A demonstration of T2 leakage effects on DSC CBV measurements

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Introduction. The permeability of the blood brain barrier (BBB) to dynamic susceptibility contrast (DSC) agents determines the compartmental distribution and consequently the properties of the resultant signal effects due to the bolus passage. For an intact BBB, the DSC agents are compartmentalized to the intravascular space and the corresponding transient signal decrease that occurs during the bolus passage can be attributed solely to intravascular-induced susceptibility gradients only. However, for a disrupted BBB, as is often observed in tumor, the DSC agent may extravasate into the extravascular extracellular space (EES). T1 and T2 shortening will result if the DSC agent exhibits longitudinal and/or transverse relaxivity, as is the case with the common paramagnetic gadolinium (Gd) chelates. T1 shortening results in signal enhancement, which competes with the susceptibility-induced signal attenuation, whereas T2 shortening results in increased signal attenuation beyond the susceptibility-induced signal decrease. Both of these effects can confound perfusion estimates obtained with DSC-MRI [1,2]. Most attention has been paid to minimizing the T1 effects resulting from agent extravasation and have not accounted for the possible modifications of the T2- and T2*-weighted signal changes that may result due to loss of contrast compartmentalization. To determine the importance of this T2 leakage effects we compared the rCBV measurements obtained with a first pass bolus of Dy-DTPA, which distributes like Gd-DTPA, but has minimal (longitudinal) relaxivity effects and strong T2 effects, to rCBV measurements obtained with both Gd-DTPA and MION, which due to its large size remains intravascular in spite of a disrupted BBB. Thus rCBV determined with MION serves as a reference.for the other measurements.

Materials and Methods. Six male Fisher rats were inoculated intracerebrally with 10^5 (10μL) 9L gliosarcoma cells and imaged 14 days after tumor inoculation. Pre- and post contrast T_1 weighted images (T_E=11 msec, T_R=450 msec) were collected. All contrast agents were administered via a femoral vein catheter. A series of three scans were performed, one for each DSC-contrast agent, using the following general parameters: FOV=4 cm^2, matrix=64x64, T_E= 26.5ms T_R=1020 msec, thickness=2 mm, 4 slices, reps=120. First, a 2.0 mg Fe/kg dose of MION was bolus injected during collection of the GE EPI data. After 20 minutes, during which time the blood MION reaches equilibrium, a 0.2mmole/kg dose of Dy-DTPA was bolus administered, and the GE EPI images obtained. After another 20 minutes, during which the compartmental distribution of Dy-DTPA achieves a steady state, a 0.2mmole/kg dose of Gd-DTPA was administered, while the final GE EPI images were obtained. Finally, the post-contrast T_1 weighted images were acquired. After converting the MR signal intensity time courses, S(t), to ΔR2*(t) concentration-time curves, rCBV was estimated on a voxel-wise basis using trapezoidal integration over the first 120 time points of ΔR2*(t) and also correction for contrast agent extravasation was performed [3,4].

Results and Discussion. Uncorrected rCBV maps obtained using each of the DSC agents are displayed in Figure 1. Substantial differences exist within the area of the contrast enhancing tumor. A negative rCBV was calculated using Gd-DTPA due the T1 leakage effects that are commonly corrected for. The residual elevated baseline of the DyDTPA data is consistent with a T2 leakage effect. However, these effects do not appear to be significant such that the blood volume is not overestimated compared to the MION-determined rCBV. Whether this is due to a small interstitial (leakage) space in this tumor model needs to be determined with comparative histologic measurements of tissue compartmental volumes.

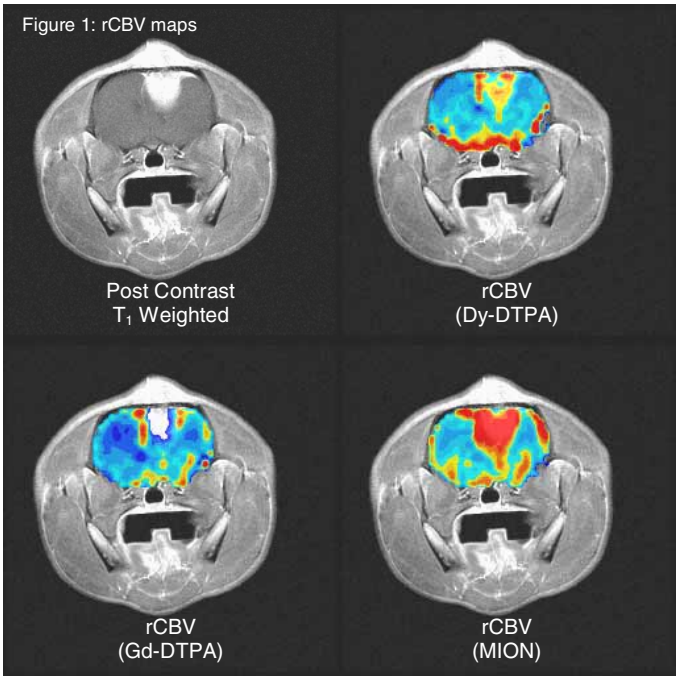


Figure 2: ΔR_2^* time courses from a single voxel within the constrast enhancing region of Figure 1.

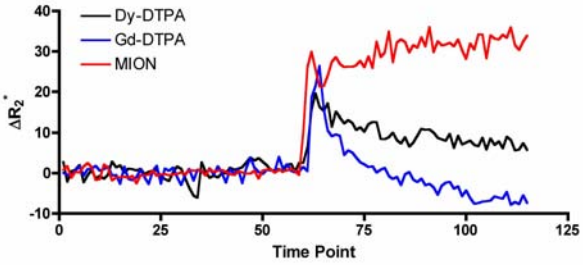
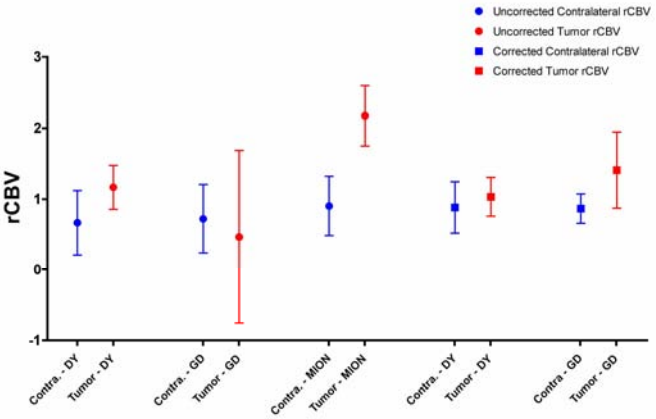


Figure 3: Corrected and Uncorrect rCBV values obtain using Dy-DTPA, Gd-DTPA, and MION in tumor and contralateral brain.



References.

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3. Miyati et al., JMRI 7:230-235 (1997)
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Acklowledgements. NIH/NCI CA082500.