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ORIGINAL ARTICLE

Laparoscopic and Robotic Surgery for Rectal Cancer—Comparative Study Between Two Centres

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Abstract

We compared short-term and long-term surgical and oncological outcomes of robotic surgery versus hand-assisted laparoscopic surgery for rectal cancers patients. Study was conducted at the National Cancer Institute and Yonsei Cancer Centre from August 2006 to December 2012. We prospectively reviewed all patients who underwent RS and HALS for upper and middle third rectal cancers. Patients' demographics, postoperative short-term and long-term outcomes were assessed. Baseline patients' characteristics were similar in both groups. Average operative time was 321.3 ± 70 min for robotic surgery versus 106.0 ± 37 min for hand-assisted laparoscopic surgery, $P < 0.001$). Higher number of patients ($n = 74$, 94.9%) with tumour in the upper rectum was found in hand-assisted laparoscopic group ($P < 0.01$). Perioperative complications were more common in the robotic surgery group (9 vs. 5 patients). In all stages, 3-year overall survival was 86.9% in the hand-assisted laparoscopic group vs. 89.6% in the robotic group: 80.0% vs. 79.2 for stage I and 82.4% vs. 88.9 for stage II and III. The 3-year DFS was 83.6% in hand-assisted laparoscopic group vs. 83.2%—robotic surgery group considering all stages. Anastomotic leakage, bleeding, number of postoperative complications, overall survival and disease-free survival were similar and not much different between robotic and hand-assisted laparoscopic rectal cancer surgery.

Keywords Rectal cancer · Total mesorectal excision · Hand-assisted laparoscopic surgery · Robotic surgery

Background

Colorectal cancer (CRC) is one of the most common cancers in the world [1]. For almost 30 years, total mesorectal excision (TME) is still considered the gold standard of rectal cancer treatment [2, 3].

Most authors agree that hand-assisted laparoscopic surgery (HALS) is a bridge between open and laparoscopic surgery having most benefits of laparoscopic surgery, and also, it makes it even easier to perform. This is succeeded by introducing the surgeon's hand into the abdomen, so intra-abdominal organs and vessels can be palpated; retraction, dissection and control of the bleeding may be performed [4].

Relatively new technology in the field of CRC is the robotic surgery (RS) which overcomes limitations of standard laparoscopy procedure. The advantages of RS are as follows: 3-dimensional high-resolution image, removal of hand tremor, internal articulated "endowrist" allowing for 7 degrees of movement and better manoeuvrability especially in a narrow pelvis [5, 6].

HALS and RS are used more often in treating rectal cancer with great success and convenience for patients as well as the surgeon; however, oncological outcome between these techniques has not been addressed well in the literature. To our knowledge, there is only one study assessing the difference between HALS and RS in terms of short-term outcome in rectal cancer [7].

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Therefore, we designed our study aiming to compare surgical and oncological outcomes between the two groups: RS and HALS TME in rectal cancer patients.

Methods

Patients

The study protocol was approved by the hospitals' Institutional Review Board.

From 2015 January to March, we analysed the prospectively collected data in two tertiary centres. We identified and reviewed all the rectal cancer patients who underwent HALS at the National Cancer Institute in Lithuania from August 2006 to December, 2012. The same procedure was performed at Yonsei University Medical College in Seoul, Republic of Korea where patients underwent robotic surgery. The analysis of case records of historical patients, a case series analysis of rectal cancer patients, was performed. We included all consented patients 18 years or older with histologically confirmed rectal carcinoma (6 to 15 cm from the anal verge measured with MRI and rigid sigmoidoscopy). The cancers were staged according to the American Joint Committee of Cancer. All locally advanced cases (clinical T3/4 or N positive), located at the middle and lower rectum, were given neoadjuvant chemoradiotherapy (CRT). Surgical resection was performed 6–8 weeks following completion of CRT. All procedures were performed only by two senior surgeons in each arm who have performed at least 200 cases of rectal resections. As a result of final histopathology, patients with stage II (with high risk factors) or III disease were offered a course of adjuvant chemotherapy afterword. Patients unfit for surgery, ASA III–IV, disseminated disease (stage IV) or not willing to undergo minimum invasive surgery were excluded from the study. Another exclusion criterion was tumour located at the lower rectum; for this group of patients, laparoscopic abdominoperineal resection or low anterior resection with transanal specimen extraction and handsewn coloanal anastomosis is performed in Lithuanian centre since there is no need to make abdominal incision for disc placement.

Patients of both groups were matched for age, sex and stage of disease. The variables included into the final database were as follows: body mass index (BMI), co-morbidities, cancer height, previous abdominal surgery, type of surgery, surgical timing, estimated blood loss, intra-operative complications, rate of conversion, length of hospital stay, postoperative complications (complications were according the Clavien-Dindo classification [8] ≥ grade II) and mortality and pathohistology results (histologic type of tumour: well-differentiated carcinoma, moderately differentiated adenocarcinoma, and poorly differentiated adenocarcinoma (signet ring cell carcinoma or mucinous carcinoma)—according to the World Health Organization [9] and the Japanese classification of colorectal carcinomas [10]), length of specimen resected, distal and proximal (CRM) margins, lymph node harvest (positive lymph node count), and oncological outcomes. Nights spent from surgery to discharge were defined as length of hospital. Overall survival (OS) time from the day of randomisation until the day of death (event) or the day of last follow-up (censored) and recurrence—time from randomisation to disease reappearance (local recurrence: lateral lymph node, peritoneum, anastomotic site; distant recurrence: liver, liver + lung, bone); the data of a patient were censored when he was alive at last follow-up and there was no evidence of the disease, or had died of the diseases other than rectal cancer without evidence of a recurrence. Disease-free survival (DFS) – time from randomisation to recurrence or death due to any cause. A large number of patients did not have a follow-up of > 5 years; DFS was used as surrogate for OS [11]. Patients' data was matched to the national death registry.

RS and HALS was performed in a standardized manner described previously [4, 12, 13].

Statistics

Fisher's exact test was used for categorical variables, and Mann-Whitney U test was used for continuous variables. All statistical analysis was performed using the SPSS 17.0 statistical package (Chicago, IL). All P values of < 0.05 are being considered statistically significant.

Results

Patients' characteristics of both groups are shown in Table 1. A total of 150 patients were included in two centres; 10 (6.6%) of them were lost for follow-up. Briefly, over the study time, 78 rectal cancer patients with an average age of 64 (26 to 89) years and 55.1% of males underwent HALS TME (Table 1). The RS group consisted of 62 patients, with 67.7% of male patients and median age of 54 years. Male to female ratio was similar in both groups. Stage distribution was also the same. More patients with upper rectal cancer were included in the HALS group (74 (94.9%) vs. 22 (35.5%) $P < 0.001$); similarly, more patients with middle rectum cancer were in the RS group 4 (5.1%) vs. 40 (64.5% $P < 0.001$).

Operative time was significantly shorter in the HALS group (average 106.0 ± 37 min vs. 321.3 ± 70 min, $P < 0.001$). However, more patients ($n = 74$, 94.9%) with upper rectum cancer was seen in this group too ($P < 0.01$). Rectal cancers were found lower in the RS group ($P < 0.001$). Groups were statistically the same according to the size of the tumour, quality of mesorectal excision, removed lymph node count and stage of the disease (Table 1). The positive circumferential margin (CRM) was seen in one RS groups' patient (1.6%).

Table 1 Demographics and histological findings of all the patients undergoing rectal cancer surgery in hand-assisted laparoscopic surgery (HALS) and robotic surgery groups (RS)

	HALS ($n = 78$)	RS ($n = 62$)	P value
Sex			0.129
Male	43 (55.1%)	42 (67.7%)	
Female	35 (44.9%)	20 (32.3%)	
Age (years)	64 (26–89)	54 (35–74)	< 0.001
BMI (m^2/kg)	27.3 ± 3.3	22.9 ± 3.0	< 0.001
Stage			0.431
0	0 (0%)	2 (3.2%)	
1	33 (42.3%)	24 (38.7%)	
2	18 (23.1%)	13 (21.0%)	
3	27 (34.6%)	23 (37.1%)	
Past operative history			0.264
No	58 (74.4%)	51 (82.3%)	
Yes	20 (25.6%)	11 (17.7%)	
Adjuvant chemotherapy			0.752
No	28 (35.9%)	19 (30.6%)	
Yes	50 (64.1%)	43 (69.4%)	
Height of lesion			< 0.001
≥ 6 cm, < 10 cm	4 (5.1%)	40 (64.5%)	
≥ 10 cm	74 (94.9%)	22 (35.5%)	
Histology			0.713
Well differentiated	10 (12.8%)	9 (14.5%)	
Moderately differentiated	65 (83.3%)	52 (83.9%)	
Poorly differentiated	3 (3.8%)	1 (1.6%)	
CRM invasion			0.260
(−)	78 (100%)	61 (98.4%)	
(+)	0 (0%)	1 (1.6%)	
Distal margin (cm)	2.7 ± 1.2	3.1 ± 1.5	0.131
Proximal margin (cm)	10.8 ± 4.7	10.3 ± 3.5	0.488
LN retrieval	15.1 ± 8	14.8 ± 7	0.788

BMI body mass index
CRM circular resection margin
LN lymph node

The average lymph nodes removed was 15.1 in the HALS group and 14.8 in the RS group ($P = 0.788$). Majority (n = 117, 78%) of the cancers were moderately differentiated.

Statistically, more non-significant perioperative complications were seen in the RS group (9 vs. 5 patients). Postoperative bowel obstruction and leakage were also seen more often in the RS group (Table 2). The median length of hospitalization stay was comparable between both groups (RS, 9.8 days vs. HALS, 9.1 days; $P = 0.270$). Mortality was equal to 0 in both groups.

The 3-year OS including all stages was 86.9% in the HALS group vs. 89.6% in the RS group: 80.0% vs. 79.2 for stage I and 82.4% vs. 88.9 for stage II and III (Fig. 1). The 3-year DFS was 83.6% in the HALS group vs. 83.2% in the RS group, considering all stages (Fig. 2).

Table 2 Intra-operative and postoperative outcomes in two groups of patients undergoing rectal cancer surgery

	HALS ($n = 78$)	RS ($n = 62$)	P value
LOS (days)	9.1 ± 4	9.8 ± 4	0.270
Operative time (min)	106.0 ± 37	321.3 ± 70	< 0.001
Recurrence	Total = 7 (8.97%)	Total = 15 (24.1%)	
Local	1 (1.2%)	1 (1.6%)	
Systemic	6 (7.7%)	11 (17.7%)	
Local + systemic	0	3 (4.8%)	
Complication	Total = 5	Total = 9	0.167
Leakage	2	4	
Bleeding	1	0	
Wound dehiscence	2	0	
Postoperative ileus	0	5	

HALS hand-assisted laparoscopic surgery
RS robotic surgery
LOS length of hospital stay

Discussion

In our study, we have showed that both techniques are safe (low rates of morbidity and good oncological results) and feasible for rectal cancer patient treatment. We found that perioperative clinical, postoperative and oncological outcomes of RS were comparable with those of HALS in our groups. Comparing the demographics of both groups, only difference in body mass index (BMI) was found to be statistically significant. Higher BMI may be the factor influencing broader usage of HALS technique in Lithuanian population.

Few studies showed that laparoscopic surgery has the same results on long-term disease-specific survival for obese and non-obese patients [14–17]. We will definitely see the benefit of laparoscopic surgery for obese patients in terms of less pain, shorter hospital stay and lower wound infection rates, but technical difficulties associated with suboptimal exposure and access in obese subjects may increase the need for conversion. HALS has some advantages over straight laparoscopy. This is tactile feedback, dissection and retraction assisted by surgeon's arm. These possibilities could be very helpful in obese patients, allowing completion of difficult laparoscopic procedures in a shorter time [18]. There are at least few studies assessing obesity as a possible risk factor of worse surgical outcome in robotic colorectal surgery [19–22]. A large regional database of 4796 patients in the Michigan Surgical Quality Collaborative (MSCQ) database showed that obesity was a risk factor for conversion during laparoscopic, but not robotic

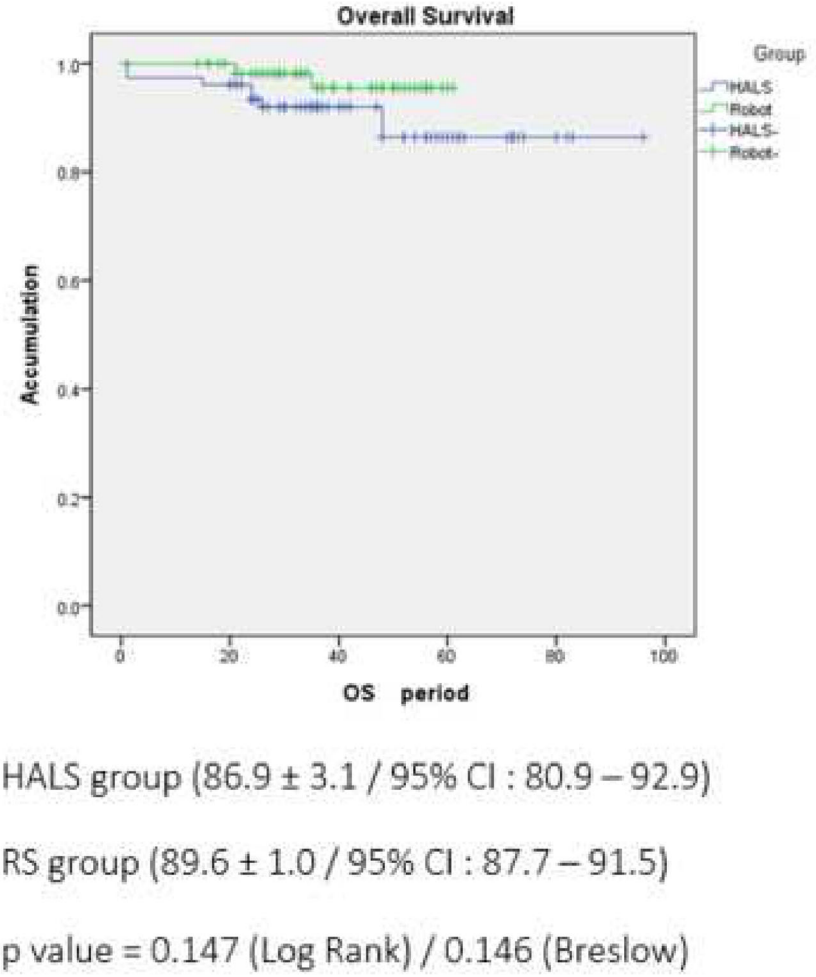

Fig. 1 Overall survival of the patients from both groups—all stages (green - Robotic, blue - HALS)

colectomy [22]. Shiomi et al. assessed almost 300 patients and the surgical effect of visceral obesity [21]. The authors concluded that RS surgical technique was not affected by visceral obesity in any of the surgical or postoperative parameters.

CRM involvement, TME quality and lymph node count are important oncological markers of rectal cancer surgical quality. We found that CRM involvement rate was higher in the RS group compared with the HALS group, although the difference did not reach statistical significance. CRM is a marker of surgical quality. It also depends from the size and location of the tumour. The reason of higher CRM involvement in the RS group should be attributed to the higher number of lower rectal cancers. Nevertheless, we found the same well-known benefits of RS comparing with any laparoscopic surgery (partly including HALS) [23]. Robotic instruments provide free arm movements, almost the same as the human hand. These movements are well seen in TME in the narrow, short, obese male patient pelvis. Comparative studies have shown lower rates of involved circumferential resection margin in RS [23, 24].

Opponents of HALS technique state that its usage decreases numbers of laparoscopy cases and it is related with slightly longer incisions. Proponents believe that HALS still has its place for obese patients or complex surgical procedures, as total colectomy [25]. Furthermore, HALS can also be a bridge for straight laparoscopy in the teaching process for young surgeons. Opponents state the disadvantage of longer incision, but most of the time, the difference is less than 2 cm and it does not translate to worse surgical outcome. For bulky tumours, the incision for extraction the tumour might be similar to HALS, but the timing of operation is much longer [26, 27]. Benlice et al. recently has published two large population-based cohort studies where authors showed most of HALS benefits [26, 27].

This is the first study to compare oncological outcomes between RS versus HALS in rectal cancer patients. Previously only one similar study was performed assessing short-term outcomes in RS and HALS groups. Authors included 38 patients and found that the procedural duration was significantly longer in the RS group (390 vs. 225 min; $P < 0.001$); but a higher proportion of patients in the HALS group required conversion to open surgery and developed perioperative morbidities. The authors also found that the cost of procedure was significantly higher in the RS group [7]. We

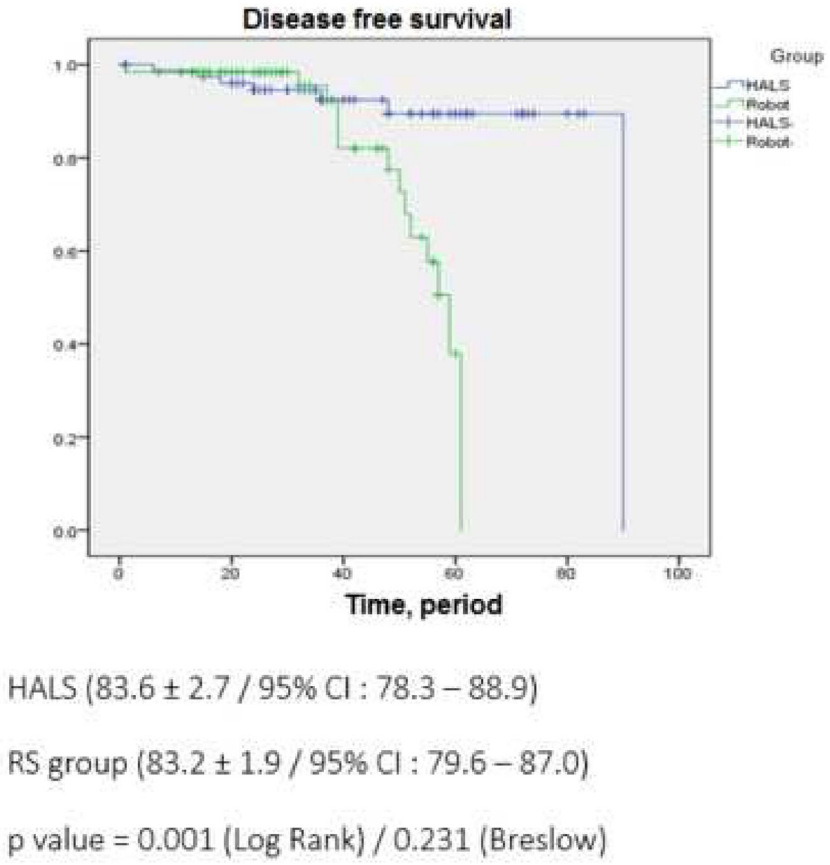

Fig. 2 Disease-free survival of the patients from both groups—all stages (green - Robotic, blue - HALS)

found significantly longer operative times in the RS group. The explanation of that may be the higher number of patients with lower rectal cancer in the RS group. According to most studies and indications, these patients were ideal candidates for robotic approach. This selection bias may also explain the lower CRM positivity rate in the HALS group. We found similar 3-year oncological outcomes between the two groups. Another more recent study on operative timing for robotic surgery showed varying results [28–30]. In a previous study from Yonsei University Hospital, we found that the operative timing was 208 ± 54 (110–338) minutes operated by another surgeon [28]. In a multicentre study from US authors, they found a mean operative time of 240 min [29]. And recent meta-analysis showed that RS had a significantly longer operative time compared with the laparoscopic (36 min), transanal (58 min) and open (60 min) techniques [30].

Our study strength is high number of patients included and multicentre manner. Another strong point is assessment of long-term oncological outcomes. These endpoints have never been previously reported in HALS vs. RS groups.

Our study also has some limitations. First of all, this was not a case-matched or randomized, blinded prospective controlled study. The patients were not selected according to any of the specific criteria. This explains the reason why more patients with upper rectum cancer was in the HALS group, compared with more patients with middle rectum cancer in the RS group. Secondly, relatively short follow-up period could not completely exclude the possibility of worse long-term oncologic outcomes or surgical complications, such as adhesive ileus or incisional hernia. Thirdly, both HALS and RS were performed by expert colorectal surgeons; additional data from the young surgeons in the learning curve would show more advantages or disadvantages in either of the treatment modalities. Lastly, postoperative pain scores, narcotic use, time to normal bowel function, urogenital function and patient satisfaction were not assessed in our study. Some biases may also be present because of some differences between the two countries.

Our study could not demonstrate the expected advantage of RS over HALS in terms of quality of surgery. Mainly this is because lower rectal cancer patients were excluded from this study—this group would have shown the real benefit of robotic surgery.

Conclusions

Robotic surgery and hand-assisted laparoscopic surgery are both oncologically safe procedures. Although large multicentre prospective study groups with long-term follow-

up data are needed, robotic surgery is still limited by long operative times.

Author Contributions AD, MA and YDH analysed the data. AD and MA wrote the manuscript. NES, VU and NKK supervised the study. All authors read and approved the final manuscript.

Availability of Data and Materials Not available.

Compliance with Ethical Standards

Conflict of Interest The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Ethics Approval and Consent to Participate Ethical approvals were received prior the study.

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References

1. Ferlay J, Soerjomataram I, Ervik M, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin DM, Forman D, Bray F GLOBOCAN 2012 v1.1 (2015) Cancer incidence and mortality worldwide. Int J Cancer 136:E359–E386.1
2. Heald RJ, Husband EM, Ryall RD (1982) The mesorectum in rectal cancer surgery—the clue to pelvic recurrence? Br J Surg 69:613–616
3. Rodríguez-Luna MR, Guarneros-Zárate JE, Tueme-Izaguirre J (2015) Total mesorectal excision, an erroneous anatomical term for the gold standard in rectal cancer treatment. Int J Surg 23:97–100
4. Samalavicius NE, Gupta RK, Dulskas A, Kazanavicius D, Petrulis K, Lunevicius R (2013) Clinical outcomes of 103 hand-assisted laparoscopic surgeries for left-sided colon and rectal cancer: single institutional review. Ann Coloproctol 29:225–230
5. Xiong B, Ma L, Huang W, Zhao Q, Cheng Y, Liu J (2015) Robotic versus laparoscopic total mesorectal excision for rectal cancer: a meta-analysis of eight studies. J Gastrointest Surg 19:516–526
6. Baek SJ, Kim CH, Cho MS, Bae SU, Hur H, Min BS, Baik SH, Lee KY, Kim NK (2015) Robotic surgery for rectal cancer can overcome difficulties associated with pelvic anatomy. Surg Endosc 29:1419–1424
7. Koh FH, Tan KK, Lieske B, Tsang ML, Tsang CB, Koh DC (2014) Endowrist versus wrist: a case-controlled study comparing robotic versus hand-assisted laparoscopic surgery for rectal cancer. Surg Laparosc Endosc Percutan Tech 24:452–526
8. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, de Santibañes E, Pekolj J, Slankamenac K, Bassi C, Graf R, Vonlanthen R, Padbury R, Cameron JL, Makuuchi M (2009) The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 250:187–196
9. Bosman FTCF, Hruban RH, Theise ND (2010) WHO classification of tumours of the digestive system, 4th edn
10. Shuppan K (2006) Japanese Research Society for Cancer of the Colon and Rectum. General rules for clinical and pathological studies on cancer of the colon, rectum and anus. 7th ed, revised version Tokyo, Japan
11. Oba K, Paoletti X, Alberts S, Bang YJ, Benedetti J, Bleiberg H, Catalano P, Lordick F, Michiels S, Morita S, Ohashi Y, Pignon JP, Rougier P, Sasako M, Sakamoto J, Sargent D, Shitara K, Cutsem EV, Buyse M, Burzykowski T, GASTRIC group (2013) Disease-free survival as a surrogate for overall survival in adjuvant trials of gastric cancer: a meta-analysis. J Natl Cancer Inst 105:1600–1607
12. Kim NK, Kim YW, Cho MS (2015) Total mesorectal excision for rectal cancer with emphasis on pelvic autonomic nerve preservation: expert technical tips for robotic surgery. Surg Oncol 24:172–180
13. Dulskas A, Samalavicius NE, Gupta RK, Zabulis V, Samalavicius RS, Kutkauskiene J, Escalante R (2015) Hand-assisted laparoscopic surgery for left sided colorectal cancer: is quality of surgery related with experience? Eur Surg 47:238–242
14. Healy LA, Ryan AM, Sutton E et al (2010) Impact of obesity on surgical and oncological outcomes in the management of colorectal cancer. Int J Color Dis 5:1293–1299
15. Khoury W, Stocchi L, Geisler D (2011) Outcomes after laparoscopic intestinal resection in obese versus non-obese patients. Br J Surg 98:293–298
16. Park JW, Lim SW, Choi HS, Jeong SY, Oh JH, Lim SB (2010) The impact of obesity on outcomes of laparoscopic surgery for colorectal cancer in Asians. Surg Endosc 24:1679–1685
17. Scheidbach H, Benedix F, Hugel O et al (2008) Laparoscopic approach to colorectal procedures in the obese patient: risk factor or benefit? Obes Surg 18:66–70
18. Heneghan HM, Martin ST, Kiran RP, Khoury W, Stocchi L, Remzi FH, Vogel JD (2013) Laparoscopic colorectal surgery for obese patients: decreased conversions with the hand-assisted technique. J Gastrointest Surg 17:548–554
19. Harr JN, Luka S, Kankaria A, Juo YY, Agarwal S, Obias V (2017) Robotic-assisted colorectal surgery in obese patients: a case-matched series. Surg Endosc 31:2813–2819
20. Gorgun E, Ozben V, Costedio M, Stocchi L, Kalady M, Remzi F (2016) Robotic versus conventional laparoscopic rectal cancer surgery in obese patients. Color Dis 18:1063–1071
21. Shiomi A, Kinugasa Y, Yamaguchi T, Kagawa H, Yamakawa Y (2016) Robot-assisted versus laparoscopic surgery for lower rectal cancer: the impact of visceral obesity on surgical outcomes. Int J Color Dis 31:1701–1710
22. Bhama AR, Wafa AM, Ferraro J, Collins SD, Mullard AJ, Vandewarker JF, Krapohl G, Byrn JC, Cleary RK (2016) Comparison of risk factors for unplanned conversion from laparoscopic and robotic to open colorectal surgery using the Michigan surgical quality collaborative (MSQC) database. J Gastrointest Surg 20:1223–1230
23. Sun Y, Xu H, Li Z, Han J, Song W, Wang J, Xu Z (2016) Robotic versus laparoscopic low anterior resection for rectal cancer: a meta-analysis. World J Surg Oncol 14:61
24. Yamaguchi T, Kinugasa Y, Shiomi A, Tomioka H, Kagawa H, Yamakawa Y (2016) Robotic-assisted vs. conventional laparoscopic surgery for rectal cancer: short-term outcomes at a single center. Surg Today 46:957–962
25. Myers EA, Feingold DL, Arnell TD, Njoh L, Cekic V, Jang JH, Naffouje S, Whelan RL (2014) The rate for the use of hand-assisted laparoscopic methods is directly proportional to body mass index. Surg Endosc 28:108–115
26. Benlice C, Costedio M, Stocchi L, Abbas MA, Gorgun E (2016) Hand-assisted laparoscopic vs open colectomy: an assessment from the American College of Surgeons National Surgical Quality Improvement Program procedure-targeted cohort. Am J Surg 212(5):808–813
27. Benlice C, Costedio M, Kessler H, Remzi FH, Gorgun E (2016) Comparison of straight vs hand-assisted laparoscopic colectomy: an

assessment from the NSQIP procedure-targeted cohort. Am J Surg 212:406–412

28. Park EJ, Kim CW, Cho MS, Kim DW, Min BS, Baik SH, Lee KY, Kim NK (2014) Is the learning curve of robotic low anterior resection shorter than laparoscopic low anterior resection for rectal cancer?: a comparative analysis of clinicopathologic outcomes between robotic and laparoscopic surgeries. Medicine (Baltimore) 93(25): e109
29. Hellan M, Ouellette J, Lagares-Garcia JA, Rauh SM, Kennedy HL, Nicholson JD, Nesbitt D, Johnson CS, Pigazzi A (2015) Robotic rectal cancer resection: a retrospective multicenter analysis. Ann Surg Oncol 22(7):2151–2158
30. Simillis C, Lal N, Thoukididou SN, Kontovounisios C, Smith JJ, Hompes R, Adamina M, Tekkis PP (2019) Open versus laparoscopic versus robotic versus transanal mesorectal excision for rectal cancer: a systematic review and network meta-analysis. Ann Surg 270(1):59–68