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ORIGINAL ARTICLE

Surgical techniques in the management of rectal cancer: a modified Delphi method by colorectal surgeons in Australia and New Zealand

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Abstract

Background Technological developments have allowed advances in minimally invasive techniques for total mesorectal excision such as laparoscopy, robotics, and transanal surgery. There remains an ongoing debate about the safety, benefits, and appropriate clinical scenarios for which each technique is employed. The aim of this study was to provide a panel of expert opinion on the role of each surgical technique currently available in the management of rectal cancer using a modified Delphi method.

Methods Surveys were designed to explore the key patient- and tumor-related factors including clinical scenarios for determining a surgeon's choice of surgical technique.

Results Open surgery was favoured in obese patients with an extra-peritoneal tumor and a positive circumferential resection margin (CRM) or T4 tumor when a restorative resection was planned. Laparoscopy was favoured in non-obese males and females, in both intra- and extra-peritoneal tumors with a clear CRM. Robotic surgery was most commonly offered to obese patients when the CRM was clear and if an abdominoperineal resection was planned. Transanal total mesorectal excision (taTME) was preferred in male patients with a mid or low rectal cancer, particularly when obese. Transanal endoscopic microsurgery/transanal minimally invasive surgery local excision was only offered to frail patients with small, early stage tumors.

Conclusions All surgical techniques for rectal cancer dissection have a role and may be considered appropriate. Some techniques have advantages over others in certain clinical situations, and the best outcomes may be achieved by considering all options before applying an individualised approach to each clinical situation.

Keywords Delphi technique · Rectal neoplasms · Procedures and techniques' utilization · Clinical decision-making

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Introduction

Colorectal cancer (CRC) is the second most common cancer in western countries, and rectal cancer specifically has remained a difficult operative conundrum, with historical results demonstrating local recurrence rates of 17–30% [1–3]. This is due to both patient characteristics and tumor-related factors, which pose challenges that can translate into poorer outcomes [3, 4]. Surgical techniques have been refined over a number of generations, but with the basic tenet of resecting the rectum, mesorectum, and surrounding fascial envelope [5, 6] which led to improvement in surgical and oncological results, providing the excellent outcomes that we expect today.

The progression of surgical refinement continued over recent decades, with the introduction of laparoscopic equipment, improved optics, and robotic-assisted surgery

[7, 8]. The purpose of all these advancements was to maintain a precise dissection in the pelvis with the benefit of an earlier recovery from surgery compared to open surgery. A number of large multicentre randomized-controlled trials (RCTs) (COLOR [9], COST [10], CLASICC [11], and ALCCaS [12]) investigated the role of laparoscopic surgery in colon cancer, with encouraging results showing equivalent oncologic outcomes, and improved short-term clinical recovery, along with some improved long-term outcomes.

These promising results led to further exploration of minimally invasive techniques directly relating to rectal cancer surgery such as ALaCaRT [13], Z6051 [14], COLOR II [15], COREAN [16], and ROLARR [8]. The COLOR II [15] and COREAN [16] trials have reported equivalent outcomes in 3-year recurrence and survival when comparing open with laparoscopic rectal dissection. The ALaCaRT [13] and Z6051 [14] trials, however, have raised concerns about the "surgical success" in terms of pathologic equivalence of laparoscopic surgery when compared to open surgery in managing rectal cancer, with both trials unable to demonstrate "non-inferiority". The 2-year recurrence and survival data from these two trials, however, have not shown any negative effect of laparoscopy, with equivalent results to open surgery [17, 18]. A recent meta-analysis of these four major RCT's has suggested that open rectal cancer excision provides a better quality mesorectum. Nonetheless, it remains to be seen if this translated into better long-term cancer outcomes [19]. Of note, in this meta-analysis, only minor mesorectal fascial defects were found to be slightly more common in the laparoscopic group (RR 1.06), with all other pathological parameters proving equivalent in open and laparoscopic surgery.

The most recent development in the surgical approach to rectal cancer has been transanal total mesorectal excision (taTME) [18]. It has long been recognised that when operating in the extra-peritoneal pelvis in certain patients, it is more difficult to achieve excellent oncologic outcomes. The technique of taTME appears to overcome some of these difficulties, with numerous recent publications demonstrating feasibility and safety [20–25]. There were concerns raised regarding potential major complications [25, 26], raising issues with respect to training, credentialing, and dissemination of this new technique.

There have also been alternative approaches described that allow a patient to avoid a major segmental resection of the rectum. The rectal preservation approach preserves function whilst maintaining the desired oncological outcome of cure. Local luminal excision by transanal endoscopic microsurgery (TEM) or transanal minimally invasive surgery (TAMIS) has been performed in selected patients with favourable tumor characteristics [27].

We aimed to explore factors considered by colorectal surgeons in Australia and New Zealand in when choosing a particular technique for resection of rectal tumors.

Materials and methods

A modified Delphi method was employed to obtain the opinions of the members of Colorectal Surgical Society of Australia and New Zealand (CSSANZ). The first-round survey asked for each surgeon's current clinical practice, including which techniques they currently offer patients and their case load in the previous year. There were also questions regarding how much weight each surgeon placed on the following factors when deciding which technique to employ for a specific patient (tumor height, tumor radial position, T stage, circumferential resection margin (CRM) status, gender, and body mass index).

Factors were defined as being clinically significant if indicated by at least 50% of respondents. Subsequent questions were generated from these results. This subsequent questioning included ranking the five operative techniques when considering each clinicopathological factor. With respect to ranking the surgical techniques, no rank was entered when a technique was not offered by that surgeon, and if a surgeon felt that two techniques were equally preferred, then they were asked to allocate them the same rank. Results were analysed both according to the number of respondents who selected a technique as their first choice only, and by a composite score derived from their rankings: first choice = 5 points, second choice = 4 points, third choice = 3 points, fourth choice = 2 points, and fifth choice = 1 point. All scores were then added to give a final value.

Descriptive analysis was performed assessing the demographics of all responders to the survey and Pearson Chi-square analysis was performed on categorical variables. A p value of < 0.05 was considered significant and all statistical analysis was performed using SPSS version 12.0.0.0. Ethical approval was obtained for the study.

Results

The Delphi method first-round survey was emailed to 224 CSSANZ members. There were 72 respondents (32%). Subsequent questions were only sent to the 72 respondents, and 65 of these completed all responses (90.3%). Of the techniques available, laparoscopic approach was the most common technique offered followed by the open approach.

There was no significant difference between surgeons offering open and laparoscopic approach (Table 1) except for age. Surgeon demographics and the techniques offered by surgeons are shown in Table 2. Gender, body mass index

Table 1 Comparing open versus laparoscopic approach according to surgeon demographics

Variables	Open		*p* value	Laparoscopic		*p* value
	Yes	No		Yes	No	
Gender						
Male	56 (86.2)	9 (13.8)		58 (89.2)	7 (10.8)	
Female	5 (83.3)	1 (16.7)	0.849	5 (83.3)	1 (16.7)	0.662
Age						
< 40	4 (100)	0		4 (100)	0	
40–45	10 (90.9)	1 (9.1)		10 (90.9)	1 (9.1)	
46–50	25 (86.2)	4 (13.8)		27 (93.1)	2 (6.9)	
51–55	11 (78.6)	3 (21.4)		14 (100)	0	
56–60	7 (77.8)	2 (22.2)		7 (77.8)	2 (22.2)	
> 60	4 (100)	0	0.753	1 (25)	3 (85)	0.001
Practice location						
Urban	58 (85.3)	10 (14.7)		60 (88.2)	8 (11.8)	
Rural	3 (100)	0	0.474	3 (100)	0	0.528

Table 2 The number of surgeons who offer each of the techniques and the mean number of cases performed per surgeon offering each technique in 2016

Variables	Frequency (%)
Gender	
Male	65 (91.5)
Female	6 (8.5)
Age	
< 40	4 (5.6)
40–45	11 (15.5)
46–50	29 (40.8)
51–55	14 (19.7)
56–60	9 (12.7)
> 60	4 (5.6)
Practice location	
Urban	68 (95.8)
Rural	3 (4.2)
Private and public practice commitments	
Public	45.3%
Private	54.7%
Surgical techniques offered for rectal cancer	
Open	61 (85.9)
Laparoscopic	63 (88.7)
Robotic	17 (23.9)
TaTME	27 (38)
TEMS/TAMIS	34 (47.9)
Mean cases performed in 2016 (range)	
Open	12.2 (0–70)
Laparoscopic	19.9 (0–82)
Robotic	8.2 (0–30)
taTME	5.9 (0–30)
TEMS/TAMIS	3.6 (0–15)
Total (all cases)	34 (2449)

(BMI), tumor height in the rectum (intra-peritoneal, extra-peritoneal/restorative, and extra-peritoneal/APR), radial position (anterior, posterior, and lateral), T stage, and CRM stage were identified as key factors in surgical decision-making for open compared to laparoscopic technique (Table 3).

Characteristics were considered to be clinically significant if indicated by more than 50% of respondents. As such, the most important characteristic for each technique was: (1) open surgery: T3 stage or positive CRM, (2); laparoscopic surgery: BMI (presumed normal BMI); (3) robotic surgery: BMI (presumed high BMI); (4) taTME: T3 stage or positive CRM; and (5) transanal endoscopic microsurgery (TEMS)/transanal minimally invasive surgery (TAMIS): T1/2 stage and intra-peritoneal (this is presumed to indicate that the surgeon would not select this technique).

Following the first survey, a second survey was designed as paired variables to further ascertain exact characteristics for choosing a specific technique. Open surgery was favoured in obese men, anterior extra-peritoneal tumors, and in locally advanced tumors with T4 disease or a positive CRM. Laparoscopic surgery was favoured over the open approach in non-obese patients (irrespective of gender), obese females, posterior or lateral extra-peritoneal tumors, early stage tumors, T3 tumors with a negative CRM, and when an abdominoperineal resection (APR) was planned.

Overall, robotic surgery, taTME, and TEMS/TAMIS local excision were less commonly favoured compared to open and laparoscopic techniques. When robotic surgery was offered, this was most commonly for obese patients. Transanal TME was mainly offered for extra-peritoneal tumors. Finally, TEMS/TAMIS local excision was only considered in T1 cancers < 3 cm in diameter (Table 4).

Based on the six common clinical scenarios generated in the subsequent survey, it remained clear that obese patients and locally advanced tumors (T4 or positive CRM) in the

Table 3 The percentage of respondents who indicated that each characteristic was important in decision-making with respect to the appropriate surgical technique to manage rectal cancer

Variables	Open (%)	Lap (%)	Robotic (%)	TaTME (%)	TEMS/TAMIS (%)
Gender	*46 (64.8)*	*47 (66.2)*	16 (22.5)	27 (38)	8 (11.3)
BMI	*55 (77.5)*	*58 (81.7)*	18 (25.4)	29 (40.8)	15 (21.1)
Intra-peritoneal	32 (45.1)	*36 (50.7)*	12 (16.9)	20 (28.2)	*36 (50.7)*
Extra-peritoneal RP	*48 (67.6)*	*45 (63.4)*	16 (22.5)	27 (38)	23 (32.4)
Extra-peritoneal APR	*43 (60.6)*	*39 (54.9)*	13 (18.3)	13 (18.3)	20 (28.2)
Anterior location	*46 (64.8)*	*39 (54.9)*	15 (21.1)	26 (36.6)	31 (43.7)
Posterior/lateral location	26 (36.6)	23 (32.4)	8 (11.3)	18 (25.4)	25 (35.2)
T1–2	26 (36.6)	22 (31)	7 (9.9)	16 (22.5)	*36 (50.7)*
T3 and negative CRM	35 (49.3)	31 (43.7)	9 (12.7)	22 (31)	30 (42.3)
T3 and positive CRM	*56 (78.9)*	*53 (74.6)*	16 (22.5)	30 (42.3)	30 (42.3)

Italics indicate values > 50%

BMI body mass index, *RP* restorative procedure, *APR* abdominoperineal resection, *CRM* circumferential resection margin, *lap* laparoscopic, *taTME* transanal total mesorectal excision, *TEMS* transanal endoscopic microsurgery, *TAMIS* transanal minimally invasive surgery

Table 4 Number of respondents who selected each technique as first choice relating to pairs of clinical factors

Clinical factors	Open	Laparoscopic	Robotic	taTME	TEMS/TAMIS
Female, BMI < 30	13 (21.3)	41 (65.1)	8 (47.1)	3 (11.1)	6 (17.6)
Male, BMI < 30	19 (31.1)	27 (42.9)	8 (47.1)	12 (44.4)	6 (17.6)
Female. BMI ≥ 30	18 (29.5)	29 (46)	11 (64.7)	12 (44.4)	5 (14.7)
Male, BMI ≥ 30	26 (42.6)	15 (23.8)	10 (58.8)	15 (55.6)	5 (14.7)
Anterior location and extra-peritoneal	24 (39.3)	17 (27)	9 (52.9)	12 (44.4)	4 (11.8)
Posterior/lateral location and extra-peritoneal	16 (26.2)	24 (38.1)	10 (58.8)	9 (33.3)	2 (5.9)
APR	23 (37.7)	34 (54)	11 (64.7)	1 (3.7)	1 (2.9)
T1, < 3 cm	13 (21.3)	25 (39.7)	8 (47.1)	7 (25.9)	14 (41.2)
T1, ≥ 3 cm	14 (23)	31 (49.2)	10 (58.8)	8 (29.6)	4 (11.8)
T2, < 3 cm	17 (27.9)	29 (46)	10 (58.8)	11 (40.7)	1 (2.9)
T2, ≥ 3 cm	13 (21.3)	30 (47.6)	9 (52.9)	9 (33.3)	1 (2.9)
T3 and negative CRM	20 (32.8)	28 (44.4)	10 (58.8)	11 (40.7)	1 (2.9)
T3 or 4 and positive CRM	48 (80.3)	7 (11.1)	6 (35.3)	3 (11.1)	1 (2.9)
Total surgeon preference for each technique	61	63	17	27	34

The percentage of surgeons preferring to use each technique for the specific situation of mT3, CRM-positive disease, when considering those surgeons who offer each technique, and excluding those who did not believe this was important

CRM circumferential resection margin, *lap* laparoscopic, *taTME* transanal total mesorectal excision, *TEMS* transanal endoscopic microsurgery, *TAMIS* transanal minimally invasive surgery

extra-peritoneal region were the key factors for choosing an open technique. Validating earlier survey responses, robotic surgery was favoured only in obese patients where the CRM was clear and if an APR was planned, whereas non-obese patients with an intra-peritoneal tumor and negative CRM could safely and appropriately be offered the laparoscopic technique (Table 5).

Discussion

To best of our knowledge, this is the first modified Delphi questionnaire that has explored key patient and tumor-related factors routinely considered by colorectal surgeons when choosing a specific surgical technique in

Table 5 Ranking composite score according to each clinical scenario

Clinical factors	Open[a]	Lap[a]	Robotic[a]	taTME[a]	TEMS/TAMIS[a]
Female. BMI < 30, IP, negative CRM	132 (12)	253 (47)	68 (6)	26 (0)	21 (1)
Male. BMI < 30, IP, negative CRM	185 (19)	212 (28)	78 (9)	88 (12)	34 (3)
Female, BMI ≥ 30, EP, positive CRM or T4 restorative procedure	269 (45)	120 (8)	59 (6)	52 (6)	18 (1)
Male, BMI ≥ 30, EP, positive CRM or T4 restorative procedure	278 (49)	104 (8)	52 (5)	52 (6)	18 (1)
Female, BMI ≥ 30, negative CRM, APR	208 (20)	217 (32)	92 (12)	31 (1)	19 (2)
Male, BMI ≥ 30, negative CRM, APR	220 (27)	197 (26)	92 (12)	33 (1)	19 (2)

IP intra-peritoneal, *EP* extra-peritoneal, *CRM* circumferential resection margin, *APR* abdominoperineal resection, *lap* laparoscopic, *taTME* transanal total mesorectal excision, *TEMS* transanal endoscopic microsurgery, *TAMIS* transanal minimally invasive surgery

[a]Number of responders who had selected each technique as their first rank

the management of rectal cancer. The results from the survey highlight some relatively obvious outcomes, but also important contemporary opinions regarding the use of minimally invasive techniques. Open surgery for rectal cancer remained the gold standard surgical technique, especially in obese patients with advanced rectal cancer (T3–4 with positive CRM). However, there is a subset of patients in whom minimally invasive approaches can still be offered on a regular basis in Australia and New Zealand.

Concerns raised with regard to the non-inferiority of laparoscopic rectal resection from ALaCaRT [13] and Z6051 [14] trials have been widely discussed in Australia, New Zealand, and globally. These studies suggested that the laparoscopic technique may not be equivalent to open surgery in the quality of mesorectal fascia dissection. In the light of this, the current practice and opinion of Australian and New Zealand colorectal surgeons has been investigated. It is apparent from their opinions expressed in the modified Delphi questionnaire that the laparoscopic technique still has a role in a proportion of patients. This was further supported by Scott Strong and Nathaniel Soper in their editorial of those two trials [28].

It is interesting to note that in the clinical situation of a male patient with an extra-peritoneal T3 cancer, most surgeons preferred minimally invasive techniques over open surgery, with the preferred overall technique being laparoscopic resection. This may still be considered controversial, but a recently published meta-analysis by Creavin et al. on the impact of laparoscopic approach in rectal cancer excision found that although there were significant differences in mesorectal quality between open and laparoscopic approaches (RR 1.06), these differences were only observed in those with minor breaches in the mesorectal fascia. The deep mesorectal defects, CRM positivity, and distance to radial and distal margins were all similar [19].

The primary end-point result presented from the ROLARR trial [8] has not deterred surgeons from considering the technical benefits of this approach. A few weaknesses were identified after the trial. The proposed conversion rate of 20% in the laparoscopic arm was not realised in the trial, which made the power calculation inaccurate and likely a sample size that is too small to identify a significant improvement in conversion with the use of the robot. Subset analysis did demonstrate a reduced conversion rate in men, obese patients, and when a restorative resection was performed. Similarly, a proportion of the contributing surgeons in this study believe in the benefits of robotic surgery, particularly in obese men in whom access to the distal pelvis is more difficult.

Proponents of taTME support its use predominantly for extra-peritoneal cancer, especially in those patients where abdominal approaches are difficult [25]. There has been a concerted effort in Australia and New Zealand to introduce this technique in a controlled and considered manner, with regular training workshops involving didactic lectures, live surgery, simulator training, and cadaveric dissection. These are importantly supported by proctoring of a surgeon's first two cases to assist translation into the clinical setting. The results of the first 159 cases performed in Australia and New Zealand have been published, suggesting a safe introduction of this new technique [29]. The data from this study affirm that taTME can be safely introduced and that surgeons are interested in offering taTME to a subset of patients. Hence, the COLOR III trial (an international, multicentre randomized clinical trial comparing taTME to laparoscopic TME of mid-to-low rectal cancers) has commenced recruitment and will further assess the oncological safety and long-term outcomes of taTME [30].

TEM and TAMIS local excision continue to be proposed for a limited number of patients, with both tumor and patient characteristics being considered important. More than 60% of surgeons surveyed did offer this approach for the management of rectal cancer, suggesting that it does have a role to play in very early stage cancers, and in the frail and elderly patients in whom a radical resection is not a good option

[29, 30]. While TEM and TAMIS are likely to be considered only in a small number of rectal cancer patients, taTME may become the preferred technique in the future given the rapid uptake and enthusiasm worldwide [22, 25, 29, 30].

Limitations

Although the modified Delphi method successfully gathered opinions from a concerted group of experts, we acknowledge that the number of respondents was lower than expected. However, we did obtain opinions from many key experts.

Conclusions

Our results confirmed that there is support amongst CSSANZ members for each surgical technique in the management of rectal cancer and that appropriate patient selection is crucial. This study is important, especially because recent trials [13–15, 31] show inconsistent short-term surgical outcomes comparing laparoscopic to open technique. There is a place for personalised treatment.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Ethical approval was obtained for the study.

Informed consent Informed consent was obtained from all individual participants involved in completing the study.

References

1. Birbeck KF, Macklin CP, Tiffin NJ, Parsons W, Dixon MF, Mapstone NP, Abbott CR, Scott N, Finan PJ, Johnston D, Quirke P (2002) Rates of circumferential resection margin involvement vary between surgeons and predict outcomes in rectal cancer surgery. Ann Surg 235:449–457
2. Cedermark B, Dahlberg M, Glimelius B, Pahlman L, Rutqvist LE, Wilking N (1997) Improved survival with preoperative radiotherapy in resectable rectal cancer. N Engl J Med 336:980–987
3. Rickles AS, Dietz DW, Chang GJ, Wexner SD, Berho ME, Remzi FH, Greene FL, Fleshman JW, Abbas MA, Peters W, Noyes K, Monson JR, Fleming FJ (2015) High rate of positive circumferential resection margins following rectal cancer surgery: a call to action. Ann Surg 262:891–898
4. den Dulk M, Collette L, van de Velde CJ, Marijnen CA, Calais G, Mineur L, Maingon P, Radosevic-Jelic L, Daban A, Bosset JF (2007) Quality of surgery in T3–4 rectal cancer: involvement of circumferential resection margin not influenced by preoperative treatment. Results from EORTC trial 22921. Eur J Cancer (Oxford, England: 1990) 43:1821–1828
5. Heald RJ, Ryall RD (1986) Recurrence and survival after total mesorectal excision for rectal cancer. Lancet 1:1479–1482
6. Heald RJ (1988) The 'Holy Plane' of rectal surgery. J R Soc Med 81:503–508
7. Stevenson AR (2017) The future for laparoscopic rectal cancer surgery. Br J Surg. https://doi.org/10.1002/bjs.10503
8. Jayne D, Pigazzi A, Marshall H, Croft J, Corrigan N, Copeland J, Quirke P, West N, Rautio T, Thomassen N, Tilney H, Gudgeon M, Bianchi PP, Edlin R, Hulme C, Brown J (2017) 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 318:1569–1580
9. Veldkamp R, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Pahlman L, Cuesta MA, Msika S, Morino M, Lacy AM (2005) Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol 6:477–484
10. Nelson H, Sargent DJ, Wieand HS, Fleshman J, Anvari M, Stryker SJ, Beart RW Jr, Hellinger M, Flanagan R Jr, Peters W, Ota D (2004) A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 350:2050–2059
11. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM (2005) Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet 365:1718–1726
12. Hewett PJ, Allardyce RA, Bagshaw PF, Frampton CM, Frizelle FA, Rieger NA, Smith JS, Solomon MJ, Stephens JH, Stevenson AR (2008) Short-term outcomes of the Australasian randomized clinical study comparing laparoscopic and conventional open surgical treatments for colon cancer: the ALCCaS trial. Ann Surg 248:728–738
13. Stevenson AR, Solomon MJ, Lumley JW, Hewett P, Clouston AD, Gebski VJ, Davies L, Wilson K, Hague W, Simes J (2015) Effect of laparoscopic-assisted resection vs open resection on pathological outcomes in rectal cancer: the ALaCaRT randomized clinical trial. JAMA 314:1356–1363
14. Fleshman J, Branda M, Sargent DJ, Boller AM, George V, Abbas M, Peters WR Jr, Maun D, Chang G, Herline A, Fichera A, Mutch M, Wexner S, Whiteford M, Marks J, Birnbaum E, Margolin D, Larson D, Marcello P, Posner M, Read T, Monson J, Wren SM, Pisters PW, Nelson H (2015) Effect of laparoscopic-assisted resection vs open resection of stage II or III rectal cancer on pathologic outcomes: the ACOSOG Z6051 randomized clinical trial. JAMA 314:1346–1355
15. van der Pas MH, Haglind E, Cuesta MA, Furst A, Lacy AM, Hop WC, Bonjer HJ (2013) Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. Lancet Oncol 14:210–218
16. Kang SB, Park JW, Jeong SY, Nam BH, Choi HS, Kim DW, Lim SB, Lee TG, Kim DY, Kim JS, Chang HJ, Lee HS, Kim SY, Jung KH, Hong YS, Kim JH, Sohn DK, Kim DH, Oh JH (2010) Open versus laparoscopic surgery for mid or low rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): short-term outcomes of an open-label randomised controlled trial. Lancet Oncol 11:637–645
17. Stevenson A, Solomon M, Brown C, Lumley J, Hewett P, Clouston A, Gebski V, Wilson K, Hague W, Simes J, ALaCaRT investigators (2018) 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. https://doi.org/10.1097/sla.0/03021
18. Fleshman J, Branda M, Sargent D, Boller A, George V, Abbas M, Peters W, Maun D, Chang G, Herline A, Fichera A, Match M, Wexner S, Whiteford M, Marks J, Birnbaum E, Margolin D, Larson D, Marcello P, Posner M, Read T, Monson J, Wren S, Pisters P, Nelson H (2018) Disease-free survival and local recurrence

for laparoscopic resection compared with open resection of stage 2 to 3 rectal cancer: follow-up results of the ACOSOG Z6051 randomized controlled trial. Ann Surg. https://doi.org/10.1097/sla.0/03002
19. Creavin B, Kelly ME, Ryan E, Winter DC (2017) Meta-analysis of the impact of surgical approach on the grade of mesorectal excision in rectal cancer. Br J Surg 104:1609–1619
20. Lacy AM, Tasende MM, Delgado S, Fernandez-Hevia M, Jimenez M, De Lacy B, Castells A, Bravo R, Wexner SD, Heald RJ (2015) Transanal total mesorectal excision for rectal cancer: outcomes after 140 patients. J Am Coll Surg 221:415–423
21. de Lacy AM, Rattner DW, Adelsdorfer C, Tasende MM, Fernandez M, Delgado S, Sylla P, Martinez-Palli G (2013) Transanal natural orifice transluminal endoscopic surgery (NOTES) rectal resection: "down-to-up" total mesorectal excision (TME)–short-term outcomes in the first 20 cases. Surg Endosc 27:3165–3172
22. Atallah S, Martin-Perez B, Albert M, deBeche-Adams T, Nassif G, Hunter L, Larach S (2014) Transanal minimally invasive surgery for total mesorectal excision (TAMIS-TME): results and experience with the first 20 patients undergoing curative-intent rectal cancer surgery at a single institution. Tech Coloproctol 18:473–480
23. Araujo SE, Crawshaw B, Mendes CR, Delaney CP (2015) Transanal total mesorectal excision: a systematic review of the experimental and clinical evidence. Tech Coloproctol 19:69–82
24. Ma B, Gao P, Song Y, Zhang C, Zhang C, Wang L, Liu H, Wang Z (2016) Transanal total mesorectal excision (taTME) for rectal cancer: a systematic review and meta-analysis of oncological and perioperative outcomes compared with laparoscopic total mesorectal excision. BMC Cancer 16:380
25. Penna M, Hompes R, Arnold S, Wynn G, Austin R, Warusavitarne J, Moran B, Hanna GB, Mortensen NJ, Tekkis PP (2017) Transanal total mesorectal excision: international registry results of the first 720 cases. Ann Surg 266:111–117
26. Rouanet P, Mourregot A, Azar CC, Carrere S, Gutowski M, Quenet F, Saint-Aubert B, Colombo PE (2013) Transanal endoscopic proctectomy: an innovative procedure for difficult resection of rectal tumors in men with narrow pelvis. Dis Colon Rectum 56:408–415
27. Maglio R, Muzi GM, Massimo MM, Masoni L (2015) Transanal minimally invasive surgery (TAMIS): new treatment for early rectal cancer and large rectal polyps-experience of an Italian center. Am Surgeon 81:273–277
28. Renehan AG, Malcomson L, Emsley R, Gollins S, Maw A, Myint AS, Rooney PS, Susnerwala S, Blower A, Saunders MP, Wilson MS, Scott N, O'Dwyer ST (2016) Watch-and-wait approach versus surgical resection after chemoradiotherapy for patients with rectal cancer (the OnCoRe project): a propensity-score matched cohort analysis. Lancet Oncol 17:174–183
29. Abbott SC, Stevenson ARL, Bell SW, Clark D, Merrie A, Hayes J, Ganesh S, Heriot AG, Warrier SK (2018) An assessment of an Australasian pathway for the introduction of transanal total mesorectal excision (taTME). Colorect Dis 20:O1–O6
30. Deijen CL, Velthuis S, Tsai A, Mavroveli S, de Lange-de Klerk ES, Sietses C, Tuynman JB, Lacy AM, Hanna GB, Bonjer HJ (2016) COLOR III: a multicentre randomised clinical trial comparing transanal TME versus laparoscopic TME for mid and low rectal cancer. Surg Endosc 30:3210–3215
31. Jeong SY, Park JW, Nam BH, Kim S, Kang SB, Lim SB, Choi HS, Kim DW, Chang HJ, Kim DY, Jung KH, Kim TY, Kang GH, Chie EK, Kim SY, Sohn DK, Kim DH, Kim JS, Lee HS, Kim JH, Oh JH (2014) Open versus laparoscopic surgery for mid-rectal or low-rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): survival outcomes of an open-label, non-inferiority, randomised controlled trial. Lancet Oncol 15:767–774