

Brain blood volume assessment using DCE in comparison to DSC methods

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TARGET AUDIENCE: Scientists and clinicians who have an interest in DSC and DCE perfusion imaging and multiparametric classification methods.

PURPOSE:

Cerebral blood volume (CBV) is an important parameter for the diagnosis and assessment of brain tumors, often obtained using DSC MRI. However, this method suffers from low spatial resolution and high sensitivity to susceptibility-induced artifacts commonly seen following surgery. DCE imaging^{1,2} has been recently proposed to study tissue permeability (K^{trans}), for tumor diagnosis and in therapy response assessment, especially of anti-angiogenic drugs. This method has high spatial resolution and is less sensitive to inhomogeneity artifacts. Using pharmacokinetic models, blood plasma volume (Vp) can also be extracted using DCE. However knowledge about the correlation of DCE-Vp with DSC-CBV and its potential use in the assessment of brain tumors is limited. **The aim** of this study was to investigate the relationship between DCE-Vp and DSC-CBV in the brains of healthy subjects and in patients with brain tumors.

METHODS:

Twenty two healthy controls (11 males, age 31 ± 8 years), and three patients with glioblastoma (GB), were included. Scans were performed on a 3T MRI and included: DSC imaging, acquired using a 2D GE-EPI, FOV/matrix=240mm/128x128, TR/TE=1300/30msec, during the injection of a double dose of Gadolinium (0.4ml/Kg); and DCE images, acquired using multi phase 3D T₁WI SPGR imaging with a temporal resolution of 6sec, during the injection of a single dose of Gadolinium, FOV/matrix=240mm/256x256, TR/TE=4.9/1.6msec. T₁ maps were calculated using the variable flip angle spoiled SPGR method³. DCE parameters were calculated using in house code written in MATLAB, based on the Extended Tofts model⁴ and DSC was analyzed using Penguin software. DCE-Vp and DSC-CBV were compared in different brain tissues in healthy subjects and in the tumor area in patients. Brain segmentation was performed on each subject, separately for the DCE and DSC data, using MATLAB's implementation of the *k*-means algorithm, with *k*=6 for the DCE data and *k*=4 for the DSC data (following optimization). In patients, segmentation was performed on the normal appearing brain tissue (excluding tumor area), for normalization purposes only. DCE-Vp and DSC-CBV values were compared for three brain tissue types in healthy subjects, in the overlap voxels within each cluster defined as white matter (WM), gray matter (GM) or major blood vessels (BV) in both methods (Fig. 1.A). In patients, DCE-Vp and DSC-CBV were measured in the tumor area.

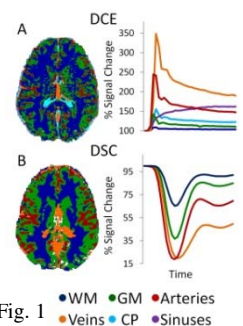


Fig. 1

RESULTS AND DISCUSSION:

Brain segmentation: Fig. 1 shows representative results of the clusters obtained by each method in a healthy brain and their signal time curves: WM (blue), GM (green), BV (red), veins (orange), sinus (violet) and choroid plexus (light blue). The WM cluster was used to normalize DCE-Vp and DSC-CBV parameters. Using overlapping voxels in each cluster within the two methods enables accurate comparison between parameters.

DCE-Vp and DSC-CBV in the healthy brain: A high correlation was found between parameters (Spearman's correlation, $r=0.9$, $p<0.001$). The DCE-Vp was 1.8 ± 0.3 while DSC-CBV was 2.1 ± 0.2 , similar to previous reports⁶. Fig. 2.B shows the relationship between DCE-Vp and DSC-CBV values obtained for all subjects for the WM, GM and BV clusters.

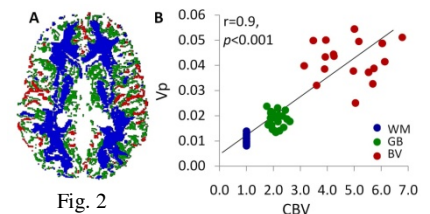


Fig. 2

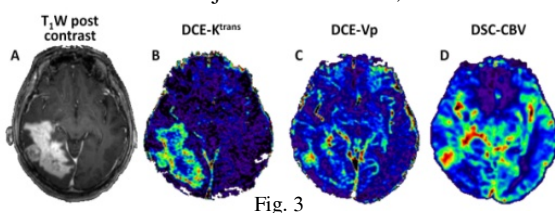


Fig. 3

DCE-Vp and DSC-CBV in tumors: In all three patients, similar maps were obtained for DCE-Vp and DSC-CBV, showing high relative blood volume ratios (relative to WM) within the tumor area, with an average of 5.00 ± 1.62 in the DCE-Vp and 6.74 ± 1.76 in the DSC-CBV. These values are above the threshold value of 1.75⁶, indicating areas with high malignancy. Fig. 3 shows an example of data obtained from a 74 yo GB patient: T₁W post contrast image (A), DCE- K^{trans} image (B), DCE-Vp image (C), and DSC-CBV image (D). These images show high concordance between the two maps, especially in the tumor area. However, using DCE, additional information regarding tissue permeability was obtained.

CONCLUSION:

This work proposes the use of the DCE method as an alternative to DSC MRI for obtaining information regarding blood volume in the assessment of brain tumors. The advantages of using this method are its higher spatial resolution, lower sensitivity to susceptibility artifacts and its ability to provide additional information regarding tissue permeability.

REFERENCES: ¹Sourbron, MRM 2009; ²Larsson, MRM 2009; ³Deoni et al. MRM 2005; ⁴Tofts MRM 1991; ⁵Artzi et al. Neuroimage. 2011; ⁶Law et al. AJNR 2003