Repeatability of diffusion weighted magnetic resonance imaging in rectal cancer at 1.5T.

Martijn Intven[1], Onne Reerink[1], and Marielle E.P. Philippens[1]
[1]*Radiation Oncology, UMC Utrecht, Utrecht, Netherlands*

Introduction

Diffusion weighted imaging (DW-MRI) is of upcoming interest in rectal cancer therapy response assessment after neo-adjuvant treatment as shown in recent publications that correlate DW-MRI findings with pathological response (1-4). Reliable prediction of pathological good response is relevant for implementation of organ-sparing treatment in good responders (5-6). Quantitative response evaluation or prediction is based on serial DW-MRI. In good responders, a higher relative increase in ADC, 45-50%, was reported compared with non-responders (2-3). Assessment of the precision of ADC values is mandatory to distinguish therapy related response from measurement variations. In this study, the repeatability of DW-MRI in rectal cancer was assessed at 1.5T.

Patients and Methods

Fourteen patients (3 women, 11 men) with resectable rectal cancer were included in this study. All patients received standard short course neo-adjuvant radiotherapy, 25 Gy, delivered in 5 daily fractions in one week and followed by surgery the week afterwards. Before each treatment fraction, MR imaging was performed including two identical DW-MRI sequences. The MRI scans were acquired at a 1.5 Tesla MRI spectrometer (Gyroscan NT Intera, Philips Medical Systems, Best, The Netherlands). Patients were scanned in supine position using a flat tabletop insert. A 4-element coil (Sense Body) was used as receive coil. All scans were performed without specific bowel preparation. The MRI protocol consisted of sagittal T1w-, transverse T2w- and two transverse DW-MRI imaging sequences. Diffusion weighting was achieved by using a free-breathing single-shot Spin-Echo Echo Planar Imaging (ssSE-EPI) sequence (TR/TE: 5912 ms/ 180 ms; EPI factor: 55), with short tau inversion recovery (STIR) fat suppression, an inversion time of 180ms and diffusion weighting with b-values: 0, 200, 800 s/mm2. Images were acquired with a 144 x 128 matrix, slice thickness of 4 mm, a slice gap of 0 mm, a number of averages of 4 and an in plane resolution of 1.89mm x 1.89mm. The duration of the DW-MRI sequence was 4.08 minutes. ADC values were calculated using all b-values with, $lnS = lnA - b\,ADC$, where A is the relative amplitude and S the signal amplitude. On the daily b0 DW-images, the tumor and in male patients the prostate central gland was delineated and the delineation was automatically transferred to the corresponding DW-images and ADC map (figure 1). Statistical analyses were performed using GraphPad Prism 5.00 (Graphpad Software Inc, USA) and SPSS 16.0.1. (2007, SPSS Inc., USA). The ADC values were compared using a paired t-test. The repeatability was depicted using a Bland-Altman plot using the relative difference expressed in percentages (7). The repeatability coefficient was defined as 1.96 times the standard deviation of the differences between two measurements. Significance was assigned at $p \leq 0.05$.

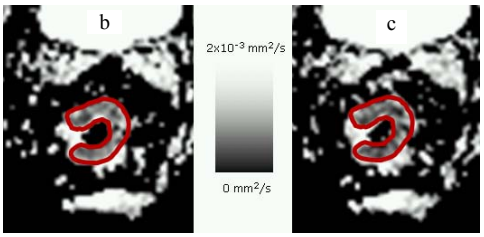

Figure 1: T2 Weighted image (a) and ADC maps (b / c) of one MRI session. The rectal tumor is delineated in red.

Results

The mean tumor ADC value was 1.02×10^{-3} mm^2/s (SD 0.14×10^{-3} mm^2). Measured tumour ADC values during the same day were not significantly different. Bland-Altman analyses of the two ADC measurements during the scan protocol showed a small bias of 1.5% (SD 5.5%). Expressed as percentage of the mean tumour ADC the repeatability coefficient was 10.0% (figure 2a). The bias for the reference structure, the prostate central gland was 0.9 % (SD 3.3%). The repeatability coefficient of the prostate central gland was 6.6% of the mean ADC (figure 2b). The repeatability coefficient for ADC measurements between consecutive days was 14.3% with a positive bias of 2.1 % (SD 7.3%).

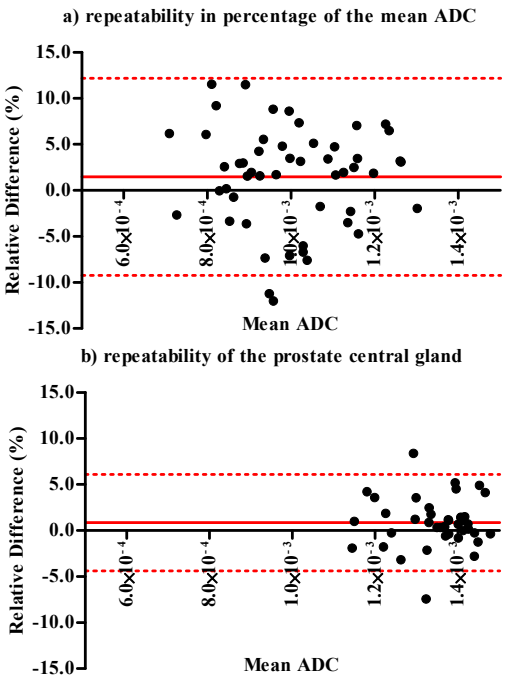

Figure 2: Bland-Altman analyses of median rectal tumor ADC values (a) and the prostate central gland (b).

Discussion

Our results show a repeatability coefficient for rectal tumor ADC of 10.0 % of the mean ADC. This was comparable to the repeatability coefficient of 8.0% to 17.7% found by Rosenkrantz et al for ADC values in the upper abdominal organs (8). Repeatability of rectal tumor ADC values is influenced by different factors. First, repeatability is affected by rectal air that caused magnetic susceptibility distortions in the DW-ssSE-EPI (9). This effect explains partially the better reproducibility of 6.6% for the reference structure, the prostate central gland. Second, repeatability analysis is influenced by intra-observer delineation variations since each DW-MRI sequence was separately delineated and small variations of analyzed tissue will lead to a lower repeatability. The repeatability between consecutive days was lower compared to measurements in one MRI session, due to the delivered radiotherapy treatment fraction between the two measurements.

Conclusion

When serial ADC measurements are implemented in the selection of candidates for organ-sparing treatment of rectal cancer, differences in ADC values of > 10% can be interpreted as therapy related response. The 95% confidence interval on ADC differences is 10%.

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