The effect of rectal washout on local recurrence following rectal cancer surgery

SR Moosvi, K Manley, J Hernon

Norfolk and Norwich University Hospitals NHS Foundation Trust, UK

ABSTRACT

INTRODUCTION Local recurrence after surgery for rectal cancer is associated with significant morbidity and debilitating symptoms. Intraoperative rectal washout has been linked to a reduction in local recurrence but there is no conclusive evidence. The aim of this study was to evaluate whether performing rectal washout had any effect on the incidence of local recurrence in patients undergoing anterior resection for rectal cancer in the context of the current surgical management.

METHODS A total of 395 consecutive patients who underwent anterior resection with or without rectal washout for rectal cancer between January 2003 and July 2009 at a high volume single institution were analysed retrospectively. A standardised process for performing washout was used and all patients had standardised surgery in the form of total mesorectal excision. Neoadjuvant and adjuvant therapy was used on a selected basis. Patients were followed up for five years and local recurrence rates were compared in the two groups.

RESULTS Of the 395 patients, 297 had rectal washout and 98 did not. Both groups were well matched with regard to various important clinical, operative and histopathological characteristics. Overall, the local recurrence rate was 5.3%. There was no significant difference in the incidence of local recurrence between the washout group (5.7%) and the no washout group (4.1%).

CONCLUSIONS Among our cohort of patients, there was no statistical difference in the incidence of local recurrence after anterior resection with or without rectal washout. This suggests that other factors are more significant in the development of local recurrence.

KEYWORDS

Rectal cancer – Local recurrence – Rectal washout

Accepted 23 July 2017

CORRESPONDENCE TO

Syed Moosvi, E: srmoosvi@gmail.com

There has been a significant improvement over recent decades in the oncological outcome after rectal cancer surgery.¹ This progress has been mainly due to the introduction and implementation of standardised surgery in the form of total mesorectal excision (TME) as well as the use of preoperative radiotherapy.² These advances have led to a reduction in the incidence of local recurrence after rectal cancer surgery to below 10% in most institutions.³ Patients with local recurrence generally have a poor prognosis, often suffering with severe intractable symptoms, and are difficult to treat.

Viable cancer cells can be shed into the bowel lumen from colorectal tumours.⁴ There is evidence to support the implantation of these cells into colorectal anastomoses, thereby increasing the chance of local recurrence.⁵ Circular stapling devices used in the majority of colorectal anastomoses have been shown to collect malignant cells, raising the possibility of implantation of these cells during anastomosis.⁶ These free intraluminal tumour cells can be eliminated with the use of rectal washout.⁷ Rectal washout can reduce both the quantity and the viability of exfoliated tumour cells either by mechanical cleansing or through the cytotoxic effect of the washout solution.^{6,8}

Rectal washout comprises cross-clamping of the rectum distal to the tumour after adequate rectal mobilisation. The rectal lumen is then irrigated from the anus to the clamp. The rectum is subsequently divided distal to the clamp across the rectal lumen that has been irrigated.¹ The cytotoxic effect of several different types of solution has been examined *in vitro* and *in vivo* with varying results.^{9,10} Some studies have also examined the volume of irrigation fluid required to effect the elimination of viable intraluminal tumour cells, again with differing recommendations.^{7,11,12}

No randomised controlled trials have been carried out to examine the effect of rectal washout on local recurrence after rectal cancer surgery. Only four comparative studies examining rectal washout and reporting on local recurrence have been published to date in English,^{13–16} with several meta-analyses.^{17–19} There were significant differences between most of the studies in terms of the type and volume of the washout fluid, and many of the studies failed to reach statistically significant conclusions with regard to local recurrence, mainly because of their relatively small sample sizes.

It is clear from the published data regarding the effect of rectal washout on local recurrence after rectal cancer surgery that there is a need for a more systematic study. It has been noted that a randomised controlled trial would require 1,400 patients followed for at least 5 years and would not be practical to perform.¹⁶ The meta-analyses performed so far have only had access to data from a relatively small number of studies and (with the exception of a large Swedish study)¹⁶ the patient numbers in these have been relatively small. For example, Constantinides *et al* only analysed 432 patients in total for their meta-analysis.¹⁷ The different types and volume of fluids used to perform rectal washout as well as differing methods employed between surgeons contribute to the significant heterogeneity among all the comparative studies published to date.

A significant amount of the published data is fairly historical and unlikely to take into account more recent advances in the management of rectal cancer in terms of surgical technique, preoperative staging, neoadjuvant and adjuvant treatments, and postoperative surveillance. A publication surveying current UK practice relating to rectal washout revealed that most colorectal surgeons believe there is an advantage in performing it.²⁰ However, most surgeons would perform rectal washout routinely in open resections but not in laparoscopic resections. Performing washout in laparoscopic surgery can be more difficult than in open surgery as well as more time consuming. No difference in oncological outcome has been demonstrated with either technique. The aim of this study was therefore to establish whether rectal washout had any effect on the incidence of local recurrence in patients undergoing anterior resection for rectal cancer as well as to examine other factors associated with local recurrence.

Methods

This was a retrospective study of patients treated electively for rectal and rectosigmoid cancer by anterior resection or Hartmann's procedure (TME without formation of an anastomosis) between January 2003 and July 2009 at a high volume single institution. The postoperative follow-up period was five years. All patients who had a resection performed with curative intent with division of the rectum below the sacral promontory were included in the study. Exclusion criteria comprised patients with evidence of definite metastatic disease at the time of surgery, patients undergoing abdominoperineal excision of the rectum and patients undergoing local resection.

Five specialist colorectal surgeons performed all of the operations; all were trained to undertake TME for rectal cancer. Most of the operations were open procedures but there were also some performed laparoscopically. All patients were discussed at a multidisciplinary meeting prior to surgery. Some patients received preoperative radiotherapy with/without chemotherapy and some had postoperative chemotherapy, both determined by the multidisciplinary team. Patients were routinely given an enema before surgery and those with a mid or low rectal cancer also had mechanical bowel preparation.

Among the five surgeons, there were two who performed rectal washout relatively rarely whereas the other three did so routinely. The other technical aspects of the operations undertaken by the different surgeons were similar and comparable.

The three who routinely perform washout employ similar techniques. This involves cross-clamping the rectum distal to the tumour, and performing washout with a standard cetrimide and chlorhexidine solution. 500–1,000ml of this is used, followed by 500–1000ml of saline; the volume is guided by the colour and consistency of the effluent. This is mostly administered via a rectal irrigation system (Proctowash™ Intermark, Bromley, UK) or a 50ml syringe if there is a low rectal cancer and only a short length of rectum to wash out. The rectum is then transected distal to the already placed cross-clamp. A colorectal anastomosis is fashioned using a circular stapling device in the vast majority of cases. There was no significant difference in the postoperative care of the patients.

Histological staging of all patients was performed using the TNM (tumour, lymph nodes, metastasis) system and the Dukes' stage was determined. Postoperative follow-up involved yearly computed tomography of the chest, abdomen and pelvis, and carcinoembryonic antigen measurement for the first 3–5 years. Colonoscopy, if already performed preoperatively, was performed at three years. Otherwise colonoscopy was performed within six months of surgery and then subsequently three years later. Clinical review was at three-monthly intervals for the first year, six-monthly intervals for the second year and then annually.

The primary endpoint was the incidence of local recurrence in patients with or without the use of rectal washout. Local recurrence was defined as clinical, radiological, endoscopic or histological evidence of a recurrent tumour below the sacral promontory. Secondary endpoints were the association of the local recurrence with pre and postoperative treatment, tumour height from the anal verge, Dukes' stage, resection margins, and intra and postoperative complications. Any association with the type of surgery (open vs laparoscopic) and operation was also examined, as well as any differences in survival. Statistical analysis was performed using Fisher's exact test and Student's t-test where appropriate. A *p*-value of <0.05 was considered statistically significant.

Results

A total of 395 patients were included in the study. The rectal washout (RW) group comprised 297 patients (75%) and the no rectal washout (NRW) group 98 patients (25%). Table 1 summarises the characteristics of the two groups in terms of clinical, surgical and histopathological parameters. Both groups were well matched in terms of age, sex and tumour location, with no significant differences. The distance from the anal verge was used to differentiate cancers of the upper (10.1–15cm), middle (5.1–10cm) and lower (0–5cm) rectum. There was a significantly higher proportion of procedures performed without anastomosis (16% vs 8%) and laparoscopically (12% vs 5%) among NRW patients.

Table 1 Characteristics for the rectal washout and no rectal washout groups

Characteristics	Rectal washout (n=297)	No rectal washout (n=98)	p-value
Sex			
Male	175 (58.9%)	62 (63.3%)	0.48
Female	122 (41.1%)	36 (36.7%)	
Age in years			
Median	68	70	0.37
Mean	69.4 (SD: 11.1)	68.2 (SD: 10.2)	
Distance of tumour from anal verge			
0–5cm	62 (20.9%)	22 (22.4%)	0.77
5.1–10cm	89 (30.0%)	33 (33.7%)	0.52
10.1–15cm	146 (49.2%)	43 (43.9%)	0.41
Operation			
Anterior resection	272 (91.6%)	82 (83.7%)	0.035
Hartmann's procedure	25 (8.4%)	16 (16.3%)	
Surgery			
Open	283 (95.3%)	86 (87.8%)	0.017
Laparoscopic	14 (4.7%)	12 (12.2%)	
Dukes' stage			
A	54 (18.2%)	26 (26.5%)	0.08
B	115 (38.7%)	30 (30.6%)	0.18
C	125 (42.1%)	40 (40.8%)	0.90
No residual cancer	3 (1.0%)	2 (2.0%)	0.60
Preoperative			
Short course radiotherapy	23 (7.7%)	10 (10.2%)	0.53
Long course chemoradiotherapy	26 (8.8%)	11 (11.2%)	0.55
Postoperative			
Chemotherapy	117 (39.4%)	28 (28.6%)	0.07
Palliative chemotherapy	6 (2.0%)	3 (3.1%)	0.70

SD = standard deviation

There was no statistical difference between the groups in the use of preoperative short course radiotherapy or long course chemoradiotherapy. However, 39% of patients in the RW group received postoperative adjuvant chemotherapy compared with 29% of NRW patients although this difference did not reach statistical significance. The use of postoperative palliative chemotherapy was similar in both groups.

In terms of Dukes' stage, the proportion of cancers categorised as Dukes' A was higher in the NRW group (27% vs 18%). The reverse was true for Dukes' B cancers, comprising 39% of RW cases compared with 31% of NRW patients. A similar proportion of Dukes' C cancers were present in both groups. There were five cases where no residual cancer was found in the specimen from surgery after preoperative treatment (3 RW patients and 2 NRW patients).

Significant differences were present in the number of patients having rectal washout depending on the surgeon performing the operation (Table 2). Surgeons C and E proportionally performed significantly fewer washouts than the other three surgeons.

The rate of local recurrence among RW patients was 5.7% (n=17) compared with 4.1% (n=4) in the NRW group (Table 3). This difference was not statistically significant.

The overall local recurrence rate was 5.3%. The follow-up period in the majority of patients lasted a minimum of five years. Four RW patients (1%) and six NRW patients (6%) were lost to follow-up before five years (range: 18–47 months). The median time from surgery to detection of local recurrence was 589 days (range: 158–1,734 days) in the RW group and 633 days (range: 168–1,286 days) in the NRW group. Consequently, the earliest a local recurrence was detected was after approximately 5 months and the latest was after 57 months.

The five-year overall survival rates were 74.4% and 75.0% in the RW and NRW groups respectively. There were no significant differences in the rates of tumour perforation during surgery (1.0% vs 2.0%), anastomotic leak (5.7% vs 6.1%) or R1 resection (5.7% vs 6.1%) between the two groups.

Comparing the patients who developed local recurrence with those who did not, there was a significant association between local recurrence and Dukes' C cancers (Table 4). This group also had a higher proportion of low rectal cancers (38% vs 20%) although this difference did not reach statistical significance. The proportion of R1 resections was higher in the local recurrence group (10% vs 6%) but this

Table 2 Practice of surgeons in terms of use of rectal washout during rectal cancer surgery

Surgeon	Rectal washout (n=297)	No rectal washout (n=98)	p-value
A	65	7	<0.001
B	78	12	0.004
C	19	49	<0.001
D	101	2	<0.001
E	34	28	<0.001

difference was also not statistically significant. There was no association with the type of surgery or whether it was performed laparoscopically.

Discussion

Local recurrence after rectal cancer surgery is associated with considerable morbidity and debilitating symptoms. It is defined by disease in the pelvis and includes anastomotic recurrence.²¹ Advances in surgical technique in the form of TME and the use of preoperative radiotherapy have greatly reduced the risk of local recurrence.^{1,2} Furthermore, the use of rectal washout during surgery for rectal cancer has been demonstrated to reduce the incidence of local recurrence.^{15,16,17} Rectal washout has been shown to reduce the quantity and viability of tumour cells in the bowel lumen, thereby reducing potential implantation in colorectal anastomoses and the development of local recurrence.⁸

Our study evaluated the association between rectal washout and development of local recurrence. No significant difference was observed in the incidence of local recurrence

following rectal cancer surgery between the RW and NRW groups (5.7% vs 4.1% respectively). Previous studies have shown either a statistically significant reduction or no difference in the incidence of local recurrence with the use of rectal washout.^{15–19}

The largest volume of data published to date has been by Kodeda *et al*, who analysed over 4,000 patients from the Swedish Rectal Cancer Registry treated with anterior resection between 1995 and 2002.¹⁶ The authors noted a more favourable outcome in terms of local recurrence with the use of rectal washout (6.0% vs 10.2%, $p<0.001$). However, the patients underwent a non-standardised washout technique and no information was given regarding the expertise or case volume of the surgeons involved.

A meta-analysis by Constantinides *et al* looked at five studies, with each using different rectal washout solutions and TME not being universally performed.¹⁷ Local recurrence was reduced for washout patients (4.8% vs 10.2%) but the difference was not statistically significant. Rondelli *et al*¹⁸ performed a meta-analysis of five non-randomised studies (including the Swedish study by Kodeda *et al*)¹⁶ and found a reduction in local recurrence with the use of rectal washout (5.9% vs 10.2%). This significantly lower rate of local recurrence after washout was also seen in patients having radical resection only, curative resection and in those undergoing preoperative radiotherapy. Zhou *et al* noted a similar reduction in local recurrence after rectal washout in a systematic review.¹⁹

The effect of different fluids used for rectal washout has been investigated as well. Jenner *et al* observed that 200–500ml of normal saline eliminated exfoliated malignant cells in the rectum in all ten patients treated.⁸ Eight out of the ten patients not given a washout had malignant cells on cytology. Long and Edwards showed a significant reduction in local recurrence with the use of 1% formalin intraluminally (2.6% vs 14.3%).¹⁵ Using 1% cetrimide for rectal washout,

Table 3 Comparison of clinical outcomes and selected operative and histopathological features in the rectal washout and no rectal washout groups

Outcomes	Rectal washout (n=297)	No rectal washout (n=98)	p-value
Local recurrence	17 (5.7%)	4 (4.1%)	0.61
Time to local recurrence in days			
Median	589	633	0.74
Mean	760 (SD: 413)	680 (SD: 466)	
Died*			
<90 days	11 (3.7%)	2 (2.0%)	0.53
>90 days but <5 years	64 (21.5%)	21 (21.4%)	1
Alive at 5 years	218 (74.4%)*	69 (75.0%)**	1
Intraoperative tumour perforation	3 (1.0%)	2 (2.0%)	0.60
Anastomotic leak	17 (5.7%)	6 (6.1%)	0.80
Residual tumour (R1 resection)	17 (5.7%)	6 (6.1%)	0.80

SD = standard deviation

*4 patients lost to follow-up; **6 patients lost to follow-up

Table 4 Comparison of characteristics of local recurrence and no local recurrence groups

Characteristics	Local recurrence (n=21)	No local recurrence (n=374)	p-value
Sex			
Male	13 (61.9%)	224 (59.9%)	1
Female	8 (38.1%)	150 (40.1%)	
Age in years			
Median	69	70	0.71
Mean	68.2 (SD: 11.1)	69.1 (SD: 10.9)	
Distance of tumour from anal verge			
0–5cm	8 (38.1%)	76 (20.3%)	0.09
5.1–10cm	6 (28.6%)	116 (31.0%)	1
10.1–15cm	7 (33.3%)	182 (48.7%)	0.19
Operation			
Anterior resection	18 (85.7%)	336 (89.8%)	0.47
Hartmann's procedure	3 (14.3%)	38 (10.2%)	
Surgery			
Open	19 (90.5%)	350 (93.6%)	0.64
Laparoscopic	2 (9.5%)	24 (6.4%)	
Dukes' stage			
A	2 (9.5%)	78 (20.9%)	0.27
B	2 (9.5%)	143 (38.2%)	0.009
C	17 (81.0%)	148 (39.6%)	<0.001
No residual cancer	0 (0%)	5 (1.3%)	1
Preoperative			
Short course radiotherapy	2 (9.5%)	31 (8.3%)	0.69
Long course chemoradiotherapy	1 (4.8%)	36 (9.6%)	0.70
Postoperative			
Chemotherapy	13 (61.9%)	132 (35.3%)	0.019
Palliative chemotherapy	2 (9.5%)	7 (1.9%)	0.08
Intraoperative tumour perforation	0 (0%)	5 (1.3%)	1
Anastomotic leak	2 (9.5%)	21 (5.6%)	0.35
Residual tumour (R1 resection)	2 (9.5%)	21 (5.6%)	0.35
Surgeon			
A	8	64	0.036
B	4	86	0.79
C	2	66	0.55
D	3	100	0.31
E	4	58	0.76

SD = standard deviation

Agaba did not observe any benefit in terms of reducing local recurrence.¹⁴ Terzi *et al* also demonstrated no benefit using 5% povidone-iodine washout with regard to local recurrence or the presence of viable malignant cells in the rectal lumen.¹⁵

Our study has analysed a higher number of patients ($n=395$) than previous comparative studies and in particular, it has included a higher number of patients who had rectal washout ($n=297$). The fact that no difference was seen with or without the use of washout suggests that there are other factors involved in the development of local recurrence besides just the implantation of viable tumour cells at the time of the original surgery. The actual rate of anastomotic

or staple line recurrence has been reported as accounting for only 5–15% of all local recurrences and so rectal washout itself will not address other potential factors.¹⁴

It is likely that multiple factors contribute to the development of local recurrence after rectal cancer surgery. In addition to the quality of surgical resection, the genetics and biology of the tumour are important. Risk factors that have been associated with the development of local recurrence include involvement of the circumferential resection margin, distal location of the tumour, size of the primary tumour, extent of extramural spread and nodal status.^{22,25} Our results support these findings by demonstrating an association between local recurrence and a more advanced stage of

cancer as well as with a more distant location of the tumour and a R1 resection.

There was no difference in local recurrence rates when patients were grouped according to type of surgery although the number of laparoscopic procedures performed was relatively small. Rectal washout is technically more difficult in laparoscopic surgery and most surgeons do not perform washout in these cases.²⁰ The 2016 National Bowel Cancer Audit report showed that up to 60% of colorectal resections are now being carried out using laparoscopic techniques; however, specific figures for rectal cancer surgery were not given.²⁴ In addition, an increasing number of rectal cancer operations are performed using robotic systems. Our study suggests that the omission of rectal washout will not significantly affect the development of local recurrence.

The use of a relatively standardised process for performing washout, the use of TME as standard surgical practice and the selected use of preoperative neoadjuvant therapy are some of the strengths of this study compared with more historical studies. Furthermore, the follow-up period was five years in the vast majority of patients, which is long enough for most local recurrences to have developed.

This study is obviously limited by its retrospective nature although both the RW and NRW groups were well matched with regard to various important clinical, operative and histopathological characteristics (Tables 1 and 3). There may have been some effect from variation in the practice of particular surgeons but the fact that they were all dedicated colorectal surgeons who performed TME with no statistical difference in the incidence of local recurrence in their patients suggests that this variation is unlikely to have contributed significantly to our results.

The size of the NRW group was significantly smaller than the RW group; overall, the number of patients was not sufficient to determine any statistical difference that could be attributed to rectal washout. Kodada *et al* suggested that 1,400 patients would be required for a randomised controlled trial, with a follow-up period of at least 5 years.¹⁶ Moreover, the fact that there was no statistical difference in the incidence of local recurrence following a R1 resection indicates that the low number of recurrences in this study is not enough to establish a cause.

Conclusions

This study found no difference in the development of local recurrence relating to whether patients had rectal washout. Local recurrence after rectal cancer surgery is a complex entity with a multifactorial aetiology. With an increasing number of rectal cancer operations now being performed using minimally invasive techniques, many without the use of rectal washout, this study suggests that this single factor does not contribute significantly to the development of local recurrence and that other factors are likely to play a far more important role. A large scale multicentre randomised

trial would provide a more definitive answer as to the effect of rectal washout on the development of local recurrence in the context of the current surgical management of rectal cancer.

References

1. Heald RJ, Moran BJ, Ryall RD *et al*. Rectal cancer: the Basingstoke experience of total mesorectal excision, 1978–1997. *Arch Surg* 1998; **133**: 894–899.
2. Jörgren F, Johansson R, Damber L, Lindmark G. Risk factors of rectal cancer local recurrence: population-based survey and validation of the Swedish rectal cancer registry. *Colorectal Dis* 2010; **12**: 977–986.
3. Kapiteijn E, Putter H, van de Velde CJ. Impact of the introduction and training of total mesorectal excision on recurrence and survival in rectal cancer in the Netherlands. *Br J Surg* 2002; **89**: 1,142–1,149.
4. Umpleby HC, Fermor B, Symes MO, Williamson RC. Viability of exfoliated colorectal carcinoma cells. *Br J Surg* 1984; **71**: 659–663.
5. Umpleby HC, Williamson RC. Anastomotic recurrence in large bowel cancer. *Br J Surg* 1987; **74**: 873–878.
6. Gertsch P, Baer HU, Kraft R *et al*. Malignant cells are collected on circular staplers. *Dis Colon Rectum* 1992; **35**: 238–241.
7. 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**: 1,710–1,712.
8. Jenner DC, de Boer WB, Clarke G, Levitt MD. Rectal washout eliminates exfoliated malignant cells. *Dis Colon Rectum* 1998; **41**: 1,432–1,434.
9. Umpleby HC, Williamson RC. The efficacy of agents employed to prevent anastomotic recurrence in colorectal carcinoma. *Ann R Coll Surg Engl* 1984; **66**: 192–194.
10. Docherty JG, McGregor JR, Purdie CA *et al*. Efficacy of tumoricidal agents in vitro and in vivo. *Br J Surg* 1995; **82**: 1,050–1,052.
11. Maeda K, Maruta M, Hanai T *et al*. Irrigation volume determines the efficacy of 'rectal washout'. *Dis Colon Rectum* 2004; **47**: 1,706–1,710.
12. Dafnis G, Nordstrom M. Evaluation of the presence of intraluminal cancer cells following rectal washout in rectal cancer surgery. *Tech Coloproctol* 2013; **17**: 363–369.
13. Long RT, Edwards RH. Implantation metastasis as a cause of local recurrence of colorectal carcinoma. *Am J Surg* 1989; **157**: 194–201.
14. Agaba EA. Does rectal washout during anterior resection prevent local tumor recurrence? *Dis Colon Rectum* 2004; **47**: 291–296.
15. Terzi C, Unek T, Sadol O *et al*. Is rectal washout necessary in anterior resection for rectal cancer? A prospective clinical study. *World J Surg* 2006; **30**: 233–241.
16. Kodada K, Holmberg E, Jörgren F *et al*. Rectal washout and local recurrence of cancer after anterior resection. *Br J Surg* 2010; **97**: 1,589–1,597.
17. Constantinides VA, Cheetham D, Nicholls RJ, Tekkis PP. Is rectal washout effective for preventing localized recurrence after anterior resection for rectal cancer? *Dis Colon Rectum* 2008; **51**: 1,339–1,344.
18. Rondelli F, Trastulli S, Cirocchi R *et al*. Rectal washout and local recurrence in rectal resection for cancer: a meta-analysis. *Colorectal Dis* 2012; **14**: 1,313–1,321.
19. Zhou C, Ren Y, Li J *et al*. Systematic review and meta-analysis of rectal washout on risk of local recurrence for rectal cancer. *J Surg Res* 2014; **189**: 7–16.
20. Simillis C, Mistry K, Prabhudesai A. Intraoperative rectal washout in rectal cancer surgery: a survey of current practice in the UK. *Int J Surg* 2013; **11**: 993–997.
21. Marsh PJ, James RD, Schofield PF. Definition of local recurrence after surgery for rectal carcinoma. *Br J Surg* 1995; **82**: 465–468.
22. Quirke P, Durdey P, Dixon MF *et al*. Local recurrence of rectal adenocarcinoma due to inadequate surgical resection. Histopathological study of lateral tumour spread and surgical excision. *Lancet* 1986; **2**: 996–999.
23. Birbeck KF, Macklin CP, Tiffin NJ *et al*. Rates of circumferential resection margin involvement vary between surgeons and predict outcomes in rectal cancer surgery. *Ann Surg* 2002; **235**: 449–457.
24. *National Bowel Cancer Audit Annual Report 2016*. London: HQIP; 2016.