CHAPTER 12 ELECTIVE SURGERY FOR RECTAL CANCER

Rectal cancer surgery has the potential for worse clinical outcomes than surgery for colon cancer. Quality of life, local recurrence and survival are generally worse after rectal cancer surgery. There has been much continuing debate about the extent of resection, the type of reconstruction, and the training of a rectal surgeon.

This chapter aims to summarise, evaluate and quantify the best levels of evidence of some of the contentious clinical aspects of elective surgery for rectal cancer. Unfortunately, for most technical aspects of rectal cancer surgery, the level of evidence on which to base decision-making is poor.

12.1 Who should perform elective cancer surgery?

Optimal treatment of rectal cancer is a special challenge that calls for the best possible clearance of the tumour in association with preservation of the anal sphincter mechanism and avoidance of injury to the pelvic autonomic nerves. Further, it requires the coordination of care of the surgeon, stomal therapy nurse, and medical and radiation oncologist.

It could be expected that such results would best be achieved only at specialist multidisciplinary centres. A recent editorial concludes there is 'remarkably consistent evidence that the more experienced doctors or health care systems have with the procedure, the better the results'. In regard to cancer, the authors claim that this provides 'striking examples of markedly better outcomes with higher volume' with 123 of 128 published studies showing evidence of a 'volume–quality' relationship.[1]

The relationship of hospital volume to colostomy rate and survival of patients with rectal cancer has recently been assessed in a paper reporting on 7257 Californian patients with rectal cancer treated between 1994 and 1997.[2] Adjusted risk to odds ratios with 95% confidence intervals were as follows:

- permanent stoma = 1.37 (1.10–1.70)
- 30-day mortality = 2.64 (1.41–4.93)
- two-year mortality = 1.28 (1.15–1.44)

All of the odds ratios were greater for low-volume hospitals.

There are at least 22 studies of Colorectal Cancer patients correlating outcome and volume (hospital/surgeon or both) since 1984 that showed clear difference in quality of life indicators such as permanent stoma rates between low-volume and high-volume surgeons.[2]

A further recent study by Schrag et al[3] examined outcomes in 2815 patients with rectal cancer between 1992 and 1996. Survival advantages for high-volume surgeons were statistically significant when adjusted for casemix and for casemix and hospital volume. Relative risk of overall mortality was significantly lower for unadjusted surgeon volume, casemix adjusted surgeon volume, and hospital-volume adjusted surgeon volume. [3]

Most recently, Wibe et al[4] published a before-and-after picture from Norway. Between 1986 and 1988, a 28% local recurrence rate was observed, with a 55% 5-year overall survival rate for patients less than 75 years old with rectal cancer. The Norwegian Rectal Cancer Group was founded in 1994. Surgeons were trained in total mesorectal excision (TME)(). Pathologists were trained in reporting. A rectal cancer registry was established. The Norwegian Surgical Society declared that 'rectal cancer surgery to be done only by specialised surgeons'. Twelve hospitals ceased the performance of rectal cancer surgery. Following these changes, outcomes were measured in 5,382 rectal cancer patients

between 1993 and 1999. The local recurrence rate had dropped to 8% and the five-year overall survival rate for patients less than 75 years of age had increased to 71%.[4]

An Australian study also provides support for specific practice leading to an increase in patient overall survival. Platell (2002) concludes improvement in survival of patients presenting with CRC and also improved survival times for patients who presented with nodal metastasis to a community based teaching hospital.

The question of whether the colorectal-trained surgeon achieves better results than the experienced general surgeon remains contentious. A study by Porter and co-workers[5] appears to indicate better outcomes by colorectal surgeons. They compared the outcomes achieved by five colorectal-trained surgeons with 47 general surgeons. Local recurrence rates were lower and survival figures were better for those either with colorectal training or a case load of more than 21 patients. Surprisingly however, even the colorectal-trained surgeons had a local recurrence rate of approximately 14% and on average, for the duration of the study, the colorectal-trained surgeons treated fewer than three patients with rectal cancer per year.

In Penninckx's review and audit of surgeon-related variability in the outcome after radical resection for rectal cancer, there was a relative risk of 0.3–0.8 for local recurrence if performed by a subspecialist surgeon, when compared with general surgeons. The relative risk for disease-free survival (0.7–0.8) was also less for subspecialised surgeons.[6]

These various studies, confirmed by the National Colorectal Cancer Care Survey in Australia,[7] support two significant observations:

- there are major variations in outcomes between different individuals and different groups
- there appears to be a correlation between clinical experience in the treatment of rectal cancer and outcome.

Who should perform elective rectal cancer surgery?

Guidelines — Elective surgery	Level of evidence	Practice recommendation	Refs
Elective surgery for rectal cancer should be carried out by a surgeon who has undergone a period of special exposure to this form of surgery during surgical training and who has maintained satisfactory experience in the surgical management of rectal cancer.	III-2	Recommend	1–7

12.2 The role of local excision and transanal endoscopic excision of rectal cancer (TEM)

Local treatment of rectal cancer can be curative only if there is no spread to regional lymph nodes.[8] The incidence of nodal metastases is associated with depth of tumour invasion, tumour differentiation, and lymphatic or venous invasion.[9–11] Tumour size is not a strong predictor.[9,10]

Well- and moderately-differentiated tumours confined to the submucosa (T1) metastasise to lymph nodes in only 3–5% of patients.[9,10] The preoperative identification of patients with nodal metastases is difficult, as up to two thirds of nodal metastases are micrometastases.[12]

Endorectal ultrasonography is currently the most accurate way of defining tumour depth of invasion and nodal status. Centres with experience in this technique report negative predictive values from 70% to 95% in determining depth of invasion and nodal involvement.[13–14] Magnetic resonance

imaging (MRI) with external phase arrayed coils is presently more costly and generally less available than endorectal ultrasound. However, its accuracy and sensitivity may eventually prove to be greater than that achieved by most surgeons using endorectal ultrasound, especially in predicting stage T1/ T2 as well as nodal status.[15]

Unfortunately, preoperative assessment of histological grade based on random biopsy is unreliable, underestimating the degree of anaplasia in 18% of patients when compared with operative specimens.[16]

Published series on highly selected patients undergoing curative local excision for rectal cancer report five-year cancer-specific survivals between 88% and 100% (absolute five-year survivals vary from 30% to 100%). Local recurrence rates are reported at between 12% and 27% in those series with more than five years of follow up. Half of the patients with local recurrence were salvaged by additional resectional surgery.[11,17–22] A recent overview has cautioned that local excision should probably be restricted to T1 cancer with favourable pathology.

A prospective randomised study published in 1997 has provided evidence (level II) in support of local excision of T1 rectal cancer.[23]

Pathological features associated with reduced survival were positive surgical margins, moderately- and poorly-differentiated histopathology, and increasing depth of invasion (T2 and T3).[8] Local excision is associated with a complication rate of between 5% and 18% and a mortality of 1%.[8]

Banerjee[20] has recently championed the use of transanal endoscopic microsurgery in the management of early rectal cancers. Transanal endoscopic microsurgery can be performed on lesions from the dentate line to around 20 cm. It allows for suturing and direct closure of full thickness defects. In a published series, in 74 patients who have undergone local excision for rectal cancer there have been only two recurrences, with a mean follow up of 14 months.[20]

There is as yet insufficient evidence to accept or reject transanal endoscopic microsurgery in the management of rectal cancer. This form of surgery is limited to lesions at or beyond the level of insertion of the instrument (<5cm). Referral to skilled centres would seem appropriate.

Patients with early rectal cancers (T1 and T2) undergoing abdominoperineal resection have a five-year cancer-specific survival between 85% and 98%, and a local recurrence rate of between 5% and 10%. The mortality associated with performing radical resectional surgery (either abdominoperineal or anterior resection) varies between 1% and 5%.[21] This mortality rises markedly in patients over 70 years of age (7% mortality in patients aged 70 to 79, and 17% in those aged over 80 years).

Local excisions may also afford reasonable palliation in patients with metastatic disease.

Adjuvant radiotherapy has also been used in patients after local excision, with improved 5-vear actuarial local control (90% vs. 72% local excision alone) and recurrence-free survival rates (74% vs 66%). This was in a study of 99 patients with rectal cancer treated by local excision, with adjuvant therapy given for T2 tumours and T1 tumours with high-risk pathological factors.[24]

There is also some evidence that endorectal radiotherapy can be used as definitive treatment or as an adjunct to local excision.[23]

When should local excision of rectal cancer be performed?

Guidelines — Local excision of rectal cancer	Level of evidence	Practice recommendation	Refs
Local excision of T1 rectal cancer may be used in selected cancer patients according to the following guidelines: • mobile tumour ≤3 cm • T1 on endorectal ultrasound • not poorly differentiated on histology (biopsy)	III-3	Equivocal	8–12, 16–21

12.3 The role of abdominoperineal versus sphincter-saving anterior resection

Numerous studies have shown similar outcomes for sphincter-saving resection and abdominoperineal resection (APR) with curative intent in terms of survival and local recurrence, and that reconstructive surgery has not compromised oncological outcome.[22,25,26] The size of the tumour has often been considered an indication for abdominperineal resection, but the United States National Surgical Adjuvant Breast and Bowel Project (NSABP) has not shown an adverse outcome even for tumours greater than 6 cm treated by sphincter-saving resection.[25]

The margin of distal clearance has been revised from the historical 5 cm to 2 cm, based on reviews comparing local recurrence rates and survival that show no advantage in outcome beyond a margin of 2 cm.[27, 28]

The length of the distal margin may vary depending on whether the specimen is measured fresh, fresh and pinned out, fixed in formalin, or fixed in formalin and pinned out. The effect of fixation is minimal if the specimen is pinned out first.[29]

Well-designed quasi-experimental studies reveal that 81–95% of all carcinomas have either no spread or intramural extension of less than 1 cm.[29–33] In all these studies, rectal carcinomas that were associated with intramural spread beyond 1 cm were almost always advanced (high-grade, stage C) tumours, or even lesions already associated with distant metastases.[10,29, 30, 31, 32, 33, 34] Therefore, in the majority, a distal margin of 2 cm would remove all microscopic disease.

A number of retrospective and prospective studies have since tried to relate length of distal margin to recurrent cancer. Essentially, all of these studies have shown no difference in local recurrence or survival when comparing 1–2 cm distal margins with greater than 5 cm distal margins.[26, 31, 33]

Hojo[33] studied 273 anterior resections, 22 with distal margins less than 2 cm. In this study, there were more Dukes C lesions in the group with margins greater than 2 cm (20% compared to 51%). Nevertheless, anastomotic recurrences still occurred with the same frequency in each group (<2 cm — two [9%]; >2 cm — 28]11%]).

Wilson and Beahrs[34] analysed 902 anterior resections. Forty-four had distal margins <2 cm. For all anterior resections (high and low), the anastomotic recurrence rate was 7% (three of 44) for the short (<2 cm) margin group and 5% (99 of 858) when the distal margin exceeded 2 cm. Local pelvic recurrence was 16% and 12% respectively.

Pollett and Nicholls[26] reviewed 334 anterior resections and found no difference between distal margins of <2 cm (55 patients), 2–5 cm (177 patients) and >5 cm (102 patients) with respect to local recurrence (7.3%, 6.2% and 7.8% respectively).

McDermott et al[35] had 505 anterior resection patients and assessed the distal margin in 1 cm increments (<1 cm, 13 patients; 1–2 cm, 37 patients; 2–3 cm, 88 patients; 3–4 cm, 132 patients; 4–5 cm 89 patients; 5–6 cm, 72 patients; >6 cm, seven patients), but there was no difference in local recurrence among the groups (23%, 22%, 16%, 25%, 16%, 15% and 20% respectively).

Vernava et al[36] looked prospectively at 243 anterior resection cases. Local recurrence was, again, no different in the group <2 cm (28 of 124 patients — 23%) and the group >2 cm (20 out of 115 patients — 17%). However, these workers did observe that, when the distal margin was less than 0.8 cm (20 patients), anastomotic recurrence was greater (six out of 20 patients — 30%) compared to the group with a margin >0.8 cm (23 of 219 patients — 11%).

Finally, Heald[37] performed 192 anterior resections: 152 were 'curative' with distal margins >1 cm in 110 patients and <1 cm in 42 patients. There were four local recurrences in the first group, but none in the group with margins <1 cm (0 of 42).

The implication of these findings is that many patients with low rectal cancers may be reasonably considered for sphincter-saving operations instead of abdominoperineal resection of the rectum with permanent colostomy.

The use of preoperative radiotherapy may also alter the decision between APR and sphincter preservation. In a prospective study of 35 patients who clinically required APR prior to radiotherapy, 27 (77%) were able to successfully undergo an ultra-low anterior resection with coloanal anastomosis. The five-year local recurrence rate was 21%, with good or excellent function in 23 of the 27 patients (85%).[38]

Function and continence are the other main considerations when deciding between APR and restorative ultra-low anterior resection.

A study by Williams and Johnston revealed a 25% incontinence rate (usually minor) with a sphincter-saving resection, compared to 66% leak rate from the stomal therapy appliance after APR, although more modern appliances may have reduced this figure. The authors concluded that patients having low anterior resection have a quality of life superior to those treated by APR.[39] Other studies have also suggested that functional results are satisfactory after low anterior resection,[40] although a reduction in rectal sensation related to loss in reservoir capacity probably contributes to incontinence.[41] However, rectal function improves with time in most cases, and with colonic pouch reconstruction (see Section 12.6).

The incidence of sexual dysfunction after low and very low anterior resection is comparable to APR (58% compared to 66%).[42]

What is an adequate distal clearance of resection?

Guideline — Adequate clearance of resection	Level of evidence	Practice recommendation	Refs
A distal distance of 2 cm (fresh) is recommended in most instances, or 1 cm fixed.	III-2	Recommend	30–35

What factors influence sphincter preservation?

Guideline — Factors influencing sphincter preservation	Level of evidence	Practice recommendation	Refs
Sphincter-saving operations are preferred to abdominoperineal resection except in the presence of: • tumours such that adequate distal clearance (>2 cm) cannot be achieved • the sphincter mechanism is not adequate for continence • access to the pelvis makes restoration technically impossible (rare).	III-3	Equivocal	10,22, 25–30

12.4 Total mesorectal excision

Equally as important as the distal margin for rectal cancer, with respect to local recurrence and disease-free survival (DFS), is the mesorectum and the circumferential (lateral) margin.

In 1982, Heald et al[43] reported metastatic carcinoma in the adjacent mesorectum in five resection specimens where the spread was distal to the lower extent of the primary tumour. In these three specimens, there were deposits of carcinoma more than 2 cm distal to the caudal limit of the carcinoma. Based on these findings, the recommendation was made that total excision of *distal* mesorectum should be performed when resecting rectal cancer.

Total mesorectal excision (TME) for rectal cancer refers to a sharp dissection in the extrafascial plane (between the fascia propria of the rectum and the presacral fascia), with complete excision of the mesorectum to the pelvic floor as well as its lateral borders.

Using this technique for all mid and low rectal tumours, Heald and Ryall[44] reported local recurrence rates of 2.6% for anterior resection. However, these figures were after excluding patients not thought to have a curative resection.

Two prospective clinicopathological studies have also looked at distal mesorectal spread. Scott et al[45] studied 20 patients where total mesorectal excision was performed, and found two patients (10%) had mesorectal spread equal to or greater than 2 cm beyond the lower level of cancer. Both patients developed distant metastases, so that radical treatment of the mesorectum did not improve survival. Reynolds et al[46] studied mesorectal spread in 50 resected specimens and found metastatic deposits more than 2 cm below the tumour in five cases (10%). Such findings had a significant relationship to tumours larger than 5 cm in diameter.

However, others have also reported very low local recurrence rates (6.5–7.3%) even when TME was not always performed.[26, 47–49]

In Killingback's series of 340 patients treated by sphincter-saving resections, including patients in whom the lateral margin was possibly involved, he reported a local recurrence of only 6.6%. Total mesorectal excision was only used for low rectal cancers. For mid-rectal lesions, the mesorectum was divided at least 5 cm distal to the tumour.[47]

Although not a randomised trial, perhaps the strongest evidence in support of the importance of surgical technique (and probably TME) was the 50% reduction in local recurrence after the introduction and training of TME to the Swedish Rectal Cancer Trials surgeons.[50]

Comparison between centres where TME is routinely used has also shown a 25% reduction in local recurrence and 30% difference in survival compared with conventional surgery hospitals.[51]

Sauer and Bacon[52] in 1951 were probably the first surgeons to emphasise the importance of adequate lateral clearance when excising carcinoma of the rectum. Quirke et al,[53] in a prospective study, found involved lateral margins in 12.8% of curative resections. In these patients the local recurrence rate was 80%, leading to the hypotheses that inadequate margins were the main cause of local recurrence.

Chapman et al,[54] in a prospective study, showed a decreased five-year survival in those patients whose resected specimens were found to have an involved lateral margin.

As part of a large randomised trial comparing preoperative radiotherapy and TME versus TME alone for rectal cancer in the Netherlands, the circumferential resection margin (CRM) was determined and compared with local recurrence and survival in 656 non-irradiated patients. CRM was found to be a strong predictor for local recurrence after TME, and is independent of TNM classification. A margin of 2 mm or less was associated with a local recurrence of 16% versus 5.8% in patients with more mesorectal tissue surrounding the tumour ($p<0.0001$). Furthermore, patients who had a margin 1 mm or less had an increased risk of distant metastases (37.6% vs.12.7%, $p<0.0001$) as well as shorter survival.[55]

What is recommended for the extent of mesorectal excision (TME)?

Guideline — Extent of mesorectal excision (TME)	Level of evidence	Practice recommendation	Refs
For mid-to-low rectal tumours, the principles of extra fascial dissection and total mesorectal excision (TME) are recommended.	III-2	Recommend	31,35, 43–55

12.5 The role of colonic reservoirs after elective anterior resection

Three prospective randomised controlled trials comparing coloanal anastomoses with and without a colonic reservoir have been reported, each demonstrating significantly improved rectal function persisting from the time of stoma closure to at least one year.[56–59]

All studies demonstrated a significant reduction in stool frequency, from a median of six stools per day to three stools per day. There was at least a trend to improvement in other functional measures in each study, including rectal compliance, urgency and continence, but small numbers reduced the power of these studies to demonstrate a significant difference in every measured parameter.

A high incidence of incomplete rectal emptying has been observed in patients with reservoirs 8 cm to 10 cm in length.[57] In the largest series of 162 patients, with a maximum follow up of seven years, 25%[60–63] of patients required an enema or suppository to empty the reservoir.[58] A reservoir length of 8 cm to 10 cm was calculated in a mathematical model to produce an ideal reservoir capacity[64] although the risks of impaired emptying were not factored into this model. In a randomised clinical trial, 5 cm reservoirs were found to have similar physiologic function to the 10 cm reservoir. There was some sacrifice in reservoir capacity, but a significantly better ability to evacuate.[65] The medium-term results (two years) suggest continued advantages from the colonic reservoir in terms of frequency, but fragmentation and continence were similar after adaptation of the straight coloanal anastomosis. Patients with a large (10 cm) reservoir were also more likely to require medication for constipation and evacuation at long-term follow up, compared with patients with a small (5–6 cm) reservoir.[61,66,67]

It has been demonstrated that there is a significantly reduced blood flow within the colonic wall at the end of a straight end-to-end coloanal anastomosis, relative to that at the site of a reservoir–anal anastomosis.[68] This may explain the anecdotal reports of a reduction in leakage seen after reservoir–anal anastomosis.[59]

More recently, a novel approach to the creation of a colonic reservoir, the transverse coloplasty reservoir, has gained some popularity. However the small trials have not shown any advantage regarding bowel function (other than evacuation difficulties), but a higher rate of anastomotic leaks.[69–71]

Should a colonic reservoir be constructed?

Guidelines — Colonic reservoir	Level of evidence	Practice recommendation	Refs
Where technically feasible, the colonic reservoir is recommended for anastomosis within 2 cm from ano-rectal junction.	II	Strongly recommend	56,57, 59,61, 65,67, 69-71,74

12.6 The role of high ligation, drains and rectal washouts

High ligation

Although no significant survival advantage has been demonstrated for high ligation of the inferior mesenteric artery, its continued use may be justified on the grounds that it does not result in increased morbidity or mortality, it technically facilitates low colorectal anastomosis and colonic J-pouch (reservoir) construction, and it may improve postoperative bowel function by allowing descending rather than sigmoid colon to be used for anastomoses.[72,73] However, a recent randomised study has found no functional difference between using the sigmoid or descending colon to construct the colonic J-pouch (reservoir).[74]

To drain or not to drain?

The routine use of pelvic drains after colorectal or coloanal anastomosis remains controversial. Proponents of drainage argue that drains allow the egress of postoperative fluid collections that have the potential to become infected and, therefore, may predispose to anastomotic complications. It has also been suggested that an anastomotic dehiscence may be more readily recognised, and perhaps controlled, if a drain has been inserted. Studies in animal models have shown that the use of drains near colonic anastomosis is associated with an increased incidence of anastomotic leakage, morbidity and mortality.[75] Randomised controlled trials have demonstrated no benefit for the use of routine drains for intraperitoneal colonic anastomoses, and their use has largely been abandoned.[76,77] Many surgeons continue to drain rectal anastomoses that lie below the peritoneal reflection within the pelvis, in which haematoma and fluid collections may accumulate.

It has been demonstrated that the quantity of fluid removed by a drain in the pelvis increases as the distance of the anastomosis from the anus decreases, suggesting that it is dependent, at least in part, on the extent of pelvic dissection, rather than on local reaction to the drain.[78]

There have been only two randomised controlled clinical trials of pelvic drainage after rectal resection in which a ‘no drain’ arm was included.[79,80] These studies compared the use of a high-pressure closed-suction drain with no drain in patients undergoing rectal resection. There was no difference in postoperative morbidity or mortality, or in the size of the pelvic fluid collection as measured by ultrasound in one of the studies.[79] It has been shown that the duration of drainage has no effect on the development of pelvic sepsis and that when anastomotic leakage does occur, the presence of a drain

does not permit its earlier recognition.[78,79,81] A recent Cochrane review also confirms that there is no difference of outcome measures after prophylactic drainage of anastomoses after elective colorectal surgery or no drainage, revealing the lack of scientific evidence for the use of drainage.[82]

Despite this, the use of pelvic drainage after rectal resection is widely practised, and there is no evidence to indicate that it has a detrimental effect on anastomotic healing.[81]

Guideline — Drainage	Level of evidence	Practice recommendation	Refs
Routine drainage should only be considered for rectal cancers	II	Equivocal	76,77, 79–81

Rectal washout

Exfoliated malignant cells have been demonstrated in the bowel lumen in patients with primary Colorectal Cancer.[83–90] The viability of these cells has been confirmed, and reduction in their viability by application of a variety of chemical constituents has been established.[81–78]

Experimentally-induced anastomotic implantation of luminal cells has been demonstrated in an animal model.[91] Cases of implantation metastases in anal wounds from occult proximal tumours have been reported.[91] Therefore, it seems logical that elimination of viable exfoliated malignant cells from the vicinity of the anastomosis may prevent implantation metastases, and so reduce the risk of locoregional tumour recurrence. This has not been investigated by a clinical trial to date.

However, irrigation of the rectal stump with normal saline immediately before anastomosis for rectal and sigmoid tumours has been shown to eliminate malignant cells from the perianastomosis zone.[90]

Irrigation of the rectal stump before anastomosis should be considered in all patients undergoing restorative resection for rectal cancer.

References

1. Smith TJ, Hillner BE, Bear HD. Taking action on the volume–quality relationship: how long can we hide our heads in the colostomy bag? J Natl Cancer Inst 2003; 95: 695–7.

2. Hodgson DC, Zhang W, Zaslavsky AM, Fuchs CS, Wright WE, Ayanian JZ. Relation of hospital volume to colostomy rates and survival for patients with rectal cancer. J Natl Cancer Inst 2003; 95: 708–16.

3. Schrag D, Panageas KS, Riedel E, et al. Hospital and surgeon procedure volume as predictors of outcome following rectal cancer resection. Ann Surg 2002; 236: 583–92.

4. Wibe A, Eriksen MT, Syse A, Myrvold HE, Soreide O. Total mesorectal excision for rectal cancer — what can be achieved by a national audit? Colorectal Dis 2003; 5: 471–7.

5. Porter GA, Soskolne CL, Yakimets WW, Newman SC. Surgeon-related factors and outcome in rectal cancer. Ann Surg 1998; 227: 157–67.

6. Penninckx F. Surgeon–related aspects of the treatment and outcome after radical resection for rectal cancer. Acta Gastroenterol Belg 2001; 64: 258–62.

7. McGrath DR, Leong DC, Armstrong BK, Spigelman AD. Management of colorectal cancer patients in Australia: the National Colorectal Cancer Care Survey. ANZ J Surg 2004; 74: 55–64.

8. Graham RA, Garnsey L, Jessup JM. Local excision of rectal carcinoma. Am J Surg 1990; 160: 306–12.

9. Brodsky JT, Richard GK, Cohen AM, Minsky BD. Variables correlated with the risk of lymph node metastasis in early rectal cancer. Cancer 1992; 69: 322–6.

10. Hermanek P, Gall FP. [Safe aboral distance in the sphincter-preserving resection of the rectum]. Chirurg 1981; 52: 25–9.

11. Killingback M. Local excision of carcinoma of the rectum: indications. World J Surg 1992; 16: 437–46.

12. Herrera-Ornelas L, Justiniano J, Castillo N, Petrelli NJ, Stulc JP, Mittelman A. Metastases in small lymph nodes from colon cancer. Arch Surg 1987; 122: 1253–6.

13. Rifkin MD, Ehrlich SM, Marks G. Staging of rectal carcinoma: prospective comparison of endorectal US and CT. Radiology 1989; 170: 319–22.

14. Mackay SG, Pager CK, Joseph D, Stewart PJ, Solomon MJ. Assessment of the accuracy of transrectal ultrasonography in anorectal neoplasia. Br J Surg 2003; 90: 346–50.

15. Gagliardi G, Bayar S, Smith R, Salem RR. Preoperative staging of rectal cancer using magnetic resonance imaging with external phase-arrayed coils. Arch Surg 2002; 137: 447–51.

16. Whiteway J, Nicholls RJ, Morson BC. The role of surgical local excision in the treatment of rectal cancer. Br J Surg 1985; 72: 694–7.

17. Bailey HR, Huval WV, Max E, Smith KW, Butts DR, Zamora LF. Local excision of carcinoma of the rectum for cure. Surgery 1992; 111: 555–61.

18. Biggers OR, Beart RW, Jr., Ilstrup DM. Local excision of rectal cancer. Dis Colon Rectum 1986; 29: 374–7.

19. Hager T, Gall FP, Hermanek P. Local excision of cancer of the rectum. Dis Colon Rectum 1983; 26: 149–51.

20. Banerjee AK, Jehle EC, Shorthouse AJ, Buess G. Local excision of rectal tumours. Br J Surg 1995; 82: 1165–73.

21. Grigg M, McDermott FT, Pihl EA, Hughes ES. Curative local excision in the treatment of carcinoma of the rectum. Dis Colon Rectum 1984; 27: 81–3.

22. Williams NS, Durdey P, Johnston D. The outcome following sphincter-saving resection and abdominoperineal resection for low rectal cancer. Br J Surg 1985; 72: 595–8.

23. Winde G, Blasius G, Herwig R. Benefit in therapy of superficial rectal neoplasms objectivized: transanal endoscopic microsurgery (TEM) compared to surgical standards. Minimally Invasive Therapy and Allied Technology 1997; 6: 315–23.

24. Chakravarti A, Compton CC, Shellito PC, et al. Long-term follow-up of patients with rectal cancer managed by local excision with and without adjuvant irradiation. Ann Surg 1999; 230: 49–54.

25. Wolmark N, Fisher B. An analysis of survival and treatment failure following abdominoperineal and sphincter-saving resection in Dukes' B and C rectal carcinoma. A report of the NSABP clinical trials. National Surgical Adjuvant Breast and Bowel Project. Ann Surg 1986; 204: 480–9.

26. Ferulano GP, Dilillo S, La Manna S, et al. Influence of the surgical treatment on local recurrence of rectal cancer: a prospective study (1980–1992). J Surg Oncol 2000; 74: 153–7.

27. Pollett WG, Nicholls RJ. The relationship between the extent of distal clearance and survival and local recurrence rates after curative anterior resection for carcinoma of the rectum. Ann Surg 1983; 198: 159–63.

28. Heimann TM, Szporn A, Bolnick K, Aufses AH, Jr. Local recurrence following surgical treatment of rectal cancer. Comparison of anterior and abdominoperineal resection. Dis Colon Rectum 1986; 29: 862–4.

29. Kirwan WO, Drumm J, Hogan JM, Keohane C. Determining safe margin of resection in low anterior resection for rectal cancer. Br J Surg 1988; 75: 720.

30. Grinnell RS. Distal intramural spread of carcinoma of the rectum and rectosigmoid. Surgical Gynecological Obstretics 1954; 99: 421–30.

31. Enker WE, Laffer UT, Block GE. Enhanced survival of patients with colon and rectal cancer is based upon wide anatomic resection. Ann Surg 1979; 190: 350–60.

32. Quer EA, Dahlin DC, Mayo CW. Retrograde intramural spread of carcinoma of the rectum and rectosigmoid. Surgical Gynecological Obstretics 1953; 96: 24–30.

33. Hojo K. Anastomotic recurrence after sphincter-saving resection for rectal cancer. Length of distal clearance of the bowel. Dis Colon Rectum 1986; 29: 11–4.

34. Wilson SM, Beahrs OH. The curative treatment of carcinoma of the sigmoid, rectosigmoid, and rectum. Ann Surg 1976; 183: 556–65.

35. McDermott FT, Hughes ES, Pihl E, Johnson WR, Price AB. Local recurrence after potentially curative resection for rectal cancer in a series of 1008 patients. Br J Surg 1985; 72: 34–7.

36. Vernava AM, III, Moran M, Rothenberger DA, Wong WD. A prospective evaluation of distal margins in carcinoma of the rectum. Surg Gynecol Obstet 1992; 175: 333–6.

37. Heald RJ, Karanjia ND. Results of radical surgery for rectal cancer. World J Surg 1992; 16: 848–57.

38. Wagman R, Minsky BD, Cohen AM, Guillem JG, Paty PP. Sphincter preservation in rectal cancer with preoperative radiation therapy and coloanal anastomosis: long term follow-up. Int J Radiat Oncol Biol Phys 1998; 42: 51–7.

39. Williams NS, Johnston D. The quality of life after rectal excision for low rectal cancer. Br J Surg 1983; 70: 460–2.

40. Christiansen J. Place of abdominoperineal excision in rectal cancer. J R Soc Med 1988; 81: 143–5.

41. Otto IC, Ito K, Ye C, et al. Causes of rectal incontinence after sphincter-preserving operations for rectal cancer. Dis Colon Rectum 1996; 39: 1423–7.

42. Santangelo ML, Romano G, Sassaroli C. Sexual function after resection for rectal cancer. Am J Surg 1987; 154: 502–4.

43. Heald RJ, Husband EM, Ryall RD. The mesorectum in rectal cancer surgery — the clue to pelvic recurrence? Br J Surg 1982; 69: 613–6.

44. Heald RJ, Ryall RD. Recurrence and survival after total mesorectal excision for rectal cancer. Lancet 1986; 1: 1479–82.

45. Scott N, Jackson P, al Jaberi T, Dixon MF, Quirke P, Finan PJ. Total mesorectal excision and local recurrence: a study of tumour spread in the mesorectum distal to rectal cancer. Br J Surg 1995; 82: 1031–3.

46. Reynolds JV, Joyce WP, Dolan J, Sheahan K, Hyland JM. Pathological evidence in support of total mesorectal excision in the management of rectal cancer. Br J Surg 1996; 83: 1112–5.

47. Killingback M. Local recurrence after restorative resection for carcinoma of the rectum (without total mesorectal excision). International Journal of Colorectal Diseases 1996; 11: 129.

48. McCall JL, Cox MR, Wattchow DA. Analysis of local recurrence rates after surgery alone for rectal cancer. Int J Colorectal Dis 1995; 10: 126–32.

49. Arbman G, Nilsson E, Hallbook O, Sjodahl R. Local recurrence following total mesorectal excision for rectal cancer. Br J Surg 1996; 83: 375–9.

50. Martling AL, Holm T, Rutqvist LE, Moran BJ, Heald RJ, Cedemark B. Effect of a surgical training programme on outcome of rectal cancer in the County of Stockholm. Stockholm Colorectal Cancer Study Group, Basingstoke Bowel Cancer Research Project. Lancet 2000; 356: 93–6.

51. Havenga K, Enker WE, Norstein J, et al. Improved survival and local control after total mesorectal excision or D3 lymphadenectomy in the treatment of primary rectal cancer: an international analysis of 1411 patients. Eur J Surg Oncol 1999; 25: 368–74.

52. Sauer I, Bacon H. Influence of lateral spread of cancer of the rectum on radicability of operation and prognosis. American Journal of Surgery 1951; 81: 111–20.

53. Quirke P, Durdey P, Dixon MF, Williams NS. Local recurrence of rectal adenocarcinoma due to inadequate surgical resection. Histopathological study of lateral tumour spread and surgical excision. Lancet 1986; 2: 996–9.

54. Chapman M, Charnley R, Sheffield J, Hardcastle J. Pelvic sidewall brushings following rectal resection complement histological examination in predicting death. British Journal of Surgery 1996; 83: 40.

55. Nagtegaal ID, Marijnen CA, Kranenbarg EK, van de Velde CJ, van Krieken JH. 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: 350–7.

56. Seow-Choen F, Goh HS. Prospective randomized trial comparing J colonic pouch-anal anastomosis and straight coloanal reconstruction. Br J Surg 1995; 82: 608–10.

57. Ortiz H, De Miguel M, Armendariz P, Rodriguez J, Chocarro C. Coloanal anastomosis: are functional results better with a pouch? Dis Colon Rectum 1995; 38: 375–7.

58. Hallbook O, Nystrom PO, Sjodahl R. Physiologic characteristics of straight and colonic J-pouch anastomoses after rectal excision for cancer. Dis Colon Rectum 1997; 40: 332–8.

59. Hallbook O, Pahlman L, Krog M, Wexner SD, Sjodahl R. Randomized comparison of straight and colonic J pouch anastomosis after low anterior resection. Ann Surg 1996; 224: 58–65.

60. Romanos J, Stebbing JF, Smiligin Humphreys MM, Takeuchi N, Mortensen NJ. Ambulatory manometric examination in patients with a colonic J pouch and in normal controls. Br J Surg 1996; 83: 1744–6.

61. Ho YH, Tan M, Seow-Choen F. Prospective randomized controlled study of clinical function and anorectal physiology after low anterior resection: comparison of straight and colonic J pouch anastomoses. Br J Surg 1996; 83: 978–80.

62. Mortensen NJ, Ramirez JM, Takeuchi N, Humphreys MM. Colonic J pouch–anal anastomosis after rectal excision for carcinoma: functional outcome. Br J Surg 1995; 82: 611–3.

63. Berger A, Tiret E, Parc R, et al. Excision of the rectum with colonic J pouch–anal anastomosis for adenocarcinoma of the low and mid rectum. World J Surg 1992; 16: 470–7.

64. Banerjee AK, Parc R. Prediction of optimum dimensions of colonic pouch reservoir. Dis Colon Rectum 1996; 39: 1293–5.

65. Hida J, Yasutomi M, Fujimoto K, et al. Functional outcome after low anterior resection with low anastomosis for rectal cancer using the colonic J-pouch. Prospective randomized study for determination of optimum pouch size. Dis Colon Rectum 1996; 39: 986–91.

66. Lazorthes F, Chiotasso P, Gamagami RA, Istvan G, Chevreau P. Late clinical outcome in a randomized prospective comparison of colonic J pouch and straight coloanal anastomosis. Br J Surg 1997; 84: 1449–51.

67. Lazorthes F, Gamagami R, Chiotasso P, Istvan G, Muhammad S. Prospective, randomized study comparing clinical results between small and large colonic J-pouch following coloanal anastomosis. Dis Colon Rectum 1997; 40: 1409–13.

68. Hallbook O, Johansson K, Sjodahl R. Laser Doppler blood flow measurement in rectal resection for carcinoma — comparison between the straight and colonic J pouch reconstruction. Br J Surg 1996; 83: 389–92.

69. Pimentel JM, Duarte A, Gregorio C, Souto P, Patricio J. Transverse coloplasty pouch and colonic J-pouch for rectal cancer — a comparative study. Colorectal dis 2003; 5: 465–70.

70. Furst A, Suttner S, Agha A, Beham A, Jauch KW. Colonic J-pouch vs. coloplasty following resection of distal rectal cancer: early results of a prospective, randomized, pilot study. Dis Colon Rectum 2003; 46: 1161–6.

71. Ho YH, Brown S, Heah SM, et al. Comparison of J-pouch and coloplasty pouch for low rectal cancers: a randomized, controlled trial investigating functional results and comparative anastomotic leak rates. Ann Surg 2002; 236: 49–55.

72. Surtees P, Ritchie JK, Phillips RK. High versus low ligation of the inferior mesenteric artery in rectal cancer. Br J Surg 1990; 77: 618–21.

73. Pezim ME, Nicholls RJ. Survival after high or low ligation of the inferior mesenteric artery during curative surgery for rectal cancer. Ann Surg 1984; 200: 729–33.

74. Heah SM, Seow-Choen F, Eu KW, Ho YH, Tang CL. Prospective, randomized trial comparing sigmoid vs. descending colonic J-pouch after total rectal excision. Dis Colon Rectum 2002; 45: 322–8.

75. Smith SR, Connolly JC, Crane PW, Gilmore OJ. The effect of surgical drainage materials on colonic healing. Br J Surg 1982; 69: 153–5.

76. Sagar PM, Couse N, Kerin M, May J, MacFie J. Randomized trial of drainage of colorectal anastomosis. Br J Surg 1993; 80: 769–71.

77. Hoffmann J, Shokouh-Amiri MH, Damm P, Jensen R. A prospective, controlled study of prophylactic drainage after colonic anastomoses. Dis Colon Rectum 1987; 30: 449–52.

78. Allen-Mersh TG, Sprague DB, Mann CV, Turner MJ. Pelvic drainage after anterior resection of the rectum. Dis Colon Rectum 1989; 32: 223–6.

79. Sagar PM, Hartley MN, MacFie J, Mancey-Jones B, Sedman P, May J. Randomized trial of pelvic drainage after rectal resection. Dis Colon Rectum 1995; 38: 254–8.

80. Brown SR, Seow-Choen F, Eu KW, Heah SM, Tang CL. A prospective randomised study of drains in infra-peritoneal rectal anastomoses. Tech Coloproctol 2001; 5: 89–92.

81. Galandiuk S, Fazio VW. Postoperative irrigation — suction drainage after pelvic colonic surgery. A prospective randomized trial. Dis Colon Rectum 1991; 34: 223–8.

82. Jesus E, Karliczek A, Matos D, Castro A, Atallah A. Prophylactic anastomotic drainage for colorectal surgery. Cochrane Database Syst Rev 2004; CD002100.

83. Skipper D, Cooper AJ, Marston JE, Taylor I. Exfoliated cells and in vitro growth in colorectal cancer. Br J Surg 1987; 74: 1049–52.

84. Docherty JG, McGregor JR, Purdie CA, Galloway DJ, O'Dwyer PJ. Efficacy of tumoricidal agents in vitro and in vivo. Br J Surg 1995; 82: 1050–2.

85. Rosenberg IL, Russell CW, Giles GR. Cell viability studies on the exfoliated colonic cancer cell. Br J Surg 1978; 65: 188–90.

86. Umpleby HC, Williamson RC. The efficacy of agents employed to prevent anastomotic recurrence in colorectal carcinoma. Ann R Coll Surg Engl 1984; 66: 192–4.

87. Umpleby HC, Williamson RC. Anastomotic recurrence in large bowel cancer. Br J Surg 1987; 74: 873–8.

88. Gertsch P, Baer HU, Kraft R, Maddern GJ, Altermatt HJ. Malignant cells are collected on circular staplers. Dis Colon Rectum 1992; 35: 238–41.

89. Jenner DC, De Boer R, Levitt M, et al. Rectal washout eliminates exfoliated malignant cells. ANZ J Surg 1997; 67: A16.

90. Southwick HW, Harridge WH, Cole WH. Recurrence at the suture line following resection of carcinoma of the colon. American Journal of Surgery 1962; 103: 86–9.

91. Sayfan J, Averbuch F, Koltun L, Benyamin N. Effect of rectal stump washout on the presence of free malignant cells in the rectum during anterior resection for rectal cancer. Dis Colon Rectum 2000; 43: 1710–2.