Impact of T1 estimate variation on DCE-MRI derived pharmacokinetic values in rectal tumours

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INTRODUCTION: Dynamic contrast enhanced (DCE-) MRI perfusion measurements use an estimate of native T1 prior to contrast arrival in order to quantify contrast agent concentration during first passage. Fitting of T1 using just two images with different flip angles is efficient, but also known to be prone to errors that may propagate into derived pharmacokinetic parameters. The aim of this study was to establish the impact of noise in the proton-density weighted scan on values obtained from pharmacokinetic analysis of DCE-MRI in the course of rectal cancer treatment monitoring.

METHODS: The study was approved by our institutional ethics committee; written informed consent was obtained from all participants before entry into study. 9 patients (4M, 5F; mean age 66 ± 11 years) with local rectal adenocarcinoma underwent DCE-MRI prior to and following combined neoadjuvant chemo- and radiotherapy. All exams were performed on a 1.5T scanner (Avanto, Siemens Medical Systems, Erlangen, Germany). Two proton density weighted scans (12 slices, FA 2°, TE/TR 1.14/4.36ms, FOV/SLT 360/5mm) were acquired with the same slice prescription prior to the DCE acquisition. The dynamic T1-weighted sequence (as per proton density with 5s/frame, 80 frames, FA 24°) over 8 minutes after intravenous injection (0.2 mL/Kg, 3.5 mL/sec) of contrast agent (Magnevist, Schering, Berlin, Germany), followed by a saline flush.

ROIs were drawn by a radiologist to delineate the tumour on the 8 central slices of the dynamic time series volume, to avoid slab profile effects, with reference to T2-weighted and pre- and post-contrast T1-weighted images. For each of the proton density scans (PD1 and PD2), in combination with the same ROI on the dynamic time series, we derived the median ROI values over the drawn ROI volume of Ktrans (transfer constant), Kep (rate constant), Ve (leakage space) using the MRI Workbench software (MRIW, Institute for Cancer Research, Sutton, England) according to the Tofts model with a cosine input function. Differences between the PD scans, primarily attributable to noise, allow the variability of the derived parameters attributable to noise or variation in the PD flip angle to be assessed without requiring multiple contrast injections.

The pharmacokinetic parameters derived using PD1 and PD2 were compared in Bland-Altman plots and the limits of agreement calculated.

RESULTS: Visible differences in the Ktrans, Kep, Ve and IAUC60 maps between PD1 and PD2 input were limited to edges of structures attributable to movement. In Figure 1, Bland-Altman plots of Ktrans, Kep, Ve are shown. Differences in Ktrans, and and Ve, scaled with the parameter values, remaining consistently less than 5%. For Kep, differences were not value dependent and instead, were consistently less than 0.01 (≤2.7% of the median Kep value).

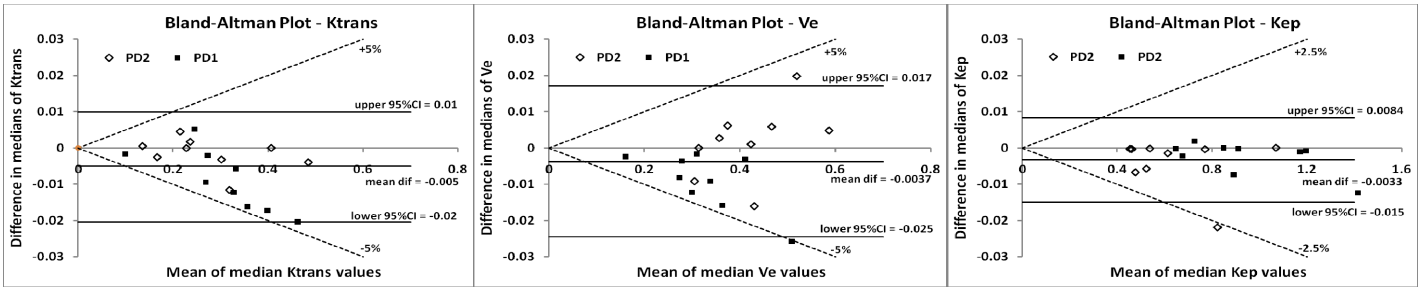

Figure 1. For Ktrans (left) and Ve, the variation due to difference in T1 estimate is proportional to the value obtained. This does not appear to be the case for Kep.

CONCLUSIONS: Our results suggest that the variation in the T1 estimate has a limited impact on Kep, with a 95% CI of about ± 0.02. For Ktrans and Ve the variation attributable to the T1 estimate amounted to about 5% of the values. A slight underestimation in both these values on the PD1 relative to the PD2 measurement in the pre-treatment visit may be due to greater motion between the PD1 scan and the dynamic timeseries. Due to peristalic motion observed in this initial group of patients, we have chosen to use Buscopan prior to DCE-MRI with the purpose to obtain less motion artifacts as possible. This may account for the lower variation in Ve in the post-treatment scans, but did not appreciably alter the variation in Ktrans values. This experiment does not take into account known spatial variations in T1 estimates due to flip angle imperfection and array coils sensitivity profiles, which we would expect to be consistent between the two PD scans, but would affect the net variation to be seen in test-retest scanning on a day to day basis.