DEVELOPMENT OF A CONTROL VOLUME FRAMEWORK FOR ANALYZING CEREBROSPINAL FLUID DYNAMICS

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ABSTRACT

Hydrocephalus is among the most common birth defects and may not be prevented nor cured. Afflicted individuals face serious issues, which at present are too complicated and not well enough understood to treat via systematic therapies. This dissertation presents the development of a framework to guide clinical measurements, direct the subsequent processing of acquired data sets, provide physically significant interpretations of derived quantities, and interrelate the various clinical quantities through conservation equations. The goal of this research is to provide a first principles framework to integrate a broad spectrum of sometimes disparate investigations into a highly complex, multidisciplinary problem. In order to accomplish this task, we propose a systems level fluid dynamics based approach to studying hydrocephalus; a complex spectrum of neuropathophysiological disorders primarily defined by enlarged cerebral ventricles and increased intracranial pressure. Previous modeling approaches have proven to be either overly simplified, excessively detailed, decidedly non-physical, or dependent upon analogies that make translation between model and clinic difficult. Integral control volume analysis utilizes a fundamental, fluid dynamics methodology to quantify intracranial dynamics within a precise, direct, and physically meaningful framework. The method is introduced as it relates to intracranial control volumes and applied in an *in vitro* and *in vivo* study. Flow phantom experiments confirmed that control volume analysis is a viable approach and provides a method to estimate pressure differentials non-invasively by processing of velocity data. A chronically shunted, hydrocephalic patient in need of a revision procedure was used as an *in vivo* case study. Magnetic resonance velocity measurements within the patient's aqueduct were obtained in four biomedical state and were analyzed using the methods presented in this dissertation. Distinct pressure force estimates were obtained, with amplitude, phase, and shape differences observed, related to the particular intracranial state. use of control volume methods in the future will provide further insight and understanding into CSF pressure, volume, and flow abnormalities of the intracranial space.