Title: Hemodialysis can contribute to acute changes in cerebral volume and white matter structure

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Structured Abstract:

Introduction: Cognitive impairment and leukoaraiosis (white matter degeneration) are common in chronic kidney disease patients undergoing hemodialysis (HD), but their etiology is poorly understood [1]. To elucidate the acute effects of HD on the brain, we used a novel system to perform magnetic resonance imaging (MRI) during HD. Diffusion tensor imaging (DTI) is an MRI modality used to characterize white matter (WM) structure using scalar metrics. Axial and radial diffusivity (AD and RD) quantify the amount of diffusion in the primary and secondary diffusion directions, respectively. Fractional anisotropy (FA) describes the directionality and mean diffusivity (MD) measures the average amount of diffusion. We predict that ischemia and the rapid reversal of uremia during HD will cause cytotoxic edema in WM [2,3]. As neurons swell, white matter expands, anisotropic diffusion from within the axons dominates the signal, and isotropic diffusion in the extracellular matrix decreases. This would result in increased FA and AD, and decreased RD and MD.

Methods: CKD patients (N=16) receiving HD 3 times/week underwent diffusion (2D EPI, 2.0 mm isotropic resolution, FoV=192 mm, TR=9800 ms, TE=102 ms, b-values = 0 and 1000 s/mm^2) and T1 weighted (MPRAGE, 1.0 mm isotropic resolution, FoV=256 mm, TR=2000 ms, TE=2.98 ms, TI=900 ms, flip angle=9 degrees) MRI scans (Siemens 3T Biograph mMR) prior to and within the last 60 minutes of HD, at peak circulatory stress. The MRI data were processed to correct for noise, motion, and artifacts prior to tensor fitting. Scalar maps were compared pairwise using trac+L-based spatial statistics (TBSS) and a general linear model with threshold-free contrast enhancement [4]. Mean scalar values within regions of interest (ROIs) where FA increased were calculated. WM volumes were extracted from T1 weighted images in CAT12. ROI means and tissue volumes were compared pairwise using Wilcoxon signed rank tests.

Results: TBSS showed FA and AD were significantly (P<0.05) elevated in several WM tracts. Within ROIs where FA increased significantly, mean RD and MD decreased (P<0.05). WM volume increased (P<0.05).

Discussion: The DTI results are consistent with those observed in the acute phase following cerebral ischemia in stroke and indicate the presence of cytotoxic edema during HD. The increase in WM volume also supports the presence of edema. This is likely caused by cerebral ischemia and rapid reversal of uremia.

Conclusion: These results may explain the decline in neurological health previously observed in HD patients. 1-year follow-up scans will be acquired to assess the long term effects of HD in this cohort and determine if they correspond to these acute changes.