Leakage Corrected rCBV Measurements using Prebolus Dosing: Applications in Differentiating Glioma Recurrence from Post-Treatment Effect at 3T Field Strength

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PURPOSE

To determine the necessary preload Gd-DTPA dosage to produce T1W leakage-corrected relative cerebral blood volume (rCBV) values which distinguish glioma recurrence from post-treatment radiation effect (PTRE) using Dynamic Susceptibility Contrast (DSC) MRI at 3T field strength.

PURPOSE

DSC-MRI quantifies rCBV and may indicate tissue microvascular density (MVD) [1] and distinguish high MVD in tumor growth from low MVD in PTRE to improve diagnostic specificity. Literature suggests there are no threshold rCBV values available for clinical use, in part because no one has established direct correlations between histopathology and rCBV measurements (2). Both tumor recurrence and PTRE often demonstrate contrast enhancement on conventional MRI, implying blood brain barrier (BBB) breakdown. In this setting, T1-shortening effects from contrast agent extravasation can lead to underestimation of rCBV measurements. An effective method to correct for leakage effects is administration of prebolus contrast agent, infused prior to the start of the DSC-MRI acquisition (3). Although a range of prebolus contrast doses have been described at 1.5T field strength (2, 3), little has been reported on the dosage needed at higher field strengths. Knowledge of optimal prebolus doses may improve leakage correction leading to acceptable correlation between DSC-MRI and histopathology.

METHODS

Our study has been approved by the Institutional Review Board. All subjects received previous multimodality treatment (including RT) for WHO grade III or IV glial neoplasms and are undergoing surgical resection or biopsy for new enhancing lesions on surveillance MRI. A perfusion MRI protocol and stereotactic T1W post-contrast MRI are obtained on a GE 3T scanner prior to surgical resection or biopsy. The perfusion-MRI protocol is six consecutive DSC-MRI acquisitions. We administer a gadolinium bolus (0.05mmol/kg) through an intravenous catheter via hand injection at 3-5 cc/sec during the T2*W DSC-MRI acquisition (TR/TE/flip angle = 2000/20/60°; FOV 24x24cm, matrix 128x128, 5 mm slices) for each acquisition. Each injection is separated by 3 minutes. Thus, each successive DSC-MRI acquisition will have a higher preload dose, equivalent to the total administered dose of Gd-DTPA from all previous injections. At surgery, we collect a minimum of 3-4 tissue specimens from separate regions of abnormal enhancement in each patient for histopathologic analysis. A STEALTH® intraoperative neuronavigational system documents stereotactic locations of all tissue specimens. We use DSC-MRI regions of interest (ROIs) from corresponding specimen stereotactic locations during all six acquisitions to calculate rCBV values. We calculate rCBV by integrating the area under $\Delta R2^*(t)$ curves and normalizing to contralateral unaffected brain as previously described (1-4). rCBV values from the six acquisitions are then compared to histopathologic diagnosis of the corresponding tissue specimen ($p < 0.05$). Statistical analysis is also performed to compare rCBV values over the six different DSC-MRI acquisitions using SPSS v.15 ($p < 0.05$).

RESULTS

We have collected 21 tissue specimens from 6 patients. Each specimen measured approximately 0.3-0.4 cm^3 and corresponded to an ROI area of approximately 0.8 cm^2. All tissue specimens were histopathologically diagnosed as either PTRE (n=13) or tumor recurrence (n=8). For each ROI, the rCBV values did not significantly differ over the six sequential DSC-MRI acquisitions (Figure 1; $F(5)=1.238$, ns), suggesting little benefit from increasing preload dose for leakage correction. The rCBV values from the first DSC-MRI acquisition, in the absence of preload dose, were larger in the tumor recurrence group (range = 0.75 to 2.13) than in the PTRE group (range = 0.02 to 0.47; $p < 0.001$), without overlap in rCBV values between the two specimen diagnostic groups (Figure 2). These results also held through the second through sixth DSC-MRI acquisitions.

DISCUSSION

Our findings that rCBV values do not vary according to preload dose do not confirm studies performed at 1.5T (3, 4). Determining the etiology requires further investigation; however, possibilities include diminished T1W leakage effects at 3T field strength, alterations in vascular permeability related to steroid or chemotherapies, and patient selection. We achieved excellent correlation between rCBV and histopathology in the absence of preload dose correction, with no overlap in rCBV values between tumor and PTRE groups.

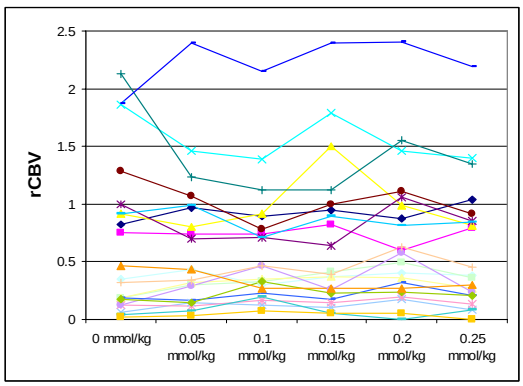

Figure 1: rCBV values over increasing preload dose over the six sequential DSC-MRI acquisitions. The x-axis depicts preload dose.

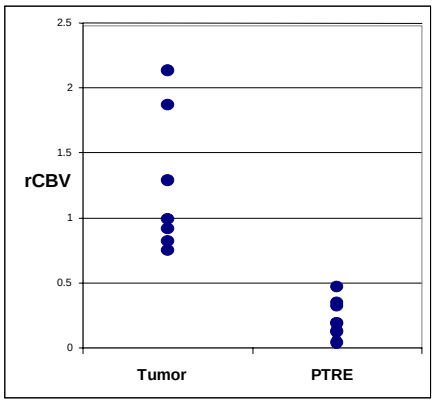

Figure 2: Distribution of rCBV values from the first DSC-MRI acquisition for Tumor and PTRE specimen groups, in the absence of preload dose correction.

REFERENCES

1) Magn Reson Med 2003; 49(5): 848-855. 2) AJNR Am J Neuroradiol. 2000 May;21(5):901-9. 3) Magn Reson Med 2000; 43:845-853. 4) AJNR Am J Neuroradiol. 2006 Apr:27(4):859-67.