Assessment of Scan-Rescan Variability in DCE-MRI Parameters Using Multiple Models

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Target Audience: This abstract should be of interest to anyone with an interest in the use of DCE-MRI for the assessment of change over time in blood flow and vascular permeability in either tumors or normal tissues.

Purpose: This experiment was designed to assess the scan-rescan reproducibility in the measurement of several vascular parameters obtainable from DCE-MRI scans in patients with GBM, and to determine if there are differences in the reproducibility of parameters measured using three different analysis models. Assessment was also made for two model-free parameters.

Methods: IRB approval was obtained for this experiment, and all patients provided informed consent. Dual baseline DCE-MRI scans were acquired for a total of six patients with GBM, with temporal separation between scans ranging from 2 – 6 days. Data were acquired using a 3D fSPGR sequence with a 6cm slab and 28cm FOV. TE/TR/FA were 1.0/3.1/26. Data were reconstructed into 12 5mm slices with a 160x128 acquisition matrix. Temporal resolution was ~2.9s/phase. Data were analyzed by VirtualScopics (Rochester, NY, USA) using internally developed software. Tumor boundaries were identified by a radiologist, and an arterial input function (AIF) was estimated for each DCE scan[1]. Vascular parameters were estimated using three separate models: Standard Tofts[2], Extended Tofts[2], and Distributed Parameter[3]. Two model-free AUC parameters were also estimated: $IAUC_{90}$ (area under the tumor time-concentration curve over the first 90s post-injection), and $AUCBN_{90}$ ($IAUC_{90}$ normalized by the area under the AIF over the same period).

Coefficients of variability (CoV) were estimated for each calculated parameter using the following process: 1. For each pair of measurements, calculate both mean and standard deviation. 2. For each pair, produce an adjusted SD by multiplying the SD by 1.25331 (this adjusts for the bias resulting from estimation using n=2). 3. For each pair, produce a local CoV by dividing the adjusted SD by the mean. 4. Produce a global CoV by averaging the local CoV across all pairs.

Results: CoV were calculated using 6 data points. Data for one patient were excluded due to a large difference in AIF between scans, which rendered the data non-comparable. Measurements were included for two separate tumors for one of the remaining five patients. CoV for the measured parameters are given in Table 1:

Table 1: Coefficients of variability for each measured parameter.

Model	Parameter	CoV	95% CI
Standard Tofts	K^{Trans}	12.1%	0.1% - 25.2%
Extended Tofts	K^{Trans}	23.4%	7.9% - 39.0%
Distributed Parameter	PS	39.7%	12.9% - 66.5%
None	$IAUC_{90}$	26.5%	5.6% - 47.4%
None	$AUCBN_{90}$	16.5%	3.7% - 29.2%

Discussion and Conclusions: Variability results for K^{Trans} (Standard) and $AUCBN_{90}$ were generally in line with those that have been reported previously[1]. Substantially higher variability was seen for other parameters, although differences failed to achieve statistical significance even in the comparison between K^{Trans} (Standard) and PS ($p = 0.13$), presumably due to the small number of samples. Improved variability for $AUCBN_{90}$ relative to $IAUC_{90}$ is as expected, as a result of compensation for differences in injection, cardiac output, etc., which are reflected in the AIF. Greater variability in the Extended Tofts model relative to the Standard Tofts model appears to be largely a result of ambiguity between K^{Trans} and vp in the Extended model, while greater variability in the Distributed Parameter model appears to be largely due to noise sensitivity in the de-convolution process that model requires.

References:

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