Differentiating Tumor and Fibrosis post-treatment in Patients with Bladder Cancer using quantitative DCE-MRI

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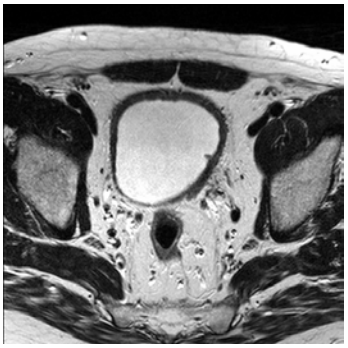
Introduction: DCE-MRI is often used for delineation and staging of bladder tumors but there remains difficulty in differentiating tumor from post-treatment fibrosis in patients treated for bladder cancer. A study by Barentsz, et al.[1] showed that, on average, bladder tumor enhances 4 s earlier than post-treatment fibrosis. A study by Dobson, et al.[2] used the height of enhancement curves at 80s following injection to predict whether tumor recurrence had occurred. Tracer kinetic parameters were not reported in either of these papers. The aim of this retrospective study was to compare DCE-MRI parameters in patients treated for bladder cancer to see if it is possible to distinguish between tumor and post-treatment fibrosis.

Methods: Data were examined from 10 patients scanned post-treatment. All had received chemoradiation for bladder cancer and follow-up confirmed that 5 had fibrosis and 5 recurrent bladder tumor. MRI studies were performed on a 1.5 T Siemens Magnetom Avanto using the body matrix coil. Staging scans including T2-weighted sequences enabled localisation of the tumour/fibrosis. A 3D axial T1-weighted VIBE sequence (TR/TE = 5.6/1.1 ms, 128 x 96 x 16 – 28 imaging matrix, slice thickness = 5.0 mm, α = 25°, acquisition time = 3.7 - 5.9 s) was used for the dynamic acquisition. The total acquisition time for the series therefore varied from between 126 and 200 s (depending on the number of slices covered by the 3D volume). Signals were converted to contrast agent concentration using assumed T1 values of 1200 ms and 1300 ms for blood and tumour/fibrosis respectively[3]. AIFs were calculated from the iliac arteries using an automated method which averages the concentration-time curve over the most enhancing pixels within 6 seconds of a defined 'onset of enhancement' image[4]. Patients were given an intravenous injection of 0.1 mmol/kg Gd-DTPA early on in the series acquisition. A modified-Kety tracer kinetic model[5] was fitted to the data to obtain estimates of the tracer kinetic parameters K^{trans} and v_e.

Results: ROIs in the tumour/fibrosis were defined with the help of a high resolution T2-weighted image covering the same FOV (figure 1). Concentration-time curves were produced for the ROI. Figure 1 shows example ΔR_1 curves from fibrosis and tumor as well as an example AIF. It can be seen that the tumor enhances rapidly reaching a peak within seconds of contrast agent administration while fibrosis enhances slowly and has not reached its peak concentration at 2 minutes following injection. Table 1 shows $IAUC_{60s}$, $IAUC_{90s}$, K^{trans} and v_e results averaged over the 5 patients with tumor and fibrosis, respectively. A t-test was used to compare the results of the two groups.



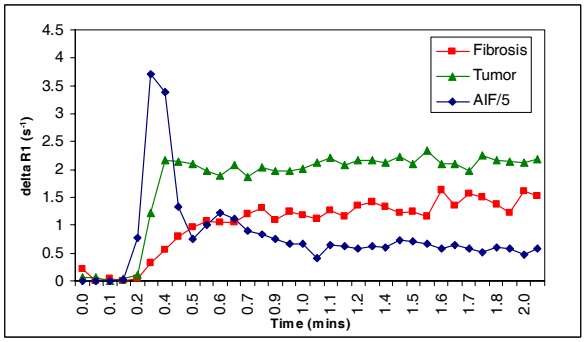


Figure 1 (left): T2-weighted image of the bladder. The thickened bladder wall was found to be fibrosis.
Figure 2 (right): Example ΔR1 curves from the areas of fibrosis, tumor and artery. The AIF has been scaled down by a factor of 5 to fit alongside the tissue curves.

	No. patients	$IAUC_{60s}$ ± S.D.	$IAUC_{90s}$ ± S.D.	k^{trans} ± S.D.	v_e ± S.D.
Fibrosis	5	9.3 ± 2.8 mMol.s	16.2 ± 5.3 mMol.s	0.16 ± 0.10 min^{-1}	0.25 ± 0.17
Tumour	5	13.8 ± 2.4 mMol.s	22.6 ± 4.6 mMol.s	0.25 ± 0.32 min^{-1}	0.34 ± 0.39
P-value	n/a	0.027*	0.076	0.570	0.647

Discussion: In this preliminary clinical study tumor and fibrosis were shown to have significantly different early-phase enhancement characteristics. Tumor enhances rapidly and plateaus while fibrosis shows a more gradual uptake until the curves eventually overlap. Significant differences in the average $IAUC_{60s}$ values for the two groups reflect this. Average $IAUC_{90s}$, K^{trans} and v_e results also differ between the two groups however the significance of the differences is reduced as it is the early enhancement curve characteristics that differ. Further protocol development is needed to introduce rapid baseline T1 measurements for accurate Gd-DTPA concentration estimates before a larger cohort can be examined. Quantitative DCE-MRI parameters obtained from high temporal resolution data may be capable of distinguishing between tumor and post-treatment fibrosis in patients treated for bladder cancer.

References:

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