Pelvic radiological imaging: a surgeon’s perspective

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Abstract

Radiological imaging of the pelvis adds an important dimension to our understanding of rectal and perianal disease. By integrating relevant information obtained from these investigations into planning and conduct of surgical procedures, outcomes for patients may be optimised. This review focuses on three areas from a clinical viewpoint. (1) With the increased use of neoadjuvant treatments pretherapeutic staging strategies become central to the management of rectal cancer patients. At present, transrectal ultrasound (TRUS), computerised tomography and magnetic resonance imaging (MRI) serve in combination to provide the essential informations. (2) The advent of endoanal ultrasound and MRI in the diagnostic workup of patients with faecal incontinence has caused a paradigm shift both conceptually and in the way treatments are tailored to individual patients. (3) Concerning primary perianal fistulas there is little place for endoanal ultrasound or MRI. However, when a recurrent or Crohn’s fistula is present, a combination of surgical exploration with either endoanal ultrasound or MRI depending on local expertise and availability may be the optimal approach to maximise benefit for these patients.

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1. Introduction

Radiological imaging of the pelvis adds an important dimension to our understanding of rectal and perianal disease. While the combination of a thorough physical exam with a good medical history complemented by endoscopy will provide sufficient information for clinical decision making in many cases, a good deal of relevant information may remain hidden. With the development of advanced endoluminal ultrasound and MRI techniques the anatomical structures in the pelvis, especially the rectum and pelvic floor muscles, may be imaged in great detail both in static and dynamic fashion. For the surgeon or physician treating patients with disorders in that area it is vital to have a thorough knowledge and understanding of the capabilities of these imaging methods. Close collaboration with the radiologist is required and the clinician also needs to be able to interpret the images properly. The surgeon then can use this additional information for the planning and conduct of surgical procedures. Thereby outcomes for patients may be optimised. This review will focus on three areas considered relevant in this context from a clinical viewpoint by the author, namely rectal cancer, faecal incontinence, and perianal fistula.

2. Rectal cancer

Surgical treatment of rectal cancer aims to remove the disease in the pelvis adequately, cause minimal complications and morbidity, and achieve acceptable functional results. Maintenance of transanal defaecation and continence has been of major concern both for patients and surgeons. However, because of the narrow confines of the bony pelvis this tumour represents a major challenge for the surgeon. In contrast to cancers situated in the colon risk of local relapse is much higher. This is mainly caused by tumour-specific factors but is also influenced by the surgeon [1]. The failure of rectal cancer to spread intramurally beyond the distal palpable tumour border to a significant degree [2,3] has led to narrow longitudinal resection margins. Using mechanical stapling devices and surgical techniques such as...
intersphincteric resection with coloanal anastomosis [4], the anal sphincters may be preserved in most cancers of the middle rectal third. Total mesorectal excision has become widely accepted as a standard procedure for mid and low rectal tumours leading both to low rates of locoregional failure [5] and improved survival compared to conventional surgery [6].

2.1. Perioperative radiotherapy

In addition to advances in surgical technique peroperative radiotherapy has been shown to substantially reduce local recurrence rates. According to the 1990 National Institutes of Health Consensus Conference recommendations [7] patients with advanced tumours should receive adjuvant treatment. This concerns either cancers with invasion beyond the bowel wall or those with involved lymph nodes. Postoperative radiotherapy has the risk of injuring residual healthy bowel and thereby impairing function and employs higher doses of radiation, whereas neoadjuvant treatment allows resection of the irradiated bowel and the use of smaller doses. Both conventional radiotherapy using 40–50.4 Gy [8,9] and the short-course regimen employing 25 Gy in 1 week preoperatively [10,11] have been shown to be highly effective in reducing local recurrence rate. The Swedish Rectal Cancer Trial to date has been the only randomised study to demonstrate improved survival in the radiotherapy group as well. While the earlier trials have been criticised for high local recurrence rates in the surgery only arms indicating suboptimal surgical technique, the Dutch Trial [11] has used rigorous quality control measures both for surgery and histopathology. The local recurrence rate at 2-year follow-up was reduced from 8.2% in the surgery-only group to 2.4% in the radiotherapy-plus surgery group. Unfortunately, in both the Swedish and Dutch trials only clinical staging was used, which led to approximately 30% of patients receiving radiotherapy unnecessarily. From these data, it is clear that in order to limit neoadjuvant treatment to patients who may benefit most from this treatment, accurate pretherapeutic staging information is required.

2.2. Local staging

Clinical staging by digital palpation will accurately stage only 67–83% of accessible lesions [12]. The introduction of transrectal ultrasound (TRUS) has improved the ability to delineate the layers of the rectal wall and identify enlarged mesorectal lymph nodes. Thereby more accurate T and N categories may be obtained improving treatment allocation. The literature demonstrates the accuracy of TRUS in the T staging of rectal carcinoma to range from 80 to 95% [12–14] compared with CT (65–75%) and magnetic resonance imaging (MRI; 75–85%) accuracy [13–19]. However, lymph node staging is relatively inaccurate, with TRUS returning correct predictions in approximately 70–75% [13,14,17,19–27] compared with CT (55–65%) [18,19] and MRI (60–65%) [16–18]. In contrast, when assessing infiltration into adjacent structures for locally advanced tumours, high-resolution MRI was shown to be superior to CT with sensitivities of 97% vs. 70%, specificities of 98% vs. 85% and accuracies of 80% vs. 19%, respectively [28]. The error most frequently made on CT was the false-positive prediction of pelvic floor and piriform muscle invasion, and the false-negative prediction concerning sacral bone invasion.

2.3. Surgical aspects

From a surgical perspective, rectal cancer does not represent a single entity but depending on its location within the rectum (anterior–posterior, lower–middle–upper third) specific aspects need to be addressed. At operation, the rectum and surrounding mesorectum are mobilised as a “package” by sharp dissection along embryologically predefined planes taking care not to breach the mesorectal surface fascia. Margins of safety not only exist along the length of the bowel (longitudinal margin), but also at the periphery, i.e., the surface of the resected specimen (circumferential margin). When a total mesorectal excision operation is performed, tumour in close proximity to this latter margin indicates advanced disease with increased risk of systemic relapse and death rather than inadequate local surgery. These patients with an involved margin may die from distant disease before local recurrence becomes apparent [29]. As the mesorectum envelopes the rectum mainly posteriorly and laterally with only a thin layer anteriorly, transmural penetration is of variable significance from a technical and management point of view. While in the middle rectal third extramural penetration of 1 cm into the fatty tissue dorsally usually will not preclude a radical resection, an identical depth at anterior position may already represent T4 disease.

2.4. Assessment of the circumferential margin

MRI with a phased-array coil may be used not only for preoperative staging but also for prediction of the distance of the tumour from the circumferential resection margin in a total mesorectal excision operation. In one study, only moderate accuracy and reproducibility for predicting the tumour stage of rectal cancers was shown [30]. The clinically more important circumferential resection margin, however, could be predicted with high accuracy and consistency. Employing this technique, a histological distance of at least 1.0 mm (i.e., a clear circumferential margin) can be predicted with high confidence when the measured distance on MRI is at
least 5.0 mm. This allows for preoperative identification of patients at risk of recurrence who might benefit from preoperative radiotherapy, more extensive surgery, or both.

2.5. The distal tumour

In addition, with tumours situated below 8 cm from the anal verge (i.e. in the distal rectal third) a number of special problems arise. The mesorectum tapers out distally leaving the last few centimetres of rectum above the anorectal junction covered only by connective tissue. This provides only a narrow margin of safety circumferentially. Accordingly, it is of importance to know before the operation the depth of tumour invasion into bowel wall and beyond, especially close to the anorectal junction. Digital examination and functional proctoscopy give only indirect evidence regarding infiltration of the levators and the anal canal [31,32]. Endorectal ultrasound examination may yield more precise information. It has been shown that in addition to circumferential invasion distal longitudinal spread of rectal cancer can be accurately determined by TRUS [33], and a recent study in 38 cases of low rectal cancer has demonstrated that anal sphincter infiltration can also be diagnosed with an accuracy of 92% [34]. Similar accuracy may also be obtained by double-contrast MRI studies. Urban et al. studied 61 patients with histologically proven primary adenocarcinoma of the lower or middle third of the rectum using a circular polarised flexible surface coil. Anal sphincter infiltration was predicted correctly in a high proportion of cases, with a specificity of 98% and a sensitivity of 100%. In the determination of tumour infiltration into adjacent organs, the specificity was 100% and the sensitivity was 90%, with surgical and histopathologic findings serving as standard [35].

2.6. Early rectal cancer

While the aforementioned aspects are true for most rectal cancers, there remains a subgroup of patients with small, early invasive lesions, where transanal resection may be used as definitive therapy. TRUS here is the preferred staging modality. Lesions are required to be T1, with favourable histology (low grade, absence of vessel invasion), as with the inclusion of T2 cancers local recurrence rates may increase up to 18% [36]. Justification for this concept is a low risk of clinically non-apparent, synchronous lymph node involvement. Recently, a large study from the Mayo Clinic [37] has demonstrated that this risk varies depending on the site of tumour in the rectum, depth of invasion into the submucosa expressed as "sm" levels according to the Japanese classification [38], and lymphovascular invasion. Hence, T1 rectal cancers situated in the lower third, with sm3 depth of invasion, and lymphovascular invasion should undergo an oncologic resection.

2.7. Cost-effectiveness and impact on treatment plans

Apart from being accurate, staging strategies also need to be cost-effective. Therefore, in a recent study, three staging strategies in the evaluation of non-metastatic rectal cancer were compared using a computerised decision model: abdominal and pelvic CT vs. abdominal CT plus TRUS vs. abdominal CT and pelvic MRI [39]. Only carcinomas at more than 4 cm distance from the anal verge were considered. Based on Medicare reimbursements abdominal CT plus TRUS proved to be the most cost-effective staging strategy. The authors conclude that staging strategies incorporating TRUS improve treatment allocation by achieving more accurate T staging, thereby optimising the benefit of preoperative radiotherapy to more advanced tumours.

With the preferential use of preoperative radiation therapy for advanced tumours extended pretherapeutic staging of rectal cancer may also alter treatment plans: In order to determine the impact of preoperative staging on the management of rectal cancer, 80 consecutive patients with newly diagnosed rectal cancer were prospectively evaluated by Harewood et al. [40]. Patients received a CT scan and TRUS with/without fine needle aspiration (FNA) biopsy of mesorectal lymph nodes by blinded investigators. Surgical consultation took place afterwards with only results of CT scans available. A treatment plan was made, then the TRUS result was revealed and a second (modified) treatment plan made. In this series, TRUS staging information changed the surgeon’s original treatment plan based on CT alone in 31% of patients and lead to more frequent use of neoadjuvant radiotherapy. FNA changed management in only one patient. Accuracy for T category was 91% (TRUS) and 71% (CT) (P ≤ 0.02), whereas for N staging there was no difference (76% CT; 82% TRUS; 76% TRUS/FNA).

In conclusion, with the increased use of neoadjuvant treatments pretherapeutic staging strategies become central to the management of rectal cancer patients. At present, TRUS, CT and MRI serve in combination to provide the essential informations.

3. Faecal incontinence

3.1. Clinical background

The maintenance of continence depends on the balance between bowel and anal sphincter function. Until now, most of the diagnostic interest in patients with incontinence has focused on the anal sphincter. Early studies established the presence of abnormal
pudendal nerve function [41] and electromyographic abnormalities [42] in many patients with faecal incontinence, with progressive weakness of the external sphincter believed to relate to denervation. Histological studies showed increased fibrous connective tissue and degenerative changes in both the striated external [43] and the smooth internal sphincter muscles [44,45].

Evidence also exists to suggest that there may be an abnormality of colonic or rectal function in patients with faecal incontinence. Rectal sensation is impaired in patients with isolated neurogenic incontinence [46]. In addition, external sphincter muscle recruitment during rises in intra-abdominal pressure is diminished in patients with incontinence, suggesting an impairment of sacral reflex arcs [47]. The incidence of abnormally increased bowel frequency and loose bowel actions is greater in patients with incontinence [48] suggesting an associated change in bowel motility, or an inability to suppress colonic activity due to impaired sphincter function. Faecal urgency can also be associated with external anal sphincter structural damage [49], suggesting that a strong sphincter can oppose or suppress high-pressure colonic activity, or even cause retrograde peristalsis if defaecation is resisted [50,51].

Finally, prolonged ambulatory colonic motility studies have demonstrated that patients with faecal incontinence may have a widespread disturbance of gut function. Urge incontinence, an urge to defaecate, and defaecation can all be associated with identical high-amplitude propagated pressure waves [52].

3.2. Detection of structural damage

The development of endoanal ultrasonography has revealed structural sphincter damage in up to 90 percent of patients presenting with incontinence [53–55]. However, there remains a proportion in whom the sphincters are intact, albeit sometimes weak. In some of these, there is an obvious neuropathy present.

3.3. MRI of the pelvic floor

Recently, MRI of the pelvic floor and anal sphincter muscles using an endoanal coil has been applied to study the integrity of the sphincters. Studies have established age- and sex-related differences [56,57] and correlated findings with histopathology from biopsies obtained at operation [58]. A strong correlation was established between cross-sectional area of external sphincter as measured in the midecrinal plane and squeeze pressure [59]. The external anal sphincter muscle and pelvic floor muscles are clearly visualised and muscle atrophy may be detected [60]. Detection of sphincter defects may be facilitated due to the high intrinsic contrast resolution and the high spatial resolution. MRI has been reported to be superior to ultrasound in diagnosing external sphincter defects [61], but others have found it to be inferior in diagnosing internal anal sphincter defects and atrophy [62]. In future, integrated approaches combining endoanal MRI and dynamic MR proctography may further aid in assessment of global pelvic floor anatomy and dynamics [63].

3.4. Clinical implications

Faecal incontinence is a troublesome condition. It may have various causes, but trauma sustained during vaginal delivery is the most common. It is generally thought that this damage also extends to the innervation of the pelvic floor muscles. Risk factors include a prolonged second stage of labour, delivery of a large baby, and use of forceps [64]. Use of endoanal ultrasound has revolutionised the assessment of sphincter injuries. Previously, many patients thought to be incontinent due to diffuse sphincter weakness and pudendal neuropathy in the absence of an obvious perineal scar at digital examination and low pressures at manometry would have undergone postanal repair [65]. Now, in a substantial proportion of these patients, structural damage may be identified and these will be offered a direct sphincter repair with good medium-term results [66]. Endoanal MRI has revealed that there may be coexistence of external sphincter atrophy in a proportion of incontinent patients and these may have a poor outcome after sphincter repair [67]. Patients may also have isolated internal anal sphincter atrophy [68], which is not amenable to direct surgical repair. For patients without any identifiable structural defect but diffuse weakness or those who have failed previous attempts at repair stimulated graciloplasty or an artificial sphincter [69], or transsacral nerve stimulation techniques [70] may be used.

In conclusion, the advent of endoanal ultrasound and MRI in the diagnostic workup of patients with faecal incontinence has caused a paradigm shift both conceptually and in the way treatments are tailored to individual patients.

4. Anal fistula

4.1. Clinical background

Perianal fistula is commonly thought to arise from cryptoglandular inflammation [71]. The resulting intersphincteric abscess tracks along lymph channels and connective tissue strands to the surface. Following spontaneous perforation of the skin or surgical drainage of an abscess a chronic tract may persist that crosses the anal sphincter mechanism at various levels. In addition, secondary tracts may form. When these traverse to the contralateral side this is termed a horseshoe extension.
Such complicated and recurrent fistulas are called complex fistulas. The Parks classification is often used to stage perianal fistulas. It describes the relation of the fistula to the anal sphincter muscles and uses the external sphincter as central point of reference [72]. Most perianal fistulas are idiopathic but do occur in up to 43% of patients with Crohn’s disease in referral populations (Refs. 1–10 in [73]).

The majority of anal fistulas have a simple fistula tract that is easily identified during surgery. High-cure rates may be achieved with procedures that have minimal consequences for the continence mechanism [74]. However, when a complex or recurrent fistula is present, surgical exploration may be made more difficult by scar tissue. Failure to assess and treat these fistulas adequately may lead to a high recurrence rate [75]. Diagnostic studies capable of correct identification of both primary and secondary tracts may, therefore, improve surgical treatment of these fistulas.

4.2. Radiological assessment

Although digital examination and probing is considered as gold standard, its accuracy is limited [76], especially when scarring and fibrosis are present. Fistulography and CT scanning are relatively unreliable, but diagnostic accuracy of MRI is reported to range from 76 to 100% [77–79]. Similar results have been reported for endoanal ultrasonography (EUS). In direct comparison, EUS and endocoil MRI show similar accuracy [80,81], while others found MRI [82] or EUS [83] to be superior. In these studies, surgical exploration was used as the gold standard. However, MRI may be better than surgical exploration regarding prediction of patient outcome [84] and in one study it has been shown to provide important additional information in 21% of patients, with the greatest benefit in Crohn’s cases (40%) and recurrent fistulas (24%), but only minor advantage in patients with primary fistulas (8%) [85]. Another study also addressed the impact of having an MR image available during operation for recurrent fistula and an even greater benefit was observed [86]. Having performed an examination under anaesthesia with treatment of fistula tracts as required in 71 patients, surgeons were confronted with an MRI that had been obtained prior to surgery. When there was a disagreement between intraoperative findings and MRI (31 patients; 57%), surgery continued at the discretion of the surgeon. All further recurrences were at the site predicted by MRI and recurrence rate was 16% for surgeons always acting on MRI and 57% for those who ignored imaging (P = 0.008). In other words, MRI reduced the risk for further recurrence by 75%. Therefore, the authors concluded that MRI should be done in all patients with recurrent fistula.

When comparing endoanal ultrasound, MR imaging and examination under anaesthesia in patients with Crohn’s disease, all three modalities showed an accuracy greater than 85%, but when any two tests were combined, accuracy was 100% [87]. In Crohn’s patients, the optimal approach may, therefore, be combining any two of these three methods depending on local expertise.

In conclusion, concerning primary perianal fistulas there is little place for endoanal ultrasound or MR imaging. However, when a recurrent or Crohn’s fistula is present, a combination of surgical exploration with either EUS or MRI depending on local expertise and availability may be the optimal approach to maximise benefit for these patients.

References


