The modern anatomical surgical approach to localised rectal cancer

R.G. Orsini [a], T. Wiggers [b], M.C. DeRuiter [c], P. Quirke [d], R.G. Beets-Tan [e], C.J. van de Velde [f], H.J.T. Rutten [a,g,*]

[a] Catharina Hospital, Eindhoven, The Netherlands
[b] University Medical Centre Groningen, Groningen, The Netherlands
[c] Leiden University Medical Centre, Leiden, The Netherlands
[d] Leeds Institute of Molecular Medicine, University of Leeds, Leeds, UK
[e] GROW School for Oncology & Developmental Biology, Department of Radiology, Maastricht University Medical Centre, Maastricht, The Netherlands
[f] Leiden University Medical Centre, Leiden, The Netherlands
[g] GROW School for Oncology & Developmental Biology, Department of Surgery, Maastricht University Medical Centre, Maastricht, The Netherlands

1. Introduction

On a worldwide scale, colorectal cancer is one of the leading causes of cancer deaths, affecting millions of people every year. One third of colorectal cancer concerns the rectum. In more than two thirds of the cases rectal cancer is still localised to the pelvis without detectable metastases. In these cases surgical resection is the cornerstone for a curative approach. Since the introduction of the combined abdomino-perineal resection by Miles and Quénu around the beginning of the 20th century [1], rectal cancer became a curable disease. However, for many decades the results of surgery have been disappointing, as it was often spoiled by a local recurrence rate of up to 40% or even higher. Uncontrolled progressive local recurrences, hardly palliated by irradiation or chemotherapy, have brought a miserable death to tens of millions of patients.

This situation lasted till the end of the last century when the anatomical basis of rectal cancer surgery was revived by Heald and Quirke [2,3]. Quirke demonstrated that the radial margin between the tumour border and the surgical resection margin was a strong prognosticator for local recurrence. He pointed out that both tumour progression and surgical quality were important for a safe margin. Poor surgery with incomplete mesorectum or tears into the mesorectal fat or muscular tube of the rectum could reduce this margin and consequently lead to local recurrences. Heald introduced the principle of total mesorectal excision (TME). In doing so he defined the optimal quality of surgery.

Worldwide surgeons have accepted as standard of care that optimally the rectum has to be removed within its enveloping mesorectal fascia. TME emphasises the importance of an anatomical resection in the planes between the mesorectal fascia and the surrounding pelvic fascias. However, the principle of resection of the rectum within its mesorectal fascia seems to fail when analysing low rectal cancer. From the early randomised controlled trials it was learned that patients requiring an abdomino-perineal excision (APE) still had high positive circumferential resection margins [4–7]. The lower rectum and anorectum are not surrounded by a protecting layer of mesorectal fat. Instead, already in an early stage, progressing tumours reach and possibly infiltrate the pelvic floor muscles, which are continuous with the external sphincter more distally. Compared with patients undergoing low anterior resection (LAR) APE patients have tumours located lower and more advanced, therefore new principles of surgery had to be developed [8]. Results of lower rectal cancer surgery improved when the principle of the extra levator approach was introduced [9–12]. This involves removal of the lower rectum during an abdomino-perineal excision en bloc with the external sphincter and levator ani muscles. In the lower rectum the role of complete removal of the mesorectal fascia is replaced by removal of the levator ani muscles. Again, the quality of the surgery can be judged by the completeness of this resection.

Modern rectal cancer surgery can be tailored to the specific topographical relationships of the tumour. In proximal tumours the mesorectal fascia acts as the guiding structure. Transection of the specimen can be performed 4–5 cm distally

* Corresponding author at: Department of Surgery, Catharina Hospital, Michelangelolaan 2, 5623 EJ Eindhoven, The Netherlands. Tel.: +31 40 2397155.
E-mail address: harm.rutten@cze.nl (H.J.T. Rutten).
1359-6349/$ - see front matter
http://dx.doi.org/10.1016/j.ejcsup.2013.07.033

from the lower tumour border or at the pelvic floor when the mesorectum terminates higher. More distal tumours can be removed by either intersphincteric resection – if the tumour is confined within the smooth muscle tube of the muscularis propria, sometimes even allowing for a colo-anal anastomosis – or extralevator resection if the pelvic floor is threatened or already involved by tumour progression. The third option for an abdomino-perineal excision is to take an even wider approach, taking out the ischiorectal fat en bloc with the levator muscles, if the tumour has perforated or fistulated through the pelvic floor muscles into this fatty area. However, this will be the case only in extremely rare circumstances.

Modern rectal cancer surgery is part of a multidisciplinary approach. Preoperative imaging with magnetic resonance imaging (MRI) is able to delineate the tumour very accurately and helps to select those patients requiring downsizing and down-staging, optimising the chances of a good tumour resection [13–15]. The pathologist plays an important role in the feedback to the surgeon, which is necessary to improve surgical outcome [16].

The first step in integration of optimal imaging, treatment modalities and pathology is taken is several countries. The next step will be to optimise treatment for the individual patient, who is interested not only in the oncological outcome but also in functional results and subsequent quality of life. Avoiding and decreasing morbidity, especially in the elderly, will require the development of new innovative strategies.

2. Contribution of pathology to the anatomical approach

It may seem odd to start a discussion on modern surgical approaches to localised rectal cancer with the findings of the pathologist. However, it was a pathologist who demonstrated the importance of the distance of the radial tumour border to the mesorectal fascia, which is called the circumferential resection margin (CRM) in TME surgery [3].

In 2002 Nagtegaal analysed the data of the Dutch TME study, and she confirmed that in 44% of the patients the involved circumferential resection margin was the result of poor-quality surgery. It was also shown that, after incomplete mesorectal excision, the overall recurrence rate was almost doubled, which could be attributed mainly to the excess of local recurrences [16]. Nagtegaal and Quirke performed a meta-analysis on the importance of the CRM in more than 17,500 patients and concluded that CRM involvement predicts not only local recurrence but also distant metastasis and subsequent overall survival. Failure to achieve a negative CRM after neoadjuvant treatment leads to a poorer prognosis compared with no neoadjuvant treatment. Possibly the explanation for this is the selection of patients with tumours more resistant to therapy. This finding could be an argument for restaging after neoadjuvant therapy, and to consider more prolonged neoadjuvant treatment, or to refer to a specialised centre for more extended resection or additional boosting of the area at risk [17].

Thus, the actual feedback of the pathologist to the surgeon should contain information on the CRM and quality of surgery [18]. Another important issue, which will be discussed later in this paper, is the evaluation of the effectiveness of the chosen neoadjuvant treatment. Preferably, macroscopic images of the resected specimens, as well as the microscopic images, should be available for internal audit and continued education and improvement of all member decisions during the multidisciplinary tumour board meetings.

Quirke proposed a 3-point grading system for the evaluation of the macroscopic specimen for both low anterior and abdomino-perineal resections. Good surgery would be qualified by an intact mesorectal fascia with only minor irregularities, or in the case of APE, a specimen with levator ani and external sphincters without any defects deeper than 5 mm and the levator ani attached to the mesorectal fascia [19,20] (see Figs. 1–3).

After moderate-quality surgery the bulk of the mesorectum is removed but shows an irregular surface, however still without exposing the muscularis propria or perforations. In the case of an APE, a specimen which shows waist formation, indicative for a less complete levator ani covering at the anorectal junction, but with intact sphincters, signifies a moderate quality of surgery.

Poor surgery would be characterised by severe irregularities on the surface of the specimen, exposing the muscularis propria or internal sphincter or even showing perforations to the lumen.

Very essential for the grading of the APE specimen is the question of whether the levator ani muscle is still attached to the mesorectum. Thus, waist formation is avoided and the result is a more cylindrical resection. In order to achieve optimal feedback, pathology reports should be standardised, not only regarding the reporting of the TNM status, but also on the quality of surgery [19].

3. The importance of MRI for the surgical treatment of rectal cancer

Magnetic resonance imaging (MRI) is a reliable diagnostic tool for clinical staging of rectal cancer, but other imaging methods for the pelvis are also being used for this purpose. Computed tomography (CT) is able to identify enlarged lymph nodes, although it is not accurate for assessing the morphology of these nodes. Furthermore, the contrast resolution of CT is insufficient to reliably assess involvement of the surgical resection plane in mid and lower rectal cancer. CT, however, is indicated for distant staging of metastatic disease and, if there is no easy access to an MRI, for assessment of resectability of high rectal tumours [21–23]. Endorectal ultrasound (EUS) cannot visualise the mesorectal fascia, but is the modality of choice to differentiate between T1 and T2 lesions for the selection of local therapies. EUS has a high sensitivity to stage depth of submucosal involvement [24]. However, MRI is the king of kings of all imaging modalities in its tissue contrast resolution and provides the necessary detailed anatomical information on pelvic fascias and dissection planes between pelvic soft tissues, which sets the scene for the planning of the resection.

Without the anatomical topographical information of an MRI, the surgeon has to rely on ad hoc decisions when unexpected problems occur during the actual surgical procedure

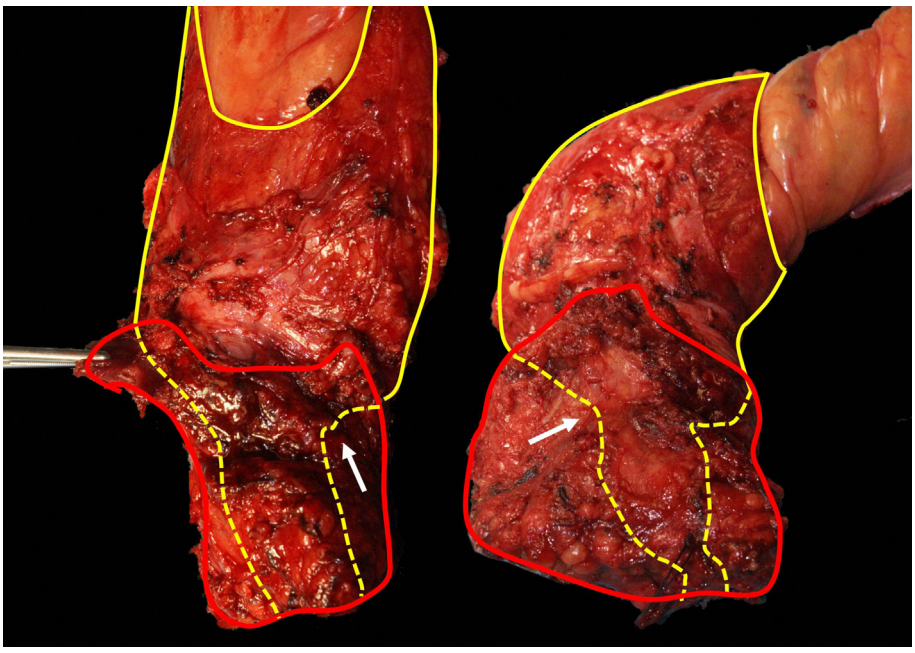

Fig. 1 – Rectal extralevator abdomino-perineal excision specimen. The solid yellow lines indicate the intact mesorectum. The red lines demonstrate the extralevator muscles attached to the specimen covering widely the anorectal junction (white arrow) where the mesorectum ends and the internal sphincter starts (dotted yellow line). Even advanced T3 or T4 tumours at the anorectal junction and below can be safely removed when covered by the extralevator muscle layer. Typically a cylindrically shaped specimen. Mesorectum intact. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

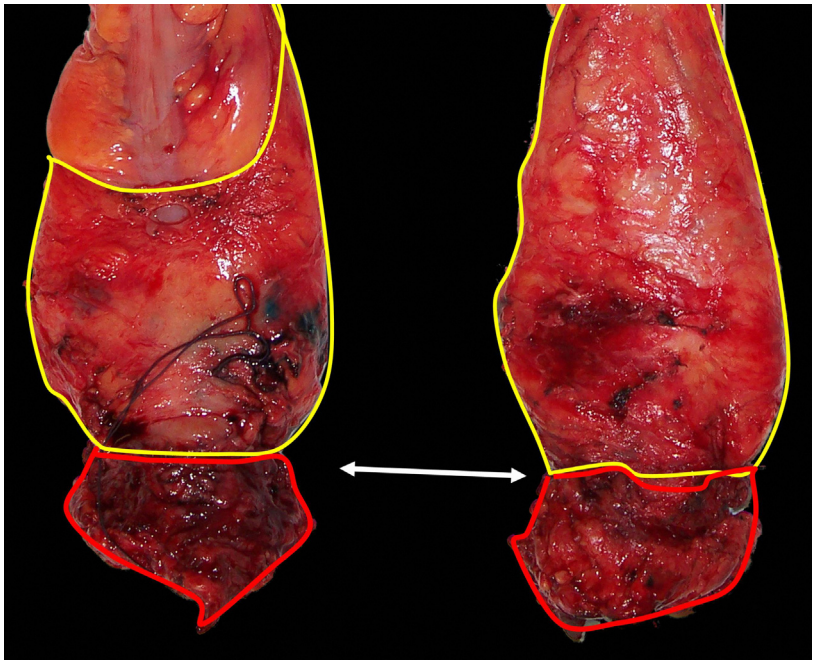

Fig. 2 – 'Standard' abdomino-perineal excision specimen, demonstrating waist formation at the anorectal junction or just above (white arrow). Only marginal coverage by the external sphincters of the distal mesorectum. Will suffice for less advanced tumours of the anorectum or anorectal junction. Specimen characterised by 'waist' formation. Mesorectum intact.

and in a worst-case scenario these problems may even go unnoticed, or have become irreversible. With the anatomical information from MRI critical sites of resection can be anticipated and addressed before surgery: i.e. use of neoadjuvant treatment or referral to a centre specialised in extended extra anatomical pelvic resection if TME surgery is not justified.

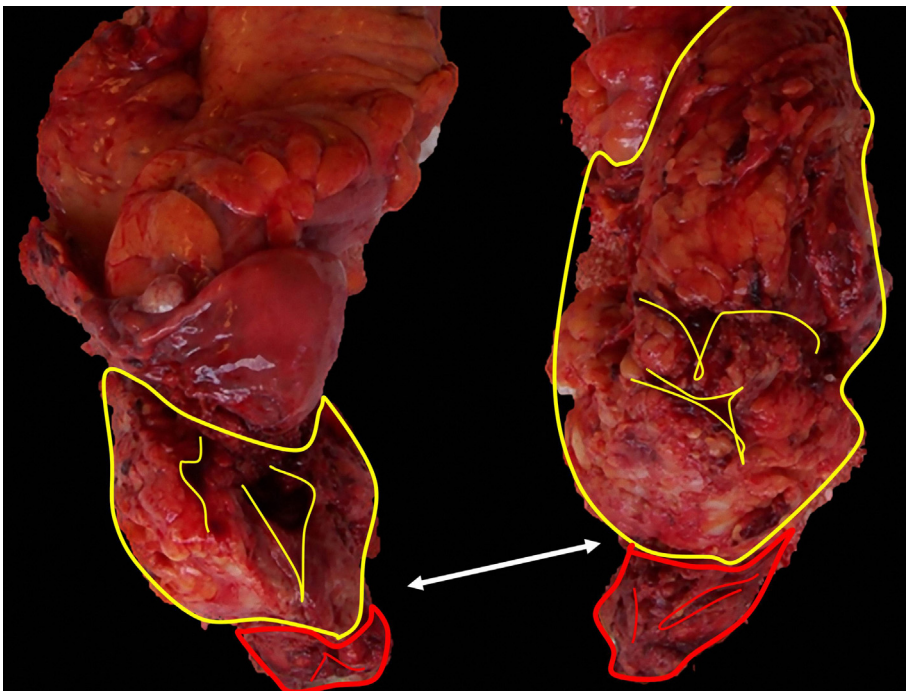

Fig. 3 – Poor specimen after abdomino-perineal excision. Deep indentations and even perforation in mesorectum. Very little coverage of the external sphincter and showing tears in the external sphincter.

The Mercury study group reported the reliability of MRI on predicting extramural depth of tumour invasion. Very good correlation of extramural spread on MRI and histopathology was found: the 95% confidence interval being <0.5 mm. The TNM classification lacks specificity in the T3 stage [25]. A T3 tumour with limited extramural spread (outside the muscularis propria) has a different prognosis to a T3 tumour with more extended spread. Merkel et al demonstrated that a cut-off point of 5 mm spread divided patients into groups with good and poor prognoses, provided that a safe CRM was obtained [26]. For the surgeon it is important that patients with limited extramural spread can be treated as T2 patients, and in most cases will not require neoadjuvant treatment with its associated adverse effect on surgical morbidity and functional outcome.

Even more important from the surgical technical point of view is the fact that MRI can reliably anticipate an involved circumferential resection margin. MRI differentiates between high-risk (<1 mm) and low-risk (>1 mm) patients for local recurrence. MR CRM margins >1 mm and <2 mm, >2 and <5 and >5 mm carried a similar risk for local recurrence of around 7%, in contrast to the 20% risk of patients with an anticipated margin of <1 mm [27]. The ability to predict a 1-mm free margin was recently confirmed by a German group [28].

The ability of MRI to discriminate between positive and negative lymph nodes is quite disappointing. Like other imaging modalities, conventional MRI without any MR contrast lacks both sensitivity and specificity to identify or rule out positive nodes, and cannot reliably be used for treatment stratification [29,30]. Size has been an unreliable variable to predict nodal involvement [31,32]. Several contrast agents have been and are under investigation, but at the time of writing results are still inconclusive [33–35]. Diffusion-weighted MRI imaging (DWI) shows a high signal in both benign and malignant nodes and therefore cannot differentiate between the two. A restaging MRI, including DWI, has a high negative predictive value (NPV) for the detection of nodal metastases and can be more reliably used for nodal restaging after neoadjuvant treatment [36]. The most reliable variable seems to be the evaluation of nodal morphology, such as roundness, irregular border or heterogeneous texture. However, this is difficult and subject to large inter-observer variability, especially in nodes <6 mm and in patients with only small nodes of limited value in clinical practices [31,37]. MRI plays an important role in the evaluation of response to neoadjuvant treatment (NT) and the consequences for the final surgical resection. NT is able to downsize the tumour. In particular, large tumours may have been overstaged at the initial MRI.

Sometimes a pushing tumour border seen on primary staging MRI may be mistaken for an infiltrating one. Restaging with MRI after NT may reveal surgical dissection planes which were obscured at the primary staging MRI. As a consequence, surgical planning can be more conservative.

Clinical T and N stage may also alter after NT and allow a change in surgical approach. MRI is furthermore accurately correlated with histopathological down-grading of the tumour. Apart from opening new possibilities for a minimal invasive surgical approach for the very good responders, non-responders can be identified who may require intensification of the treatment plan [38–44].

In order to understand the consequences of NT, it is of crucial importance that radiologists and pathologists participate in the multidisciplinary treatment team.

4. Role of neoadjuvant treatment for the surgeon

The primary objective in rectal cancer surgery is to achieve a free surgical resection margin. The purpose of NT is twofold: first, to sterilise the potential tumour-cell-bearing volume in the pelvis, which is not removed during surgery, more specifically the lateral zones of lymphatic spread; and second, to change the size and stage of the primary rectal cancer in order to facilitate surgical resection and even to allow for more limited surgery. In Japan the lateral lymph nodes are removed as standard procedure during rectal cancer surgery. By doing so, NT can be safely omitted according to the Japanese workers. Comparison between the Japanese results with extended lymphadenectomy and the Dutch TME study (which randomised between TME surgery with and without 5×5 Gy preoperative radiotherapy) showed that 5×5 with standard TME surgery was as effective as extended lateral lymphadenectomy for the prevention of local recurrences [45].

The Swedish Rectal Cancer Trials, the Dutch TME study and the British CRO7 study have clearly demonstrated that preoperative 5×5 Gy followed by immediate surgery (preferably within 1 week) yields excellent oncological results in patients in whom a CRM-negative margin can be achieved [46–49]. A recent update of the third Swedish Rectal Cancer Trial shows that a waiting period after 5×5 Gy short-course radiotherapy effectively reduces postoperative morbidity, while also a down-staging effect was noticed [50].

In contrast, advanced tumours, invading the mesorectal fascia or even penetrating into the surrounding pelvic structures, would inevitably lead to positive surgical margins if the surgeon sticks to the principle of dissection along the mesorectal fascia. These patients require a more extended resection, peripheral to the mesorectal fascia. In the pelvis with organs packed tightly together these extended resections often result in loss of autonomic nerves, other pelvic supporting structures (sacrum, pelvic floor muscles) or organs (bladder, genital organs and ureters). Preoperative treatment with radiotherapy and concomitant chemotherapy can effectively downsize and even down-stage locally advanced tumours and thus take away the threat of an involved margin, allowing for a more preservative approach [51–53]. Whereas the lateral margin is influenced by NT, it is not evident that the distal margin moves upwards, or that it is possible or even wise to perform a low anastomosis in a previously irradiated part of the (ano-)rectum [54,55].

Systemic chemotherapy may also be incorporated into an NT scheme. In metastasised patients it helps to select the responders, who may be good candidates for metastasectomy as well as resection of the primary from those patients who are progressive and would not benefit from extended surgery [56]. The Dutch Colorectal Cancer Group initiated the international RAPIDO study, which seeks to find answers for the question of whether upfront systemic chemotherapy as part of NT can reduce the occurrence of metastases in localised rectal cancer [57].

5. The anatomical surgical approach to localised rectal cancer

The surgical approach is based on the preoperative MRI image and may also take into account the response to neoadjuvant treatment. The resection itself follows anatomical principles and is based on removal of the rectum within its covering mesorectal fascia. In proximal tumours, the distal rectum may be preserved, provided that at least 4–5 cm of the mesorectum is removed distally from the tumour [58]. In low rectal cancers at the anorectal junction or below, depending on the infiltration depth of the tumour, the pelvic floor muscles and external sphincter often need to be removed en bloc with the rectum to assure a complete resection with a CRM of more than 1 mm [10,11].

A secondary objective is to avoid damage to the nerve system as little as possible. The pelvic autonomic nerves consist of a fine network originating around the aorta, which descends as a fine mesh lining the mesorectal fascia. The hypogastric nerves condense and split into two lateral bundles which can easily be identified and followed to the inferior hypogastric plexus. In this area innervation, lymphatic drainage and blood supply mingle in the lateral pillars of the rectum. The nervi erigentes also join the inferior hypogastric plexus from the dorsolateral and also lie in close approximation to the dorsolateral mesorectal fascia. The somatic levator ani and pudendal nerves are protected by the pelvic fascia and are less at risk than the autonomic nerves [59].

The anterior mesorectum distally to the peritoneal reflection is thin, but, similarly to the rest of the mesorectum, is also covered with a fascia-like structure (fascia of Denonvilliers), which allows for dissection of the anterior mesorectal fascia from the prostate/vesicles or posterior vaginal wall [60,61]. More distally, this layer ends and is replaced by intertwining bundles of somatic perineal muscles joining with the smooth muscular layer of the muscularis propria of the anorectum. This organisation of muscle fibres anchors the anorectum to the pelvis. More laterally and dorsally at the level of the sphincters, the adherence of the smooth muscles to the surrounding external sphincter muscles is much more loosely organised. The external sphincter may be considered the distal part of the funnel shaped pelvic floor muscles enveloping the smooth-muscular layer of the internal sphincter. As mentioned above, laterally and dorsally the adherence between internal and external sphincters is low and allows for the development of an intersphincteric resection plane. On the anterior side the somatic pelvic floor muscles, which distally join in a tendinous perineal body, are very adherent to the anterior part of the anal rectum. Therefore no such thing as an intersphincteric dissection plane is present on the anterior side of the distal rectum [62]. This is a very important anatomical fact which influences the way low rectal tumours can be dissected. An abdomino-perineal excision (APE) can be performed in three dissection planes: (1) the intersphincteric plane which is close to the internal sphincter and suitable only for tumours which are confined to the muscularis propria of the rectum; (2) the extralevator plane which

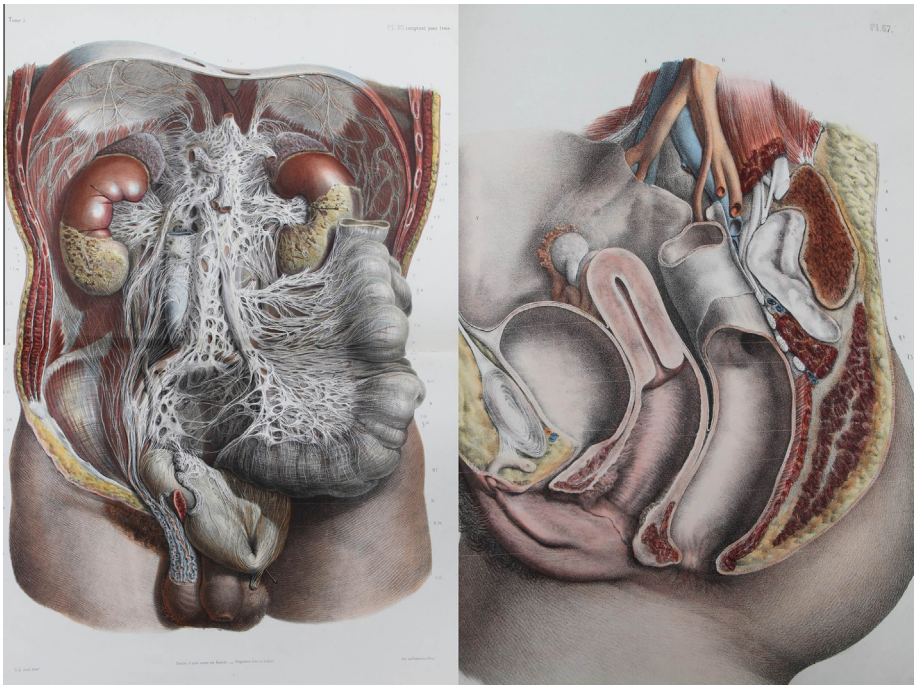

Fig. 4 – Early 19th century anatomical lithography demonstrating the intense autonomous nerve network in the abdomen, illustrating the high risk of surgery to damage the nerves. Furthermore the levator ani muscle can be seen as an envelope around the distal rectum.

follows the external fascia of the external sphincter continuously along the external fascia of the levator ani muscles and transects these muscles as laterally as possible before entering the abdomen; and (3) the ischiorectal plane which also removes the ischiorectal fat and which follows the external fascia of the pelvis, removing the ischiorectal fat en bloc with the levator ani muscles. Again, the abdomen is entered as laterally as possible at the level of the attachment of the levator ani muscles to the pelvic wall see (Fig. 4).

In most distal rectal carcinomas the extralevator abdomino-perineal excision (ELAPE) is recommended to achieve a complete resection with a negative CRM [63]. Either the patient may be operated in a supine position with the legs in movable stirrups, or the patient may be turned to prone position for the perineal resection [64]. When the operation is performed in the supine position the patient does not need to be turned and the procedure can start with either the perineal phase or the abdominal phase.

In the supine position the dissection starts with an incision around and subsequent closure of the anus [10,19] (Fig. 5). The external perineal fascia which covers the external sphincter can be followed up to the lateral attachment of the levator ani to the pelvic sidewall. At this level the levator ani can be cut, exposing the mesorectum. Dorsally, the anococcygeal ligament has to be transected. Depending on the location of the tumour, the presacral space may be entered ventrally to the coccyx, or in dorsally located tumours, the coccyx may be removed to enter the presacral space. After transection of the levator on both sides, exposing the mesorectum and opening the presacral space exposing the dorsal part of the distal mesorectum, the anterior dissection may commence. The anterior part of the levator ani muscle encloses the internal genital organs and needs to be transected at the level of Denonvilliers' fascia. After exposing Denonvilliers' fascia the dissection continues distally; retracting the specimen dorsally helps to identify the somatic perineal muscles, which are closely adherent to the anorectum. The transection takes place in the somatic muscles, avoiding a fausse route into the bowel. If the operation was not started with the abdominal phase, the abdomen is opened now. Dissection is according to TME principles, avoiding nerve damage. As the pelvic floor muscles are already transected, taking out the specimen is a relatively uncomplicated procedure.

If the operation is performed in prone position, the procedure most often starts with the abdominal phase, with the patient lying in supine position [65] (Fig. 6). Again, care must be taken not to push the dissection too deep down because of the risk of coning in, resulting in dissection of the pelvic floor off the mesorectum and subsequent waist formation. However, it is important to develop the presacral space until the os coccygis is exposed. On the lateral side the low hypogastric plexus has to be dissected off the mesorectum and the lateral pillars also have to be transected. Denonvilliers' fascia has to be exposed before the abdominal phase can be ended and the patient can be turned into prone position for the perineal phase.

In prone position a teardrop like incision is made around the anal skin and extended proximally above the ano-coccygeal joint. After closure of the anus, the deep perineal fascia is followed from the external sphincter to the lateral attachments of the levator ani. After the coccyx has been cut, the already opened presacral space is entered and the lateral

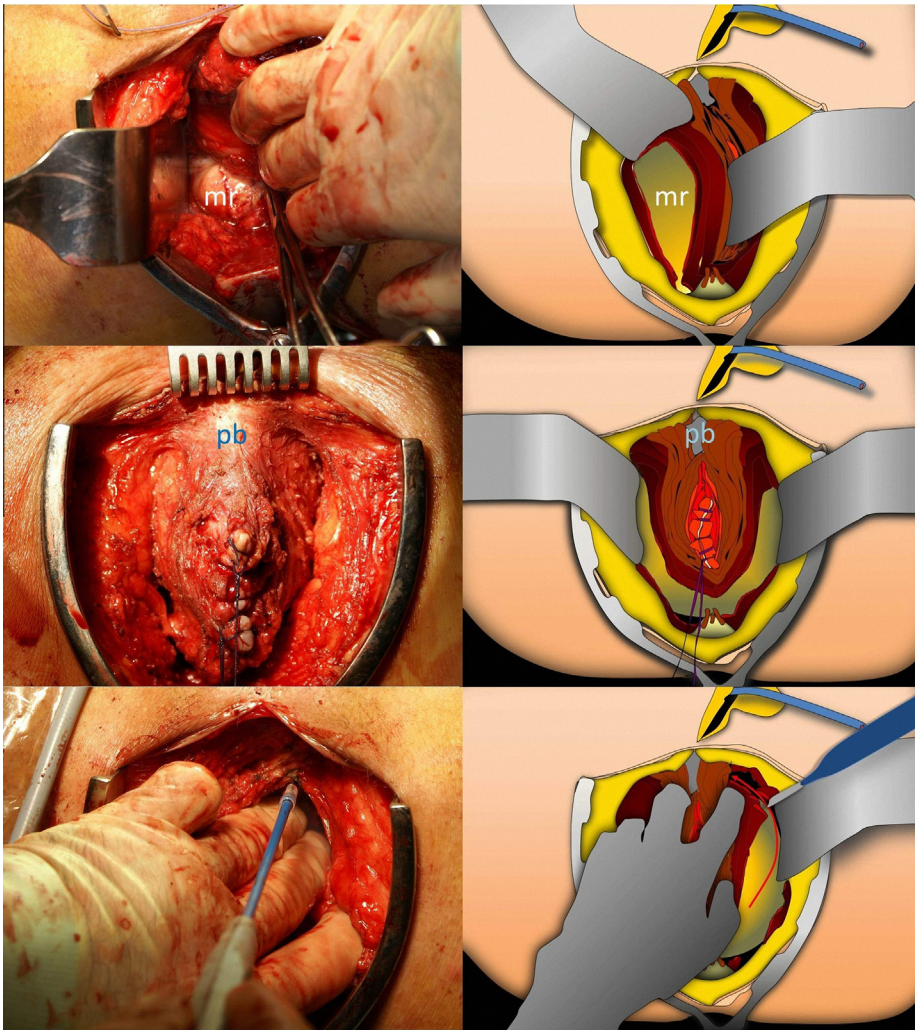

Fig. 5 – Perineal phases of an extralevator abdomino-perineal excision in supine position. mr, mesorectum; pb, perineal body.

attachments of the levator ani can be cut. After arriving at the level of Denonvilliers' fascia, the specimen can be everted through the perineal wound and the dissection of the anterior plane of the specimen commences under direct vision. First, the puborectal sling has to be cut, as also the deep perineal muscles which are closely adherent to the anterior part of the anorectum. Again the dissection is carried out proximally to distally. Cutting the perineal body is the last part of the operation before the specimen is taken out. Care must be taken not to damage the urethra and the neural bundles of Walsh, which are very close to this dissection plane.

In both positions a complete extralevator abdomino-perineal excision can be performed. In prone position visibility of the perineal operating field is better at the cost of a wider incision, which requires closure with a (biological) mesh or musculo-cutaneous flap [9]. In the supine position simultaneous access to the tumour from the abdomen and perineum may be an advantage in more advanced tumours. An intersphincteric or ischiorectal approach is more commonly performed in supine position. In both positions, the abdominal phase may also be performed laparoscopically.

6. Future perspectives

6.1. *Registry*

On a population-based level, outcome of rectal cancer treatment differs not only widely among countries, but also within countries among hospitals and even within hospitals among individual surgeons [18,66–68]. But in the end, the chain of treatments given to an individual patient can be traced back to each individual link of the chain. If the quality of pathology is excellent, it will enable one to unravel the different prognostic variables which apply to an individual patient. Not only can the biology of the tumour be ascertained but also the quality of surgery and the effect of neoadjuvant treatment. Furthermore the anatomical information from the MRI may be linked to the outcome and quality of the surgical procedure.

Registration of these variables will identify the weak links and will allow better quality of the complete chain, improving outcome and reducing the burden of treatment costs for avoidable poor results [69] (Fig. 7).

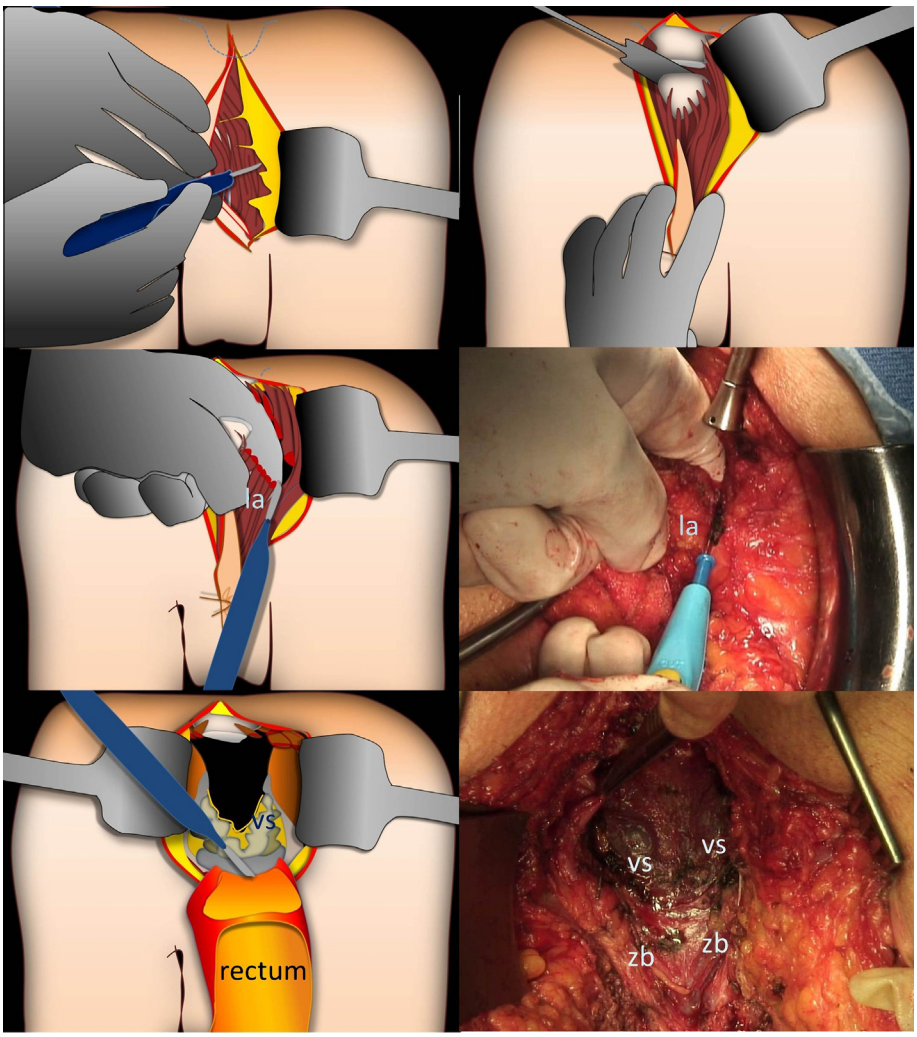

Fig. 6 – Perineal phases of an extralevator abdomino-perineal excision in prone position. La, levator ani muscle; vs, vesiculea seminales; zb, nerve bundles of Walsh.

Localised rectal cancer – but also metastasised rectal cancer – must be treated by a multidisciplinary team. In order to achieve the best quality of treatment, the planning of the treatment and the sequence of the different treatment modalities have to be decided upon before any treatment is given. During a multidisciplinary team meeting (MDT), after the results of imaging and histopathological biopsies have become available, the specific problems of a rectal cancer can be identified and the best approach for the individual patient may be selected, depending on the presence/exclusion of metastatic disease, local extent of the tumour and the patient's condition. It is important for the patient to know who has the role of the director of the treatment. In most cases this responsibility lies with the surgeon, who is responsible not only for the surgery but for all components involved in the treatment planning.

On a local level the use of standard protocols, the registration of the MDT meetings and the registration of the important outcome parameters can help to identify blind spots. These data can constitute the basis for a larger – possibly national – registry [70]. These national registries can be used to compare countries. In Norway, Sweden, Denmark, the UK and the Netherlands mandatory registration has led to almost 100% coverage of the population.

EUROCARE collects colorectal cancer data from all European countries and was able to show large differences in outcome in Europe [66].

A limitation on the overall use of the EUROCARE database is the wide spread in coverage of their populations between the European countries. It is difficult to compare results between countries with coverage of less than 50% and countries with coverage of 100%. Furthermore, the completeness of important clinical data such as stage distribution and cancer subsites varies widely between registries. For example, the United Kingdom had poorer oncological results than France and Germany; however, the UK has coverage of 100% compared with coverage of 18% and 1% respectively for France and Germany. Explaining difference in outcome between countries with different coverage is difficult, particularly when it is unclear whether coverage of less than 50% is representative for the country as a whole.

But then again, there is no need to create a scale of the outcome of different countries. It is more relevant to identify the best practice and to set European guidelines based on the

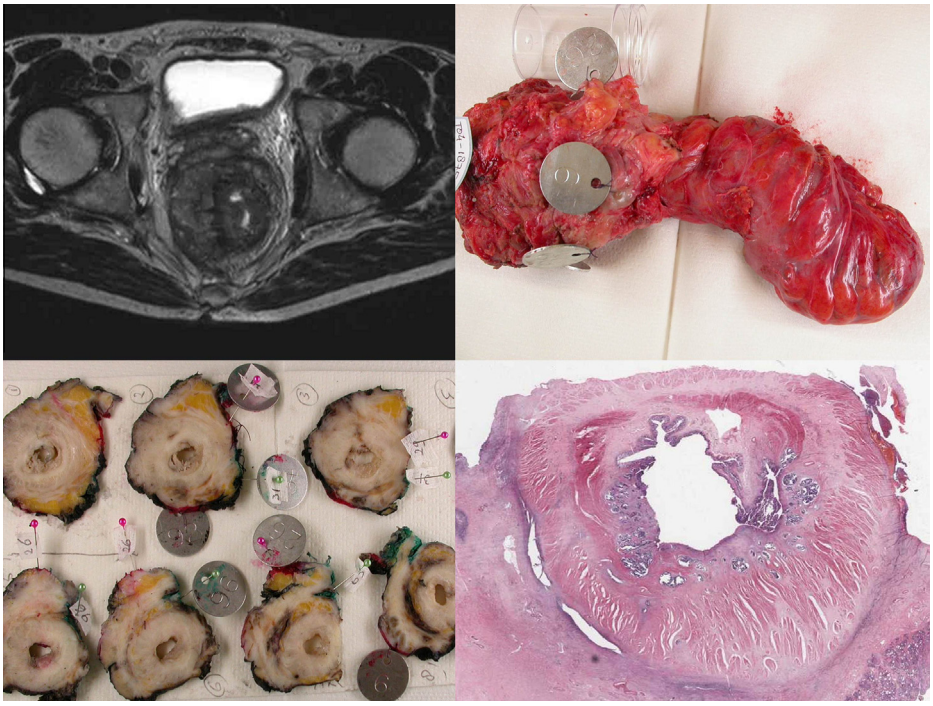

Fig. 7 – Good collaboration of radiologist, surgeon and pathologist enables continuous quality improvement. Good registration is an indispensable prerequisite (http://www.virtualpathology.leeds.ac.uk)

best knowledge available [71,72]. The EURECCA colorectal project, which promotes registry based on consensus and subsequent sharing of data, can lead to a better outcome for rectal cancer patients all over the world [66,73–76].

6.2. *Centralisation*

With the improvement in care during the last decades and the introduction of MDT meetings, the oncological outcome of rectal cancer has greatly improved. Another more recent development and improvement in cancer care is the introduction of centralisation of care for advanced cases and major surgery. In rectal cancer this also plays an important role. In advanced cases the cancer grows through its surrounding fascia into other organs and structures. In those advanced cases, when an exenteration is needed, the resection could consist of an orthopaedic, gynaecological and urological en bloc resection combined with the rectal resection. It is not desirable that such a procedure is performed by multiple surgeons. Therefore the rectal cancer surgeon has to be a complete pelvic surgeon. However, normally these advanced cases have a low incidence in a normal regional hospital. The small numbers increase the risk of performing an irradical resection as the experience with these cases is limited. Centralisation of advanced rectal cancer cases will not only result in less irradical resections but also in better postoperative care. As a hospital treats more advanced cases, all specialties involved in rectal cancer care gain more experience. Furthermore postoperative complications are seen sooner, radiological imaging is interpreted better by the radiologist and pathologists gain more experience with large specimens and the influence of neoadjuvant treatment. All this will result in lower mortality rates and better oncological outcome. Specialisation has led to improved outcome in rectal cancer treatment; how much more this will be true for locally advanced cases requiring more individualised surgery [77–79].

6.3. *Patient reported outcome measures*

Due to the major improvements in therapy and oncological outcome in the last decades, the influence of treatment on the individual patient has become more and more important. Particularly in the last decade, where outcome of a disease is not the only measurement of adequate treatment, there is an increasing interest in the influence of treatment on patients' quality of life (QOL). Most of the studies published on quality of life and rectal cancer use generally used questionnaires such as the sf-36, EORTC QLQ-C30 OR EORTC QLQ-C38. These questionnaires are reliable, valid and responsive, but have not been developed to assess treatment on an individual level [80–82].

The modern rectal cancer patient is confronted with a combination of treatments, all of which will to a certain extent influence his way of living. The patient would probably like to be informed about alternatives in their treatment schedule and about the consequences of their choice.

It is important for future research to focus on different and more interesting patient groups, such as frail and elderly patients. In these patients, it is more likely that the assumed benefits of survival give an increase in morbidity and could have an adverse effect on QOL. Future studies on rectal cancer have not only to focus on the effect of additional treatments on survival, but also the influence of the treatment on QOL. If the treatment results in increase in QOL, is the possible

consequent decrease in QOL worthwhile? It is likely that these studies will make the decision process easier for the involved specialties in the treatment of rectal cancer and will result in a more patient-tailored treatment.

7. Conclusion

Surgery is still the cornerstone of rectal cancer treatment for the time being. Therefore, the surgeon should take the role of the director of the treatment plan, and should realise that surgery is an integral part of a comprehensive multidisciplinary approach. The basis for quality assurance is registration. A modern anatomical surgical approach requires also a modern attitude towards quality assurance and an obligation to keep the patient well informed about the choices which have been made and to allow the patient to have his/her own say in the matter.

Conflict of interest statement

None declared.

REFERENCES

[1] Lange MM, Rutten HJ, van de Velde CJ. One hundred years of curative surgery for rectal cancer: 1908–2008. Eur J Surg Oncol 2009;35:456–63.

[2] Heald RJ, Ryall RD. Recurrence and survival after total mesorectal excision for rectal cancer. Lancet 1986;1(8496):1479–82.

[3] 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(8514):996–9.

[4] den Dulk M, Marijnen CA, Putter H, et al. Risk factors for adverse outcome in patients with rectal cancer treated with an abdominoperineal resection in the total mesorectal excision trial. Ann Surg 2007;246:83–90.

[5] den Dulk M, Putter H, Collette L, et al. The abdominoperineal resection itself is associated with an adverse outcome: the European experience based on a pooled analysis of five European randomised clinical trials on rectal cancer. Eur J Cancer 2009;45:1175–83.

[6] Marr R, Birbeck K, Garvican J, et al. The modern abdominoperineal excision: the next challenge after total mesorectal excision. Ann Surg 2005;242:74–82.

[7] Nagtegaal ID, van de Velde CJ, Marijnen CA, van Krieken JH, Quirke P. Low rectal cancer: a call for a change of approach in abdominoperineal resection. J Clin Oncol 2005;23:9257–64.

[8] How P, Shihab O, Tekkis P, et al. A systematic review of cancer related patient outcomes after anterior resection and abdominoperineal excision for rectal cancer in the total mesorectal excision era. Surg Oncol 2011;20:e149–55.

[9] Holm T, Ljung A, Haggmark T, Jurell G, Lagergren J. Extended abdominoperineal resection with gluteus maximus flap reconstruction of the pelvic floor for rectal cancer. Br J Surg 2007;94:232–8.

[10] Martijnse IS, Dudink RL, West NP, et al. Focus on extralevator perineal dissection in supine position for low rectal cancer has led to better quality of surgery and oncologic outcome. Ann Surg Oncol 2012;19:786–93.

[11] West NP, Finan PJ, Anderin C, Lindholm J, Holm T, Quirke P. Evidence of the oncologic superiority of cylindrical abdominoperineal excision for low rectal cancer. J Clin Oncol 2008;26:3517–22.

[12] West NP, Anderin C, Smith KJ, Holm T, Quirke P. Multicentre experience with extralevator abdominoperineal excision for low rectal cancer. Br J Surg 2010;97:588–99.

[13] Beets-Tan RG, Beets GL, Vliegen RF, et al. Accuracy of magnetic resonance imaging in prediction of tumour-free resection margin in rectal cancer surgery. Lancet 2001;357:497–504.

[14] Brown G, Radcliffe AG, Newcombe RG, Dallimore NS, Bourne MW, Williams GT. Preoperative assessment of prognostic factors in rectal cancer using high-resolution magnetic resonance imaging. Br J Surg 2003;90:355–64.

[15] Radcliffe A, Brown G. Will MRI provide maps of lines of excision for rectal cancer? Lancet 2001;357:495–6.

[16] Nagtegaal ID, van de Velde CJ, van der Worp E, Kapiteijn E, Quirke P, van Krieken JH. Macroscopic evaluation of rectal cancer resection specimen: clinical significance of the pathologist in quality control. J Clin Oncol 2002;20:1729–34.

[17] Nagtegaal ID, Quirke P. What is the role for the circumferential margin in the modern treatment of rectal cancer? J Clin Oncol 2008;26:303–12.

[18] 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;235:449–57.

[19] Martijnse I, West N, Quirke P, Heald R, van de Velde C, Rutten HJ. Will extralevator abdominoperineal excision become the new gold standard? In: Valentini V, Schmoll H-J, van de Velde C, editors. Multidisciplinary management of rectal cancer. New York: Springer; 2012. p. 261–74.

[20] Quirke P, Steele R, Monson J, et al. Effect of the plane of surgery achieved on local recurrence in patients with operable rectal cancer: a prospective study using data from the MRC CR07 and NCIC-CTG CO16 randomised clinical trial. Lancet 2009;373:821–8.

[21] Vliegen R, Dresen R, Beets G, et al. The accuracy of multi-detector row CT for the assessment of tumor invasion of the mesorectal fascia in primary rectal cancer. Abdom Imaging 2008;33:604–10.

[22] Wolberink SV, Beets-Tan RG, Nagtegaal ID, Wiggers T. Preoperative assessment of the circumferential margin in rectal cancer is more informative in treatment planning than the T stage. Tech Coloproctol 2006;10:171–6.

[23] Maizlin ZV, Brown JA, So G, et al. Can CT replace MRI in preoperative assessment of the circumferential resection margin in rectal cancer? Dis Colon Rectum 2010;53:308–14.

[24] Doornebosch PG, Bronkhorst PJ, Hop WC, et al. The role of endorectal ultrasound in therapeutic decision-making for local vs. transabdominal resection of rectal tumors. Dis Colon Rectum 2008;51:38–42.

[25] Extramural depth of tumor invasion at thin-section MR in patients with rectal cancer: results of the MERCURY study. *Radiology* 2007;**243**:132–139.

[26] Merkel S, Mansmann U, Siassi M, et al. The prognostic inhomogeneity in pT3 rectal carcinomas. Int J Colorectal Dis 2001;16:298–304.

[27] Taylor FG, Quirke P, Heald RJ, et al. One millimetre is the safe cut-off for magnetic resonance imaging prediction of surgical margin status in rectal cancer. Br J Surg 2011;98:872–9.

[28] Ptok H, Ruppert R, Stassburg J, et al. Pretherapeutic MRI for decision-making regarding selective neoadjuvant radiochemotherapy for rectal carcinoma: interim analysis of a multicentric prospective observational study. J Magn Reson Imaging 2013;37:1122–8.

[29] Bipat S, Glas AS, Slors FJ, et al. Rectal cancer: local staging and assessment of lymph node involvement with endoluminal US, CT, and MR imaging – a meta-analysis. Radiology 2004;232:773–83.
[30] Lahaye MJ, Engelen SM, Nelemans PJ, et al. Imaging for predicting the risk factors – the circumferential resection margin and nodal disease – of local recurrence in rectal cancer: a meta-analysis. Semin Ultrasound CT MR 2005;26:259–68.
[31] Kim JH, Beets GL, Kim MJ, Kessels AG, Beets-Tan RG. High-resolution MR imaging for nodal staging in rectal cancer: are there any criteria in addition to the size? Eur J Radiol 2004;52:78–83.
[32] Kotanagi H, Fukuoka T, Shibata Y, et al. The size of regional lymph nodes does not correlate with the presence or absence of metastasis in lymph nodes in rectal cancer. J Surg Oncol 1993;54:252–4.
[33] Koh DM, Brown G, Temple L, et al. Rectal cancer: mesorectal lymph nodes at MR imaging with USPIO versus histopathologic findings – initial observations. Radiology 2004;231:91–9.
[34] Lahaye MJ, Engelen SM, Kessels AG, et al. USPIO-enhanced MR imaging for nodal staging in patients with primary rectal cancer: predictive criteria. Radiology 2008;246:804–11.
[35] Lambregts DM, Beets GL, Maas M, et al. Accuracy of gadofosveset-enhanced MRI for nodal staging and restaging in rectal cancer. Ann Surg 2011;253:539–45.
[36] Lambregts DM, Beets GL, Maas M, et al. Tumour ADC measurements in rectal cancer: effect of ROI methods on ADC values and interobserver variability. Eur Radiol 2011;21:2567–74.
[37] Brown G, Richards CJ, Bourne MW, et al. Morphologic predictors of lymph node status in rectal cancer with use of high-spatial-resolution MR imaging with histopathologic comparison. Radiology 2003;227:371–7.
[38] Patel UB, Taylor F, Blomqvist L, et al. Magnetic resonance imaging-detected tumor response for locally advanced rectal cancer predicts survival outcomes: MERCURY experience. J Clin Oncol 2011;29:3753–60.
[39] Patel UB, Brown G, Rutten H, et al. Comparison of magnetic resonance imaging and histopathological response to chemoradiotherapy in locally advanced rectal cancer. Ann Surg Oncol 2012;19:2842–52.
[40] Vliegen RF, Beets GL, Lammering G, et al. Mesorectal fascia invasion after neoadjuvant chemotherapy and radiation therapy for locally advanced rectal cancer: accuracy of MR imaging for prediction. Radiology 2008;246:454–62.
[41] Patel UB, Blomqvist LK, Taylor F, et al. MRI after treatment of locally advanced rectal cancer: how to report tumor response – the MERCURY experience. AJR Am J Roentgenol 2012;199:W486–95.
[42] Lahaye MJ, Beets GL, Engelen SM, et al. Locally advanced rectal cancer: MR imaging for restaging after neoadjuvant radiation therapy with concomitant chemotherapy. Part II. What are the criteria to predict involved lymph nodes? Radiology 2009;252:81–91.
[43] Barbaro B, Fiorucci C, Tebala C, et al. Locally advanced rectal cancer: MR imaging in prediction of response after preoperative chemotherapy and radiation therapy. Radiology 2009;250:730–9.
[44] Barbaro B, Vitale R, Leccisotti L, et al. Restaging locally advanced rectal cancer with MR imaging after chemoradiation therapy. Radiographics 2010;30:699–716.
[45] Kusters M, Beets GL, van de Velde CJ, et al. A comparison between the treatment of low rectal cancer in Japan and the Netherlands, focusing on the patterns of local recurrence. Ann Surg 2009;249:229–35.
[46] Folkesson J, Birgisson H, Pahlman L, et al. Swedish Rectal Cancer Trial: long lasting benefits from radiotherapy on survival and local recurrence rate. J Clin Oncol 2005;23:5644–50.
[47] Sebag-Montefiore D, Stephens RJ, Steele R, et al. Preoperative radiotherapy versus selective postoperative chemoradiotherapy in patients with rectal cancer (MRC CR07 and NCIC-CTG C016): a multicentre, randomised trial. Lancet 2009;373:811–20.
[48] van Gijn W, Marijnen CA, Nagtegaal ID, et al. Preoperative radiotherapy combined with total mesorectal excision for resectable rectal cancer: 12-year follow-up of the multicentre, randomised controlled TME trial. Lancet Oncol 2011;12:575–82.
[49] Martling A, Holm T, Johansson H, Rutqvist LE, Cedermark B. The Stockholm II trial on preoperative radiotherapy in rectal carcinoma: long-term follow-up of a population-based study. Cancer 2001;92:896–902.
[50] Pettersson D, Glimelius B, Iversen H, et al. Impaired postoperative leucocyte counts after preoperative radiotherapy for rectal cancer in the Stockholm III Trial. Br J Surg 2013;100:969–75.
[51] Sauer R, Liersch T, Merkel S, et al. Preoperative versus postoperative chemoradiotherapy for locally advanced rectal cancer: results of the German CAO/ARO/AIO-94 randomized phase III trial after a median follow-up of 11 years. J Clin Oncol 2012;30:1926–33.
[52] Bosset JF, Calais G, Mineur L, et al. Enhanced tumorocidal effect of chemotherapy with preoperative radiotherapy for rectal cancer: preliminary results – EORTC 22921. J Clin Oncol 2005;23:5620–7.
[53] Valentini V, van Stiphout RG, Lammering G, et al. Nomograms for predicting local recurrence, distant metastases, and overall survival for patients with locally advanced rectal cancer on the basis of European randomized clinical trials. J Clin Oncol 2011;29:3163–72.
[54] Bujko K, Nowacki MP, Nasierowska-Guttmejer A, et al. Long-term results of a randomized trial comparing preoperative short-course radiotherapy with preoperative conventionally fractionated chemoradiation for rectal cancer. Br J Surg 2006;93:1215–23.
[55] Bujko K, Kepka L, Michalski W, Nowacki MP. Does rectal cancer shrinkage induced by preoperative radio(chemo)therapy increase the likelihood of anterior resection? A systematic review of randomised trials. Radiother Oncol 2006;80:4–12.
[56] van Dijk TH, Tamas K, Beukema JC et al. Evaluation of short-course radiotherapy followed by neoadjuvant bevacizumab, capecitabine, and oxaliplatin and subsequent radical surgical treatment in primary stage IV rectal cancer. *Ann Oncol* 2013; (in press).
[57] RAPIDO. 2013. http://www.dccg.nl/node/99.
[58] Law WL, Chu KW. Anterior resection for rectal cancer with mesorectal excision: a prospective evaluation of 622 patients. Ann Surg 2004;240:260–8.
[59] Wallner C, Lange MM, Bonsing BA, et al. Causes of fecal and urinary incontinence after total mesorectal excision for rectal cancer based on cadaveric surgery: a study from the Cooperative Clinical Investigators of the Dutch total mesorectal excision trial. J Clin Oncol 2008;26:4466–72.
[60] Lindsey I, Guy RJ, Warren BF, Mortensen NJ. Anatomy of Denonvilliers' fascia and pelvic nerves, impotence, and implications for the colorectal surgeon. Br J Surg 2000;87:1288–99.
[61] Lindsey I, Warren BF, Mortensen NJ. Denonvilliers' fascia lies anterior to the fascia propria and rectal dissection plane in total mesorectal excision. Dis Colon Rectum 2005;48:37–42.

[62] Stelzner S, Holm T, Moran BJ, et al. Deep pelvic anatomy revisited for a description of crucial steps in extralevator abdominoperineal excision for rectal cancer. Dis Colon Rectum 2011;54:947–57.
[63] Stelzner S, Koehler C, Stelzer J, Sims A, Witzigmann H. Extended abdominoperineal excision vs. standard abdominoperineal excision in rectal cancer – a systematic overview. Int J Colorectal Dis 2011;26:1227–40.
[64] Holm T. Abdominoperineal resection revisited: is positioning an important issue? Dis Colon Rectum 2011;54:921–2.
[65] Shihab OC, Heald RJ, Holm T, et al. A pictorial description of extralevator abdominoperineal excision for low rectal cancer. Colorectal Dis 2012;14:e655–60.
[66] Brenner H, Bouvier AM, Foschi R, et al. Progress in colorectal cancer survival in Europe from the late 1980s to the early 21st century: the EUROCARE study. Int J Cancer 2012;131:1649–58.
[67] Porter GA, Soskolne CL, Yakimets WW, Newman SC. Surgeon-related factors and outcome in rectal cancer. Ann Surg 1998;227:157–67.
[68] Richardson DP, Porter GA, Johnson PM. Surgeon knowledge contributes to the relationship between surgeon volume and patient outcomes in rectal cancer. Ann Surg 2013;257:295–301.
[69] Pahlman L, Bohe M, Cedermark B, et al. The Swedish rectal cancer registry. Br J Surg 2007;94:1285–92.
[70] van Gijn W, van de Velde CJ. Improving quality of cancer care through surgical audit. Eur J Surg Oncol 2010;36(Suppl 1):S23–6.
[71] Taylor I, Van DV, van GW. A consensus approach to rectal cancer management. Eur J Surg Oncol 2010;36:111–3.
[72] van Gijn W, Wouters MW, Peeters KC, van de Velde CJ. Nationwide outcome registrations to improve quality of care in rectal surgery. An initiative of the European Society of Surgical Oncology. J Surg Oncol 2009;99:491–6.
[73] van de Velde CJ, Aristei C, Boelens PG, Beets-Tan RG, Blomqvist L, Borras JM, et al. EURECCA colorectal: Multidisciplinary mission statement on better care for patients with colon and rectal cancer in Europe. Eur J Cancer 2013;49:2784–90.
[74] Valentini V, Aristei C, Glimelius B, et al. Multidisciplinary rectal cancer management: 2nd European Rectal Cancer Consensus Conference (EURECA-CC2). Radiother Oncol 2009;92:14863.
[75] Valentini V, van Stiphout RG, Lammering G, et al. Nomograms for predicting local recurrence, distant metastases, and overall survival for patients with locally advanced rectal cancer on the basis of European randomized clinical trials. J Clin Oncol 2011;29:3163–72.
[76] van Gijn W, van den Broek CB, Mroczkowski P, et al. The EURECCA project: data items scored by European colorectal cancer audit registries. Eur J Surg Oncol 2012;38:467–71.
[77] Borowski DW, Kelly SB, Bradburn DM, et al. Impact of surgeon volume and specialization on short-term outcomes in colorectal cancer surgery. Br J Surg 2007;94:880–9.
[78] Borowski DW, Bradburn DM, Mills SJ, et al. Volume-outcome analysis of colorectal cancer-related outcomes. Br J Surg 2010;97:1416–30.
[79] McArdle CS, Hole DJ. Influence of volume and specialization on survival following surgery for colorectal cancer. Br J Surg 2004;91:610–7.
[80] Orsini RG, Thong MS, van de Poll-Franse LV, et al. Quality of life of older rectal cancer patients is not impaired by a permanent stoma. Eur J Surg Oncol 2013;39:164–70.
[81] Rauch P, Miny J, Conroy T, Neyton L, Guillemin F. Quality of life among disease-free survivors of rectal cancer. J Clin Oncol 2004;22:354–60.
[82] Vironen JH, Kairaluoma M, Aalto AM, Kellokumpu IH. Impact of functional results on quality of life after rectal cancer surgery. Dis Colon Rectum 2006;49:568–78.