DCE-MRI appearance of prostate after androgen deprivation therapy – preliminary results

Lucy E Kershaw[1,2], Andrew J McPartlin[2,3], and Ananya Choudhury[2,3]

[1]CMPE, The Christie NHSFT, Manchester, United Kingdom, [2]Institute of Cancer Sciences, The University of Manchester, Manchester, United Kingdom, [3]Oncology, The Christie NHSFT, Manchester, United Kingdom

Purpose: Globally, prostate cancer is the fourth most common cancer and the second most common cancer in men. Incidence is increasing due to population ageing and use of prostate specific antigen (PSA) screening for early detection [1]. Androgen deprivation therapy (ADT) is commonly given before radiotherapy in high and intermediate-risk disease, resulting in a reduction in prostate and tumour volume, but also a loss of contrast in T2w MR images, making lesions less conspicuous [2]. DCE-MRI has been used in previous studies to monitor response to ADT [2,3,4] and identify foci for local radiotherapy boost, [5] but these studies did not always include a measurement of T_1 for quantification of contrast agent concentration, or an individually measured arterial input function (AIF) for modelling of tracer kinetics. In addition, previous studies have used models that estimate the composite parameter K^{trans} rather than providing separate estimates of microvascular plasma flow (F_p) and permeability-surface area product (PS). The aim of this work was to evaluate DCE-MRI parameters after ADT in prostate tumours and normal-appearing peripheral zone (PZ) (to avoid confounding influence from benign prostatic hyperplasia in the central gland).

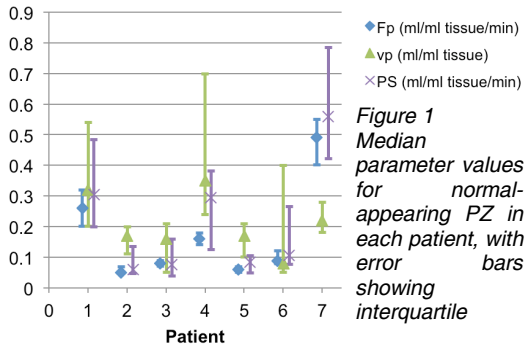

Figure 1 Median parameter values for normal-appearing PZ in each patient, with error bars showing interquartile

Methods: 8 patients with prostate cancer stage T2b or greater were recruited after 3 months of ADT. Patients were imaged at 1.5 T (Achieva, Philips Medical Systems, Best, The Netherlands) using the cardiac coil and a flat perspex table top (made in-house) to match the radiotherapy treatment position. An imaging volume 400 x 400 x 100 mm was chosen, with the prostate toward the inferior slices. The MR examination began with high resolution T_2w imaging (TSE, TR/TE=4800/120 ms, matrix 560 x 560 x 20), then all subsequent images were acquired with matrix 176x176x20 (overcontiguous slices) and SENSE factor 2.5 in the PE (LR) direction (except DWI SENSE=2 LR). Inversion-recovery turbo field echo (IRTFE) was used to measure T_1 (TR/TE/α=2.38/0.77 ms/12°, shot interval 4 s, ETL=51, TI = 64, 250, 1000, 2500, 3900 ms), and was followed by DCE-MRI images (turbo field echo TR/TE/α =2.47/0.86 ms/30°, temporal resolution 1.2 s for 260 time points) acquired during injection of 0.2 ml/kg gadoterate meglumine at 2 ml/s followed by a saline chaser, and finally DWI (EPI, TR/TE=8000/70 ms, b=100, 400, 800). ADC maps were processed offline (ADCmap plugin for Osirix, Pixmeo, Geneva,Switzerland). Analysis of DCE-MRI data were as described in [6]; the AIF was extracted from the external iliac artery, T_1 was estimated from fitting to the IRTFE data, signal-intensity *vs* time curves were converted to contrast agent concentration *vs* time curves and finally model fitting was performed on a voxelwise basis using in house-software (Python 3.4). Haematocrit was assumed to be 0.4. Reports and images from pretreatment imaging at the referring hospital were available for comparison with post HT images.

Results: Median v_p, F_p and PS for normal-appearing peripheral zone are shown in figure 1 for 7 patients (one patient had no normal-appearing peripheral zone), along with their interquartile ranges. Median (IQR) values over all patients were F_p - 0.09 (0.07-0.21) ml/ml tissue/min, v_p – 0.17 (0.16-0.27) ml/ml tissue, PS – 0.11 (0.08-0.30) ml/ml tissue/min. Values for v_e tended to be close to 1. Figure 2 shows example maps of F_p and ADC for two patients, as an overlay on T_2w images. Arrows show high flow regions matching those reported on pre-treatment imaging.

Discussion: Previous work showed a wide variation in DCE-MRI parameters after 1 month of ADT [2,3,4] which is also seen in this patient group. The median values for F_p and PS in normal-appearing PZ over all patients show good agreement with our previous work [6,7]. Values for v_p are higher than those reported in [7] but note that this was before ADT. Two patients had the dynamic time series curtailed for model fitting due to contrast agent in the urine corrupting the end of the time course. The large fitted v_e values may therefore indicate that the dynamic time series was not long enough, suggesting that an uptake model, which assumes an infinite v_e, may be more suitable for these data. The F_p maps show potential for identifying lesions that are unresponsive to ADT that could receive a local boost. In the left-hand case in figure 2, the two dominant lesions described in the pretreatment imaging report remain, but in the right hand patient, the originally dominant lesion in the right PZ has responded to therapy as seen in the T_2w imaging. DCE-MRI identifies a remaining lesion in the L anterior central gland that would be a candidate for local boost. These are the first 8 patients in a study of 15 due to be imaged three times during the course of their radiotherapy. Future work will focus on registration of functional imaging with radiotherapy planning CT, and changes in DCE-MRI and DWI parameters as a predictor of outcome. This is the first time, to our knowledge, that post-ADT DCE-MRI has been reported using an individually measured AIF and a 4-parameter model that allows separation of microvascular flow and permeability.

Conclusion: DCE-MRI shows potential as a method for locating dominant lesions for local boost in subsequent radiotherapy treatment.

References: [1] CRUK cancer stats for 2011, cruk.org/cancerstats [2] Padhani *et al*, Radiology 218:365-374, 2001 [3] Alonzi *et al*, IJROBP 80:721-727 2011 [4] Barrett *et al*, MRM 67:778-785 2012 [5] Groenendaal *et al* Radiotherapy and Oncology 103:233-238 2012 [6] Kershaw *et al* JMRI 29:641-648 2009 [7] Kershaw *et al* MRM 56:986-992 2006 **Acknowledgements:** WMIC radiographers

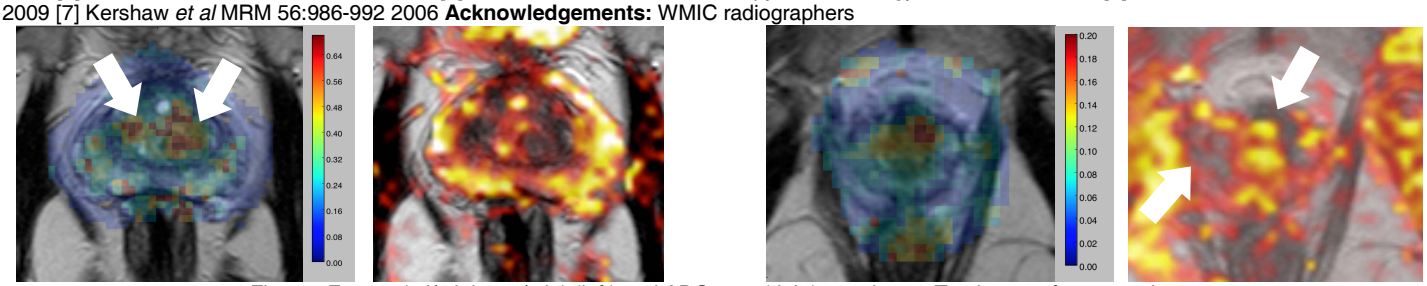

Fig. 2 – F_p map (ml/ml tissue/min) (left) and ADC map (right), overlay on T_2w images for two patients