

Simultaneous Quantification of Permeability and Perfusion in Multiple Sclerosis Lesions

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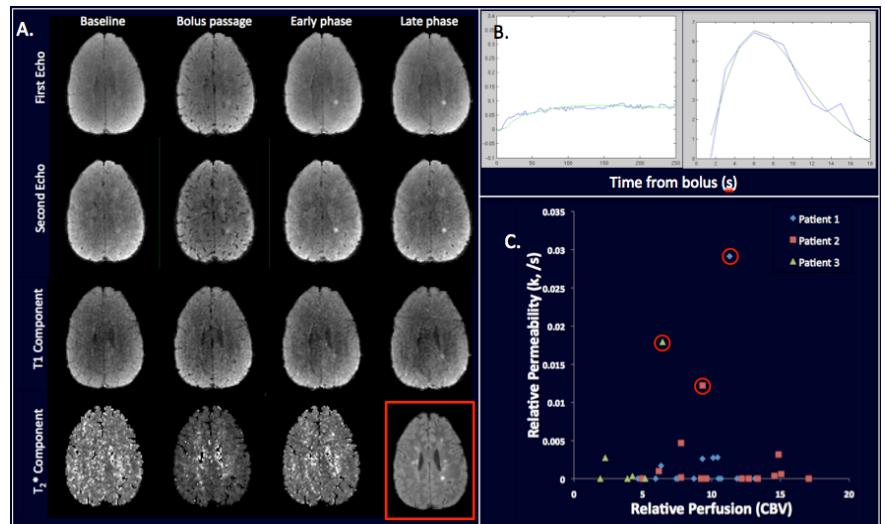
Target Audience: Scientists and clinicians studying and treating MS

Purpose: Patients with MS typically develop lesions around inflamed blood vessels in the brain. Since permeability and perfusion of MS lesions have been shown to change with time^{1,2}, ascertaining these parameters within individual MS lesions at a particular time point may provide a snapshot of the underlying inflammatory and pathophysiological processes. By acquiring a dual-echo T1-weighted dynamic scan during a single bolus of MRI contrast, permeability and perfusion can be simultaneously calculated³.

Methods: We scanned 3 MS patients with a Siemens 3T machine and 32-channel head coil. Dynamic images were acquired using a 2D multi-echo gradient-echo EPI sequence (TR=1.5 s, TE=17/28ms, FA=90 deg, 1.5x1.5 mm nominal in-plane resolution, 1.5 mm slice thickness, 21 slices through the corpus callosum and corona radiata) for five minutes during MRI contrast agent injection (gadobutrol, 0.1 mmol/kg at 3 ml/s). At each time point, T1-weighted and T2* maps were generated from the two echoes for dynamic contrast enhancement (DCE) and dynamic susceptibility contrast (DSC), respectively. T1 maps were constructed with a 3D-GRE sequence (TR=7.8 ms, TE=3 ms, FA=3/16 deg) before and after contrast injection. Using 3D T2-FLAIR images (1 mm isotropic voxels) acquired post-contrast, ROIs were drawn around each lesion and on the internal carotid artery and superior sagittal sinus. Images from each patient were coregistered in MIPAV. In Matlab, optimized step-by-step convolution was used to calculate permeability, and gamma-variate function fitting with deconvolution of arterial input function was used to calculate perfusion parameters.

Results and Discussion:

A few seconds after contrast bolus arrival, enhancing lesions were visible on from the T1-component of the two echoes, as well as on the two individual echoes (Fig. A). All lesions were identified on FLAIR images, and active lesions were identified on post-contrast T1w images. Figure B shows the DCE signal and its optimized convolution (right panel) as well as the DSC signal and its gamma-variate fit from a representative enhancing lesion. As expected, enhancing lesions (circled in red) had the highest permeability (Fig. C). Additionally, some chronic lesions had non-zero permeabilities, which may reflect inflammatory activity that is no longer detectable as enhancement in post-contrast T1-weighted images. Larger blood volume and more blood flow in some chronic lesions compared to enhancing lesions may be due to the presence of a prominent central vein.



Conclusion: Studies that allow for simultaneous perfusion and permeability calculations can elucidate vascular pathophysiology and inflammatory processes in lesions. Longitudinal studies are underway to track changes in lesion permeability and perfusion over time and will determine whether this methodology can be used to assess the effects of disease-modifying therapies that reduce inflammation and maintain the blood-brain-barrier.

References:

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