the past few decades for colectomies and has resulted in less pain, faster recovery, and shorter hospital length of stay without jeopardizing oncological outcomes. Lee et al[4] summarized the existing high-quality data regarding open vs laparoscopic resection of colon cancer including the North American Clinical Outcomes of Surgical Therapy Trial, the European Colon carcinoma Laparoscopic or Open Resection trial, and the UK Conventional versus Laparoscopic-Assisted Surgery In Colorectal Cancer trial. Laparoscopy naturally expanded to proctectomies, hoping to help overcome the challenges that the fixed anatomy of the confined pelvis presents. A few multicenter randomized surgical trials comparing open vs laparoscopic rectal cancer were recently published and showed no significant differences in terms of disease-free survival and local recurrence between the two techniques.[5–7]

There are still significant limitations to traditional laparoscopic instrumentation that the robotic platform attempts to improve. Greater degrees of freedom in movement of wristed instruments, additional assistant arms, and three-dimensional visualization are advantages of the robotic system that are particularly attractive for operations in the challenging anatomic space of the pelvis.[8,9] Robotic-assisted surgery is already widely used in the fields of urology, gynecology, thoracic surgery, and head and neck surgery for these reasons, and interest in applying this platform to surgery for rectal cancer continues to grow.

An increasing number of studies have been done to compare oncological outcomes of robot-assisted surgery to laparoscopic surgery in the treatment of rectal cancer. The main markers of quality oncological resection include TME grade, circumferential margin status, distal and proximal margin status, and adequate lymph node harvest, as these have been shown to correlate with decreased recurrence and improved survival.[10–12] This literature review summarizes the current data on TME grade and other aspects of oncological outcome in robot-assisted operations for rectal cancer vs traditional laparoscopy.

INCLUDED STUDIES

A literature search was conducted on PubMed for journal articles using the search terms "rectal cancer," "robotic," and "laparoscopic." Review articles, meta-analyses, and papers not in English were excluded. From this se search result, we selected studies comparing oncological outcomes (TME grade, margin status, lymph node harvest, survival) in robot-assisted surgery to laparoscopy in rectal cancer resection and TME (Figure 1). Selected studies were published between 2009 and 2019. There were two prospective randomized controlled trials comparing the two technologies: the multicenter Robotic vs Laparoscopic Resection for Rectal Cancer (ROLARR) trial published in 2017 by Jayne et al,[13] and the single-center study by Kim et al in 2018.[14] The remainder of relevant studies were comparative studies of nonrandomized robotic vs laparoscopic cases or retrospective case-matched

Author Affiliations

[1]Department of Surgery, Kaiser Permanente Riverside Medical Center, Riverside, CA

[2]Department of Surgery, Kaiser Permanente Los Angeles Medical Center, Los Angeles, CA

Corresponding Author

Michael S Tam (michael.s.tam@kp.org)

Keywords: laparoscopic, minimally invasive surgery, rectal cancer, rectal carcinoma, robotic, TME, total mesorectal excision

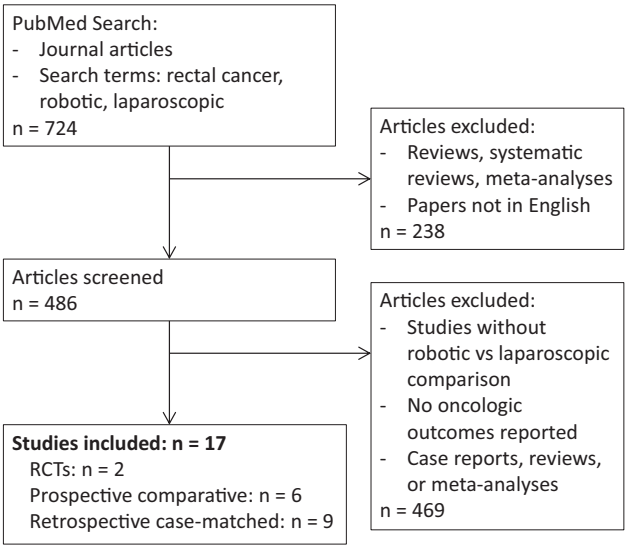

Figure 1. 17 studies were selected from an initial search of 724 articles on PubMed. RCTs = randomized controlled trials.

series. A study in 2019 by Garfinkle et al[15] used a large nationwide database (American College of Surgeons National Surgical Quality Improvement Program) to perform a propensity score analysis of open vs laparoscopic vs robotic surgery for rectal cancer.

Multiple abdominal-type operations for rectal cancer were described in these trials, including tumor-specific TME, TME, and abdominoperineal resection (APR). Most studies included both patients who received neoadjuvant chemoradiation therapy and those who did not, according to institution or guideline criteria, whereas three studies (Kim et al,[16] Huang et al,[17] and Lim et al[18]) focused specifically on rectal cancer resections after neoadjuvant chemoradiation. The included studies in this review are summarized in Table 1.

TME GRADE OUTCOMES

TME has been the gold standard for oncological resection of mid to low rectal cancer since its wide adoption in the mid-1980s.[19] High-quality TME has been shown to reduce local recurrence rates and increase disease-free survival.[3,20–22] However, surgical quality assessment of correct anatomic dissection via TME grade reporting continues to be inconsistent in clinical practice.[23]

Nagtegaal et al[10] recommended three defined groups to categorize macroscopic mesorectal grading based on the Dutch TME trial: 1) complete, intact mesorectum with only minor irregularities of a smooth mesorectal surface and no defect deeper than 5 mm and no coning toward the distal margin; 2) nearly complete, moderate bulk to the mesorectum, but irregularity of the mesorectal surface and/or moderate coning of the specimen, without visible muscularis propria; and 3) incomplete, little bulk to the mesorectum with defects down onto muscular propria and/or very irregular circumferential resection margin. This seminal article did not observe any difference in prognosis between the complete and near-complete groups, but did note that overall recurrence rates were statistically significantly worse at 2 years in the group with an incomplete mesorectum (35.6% vs 21.5%, p = 0.01). Another study dedicated to investigating surgical TME quality confirmed that the presence of defects in the mesorectum predisposes patients to local and distant recurrences, reiterating the importance of sound surgical dissection in the correct TME plane.[24]

Various factors besides surgical skill can affect the success of TME completeness. Sapci et al[25] showed in a study of nearly 700 patients that operative approach (open vs laparoscopic vs robotic), body mass index, and gender were not associated with a noncomplete mesorectal grade, but distal tumors within 5 cm from the anal verge, nonrestorative procedures (abdominoperineal resection), and positive circumferential margins were associated with a noncomplete mesorectum. This suggests that the confines of the narrow pelvis complicate a complete TME for a low-lying rectal mass, a problem the robotic platform hopes to alleviate.

Given the importance of TME completeness on short- and long-term oncological outcomes, it is surprising that TME grade is sparsely reported in the robotic literature. Table 2 summarizes the studies that included data on TME grade and completeness. Only Baik et al[26] in 2009 reported a statistically significant difference in favor of robot over laparoscopy, with 92.9% in their robotic group achieving a complete TME compared to 75.4% in their laparoscopic group (p = 0.033). In contrast, the ROLARR trial reported a similar 76.4% vs 77.6% complete TME in robot vs laparoscopy (p = 0.14).[13] Kim et al[14] in their smaller randomized controlled trial in 2018 also achieved similar results, with 80.3% in their robotic group vs 78.1% in the laparoscopic group (p = 0.599). A case-matched cohort study in 2016 by Kim et al[16] also reported no difference in TME completeness (97.0% in robotic vs 90.9% in laparoscopic, p = 0.41). Similarly, independent, prospective nonrandomized studies by Lim et al[18] and Valverde et al[27] in 2017 comparing robotic to laparoscopic rectal cancer resections and found no difference in TME grade completeness, (95.9% vs 100%, p = 0.384; and 88% vs 82%, p = 0.28, respectively). This comprehensive review highlights the current low standardized reporting of TME grade in the robotic rectal resection literature. As more oncological data mature, TME grade is expected to be reported more often because it has become a more recognized universal outcome measure.

The Commission on Cancer National Accreditation Program for Rectal Cancer recommends standardized synoptic

Table 1. Characteristics and reported oncological outcomes of included studies

Year	Authors	Study design	Operations	n (R vs L)	TME complete	CRM negative	Distal margin	Proximal margin	LN harvest	DFS	CSS	OS	Other endpoints
2009	Baik et al[26]	Prospective, comparative, nonrandomized	LAR	56 vs 57	✓	✓	✓	✓	✓	—	—	—	Postoperative complications, operation time, hemoglobin change, time to flatus passage, time to soft diet, LOS, conversion to open, recurrence
2009	Patriti et al[36]	Prospective, comparative, nonrandomized	PME, TME, APR, CAA	29 vs 37	—	✓	✓	—	✓	✓		✓	Operation time, EBL, conversion to open, hospital stay, 30-day morbidity, long-term morbidity
2010	Park et al[38]	Case-matched cohort	TME (LAR, CAA, APR)	41 vs 82	—	✓	✓	✓	✓	—	—	—	Operation time, conversion to open, time to flatus passage, time to regular diet, LOS, postoperative mortality, postoperative morbidity
2011	Kwak et al[39]	Case-matched cohort	TME (LAR, CAA, APR)	59 vs 59	—	✓	✓	—	✓	—	—	—	Operation time, conversion to open, postoperative morbidity, operative mortality, recurrence
2013	D'Annibale et al[34]	Prospective, comparative, nonrandomized	TME	50 vs 50	—	✓	✓	—	✓	—	—	—	Operation time, conversion to open, postoperative complications, anastomotic leak, oral reintake, LOS, IPSS, IIEF
2015	Cho et al[31]	Case-matched cohort	LAR, CAA	278 vs 278	—	✓	✓	✓	✓	✓	✓	✓	Conversion to open, operation time, EBL, LOS, time to flatus passage, time to liquid diet, time to soft diet, postoperative complications, postoperative mortality, late complications
2015	Park et al[37]	Case-matched cohort	ISR-CAA	106 vs 106	—	✓	✓	✓	✓	✓	—	✓	Operation time, EBL, conversion to open, protective stoma, time to diet, LOS, stoma-free at last follow-up, postoperative mortality, postoperative morbidity, LN positivity, local recurrence
2016	Kim et al[16]	Case-matched cohort	NA-CRT: LAR, Hartmann, APR	33 vs 66	✓	✓	✓	✓	✓	—	—	—	EBL, conversion to open, operation time, time to flatus passage, LOS, postoperative morbidity, reoperation

(*continued*)

Table 1. Characteristics and reported oncological outcomes of included studies (cont.)

Year	Authors	Study design	Operations	n (R vs L)	TME complete	CRM negative	Distal margin	Proximal margin	LN harvest	DFS	CSS	OS	Other endpoints
2017	Huang et al[17]	Case-matched cohort	NA-CRT: LAR, ultra-low, ISR-CAA	40 vs 38	—	✓	✓	✓	✓	—	—	—	Operation time, EBL, postoperative complications, time to flatus passage, time to soft diet, LOS
2017	Jayne et al[13]	Randomized clinical trial	HAR, LAR, APR	235 vs 224	✓	✓	—	—	✓	—	—	—	Conversion to open, intraoperative complications, early postoperative complications, late postoperative complications, 30-day mortality
2017	Kim et al[32]	Case-matched cohort	AR, LAR, APR	224 vs 224	—	✓	✓	—	✓	—	—	—	Operation time, conversion to open, diverting stoma, postoperative morbidity, postoperative mortality, LOS
		Case-matched cohort for 5-year follow-up		196 vs 192	—	—	—	—	—	✓	✓	✓	
2017	Lim et al[18]	Prospective, comparative, nonrandomized	NA-CRT: LAR, ISR, CAA, APR	74 vs 64	✓	✓	✓	✓	✓	✓	—	✓	Operation time, conversion to open, recurrence
2017	Valverde et al[27]	Prospective, comparative, nonrandomized	Sphincter-sparing	65 vs 65	✓	✓	✓	✓	—	—	—	—	Operation time, diverting ostomy, EBL, drainage, conversion to open, reoperation, morbidity, LOS, mortality
2018	Crolla et al[33]	Prospective, comparative, nonrandomized	AR, LAR, APR	168 vs 184	—	✓	—	—	✓	—	—	—	Operation time, LOS, conversion to open, SSI, anastomotic leak, mortality, other
2018	Kim et al[14]	Randomized controlled trial	LAR, APR, Hartmann	66 vs 73	✓	✓	✓	✓	✓	—	—	—	GOALS, return of bowel function, morbidity, postoperative pain scores, QOL
2018	Panteleimonitis et al[40]	Case-matched cohort	HAR, LAR, APR, Hartmann	63 vs 61	—	✓	—	—	✓	—	—	—	Operation time, EBL, conversion to open, LOS, 30-day readmission, 30-day reoperation, 30-day mortality, anastomotic leak
2019	Garfinkle et al[15]												Cohort–propensity score analysis
LAR, APR	154 vs 213	—	✓	✓	—	✓	—	—	—				Operation time, conversion, postoperative morbidity and mortality, LOS, hospital readmission

APR = abdominoperineal resection; AR = anterior resection; CAA = coloanal anastomosis; CRM = circumferential resection margin; CSS = cancer-specific survival; DFS = disease-free survival; EBL = estimated blood loss; GOALS: global operative assessment of laparoscopic skills; HAR = high anterior resection; IIEF = International Index of Erectile Function; IPSS = International Prostate Symptoms Score; ISR = intersphincteric resection; L = laparoscopic; LAR = low anterior resection; LN = lymph node; LOS = hospital length of stay; NA-CRT = neoadjuvant chemoradiation therapy; OS = overall survival; PME = partial mesorectal excision; QOL = quality of life; R = robotic; SSI = surgical site infection; TME = total mesorectal excision.

Table 2. Total mesorectal excision grade outcomes			
Study	TME complete		*p* Value
	Robot	Lap	
Baik et al[26]	92.9%	75.4%	0.033
Kim et al[16]	97.0%	90.9%	0.41
Jayne et al[13]	76.4%	77.6%	0.14
Lim et al[18]	95.9%	100%	0.384
Valverde et al[27]	88.0%	82.0%	0.28
Kim et al[14]	80.3%	78.1%	0.599

Lap = laparoscopic; TME = total mesorectal excision.

format pathological reporting to include all required data elements outlined in the College of American Pathologists rectal cancer protocols, including tumor depth of invasion, nodal status, completeness of the mesorectal excision, status of the circumferential margin, and the response of the tumor to neoadjuvant therapy.[28] The National Accreditation Program for Rectal Cancer guidelines also highlight the importance of photographic documentation of the TME specimen to be presented at a rectal cancer tumor board to assess surgical quality as a multidisciplinary group. Not only does this pathological information form the basis for decisions on adjuvant therapy, but also it serves as an important indicator of surgical quality and can function as a guide for surgical improvement.[29]

Given the paucity of TME completeness in the current robotic literature, the oncological outcomes remain important and are highlighted here.

OTHER ONCOLOGICAL OUTCOMES

Circumferential Margin

A negative circumferential resection margin (CRM) is strong prognostic indicator of survival. To date, it has been the most studied element of oncological resection and is associated intimately with a complete TME.[11]

Table 3. Circumferential margin outcomes			
Study	CRM negative (> 1 mm)		*p* Value
	Robot	Lap	
Baik et al[26]	92.9%	91.2%	0.749
Patriti et al[36]	100%	100%	Not reported
Park et al[38]	92.7%	96.3%	0.542
Kwak et al[39]	98.3%	100.0%	> 0.999
D'Annibale et al*[34]	100%	88%	0.022
Cho et al[31]	95.0%	95.3%	1.000
Park et al[37]	92%	91%	0.976
Kim et al[16]	78.8%	84.8%	0.42
Huang et al[17]	100%	94.7%	0.14
Jayne et al[13]	94.9%	93.8%	0.56
Kim et al[32]	96.0%	95.1%	0.8231
Lim et al[18]	95.9%	100%	0.384
Valverde et al[27]	94%	89%	0.47
Crolla et al[33]	95.2%	97.8%	Univariable p = 0.24, multivariable p = 1.00
Kim et al[14]	92.4%	93.2%	0.999
Panteleimonitis et al[40]	96.8%	98.4%	1.000
Garfinkle et al[15]	94.8%	96.2%	0.46

CRM = circumferential resection margin; Lap = laparoscopic, *CRM > 2 mm corresponds to the study by D'Annibale et al. exclusively.

Factors shown to increase the risk of a positive CRM include tumor size > 5.9 cm, a distance of ≤ 2.6 cm from the dentate line, incomplete TME, and high-risk features such as microvascular and perineural invasion.[30] Furthermore, Nagtegaal et al[10] showed that even in patients with a negative CRM, the overall recurrence rate was greater with incomplete TME (28.6% vs 14.9%, p = 0.03), highlighting that the quality of macroscopic TME has additional value beyond microscopic CRM determination.

In the ROLARR trial, there was no statistical difference in the CRM-negative resection rate between the robotic group and the laparoscopic group (94.9% vs 93.8%, p = 0.56).[13] The remaining nonrandomized comparative trials and case-matched series also did not show any statistically significant difference in CRM-negative rates. Most showed a greater than 90% CRM-negative rate in both robotic and laparoscopic resections. In 2015, Cho et al[31] compared 278 robotic cases with a case-matched group of 278 laparoscopic cases and demonstrated CRM-negative rates of 95% vs 95.3%, respectively (p = 1.0). In a similar-size and -design study published in 2017, Kim et al[32] found comparable results (96% robotic vs 95.1% laparoscopic, p = 0.823). A Dutch study in 2018 comparing 168 robotic rectal cancer patients to 184 laparoscopic patients produced similar findings (95.2% vs 97.8%, p = 0.24).[33] Of note, one small Italian study in 2012 by D'Annibale et al[34,35] reported a statistically significant difference in CRM status in favor of robotic surgery when using a CRM cutoff of 2 mm, with 100% negative margins in the robotic arm vs 88% in the laparoscopic arm (p = 0.022). The clinical importance of this result when compared to the rest of the studies is unclear. See Table 3 for all reported CRM outcomes. In summary, the use of robotic technology does not appear to improve CRM negativity rates when compared to laparoscopy.

Distal Margin

Another principle of rectal cancer surgery is achieving an adequate distal resection margin, as this contributes to lower local recurrence rates. The National Comprehensive Cancer Network guidelines recommend a gross resection margin of 4 to 5 cm below the distal edge of the tumor. The robotic platform theoretically helps to overcome the surgical challenges of the narrow anatomic space of the pelvis. The ROLARR trial did not report measured distal margins but did report one patient in their laparoscopic arm with a positive distal margin compared to none in the robotic arm.[13] Cho et al,[31] in 2015, reported a mean distal margin of 2.0 cm in the robotic group compared to 2.2 cm in their laparoscopic group, with a nonsignificant p value of 0.161. Kim et al,[32] in 2017, also reported no difference in mean distal margins of 2.3 cm vs 2.4 cm in their robotic vs laparoscopic groups (p = 0.374). No studies demonstrated a statistically significant difference between the two platforms for distal margin. Some studies also compared proximal margins, all showing no statistically significant differences when reporting greater than 5 cm both robotically and laparoscopically. Distal and proximal margin outcome data are consolidated in Table 4.

Table 4. Distal and proximal margin outcomes

Study	Distal margin		p Value	Proximal margin		*p* Value
	Robot	Lap		Robot	Lap	
Baik et al,[26] mean ± SD	4.0 ± 1.6 cm	3.6 ± 1.7 cm	0.497	10.9 ± 4.0 cm	10.8 ± 4.3 cm	0.971
Patriti et al,[36] mean ± SD	2.1 ± 0.9 cm	4.5 ± 7.2 cm	> 0.05	—	—	—
Park et al,[38] mean ± SD	2.1 ± 1.4 cm	2.3 ± 1.5 cm	0.438	17.2 ± 6.2 cm	18.5 ± 8.5 cm	0.417
Kwak et al,[39] median (IQR)	2.2 cm (1.5–3.0 cm)	2.0 cm (1.2–3.5 cm)	0.865	—	—	—
D'Annibale et al,[34] mean ± SD	3 ± 1.1 cm	3 ± 1.6 cm	0.908	—	—	—
Cho et al,[31] mean ± SD	2.0 ± 1.4 cm	2.2 ± 1.4 cm	0.161	10.8 ± 6.0 cm	11.2 ± 6.1 cm	0.536
Park et al[37], mean ± SD	1.2 ± 0.8 cm	1.2 ± 0.7 cm	0.739	20.3 ± 7.4 cm	21.0 ± 10.7 cm	0.575
Kim et al,[16] mean ± SD	2.2 ± 1.5 cm	2.2 ± 1.7 cm	0.95	17.4 ± 2.7 cm	14.2 ± 6.0 cm	0.15
Huang et al,[17] mean ± SD	1.7 ± 1.4 cm	1.7 ± 1.1 cm	0.99	9.6 ± 3.4 cm	11.0 ± 6.3 cm	0.23
Kim et al,[32] mean ± SD	2.3 ± 2.6 cm	2.4 ± 2.2 cm	0.3746	—	—	—
Lim et al,[18] mean ± SD	1.7 ± 1.4 cm	2.2 ± 1.5 cm	0.339	12.8 ± 4.1 cm	14.0 ± 5.1 cm	0.070
Valverde et al,[27] distal margin > 1 mm	98%	87%	0.61	17 ± 9 cm	19 ± 10 cm	0.17
Kim et al,[14] median (range)	1.5 cm (0.04–6.7 cm)	0.7 cm (0–2.5 cm)	0.11	12.3 cm (4.7–35.8 cm)	13.2 cm (6.8–29.0 cm)	0.727
Garfinkle et al,[15] distal margin negative	98.7%	100%	—	—	—	—

IQR = interquartile range; Lap = laparoscopic; SD = standard deviation.

Table 5. Lymph node harvest outcomes

Study	Lymph node harvest (mean ± SD)		*p* Value
	Robot	Lap	
Baik et al,[26] mean ± SD	18.4 ± 9.2	18.7 ± 12	0.831
Patriti et al,[36] mean ± SD	10.3 ± 4	11.2 ± 5	> 0.05
Park et al,[38] mean ± SD	17.3 ± 7.7	14.2 ± 8.9	0.060
Kwak et al,[39] median (IQR)	20 (12–27)	21 (14–28)	0.702
D'Annibale et al,[34] mean ± SD	16.5 ± 7.1	13.8 ± 6.7	0.053
Cho et al,[31] mean ± SD	15.0 ± 8.1	16.2 ± 8.1	0.069
Park et al,[37] mean ± SD	13.2 ± 7.3	15.2 ± 10.8	0.126
Kim et al,[16] mean ± SD	22.3 ± 11.7	21.6 ± 11.0	0.82
Huang et al,[17] mean (range)	16.7 (4–46)	15.6 (6–29)	0.49
Jayne et al,[13] mean ± SD	23.2 ± 11.97	24.1 ± 12.91	—
Kim et al,[32] mean ± SD	20.2 ± 12.1	21.0 ± 14.4	0.4410
Lim et al,[18] mean ± SD	11.6 ± 6.9	14.7 ± 6.5	0.971
Crolla et al,[33] median (range)	14 (2–44)	7 (0–44)	Univariable p < 0.0005
Kim et al,[14] median (range)	18 (7–59)	15 (4–40)	0.04
Panteleimonitis et al,[40] median (IQR)	17 (13–23.35)	16 (12–23.5)	0.639
Garfinkle et al,[15] mean ± SD	15.6 ± 7.6	16.6 ± 7.4	0.29

IQR = interquartile range; Lap = laparoscopic; SD = standard deviation.

Lymph Node Harvest

Only one study reported a statistically significant difference in the number of lymph nodes harvested using robotic vs laparoscopic surgery, highlighted in Table 5. Kim et al,[14] in 2018, obtained a median harvest of 18 lymph nodes in their robotic group vs 15 in their laparoscopic group (p = 0.04). In addition, they reported 90.9% of the robotic group vs 74.0% of their laparoscopic group had more than 12 lymph nodes harvested (p = 0.009). This was their only statistically significantly different outcome among all their postoperative pathological outcomes. The largest study by Cho et al,[31] in 2015, reported the mean number of lymph nodes harvested by robotic vs laparoscopic surgery to be 15.0 vs 16.2, with a nonsignificant difference (p = 0.069). The randomized ROLARR trial described the mean lymph node harvest as 23.2 vs 24.1, but no statistical comparison was performed.[13] Kim et al,[32] in 2017, also found no statistically significant difference in the mean number of lymph nodes harvested, with 20.2 in their robotic group and 21.0 in their laparoscopic group (p = 0.4410). Interestingly, several studies reported mean lymph nodes harvested to be less than the ideal 12 lymph nodes recommended by the American Joint Committee on Cancer, the College of American Pathologists, and the National Comprehensive Cancer Network, but still found no statistically significant difference.[18,33,36] Because lymph node harvest is often determined by a sufficiently high ligation of the mesenteric vessels, it is not unexpected that the robotic platform does not clearly confer an advantage over laparoscopy in this oncological outcome.

Survival

Few studies reported on long-term overall or disease-free survival, and their results are tabulated in Table 6. Patriti et al,[36] in 2009, stated no difference in overall and disease-free survival between the robotic and laparoscopic groups throughout the

Table 6. Survival outcomes

Study	DFS (5-year)			CSS			OS		
	Robot	Lap	p Value	Robot	Lap	p Value	Robot	Lap	*p* Value
Patriti et al[36]	No difference		—	—	—	—	No difference		—
Cho et al[31]	81.8%	79.6%	0.538	93.6%	95.5%	0.120	92.2%	93.1%	0.422
Park et al[37]	80.6%	82.8%	0.298	—	—	—	88.5%	88.4%	0.899
Kim et al[32]	72.6%	68.0%	0.6409	90.5%	79.5%	0.4465	90.5%	78.0%	0.3231
Lim et al[18]	76.8%	76.0%	0.834	—	—	—	90%	93.3%	0.424

CSS = cancer-specific survival; DFS = disease-free survival; Lap = laparoscopy; OS = overall survival.

duration of the study, but did not report a full 5-year follow-up. In the 2015 study by Cho et al,[31] 92.2% of the robotic group survived whereas 93.1% of the laparoscopic group survived to 5 years (p = 0.422); 81.8% (robotic) vs 79.6% (laparoscopic) were cancer free at 5 years (p = 0.538).[31] Park et al, [37] in 2015, compared robotic vs laparoscopic outcomes for intersphincteric resections and reported a 5-year overall survival of 88.5% vs 88.4% (p = 0.899) and a disease-free survival of 80.6% vs 82.8% (p = 0.298). Kim et al, [32] in 2017, compared a case-matched subset of their robotic vs laparoscopic patients who reached the 5-year follow-up and reported 90.5% vs 78.0% overall survival, respectively, without a statistically significant difference (p = 0.3231); and 72.6% vs 68.0% disease-free survival, respectively, without a statistically significant difference (p = 0.6409). However, after multivariate analysis of their matched patients, they reported the robotic approach was a statistically significant prognostic factor for overall survival and cancer-specific survival (p = 0.0040, Hazard Ratio = 0.333; p = 0.0161, Hazard Ratio = 0.367).[32] Last, in 2017, Lim et al[18] reported no statistically significant difference in overall survival (90% vs 93.3%, p = 0.424) or disease-free survival (76.8% vs 76.0%, p = 0.834) between robot and laparoscopy. In summary, no studies thus far have demonstrated a statistically significant difference in overall survival, disease-free survival, or cancer-specific survival.

CONCLUSION

The majority of studies comparing robotic vs laparoscopic surgery for rectal cancer showed no statistically significant differences in oncological outcomes of TME completeness, CRM, distal margin, lymph nodes harvested, and survival (overall, disease free, and cancer specific). Data thus far confirm the noninferiority of the robotic approach compared to laparoscopy in terms of oncological outcomes. Although not addressed in this review, nononcological outcomes such as complications, hospital length of stay, patients' postoperative experience, cost, and surgical ergonomics also weigh in on the potential advantages or disadvantages of the robotic platform. Further prospective, randomized multicenter trials are needed to evaluate and weigh the potential benefits of the robotic platform against the cost of technology in the treatment of rectal cancer to define more fully the indications for its use. The oncological data for robotic rectal cancer resection are still immature because the majority of publications do not include data on TME grade and completeness, which is well correlated with lower local recurrence rates and greater survival rates. Because TME grade, at its core, is an indication of surgical quality, it would seem to be a good indicator of whether the robotic platform truly provides the technical advantages over laparoscopy it claims to provide. ❖

Disclosure Statement

The authors have no conflicts of interest to disclose.

Funding Support

No funding was received in support of this project.

Author Contributions

Jessica Lam, MD, Michael S Tam, MD, and Elisabeth C McLemore, MD, participated in conception and design. Jessica Lam, MD, Michael S Tam, MD, and R. Luke Rettig, MD, participated in data analysis and interpretation. Jessica Lam, MD, Michael S Tam, MD, R. Luke Rettig, MD, and Elisabeth C McLemore, MD, provided administrative, technical, and material support.

REFERENCES

1. National Comprehensive Cancer Network. Rectal cancer (Version 6.2020). Accessed November 29, 2020. http://www.nccn.org/professionals/physician_gls/pdf/rectal.pdf
2. Cercek A, Roxburgh CSD, Strombom P, et al. Adoption of total neoadjuvant therapy for locally advanced rectal cancer. JAMA Oncol 2018 Jun;4(6):e180071:1–8. DOI: https://doi.org/10.1001/jamaoncol.2018.0071
3. Quirke P, Steele R, Monson J, et al. Effect of the plane of surgery achieved on local recurrence in patients with operable rectal cancer: A prospective study using data from the MRC CR07 and NCIC-CTG CO16 randomised clinical trial. Lancet 2009 Mar;373 (9666):821–8. DOI: https://doi.org/10.1016/S0140-6736(09)60485-2
4. Lee JK, Delaney CP, Lipman JM. Current state of the art in laparoscopic colorectal surgery for cancer: Update on the multi-centric international trials. Ann Surg Innov Res 2012 Jul;6(1):1–8. DOI: https://doi.org/10.1186/1750-1164-6-5
5. Bonjer HJ, Deijen CL, Abis GA, et al. A randomized trial of laparoscopic versus open surgery for rectal cancer. N Engl J Med 2015 Apr;372(14):1324–32. DOI: https://doi.org/10.1056/NEJMoa1414882
6. Fleshman J, Branda ME, Sargent DJ, et al. Disease-free survival and local recurrence for laparoscopic resection compared with open resection of stage II to III rectal cancer: Follow-up results of the ACOSOG Z6051 randomized controlled trial. Ann Surg 2019 Apr;269(4):589–95. DOI: https://doi.org/10.1097/SLA.0000000000003002
7. Stevenson ARL, Solomon MJ, Brown CSB, et al. Disease-free survival and local recurrence after laparoscopic-assisted resection or open resection for rectal cancer: The Australasian laparoscopic cancer of the rectum randomized clinical trial. Ann Surg 2019 Apr;269(4):596–602. DOI: https://doi.org/10.1097/SLA.0000000000003021
8. Intuitive. da Vinci: Robotic surgical systems. Accessed November 29, 2020. https://www.intuitive.com/en-us/products-and-services/da-vinci
9. Hance J, Rockall T, Darzi A. Robotics in colorectal surgery. Dig Surg 2004 21(5–6): 339–43. DOI: https://doi.org/10.1159/000081350
10. Nagtegaal ID, van de Velde CJH, van der Worp E, Kapiteijn E, Quirke P, van Krieken JHJM, Cooperative Clinical Investigators of the Dutch Colorectal Cancer Group. Macroscopic evaluation of rectal cancer resection specimen: Clinical significance of the pathologist in quality control. J Clin Oncol 2002 Apr;20(7):1729–34. DOI: https://doi.org/10.1200/JCO.2002.07.010
11. Nagtegaal ID, Quirke P. What is the role for the circumferential margin in the modern treatment of rectal cancer? J Clin Oncol 2008 Jan;26(2):303–12. DOI: https://doi.org/10.1200/JCO.2007.12.7027
12. Tepper JE, O'Connell MJ, Niedzwiecki D, et al. Impact of number of nodes retrieved on outcome in patients with rectal cancer. J Clin Oncol 2001 Jan;19(1):157–63. DOI: https://doi.org/10.1200/JCO.2001.19.1.157
13. Jayne D, Pigazzi A, Marshall H, et al. Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer: The ROLARR randomized clinical trial. JAMA 2017 Oct;318(16):1569–80. DOI: https://doi.org/10.1001/jama.2017.7219
14. Kim MJ, Park SC, Park JW, et al. Robot-assisted versus laparoscopic surgery for rectal cancer: A phase II open label prospective randomized controlled trial. Ann Surg 2018 Feb;267(2):243–51. DOI: https://doi.org/10.1097/SLA.0000000000002321
15. Garfinkle R, Abou-Khalil M, Bhatnagar S, et al. A comparison of pathologic outcomes of open, laparoscopic, and robotic resections for rectal cancer using the ACS-NSQIP proctectomy-targeted database: A propensity score analysis. J Gastrointest Surg 2019 Feb;23(2):348–56. DOI: https://doi.org/10.1007/s11605-018-3974-8
16. Kim YS, Kim MJ, Park SC, et al. Robotic versus laparoscopic surgery for rectal cancer after preoperative chemoradiotherapy: Case-matched study of short-term outcomes. Cancer Res Treat 2016 Jan;48(1):225–31. DOI: https://doi.org/10.4143/crt.2014.365
17. Huang YM, Huang YJ, Wei PL. Outcomes of robotic versus laparoscopic surgery for mid and low rectal cancer after neoadjuvant chemoradiation therapy and the effect of learning curve. Medicine (Baltimore) 2017 Oct;96(40):e81711–7. DOI: https://doi.org/10.1097/MD.0000000000008171

18. Lim DR, Bae SU, Hur H, et al. Long-term oncological outcomes of robotic versus laparoscopic total mesorectal excision of mid-low rectal cancer following neoadjuvant chemoradiation therapy. Surg Endosc 2017 Apr;31(4):1728–37. DOI: https://doi.org/10.1007/s00464-016-5165-6
19. Heald RJ, Ryall RD. Recurrence and survival after total mesorectal excision for rectal cancer. Lancet 1986 Jun;1(8496):1479–82. DOI: https://doi.org/10.1016/S0140-6736(86)91510-2
20. Arbman G, Nilsson E, Hallböök O, Sjödahl R. Local recurrence following total mesorectal excision for rectal cancer. Br J Surg 1996 Mar;83(3):375–9. DOI: https://doi.org/10.1002/bjs.1800830326
21. Heald RJ, Moran BJ, Ryall RD, Sexton R, MacFarlane JK. Rectal cancer: The Basingstoke experience of total mesorectal excision, 1978–1997. Arch Surg 1998 Aug;133(8):894–9. DOI: https://doi.org/10.1001/archsurg.133.8.894
22. Kapiteijn E, Marijnen CA, Nagtegaal ID, et al. Preoperative radiotherapy combined with total mesorectal excision for resectable rectal cancer. N Engl J Med 2001 Aug;345(9):638–46. DOI: https://doi.org/10.1056/NEJMoa010580
23. Kanters AE, Cleary RK, Obi SH, et al. Uptake of total mesorectal excision and total mesorectal excision grading for rectal cancer: A statewide study. Dis Colon Rectum 2020 Jan;63(1):53–9. DOI: https://doi.org/10.1097/DCR.0000000000001526
24. Maurer CA, Renzulli P, Kull C, et al. The impact of the introduction of total mesorectal excision on local recurrence rate and survival in rectal cancer: Long-term results. Ann Surg Oncol 2011 Jul;18(7):1899–906. DOI: https://doi.org/10.1245/s10434-011-1571-0
25. Sapci I, Velazco JS, Xhaja X, et al. Factors associated with noncomplete mesorectal excision following surgery for rectal adenocarcinoma. Am J Surg 2019 Mar;217(3):465–8. DOI: https://doi.org/10.1016/j.amjsurg.2018.10.051
26. Baik SH, Kwon HY, Kim JS, et al. Robotic versus laparoscopic low anterior resection of rectal cancer: Short-term outcome of a prospective comparative study. Ann Surg Oncol 2009 Jun;16(6):1480–7. DOI: https://doi.org/10.1245/s10434-009-0435-3
27. Valverde A, Goasguen N, Oberlin O, et al. Robotic versus laparoscopic rectal resection for sphincter-saving surgery: Pathological and short-term outcomes in a single-center analysis of 130 consecutive patients. Surg Endosc 2017 Oct;31(10):4085–91. DOI: https://doi.org/10.1007/s00464-017-5455-7
28. Commission on Cancer. National Accreditation Program for Rectal Cancer: A quality program of the American College of Surgeons: Optimal resources for rectal cancer care, 2020 standards. Accessed December 28, 2020. https://www.facs.org/-/media/files/quality-programs/cancer/naprc/optimal_resources_for_rectal_cancer_care_2020_standards.ashx
29. Hendren S, McKeown E, Morris AM, et al. Implementation of a hospital-based quality assessment program for rectal cancer. J Oncol Pract 2014 May;10(3):e120–9. DOI: https://doi.org/10.1200/JOP.2014.001387
30. Hiranyakas A, da Silva G, Wexner SD, Ho YH, Allende D, Berho M. Factors influencing circumferential resection margin in rectal cancer. Colorectal Dis 2013 Mar;15(3):298–303. DOI: https://doi.org/10.1111/j.1463-1318.2012.03179.x
31. Cho MS, Baek SJ, Hur H, et al. Short and long-term outcomes of robotic versus laparoscopic total mesorectal excision for rectal cancer: A case-matched retrospective study. Medicine (Baltimore) 2015 Mar;94(11):e5221–10. DOI: https://doi.org/10.1097/MD.0000000000000522
32. Kim J, Baek SJ, Kang DW, et al. Robotic resection is a good prognostic factor in rectal cancer compared with laparoscopic resection: Long-term survival analysis using propensity score matching. Dis Colon Rectum 2017 Mar;60(3):266–73. DOI: https://doi.org/10.1097/DCR.0000000000000770
33. Crolla RMPH, Mulder PG, van der Schelling GP. Does robotic rectal cancer surgery improve the results of experienced laparoscopic surgeons? An observational single institution study comparing 168 robotic assisted with 184 laparoscopic rectal resections. Surg Endosc 2018 Nov;32(11):4562–70. DOI: https://doi.org/10.1007/s00464-018-6209-x
34. D'Annibale A, Pernazza G, Monsellato I, et al. Total mesorectal excision: A comparison of oncological and functional outcomes between robotic and laparoscopic surgery for rectal cancer. Surg Endosc 2013 Jun;27(6):1887–95. DOI: https://doi.org/10.1007/s00464-012-2731-4
35. Nagtegaal ID, Marijnen CA, Kranenbarg EK, van de Velde CJ, van Krieken JH, Pathology Review Committee Cooperative Clinical Investigators. Circumferential margin involvement is still an important predictor of local recurrence in rectal carcinoma: Not one millimeter but two millimeters is the limit. Am J Surg Pathol 2002 Mar;26(3):350–7. DOI: https://doi.org/10.1097/00000478-200203000-00009
36. Patriti A, Ceccarelli G, Bartoli A, Spaziani A, Biancafarina A, Casciola L. Short- and medium-term outcome of robot-assisted and traditional laparoscopic rectal resection. JSLS 2009 Apr–Jun;13(2):176–83.
37. Park JS, Kim NK, Kim SH, et al. Multicentre study of robotic intersphincteric resection for low rectal cancer. Br J Surg 2015 Nov;102(12):1567–73. DOI: https://doi.org/10.1002/bjs.9914
38. Park JS, Choi GS, Lim KH, Jang YS, Jun SH. Robotic-assisted versus laparoscopic surgery for low rectal cancer: Case-matched analysis of short-term outcomes. Ann Surg Oncol 2010 Dec;17(12):3195–202. DOI: https://doi.org/10.1245/s10434-010-1162-5
39. Kwak JM, Kim SH, Kim J, Son DN, Baek SJ, Cho JS. Robotic vs laparoscopic resection of rectal cancer: Short-term outcomes of a case–control study. Dis Colon Rectum 2011 Feb;54(2):151–6. DOI: https://doi.org/10.1007/DCR.0b013e3181fec4fd
40. Panteleimonitis S, Pickering O, Abbas H, et al. Robotic rectal cancer surgery in obese patients may lead to better short-term outcomes when compared to laparoscopy: A comparative propensity scored match study. Int J Colorectal Dis 2018 Aug;33(8):1079–86. DOI: https://doi.org/10.1007/s00384-018-3030-x