RECTAL CANCER STAGING WITH HIGH-RESOLUTION 3D IMAGING SEQUENCES

T. Baumann[1], M. Treier[1], A. zur Hausen[2], M. Langer[1], and A-O. Schäfer[1]

[1]Department of Diagnostic Radiology, University Hospital Freiburg, Freiburg, Germany, [2]Department of Pathology, University Hospital Freiburg, Freiburg, Germany

INTRODUCTION

The introduction of total mesorectal excision (TME) and neoadjuvant chemoradiotherapy have further promoted pelvic MRI as the staging procedure of choice in rectal cancer [1]. Circumferential resection margin (CRM), local T-stage and nodal stage are the most important factors influencing therapy and outcome, but the optimal imaging protocol to accurately assess these image features is yet under debate [2]. Although the necessity to perform high-resolution T2-weighted imaging is commonly accepted, clinical data with an image slice thickness of less than 3mm is not yet available. In this study we therefore sought to evaluate thin-slice, high-resolution pelvic MRI with 3D sequences for rectal cancer staging with a focus on detection of nodal disease and the diagnostic value of contrast enhanced imaging.

METHODS

61 patients (22 women; 39 men) with histologically proven adeno-carcinoma of the rectum (mean age, 62.1; age range, 24 – 82) were examined. 37 of these patients had received neoadjuvant chemoradiotherapy before the examination. All MRI studies were performed on 1.5 T whole-body MR systems (Magnetom Symphony or Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany) using the following protocol: Patients received rectal filling with 150ml tap water and intravenous injection of butylscopolamin as antiperistaltic agent. First, a 3D Constructive Interference Steady State (CISS) sequence was obtained, followed by a 3D Volumetric Interpolated Breath Hold Examination (VIBE) sequence after injection of 20ml gadobenate dimeglumine. Sequence parameters for the 3D CISS sequence are given as follows: TR/TE, 10.2/4.38ms; slice thickness, 2mm; slices per slab, 64; matrix, 512 x 256; FOV, $(250 \times 235)mm^2$; flip angle, 70°; bandwidth, 130Hz/pixel; acquisition time, 5:24min. Sequence parameters for the VIBE sequence are given as follows: TR/TE, 8.30/3.23ms; slice thickness, 2 mm; slices per slab, 64; matrix, 512 x 256; FOV, $(250 \times 235)mm^2$; flip angle, 25°; bandwidth, 150 Hz/pixel; averages, 4; chemical fat saturation; acquisition time, 4:57 min. CISS and VIBE images were reviewed separately by three radiologists with 1, 3, and 8 years experience in pelvic MRI (readers 3, 2, 1, respectively). T-stage, CRM infiltration, size of each visible lymph node, and the presence of at least one inhomogeneous or irregularly defined lymph node (CISS) or a node with peripheral enhancement (VIBE) were recorded. Histopathology served as the standard of reference for all patients. The detailed lymph node measurements were used to compute the maximum, average, and accumulated diameters and the number of nodes on a per-patient basis. Data were analyzed by receiver-operator-characteristic (ROC) analysis and Wilcoxon's signed rank test.

RESULTS

Histopathology revealed 24, 30 and 7 patients with T2, T3 and T4 disease, respectively. Lymph node metastases were found in 31 patients and a positive CRM was present in 6 patients. Figure 1 shows exemplary images of both sequences. For T-staging no significant differences between CISS and VIBE images could be noted for any reader, but accuracy for T-stage was reduced in patients with prior chemoradiotherapy (Tab. 1). Furthermore, the staging accuracy was strongly influenced by observer experience. Both sequences allowed excellent detection of CRM involvement with a mean sensitivity of 100 ± 0% and mean specificity of 92.1 ± 1.1% for both sequences and without notable differences between the observers. Readers 1 to 3 found 499, 438, and 432 visible lymph nodes on CISS images and 322, 282, and 215 nodes on VIBE images, respectively. Paired comparison revealed significant differences for maximum, mean and accumulated diameters and number of nodes between both sequences on a per-patient basis. ROC analysis revealed an area-under-the-curve (AUC) that was significantly higher than 0.5 for all criteria except for the number of nodes (Fig. 2). For the remaining criteria, CISS exhibited significantly higher AUCs compared to VIBE with the maximum node diameter showing the highest AUC of 0.744. According to this finding the sensitivity and specificity were computed for different maximum diameter cut-off values. Additionally, we evaluated the ability of descriptive morphologic criteria, alone and in combination, to identify patients with nodal involvement (Tab. 2). Throughout the lymph node analysis no significant effect of neoadjuvant therapy on diagnostic accuracy could be observed.

DISCUSSION

In accordance with published data the ability of MRI to correctly stage rectal cancer after neoadjuvant therapy is reduced [3]. In our opinion the limited contrast between tumor and rectal wall is a drawback of CISS compared to T2 TSE imaging and might explain the lower accuracy in comparison with the literature. Techniques to further reduce the slice thickness in pelvic MRI have been reported, e.g. 3D TSE with restore pulses, and might be expected to further improve rectal cancer staging [4]. Additionally, our data reflect the need for specialized radiologists to correctly stage rectal cancer. To date, various criteria have been proposed for lymph node assessment in pelvic MRI [2]. Meta analysis revealed sensitivities of 66% and 85% for size and morphologic criteria, respectively [5]. Our data argue for a higher accuracy of size criteria derived from CISS images, but to obtain higher accuracy with very high specificity and acceptable sensitivity, the combination of morphologic criteria from CISS and VIBE images was necessary. In conclusion our study demonstrated the feasibility of rectal cancer staging with high-resolution 3D sequences and a possible role of contrast enhanced imaging for nodal staging.

Fig.1: Axial CISS (A) and VIBE (B) images with 2mm slice thickness of a patient with T3N+ rectal cancer. Hypointense linear extensions in the mesorectal fat represent the transmural infiltration (arrow). Note the irregular shape of a mesorectal lymph node (arrowhead).

Table 1. Diagnostic accuracy for T-stage in patients with (+) or without (-) prior chemoradiotherapy

		reader 1	reader 2	reader 3
- therapy	CISS	75.0 %	58.3 %	56.8 %
	VIBE	75.0 %	62.5 %	45.8 %
+ therapy	CISS	59.5 %	54.1 %	50.8 %
	VIBE	51.4 %	57.8 %	45.9 %
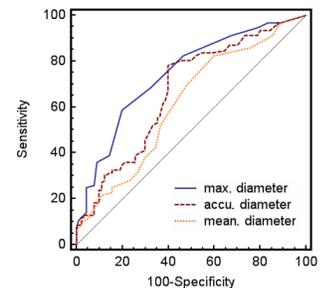
Fig. 2: ROC curves for different lymph node criteria.

Table 2. Mean sensitivity, specificity and accuracy to define nodal disease for different criteria

	inhomog.	irregular	enhancem.	2 / 3 crit.	all 3 crit.	> 5mm	> 7mm	> 10mm
sensitivity	51,6%	64,5%	61,3%	67,7%	29,0%	**82,8%**	58,1%	25,8%
specificity	83,3%	90,0%	93,3%	90,0%	**100,0%**	53,3%	80,0%	92,2%
accuracy	67,2%	77,0%	77,0%	**78,7%**	63,9%	68,3%	68,9%	58,5%

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[1] Akasu T, et al. AJR 2005; 184:531–538; [2] Brown G, et al. Radiology 2003; 227:371–377; [3] Kulkarni T, et al. Colorectal Disease 2008; 10:479–489; [4] Lichy MP, et al. Invest Radiol 2005; 40:754–760; [5] Bipat S, e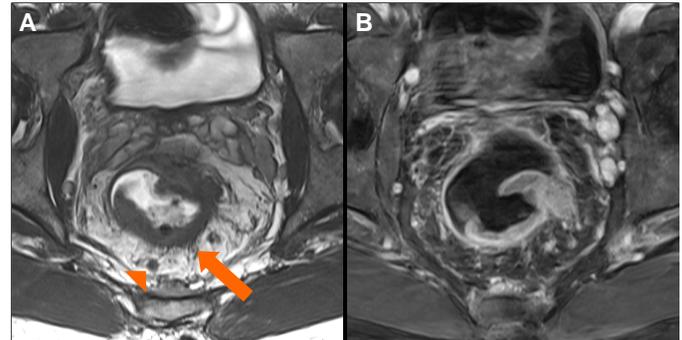t al. Radiology 2004; 232:773–783