Applications of Dynamic Contrast Enhanced MRI in Neurovascular Disease

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Purpose. Dynamic contrast enhanced (DCE) MRI is an established method for quantifying blood brain barrier permeability, commonly used for assessing contrast agent leakage in brain tumors (1), multiple sclerosis(2), and infectious diseases(3). However its application to neurovascular pathologies are not as thoroughly explored. In this study we demonstrate for the first time, the utility of DCE-MRI in assessing the permeability of the vessel wall in patients with intracranial atherosclerotic disease (ICAD), intracranial aneurysms (IAs), marfan's syndrome, and vasculitis.

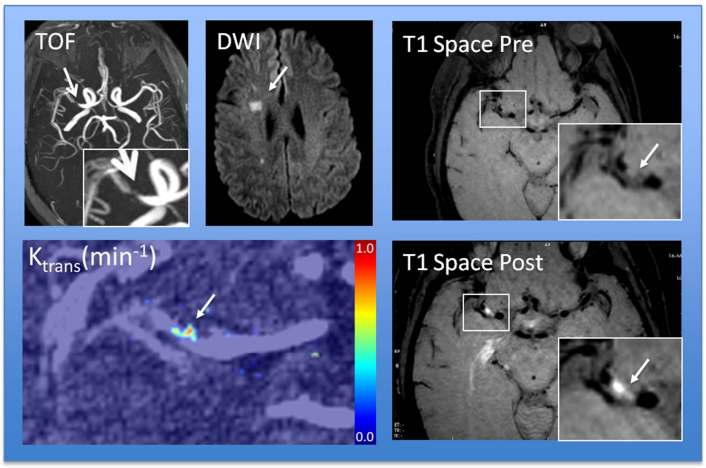

Figure 1 An example of the utility of DCE-MRI in a patient suffering an acute ischemic stroke (DWI) due to partial occlusion of the middle cerebral artery (TOF) by an atherosclerotic plaque. DCE-MRI k_{trans} imaging found high contrast uptake rates in this plaque (0.3 min^{-1}). The contrast uptake is further corroborated by dark blood T1-SPACE imaging acquired pre and post contrast injection. The plaque is shown to enhance in the T1-post imaging.

Methods. We imaged the lumen and the vessel walls in the intracranial circulation of N=32 patients using a standard dynamic contrast enhanced protocol based on a multi-phase spoiled gradient echo pulse sequence. The imaged vessels had the following pathologies: (n=4) atherosclerotic plaques, (n=23) saccular aneurysms, (n=3) fusiform aneurysms, (n=1) Marfan's syndrome, (n=1) vasculitis. DCE-MRI parameters k_{Trans}, v_L, and area under the curve (AUC) were derived in each case and compared against other imaging modalities (DWI, T1-SPACE Dark Blood Imaging) and clinical findings (symptomology). Optimal imaging parameters such as slice thickness and imaging time were identified for each imaging protocol.

Results. Higher K_{Trans} was observed in symptomatic versus asymptomatic atherosclerotic plaques verus healthy vessel walls (0.18 min^{-1} vs. 0.02 min^{-1} vs. 0.0083 min^{-1} respectively, $p<0.001$). IAs demonstrated larger arterial wall permeability than healthy vessel walls (IA: 0.1778 ± 0.0230 min^{-1} vs. healthy vessel: 0.0083 ± 0.0012 min^{-1} respectively, $p<0.001$) but smaller contrast uptake rates than in the choroid plexus (0.4058 ± 0.0567 min^{-1}, $p<0.001$). ICAD plaques associated with acute stroke had much larger plaque K_{Trans} than non-stroke ICAD patients (0.31 min^{-1} vs. 0.105 min^{-1}, $p<0.05$). Finally all ICAD and vasculitis patients with positive k_{Trans} findings had corroborating post-gadolinium enhancement on T1-SPACE Imaging.

Discussion/Conclusions. DCE-MRI can be used to quantify the permeability of the vessel wall in a variety of neurovascular pathologies with parameters k_{Trans} and v_L. Initial results show these parameters may be used to striate symptomatic and asymptomatic patients as well as identify those at risk for suffering stroke. DCE-MRI studies on patients with neurovascular disease may provide useful information about disease progression especially in a longitudinal study of patients.

References: 1) Mill et al. *AJNR*, 2005 2) Ingrisch et al. *Invest Radiol*, 2012. 3) Berger et al. *Front Biosci*, 2004.