Short-term surgical outcomes and patient quality of life between robotic and laparoscopic extralevator abdominoperineal excision for adenocarcinoma of the rectum

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ABSTRACT

INTRODUCTION Some studies advocate a laparoscopic extralevator abdominoperineal excision (I-ELAPE) approach for low rectal cancer. The da Vinci™ robot (r-ELAPE) technique has potential to overcome some limitations of I-ELAPE, such as reduction of the learning curve and more precise tissue handling. It is unknown whether this approach results in improved surgical or quality of life outcomes compared with I-ELAPE. This study aimed to address this issue.

METHODS Consecutive patients having undergone either robotic or laparoscopic ELAPE for adenocarcinoma were studied. All operations were performed by two surgeons experienced in laparoscopic and recently introduced robotic surgery. Surgical outcomes were determined by postoperative histology and short-term complications. Quality of life was prospectively assessed using the European Organisation for Research and Treatment of Cancer QLC-CR30 and QLC-CR29 questionnaires.

RESULTS A total of 22 patients (11 r-ELAPE) with a median follow-up of 13 months (8 months robotic; 22 months laparoscopic) were studied. The groups were similarly matched for age, gender, American Society of Anesthesiologists status, preoperative chemoradiotherapy and tumour height. All had R0 resection. There was no significant difference in short-term surgical outcomes between groups. There was no significant difference in mean global health scores between the two groups (74 ± 14 r-ELAPE vs. 73 ± 10 I-ELAPE). The r-ELAPE group had a lower mean impotence score compared with the I-ELAPE group (55.5 ± 40 vs. 72.2 ± 44), although this was not statistically significant.

CONCLUSIONS The newly introduced r-ELAPE was non-inferior to I-ELAPE in either patient quality of life or surgical outcomes. Robotic surgery could be particularly beneficial in the technically challenging area of low rectal cancer surgery with a shorter learning curve than laparoscopy.

KEYWORDS

Robotic surgery – Laparoscopy – Quality of life – Rectal cancer – Abdominoperineal excision

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Introduction

The introduction of total mesorectal excision as the standard technique for the treatment of rectal cancer has dramatically reduced the rates of local recurrence.¹ However, such a reduction in tumour recurrences has yet to be observed in patients undergoing abdominoperineal excision.^{1,2} To overcome this, some surgeons have advocated extralevator abdominoperineal excision (ELAPE) for low rectal cancer. The ELAPE approach aims to reduce tumour perforation rates, circumferential resection margin positivity and eventually local recurrence.^{3,4} At present, laparoscopic total mesorectal excision is the popular approach for rectal cancer resection and is considered safe for abdominoperineal excision.⁵ The laparoscopic approach has been shown to demonstrate favourable short-term outcomes in comparison with

open surgery in the treatment of colon cancer. These include reduced blood loss, less pain and shorter recovery time.⁶ Recently published randomised trials of rectal cancer have not demonstrated oncological superiority for either approach.^{7,8} Laparoscopic total mesorectal excision is a difficult operation to master, with some studies stating a minimum of 50 cases to achieve consistent results.⁹ The use of the da Vinci™ robot technique in the treatment of rectal cancer has the potential to reduce this learning curve.¹⁰ Some studies have also demonstrated that robotic surgery performed by experienced surgeons has favourable clinical and oncological outcomes compared with the laparoscopic approach for rectal cancer.¹¹ This technique is increasingly embraced by surgeons as it overcomes some restrictions posed by laparoscopic surgery, namely the three-dimensional view, tremor elimination and six-degree EndoWrist® manipulation.

Quality of life is considered an essential outcome measure when undertaking a new surgical technique. A systematic review demonstrated no difference in quality of life between the laparoscopic and open approach for colorectal cancer.¹² There are studies evaluating clinical and oncological outcomes of robotic extralevator abdominoperineal excision (r-ELAPE);¹³ however, quality of life outcomes for these patients have yet to be addressed. This supports the view that such an important issue is often not assessed or its impact is overlooked.¹⁴ There is a lack of evidence comparing oncological outcomes between robotic ELAPE and laparoscopic extralevator abdominoperineal excision (l-ELAPE). The present study compared surgical and quality of life outcomes in patients with rectal cancer following treatment between these two approaches.

Materials and methods

All patients undergoing r-ELAPE between February 2015 and August 2016 were identified from a prospective database. Using February 2015 as a reference point, which coincides with the introduction of robotic surgery at the James Cook University Hospital, identical numbers of consecutive l-ELAPE cases were identified from the same database for comparison. The decision for ELAPE, with or without neoadjuvant treatment for each patient, was made by a multidisciplinary team. The indication for ELAPE was for low rectal cancers which prevented the prospect of a successful anastomosis or tumours that threatened the sphincter complex. For such tumours, ELAPE is the standard approach in our centre, owing to its perceived oncological superiority to conventional abdominoperineal excision. Data capture was achieved using patient notes, discharge letters, clinic letters and the hospital's operation database.

From February 2015, all patients were initially offered a robotic approach. However, allocation of either approach was determined solely upon the availability of the da Vinci system, as it is shared with other surgical specialties. The laparoscopic approach remains the standard default approach in our unit. Patients with a diagnosis other than adenocarcinoma were excluded. All operations were performed by two surgeons, both of whom are experienced in laparoscopic surgery (more than 100 cases) and trained in the recently introduced robotic surgery. The surgeons had not performed any robotic cases prior to commencement of this study. Patient demographics including age, gender and the American Society of Anesthesiologists (ASA) status were recorded. Preoperative information such as the use of neoadjuvant therapy and preoperative tumour staging were captured for comparison. Postoperative information included tumour height, tumour histology, circumferential resection margin involvement, intraoperative perforation, complication rate, return to theatre and mortality. Quality of the tumour microenvironment component of the resected specimen was graded as described by Nagtegaal et al.¹⁵ Tumour height was determined by pathological examination of the specimen and was described as the distance from the anal verge. Postoperative quality of life data were collected in September 2016 using the European Organisation for

Research and Treatment of Cancer (EORTC) QLC CR29 and QLC CR30 version 3.0 questionnaires.¹⁶

Operative approach

The ELAPE technique used by the surgeons was as described by Holm.² In the case of the laparoscopic approach, a standard four-port technique was used for the abdominal phase. However, an extra 12-mm assistant port was used in addition to a four-arm da Vinci robot for robotic cases. A Harmonic© scalpel or monopolar scissors were used as an energy device in the laparoscopic and robotic cases, respectively. The resultant perineal defect was closed in all with the use of a prosthetic mesh.

Statistical analysis

Statistical analysis was performed using SPSS Version 17.0 (SPSS Inc). The chi-squared test and analysis of variance were used for the comparison of categorical and continuous variables, respectively. The Mann–Whitney U test was used for the analysis of the quality of life variables. Data are presented as mean plus or minus standard deviation unless stated otherwise. A *P*-value of less than 0.05 was considered to be statistically significant.

Ethical considerations

Following completion of an online decision tool developed by the Medical Research Council regulatory support centre, it was determined that this study did not require research ethic committee approval. Informed consent was obtained from all patients who undertook the questionnaire.

Results

Patient characteristics

All 11 r-ELAPE procedures (in 7 men and 4 women) between March 2015 and August 2016 and 11 consecutive l-ELAPE procedures (in 9 men and 2 women) between July 2014 and August 2016 were evaluated. Mean age of the patients was 71 years (range 54–82 years; standard deviation, SD $\pm$ 10.1 years) in the r-ELAPE group and 57 years (range 45–85 years; SD $\pm$ 12.7 years) in the l-ELAPE group (*P* = 0.1). There were no significant differences between the two groups of patients for age, gender, ASA score, preoperative chemoradiotherapy and predicted preoperative stage or length of stay (Table 1). Median length of stay was 6 days (range 2–26 days; SD $\pm$ 6.5 days) in the r-ELAPE group and 6 days (range 4–34 days; SD $\pm$ 8.6 days), *P* = 0.4.

Operative outcomes

Data on operative findings are presented in Table 2. Mean operating time was significantly shorter in laparoscopic compared to robotic procedures in patients undergoing ELAPE (251 minutes, SD $\pm$ 55 minutes vs. 327 minutes, SD $\pm$ 34 minutes; *P* = 0.01). Macroscopic pathological assessment revealed no difference in the mesorectal plane of excision, sphincter grade, length of specimen or median tumour height. Microscopic pathological assessment revealed comparable postoperative tumour grade and mean lymph node harvest. All patients had R0 resection. There were no

Table 1 Patient preoperative data

	r-ELAPE (n = 11)	l-ELAPE (n = 11)	P-value
ASA grade (n):			0.07
II	9	5	
III	2	6	
Preoperative tumour grade (n):			
T stage:			0.35
T1	0	2	
T2	4	3	
T3	6	6	
Not specified	1	–	
N stage:			0.43
N0	5	8	
N1	3	1	
N2	2	2	
Not specified	1	–	
Neoadjuvant chemoradiotherapy (n)	7	4	0.2

ASA, American Society of Aesthesiologists; ELAPE, extralevator abdominoperineal excision; l-ELAPE, laparoscopic ELAPE; r-ELAPE, robotic ELAPE

tumour perforations in either group. There was one conversion in the robotic group to laparoscopy because of dense adhesions.

Complications

30-day morbidity data are presented in Table 3. One patient in the laparoscopic group died, secondary to a myocardial infarction 34 days after surgery. There were two 30-day readmissions (one r-ELAPE and one l-ELAPE) with superficial wound infection and non-specific abdominal pain, respectively. Three patients (two r-ELAPE and one l-ELAPE), all of whom had preoperative chemoradiotherapy, developed superficial perineal wound dehiscence. Two patients (one in each group) required antibiotics and one r-ELAPE patient needed a minor surgical procedure. All wounds healed by secondary intention during the course of follow-up. Three patients developed postoperative urinary retention, requiring discharge with a urinary catheter. One patient in the robotic group developed hospital acquired pneumonia which resolved with antibiotics and chest physiotherapy.

Quality of life for patients after r-ELAPE and l-ELAPE

EORTC QLQ-CR30 and QLQ-CR29 questionnaires were completed by the surviving patients (100%, $n = 10$ laparoscopic vs. 82%, $n = 9$ robotic) with a median follow-up of 13 months. For patients in the robotic group, median follow-up

was 8 months (range 1–19 months) and in the laparoscopic group 22 months (range 3–26 months). Results of key elements are presented in Tables 4 and 5. Linear transformation of the raw data enabled the individual responses to be assigned to a score of between 0 and 100, as described by the standard EORTC scoring system.¹⁷ A higher functioning score describes a better level of function, whereas a higher symptom score describes a greater severity of symptom. There was no statistically significant difference in global health status between patients treated with r-ELAPE and l-ELAPE (74 ± 14 vs. 73 ± 10). There was no statistically significant difference in the functional scale between the two groups of patients. QLQ-CR29 symptom scores revealed higher mean score for male impotence in the l-ELAPE group of patients compared with that for r-ELAPE patients (72.2 ± 44 v 55.5 ± 40) although this was not statistically significant. Patients in the l-ELAPE group also reported a higher mean rate of urinary frequency (20 ± 20.1) compared with r-ELAPE (7.4 ± 12.1) but this was not statistically significant.

Discussion

Since its introduction at the beginning of the 21st century, robotic colorectal surgery and its potential benefit to patients has been a topic of debate. The potential advantages of this compared with other approaches can be best observed in the narrow male pelvis.¹⁸ By the same principle, we consider that robotic surgery may be particularly beneficial for patients undergoing ELAPE.

Circumferential resection margin positivity and tumour perforation are considered to be important determinants of local recurrence.¹ The absence of any oncological adverse parameters and no conversions observed in our study population undergoing laparoscopic ELAPE is in keeping with previous studies,¹⁹ although it is important to note that the laparoscopic operations were performed by experienced surgeons. Compared with the laparoscopic technique, robotic surgery took longer to perform. This was somewhat expected, as the robotic surgery technique was a recent introduction to our centre. Despite the fact that the surgeons had performed no robotic cases prior to commencement of this study, surgical outcomes were similar to those with laparoscopic surgery. This suggests that robotic surgery is at least as safe and effective as laparoscopic surgery, which is in keeping with previous research.²⁰ The observed surgical outcomes between the two groups, despite the surgeons' limited experience of the robotic technique, supports the view that robotic surgery training may have a shorter learning curve.²¹ However, it is plausible that, as experienced laparoscopic surgeons, some translational skills learnt from this technique may account in part for the parity in surgical outcomes between the two groups. Kim and colleagues suggest, however, that robotic rectal cancer surgery can be carried out competently without the need for extensive prior laparoscopic experience.²² Robotic surgery could therefore be an attractive option allowing trainee surgeons to develop competency in the technique within a relatively short period of time, which may not otherwise be possible with the laparoscopic technique.

Table 2 Operative and histopathological results

	r-ELAPE (<i>n</i> = 11)	I-ELAPE (<i>n</i> = 11)	<i>P</i> -value
Mean tumour height (mm)	37.5 (range 15–60; SD ± 15.6)	37.2 (range 10–60; SD ± 17.5)	0.6
Median distance to CRM (mm)	6 (range 1.5–1.9; SD ± 6)	7 (range 1.5–15; SD ± 4.7)	
Postoperative tumour grade (<i>n</i>):	2	6	
T stage:			0.27
Tx	0	3	
T1	0	1	
T2	1	1	
T3	9	5	
Not specified	1	1	
N stage:			0.76
N0	7	7	
N1	2	3	
N2	2	1	
Not specified			
V0	5	7	
V1	6	4	
R0	11	11	
Tumour perforation (<i>n</i>)	0	0	–
Mean total lymph nodes (<i>n</i>)	18.8 (range 6–30; SD ± 8.0)	23.5 (range 7–39; SD ± 10.3)	0.2
Mean length of specimen (cm)	25.2 (range 10–35; SD ± 7.4)	28.7 (range 22–40; SD ± 5.7)	0.2
Mean length of operation (minutes)	327 (SD ± 34)	251 (SD ± 55)	0.01

CRM, circumferential resection margin; ELAPE, extralevator abdominoperineal excision; I-ELAPE, laparoscopic ELAPE; r-ELAPE, robotic ELAPE; SD, standard deviation

Table 3 Thirty-day morbidity results

	r-ELAPE (<i>n</i> = 10)	I-ELAPE (<i>n</i> = 10)	<i>P</i> -value
Readmission	1	1	–
Complications	5	4	0.66
Perineal wound breakdown	2	1	0.53
Urinary retention	1	2	0.53
Conversion	1	0	0.30
Mortality	0	1	0.30

ELAPE, extralevator abdominoperineal excision; I-ELAPE, laparoscopic ELAPE; r-ELAPE, robotic ELAPE

Quality of life is an important outcome measure when comparing new surgical techniques against an established practice. To our knowledge, this is the first study which compares quality of life outcomes in patients with rectal cancer following robotic and laparoscopic ELAPE. Despite similar

surgical outcomes between the two groups in our study, it was previously unclear whether this will reflect similarly on other aspects of patient health and wellbeing. Although small, the overall quality of life outcome parameters were found to be similar between both groups in our study. The

Table 4 Selected QLQ-C30 scores

Scale	r-ELAPE Mean (SD)	I-ELAPE Mean (SD)	P-value
Global health	74 (± 14)	73.3 (± 14.0)	0.76
Functioning scales:			
Physical	86.7 (± 30)	85 (± 18.3)	0.86
Role	75.9 (± 35.4)	84.9 (± 16.6)	0.79
Emotional	93.5 (± 11.6)	90 (± 13.49)	0.49
Cognitive	90.7 (± 14.7)	90 (± 16.09)	1
Social	85.2 (± 24.2)	83.3 (± 20.8)	0.64
Symptom scales:			
Fatigue	34 (± 36.5)	16.6 (± 22.9)	0.58
Nausea and vomiting	3.7 (± .35)	1.6 (± 5.27)	0.47

ELAPE, extralevator abdominoperineal excision; I-ELAPE, laparoscopic ELAPE; r-ELAPE, robotic ELAPE; SD, standard deviation

Table 5 Selected QLQ-C29 scores

Scale	r-ELAPE Mean (SD)	I-ELAPE Mean (SD)	P-value
Global health	74 (± 14)	73.3 (± 14.0)	0.76
Functioning scales:			
Body image	80.2 (± 31.3)	77.8 (± 23.4)	0.7
Anxiety	81.4 (± 24.2)	83.3 (± 17.5)	1
Weight	96.3 (± 11.1)	76.6 (± 31.6)	0.12
Symptom scales:			
Urine frequency	7.4 (± 12.1)	20 (± 20.5)	0.15
Impotence	55.5 (± 40.3)	72.2 (± 44.3)	0.4
Abdominal pain	7.4 (± 14.7)	16.6 (± 32.4)	0.63

ELAPE, extralevator abdominoperineal excision; I-ELAPE, laparoscopic ELAPE; r-ELAPE, robotic ELAPE; SD, standard deviation

observed global health and functioning scores for our study population are also comparable to those reported in previous meta-analyses and systematic reviews of ELAPE.²⁵

Preservation of bladder and sexual function for patients undergoing rectal cancer surgery has an important effect on quality of life. We found no significant difference in genitourinary or sexual function between robotic and laparoscopic groups at a median follow-up of 8 and 22 months, respectively. Injury to the pelvic autonomic nerves is not uncommon in rectal cancer surgery,²⁴ with the reported incidence of sexual dysfunction following rectal cancer being as high as 80%.²⁵ In this regard, the advantage of each approach is topic of debate. Findings from the CLASSIC trial suggested a higher rate of sexual dysfunction among patients following laparoscopic surgery,²⁶ whereas Asoglu and colleagues demonstrated the contrary.²⁷ Another study by Luca et al.,

looking at bladder and sexual function, reported a complete recovery of these problems 12 months following robotic rectal cancer surgery.²⁸ It is possible that a shorter median follow-up in the r-ELAPE group may be responsible for the absence of significant difference. However, the observed mean symptom score for impotence in the robotic group is also lower in our study in comparison with reported laparoscopic ELAPE studies.²⁹ Although not statistically significant within our study, a higher proportion of patients in the robotic group (7/11) had preoperative chemoradiotherapy compared with the laparoscopic group (4/11), which has clinical significance. Preoperative chemoradiotherapy has been shown to cause tissue fibrosis and oedema, which in turn can produce extensive mist from exudates, which can impede the speed of dissection.³⁰ This in part may account for the increased operative time within the robotic group.

Strengths and weaknesses of this research

To our knowledge, this is the first study that compares the quality of life of patients after extralevator abdominoperineal resection between the robotic and laparoscopic approach. This research used an externally validated, appropriate and specific questionnaire to identify quality of life outcomes in patients following laparoscopic and robotic ELAPE. We acknowledge that quality of life outcomes are being addressed in the ROLARR trial, the results of which we await with interest.³¹ However, we are the first group to look at the other aspects relating to quality of life using the cancer-specific questionnaire. We found this tool helpful in answering complicated and multi-faceted research questions. To minimise bias, patients were recruited consecutively for both study arms. The quality of life questionnaires were administered to patients at different points during follow up which may have affected their responses.³² The lack of baseline quality of life scores also prevents a direct post-operative comparison.

We were unable to demonstrate a significant difference in quality of life measures between patients undergoing r-ELAPE or l-ELAPE because of the large variability amongst patients in quality of life scores. This study was not sufficiently powered to achieve the level of significance, which raises the possibility of type II errors within our results. A post-hoc power calculation, which was performed using global health (as a continuous variable) as the primary endpoint with an alpha level set at 0.05, revealed a power of 3.9%.

Although not addressed in this study, the cost of robotic surgery remains a factor, as it incurs higher costs than conventional laparoscopic surgery, which is of particular importance in the current climate. For robotic surgery to be considered a viable alternative to laparoscopy, a purposefully designed and sufficiently powered study is needed to substantiate results found within this study.

Conclusions

Our study findings suggest that the newly introduced robotic approach offers comparable high standards of surgical and quality of life outcomes against the established laparoscopic technique. The parity in outcomes between the two approaches, despite the limited experience of surgeons with robotic surgery, may be explained on the basis of a shorter learning curve for the robotic technique.

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References

- Wibe A, Syse A, Andersen E *et al.* Oncological outcomes after total mesorectal excision for cure for cancer of the lower rectum: anterior vs. abdominoperineal resection. *Dis Colon Rectum* 2004; **47**(1): 48–58.
- Heald RJ, Smedh RK, Kald A *et al.* Abdominoperineal excision of the rectum: an endangered operation. Norman Nigro Lectureship. *Dis Colon Rectum* 1997; **40**: 747–751.
- Holm T, Ljung A, Häggmark T *et al.* Extended abdominoperineal resection with gluteus maximus flap reconstruction of the pelvic floor for rectal cancer. *Br J Surg* 2007; **94**(2): 232–238.
- Huang A, Zhao H, Ling T *et al.* Oncological superiority of extralevator abdominoperineal resection over conventional abdominoperineal resection: a meta-analysis. *Int J Colorectal Dis* 2014; **29**(3): 321–327.
- Simirov A, Reynoso JE, Dolighi O *et al.* Comparison of perioperative outcomes in patients undergoing laparoscopic versus open abdominoperineal resection. *Am J Surg* 2011; **202**: 666–672.
- Veldkamp R, Kuhry E, Hop WC *et al.* Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol* 2005; **6**(7): 477–484.
- Stevenson ARL, Solomon MJ, Lumley JW *et al.*, for the ALaCaRT Investigators. Effect of Laparoscopic-Assisted Resection vs Open Resection on Pathological Outcomes in Rectal CancerThe ALaCaRT Randomized Clinical Trial. *JAMA* 2015; **314**(13): 1,356–1,363.
- Freshman J, Branda M, Sargent D *et al.* Effect of laparoscopic-assisted resection vs. open resection of stage II or III Rectal cancer on pathologic outcomes: The ACOSOG Z6051 Randomised Clinical Trial. *JAMA* 2015; **314**(13): 1,346–1,355.
- Kayano H, Okuda J, Tanaka K *et al.* Evaluation of the learning curve in laparoscopic low anterior resection for rectal cancer. *Surg Endosc* 2011; **25**: 2,972–2,979.
- Kim YW, Lee HM, Kim NK *et al.* The learning curve for robot-assisted total mesorectal excision for rectal cancer. *Surg Laparosc Endosc Percutan Tech* 2012; **22**: 400–405.
- deSouza AL, Prasad LM, Marecik SJ *et al.* Total mesorectal excision for rectal cancer: the potential advantage of robotic assistance. *Dis Colon Rectum* 2010; **53**: 1,611–1,617.
- Bartels SA, Vlug MS, Ubbink DT *et al.* Quality of life after laparoscopic and open colorectal surgery: a systematic review. *Wld J Gastroenterol* 2010; **16**(40): 5,035–5,041.
- Eftaiha SM, Pai A, Sulo S *et al.* Robot-assisted abdominoperineal resection: clinical, pathologic, and oncologic outcomes. *Dis Colon Rectum* 2016; **59**(7): 607–614.
- Hassan I, Cima RR. Quality of life after rectal resection and multimodality therapy. *J Surg Oncol* 2007; **96**(8): 684–692.
- Nagtegaal ID, Marijnen CA, Kranenbarg EK *et al.* 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; **26**: 350–357.
- Aaronson NK, Ahmedzai S, Bergman B *et al.* The European Organisation for Research and Treatment of Cancer QLQ-C30: a quality-of-life instrument for use in international clinical trials in oncology. *J Natl Cancer Inst* 1993; **85**: 365–376.
- Fayers PM, Aaronson NK, Bjordal K *et al.*, on behalf of the EORTC Quality of Life Group. *The EORTC QLQ-C30 Scoring Manual*. 3rd ed. Brussels: European Organisation for Research and Treatment of Cancer; 2001.
- Pigazzi A, Luca F, Patriti A *et al.* Multicentric study on robotic tumor-specific mesorectal excision for the treatment of rectal cancer. *Ann Surg Oncol* 2010; **17**: 1,614–1,620.
- West NP, Anderin C, Smith KJ *et al.* European Extralevator Abdominoperineal Excision Study Group. Multicentre experience with extralevator abdominoperineal excision for low rectal cancer. *Br J Surg* 2010; **97**: 588–599.
- Hellan M, Ouellette J, Lagares-Garcia JA *et al.* Robotic rectal cancer resection: a retrospective multicenter analysis. *Ann Surg Oncol* 2015; **22**: 2,151–2,158.
- Tekkis PP, Senagore AJ, Delaney CP *et al.* Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. *Ann Surg* 2005; **242**(1): 83–91.
- Kim IK, Kang J, Park YA *et al.* Is prior laparoscopy experience required for adaptation to robotic rectal surgery? feasibility of one-step transition from open to robotic surgery. *Int J Colorectal Dis* 2014; **29**: 693–699.
- De Nardi P, Summo V, Vignali A *et al.* Standard versus extralevator abdominoperineal low rectal cancer excision outcomes: a systematic review and meta-analysis. *Ann Surg Oncol* 2015; **22**: 2,997–3,006.
- Havenga K, Maas CP, DeRuiter MC *et al.* Avoiding long-term disturbance to bladder and sexual function in pelvic surgery, particularly with rectal cancer. *Semin Surg Oncol* 2000; **18**(3): 235–243.
- Nishizawa Y, Ito M, Saito N *et al.* Male sexual dysfunction after rectal cancer surgery. *Int J Colorectal Dis* 2011; **26**: 1,541–1,548.

26. Jayne DG, Brown JM, Thorpe H *et al*. Bladder and sexual function following resection for rectal cancer in a randomized clinical trial of laparoscopic versus open technique. *Br J Surg* 2005; **92**: 1,124–1,132.
27. Asoglu O, Matlim T, Karanlik H *et al*. Impact of laparoscopic surgery on bladder and sexual function after total mesorectal excision for rectal cancer. *Surg Endosc* 2009; **23**: 296–302.
28. Luca F, Valvo M, Ghezzi TL *et al*. Impact of robotic surgery on sexual and urinary functions after fully robotic nerve-sparing total mesorectal excision for rectal cancer. *Ann Surg* 2013; **257**: 672–678.
29. Vaughan-Shaw PG, Cheung T, Knight JS, *et al*. A prospective case–control study of extralevator abdominoperineal excision (ELAPE) of the rectum versus conventional laparoscopic and open abdominoperineal excision: comparative analysis of short-term outcomes and quality of life. *Tech Coloproctol* 2012; **16** (5): 355–362.
30. Ishihara S, Watanabe T, Fukushima Y *et al*. Safety and factors contributing to the difficulty of laparoscopic surgery for rectal cancer treated with preoperative chemoradiotherapy. *Tech Coloproctol* 2014; **18**(3): 247–255.
31. Collinson FJ, Jayne DG, Pigazzi A *et al*. An international, multicentre, prospective, randomised, controlled, unblinded, parallel-group trial of robotic-assisted versus standard laparoscopic surgery for the curative treatment of rectal cancer. *Int J Colorectal Dis* 2012; **27**(2): 233–241.
32. Schmidt CE, Bestmann B, Kuchler T *et al*. Prospective evaluation of quality of life of patients receiving either abdominoperineal resection or sphincter-preserving procedure for rectal cancer. *Ann Surg Oncol* 2005; **12**: 117–123.