4D Flow MRI Post-Processing Strategies for Neuropathologies

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4D flow MRI allows for the measurement of a dynamic 3D velocity vector field. Blood flow velocities in large vascular territories can be qualitatively visualized with the added benefit of quantitative probing. Within cranial pathologies theorized to have vascular-based contributions or effects, 4D flow MRI provides a unique platform for comprehensive assessment of hemodynamic parameters. Targeted blood flow derived measurements, such as flow rate, pulsatility, retrograde flow, or wall shear stress may provide insight into the onset or characterization of more complex neuropathologies. Therefore, the thorough assessment of each parameter within the context of a given disease has important medical implications.

Not surprisingly, the last decade has seen rapid growth in the use of 4D flow MRI. Data acquisition sequences are available to researchers on all major scanner platforms. However, the use has been limited mostly to small research trials. One major reason that has hindered the more widespread use and application in larger clinical trials is the complexity of the post-processing tasks and the lack of adequate tools for these tasks. Post-processing of 4D flow MRI must be semi-automated, fast, user-independent, robust, and reliably consistent for use in a clinical setting, within large patient studies, or across a multicenter trial. Development of proper post-processing methods coupled with systematic investigation in normal and patient populations pushes 4D flow MRI closer to clinical realization while elucidating potential underlying neuropathological origins.

Within this framework, the work in this thesis assesses venous flow reproducibility and internal consistency in a healthy population. A preliminary analysis of venous flow parameters in healthy controls and multiple sclerosis patients is performed in a large study employing 4D flow MRI. These studies are performed in the context of the chronic cerebrospinal venous insufficiency hypothesis. Additionally, a double-gated flow acquisition and reconstruction scheme demonstrates respiratory-induced changes in internal jugular vein flow. Finally, a semi-automated intracranial vessel segmentation and flow parameter measurement software tool for fast and consistent 4D flow post-processing analysis is developed, validated, and exhibited an in-vivo.