AUTOMATED PC MRI IMAGE SEGMENTATION OF CSF FLOW

Ehsan S. Parizy[1,2], Hamid Bahrami[2], Nick Shaffer[1], Francis Loth[1], Bryn A. Martin[1]
[1]*Conquer Chiari Research Center, University of Akron, OH,* [2]*Wireless Communication Lab, E.C.E Dept., University of Akron, OH.*

IMPORTANCE FOR CHIARI PATIENTS

Cerebrospinal fluid system flexibility (compliance) is thought to be an important factor to assess Chiari malformation and syringomyelia. However, at present compliance measurement requires invasive techniques such as lumbar puncture. In this project we are developing a novel MRI technique to measure cerebrospinal fluid system compliance based on detection of the wave propagation speed along the spine. This technique could provide a new compliance based parameter to help medical doctors assess Chiari patients.

ABSTRACT

In this work, a novel noninvasive MRI based technique to help quantify the CSF system compliance is demonstrated for a patient with Chiari malformation. A high speed sagittal MRI measurement of in plane velocity is obtained. The velocity data is filtered by a semi-automated cross-correlation based on an optimal level and duration. Results show that the technique is automated and picks velocity points that are relevant to CSF flow. The wave speed along the spine is quantified.

INTRODUCTION

Noninvasive measurement of the speed that the CSF pulse travels through the spinal canal is of interest as a potential indicator of CSF system pressure and compliance. It is known that the pulse wave velocity (PWV) in a compliant vessel increases as wall stiffness increases and has been of interest since arterial stiffness is thought to be a risk factor for arterial disease [2]. Our hypothesis is that a stiff spinal CSF system would result in a faster moving CSF wave in the spine and that the speed of this wave could be an indicator of Chiari disease severity.

METHODS

Our approach was to develop a CSF wave speed measurement technique that required minimal user input. A high speed MRI measurement of CSF velocity with time interval <10ms was obtained in the sagittal plane (Figure 1) for a patient with Chiari malformation. The MRI velocity data was filtered using a cross-correlation filter with optimum level and duration settings (Figure 2). These settings were determined by a semi-automated technique requiring the user to pick a few "good" and "bad" pixels in the MRI image.

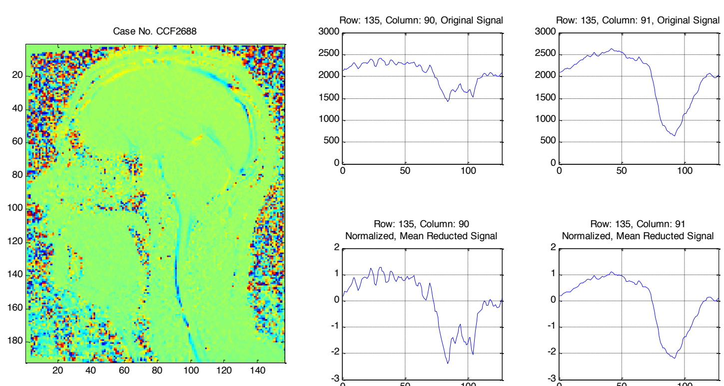

Figure 1. Sagittal view of Chiari patient (left). Velocity waveforms over the CSF flow cycle for two adjacent pixels in the CSF space (right).

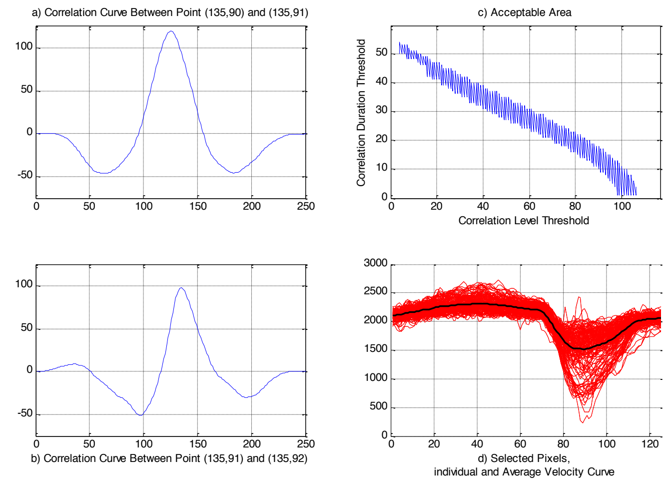

Figure 2. a & b) correlation curve for point 90/91 and 91/21, c) acceptable area and d) selected pixel velocity curves.

RESULTS AND DISCUSSION

The movement of the CSF wave down the spine can be visualized in the spatial-temporal plane (Figure 3). The slope of the wave-front provides information about the CSF wave speed which is thought to correlated with compliance of the spine. The semi-automated technique successfully filtered out pixels in the MRI image that had CSF type flow waveforms. Next steps on this project will be to process more MRI data sets for Chiari patients and compare the CSF wave speed to healthy controls.

Limitations

A major limitation of this study is that we need to validate the method using an in vitro model of a flexible spine. Also, faster moving CSF waves will make a greater level of noise in the MRI measurements and the presently used filtering technique cannot differentiate arterial from CSF regions.

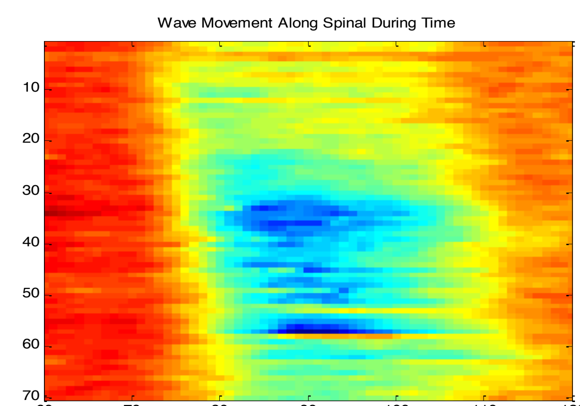

Figure 3. CSF velocity wave moving down the spine (y-axis represents distance moving down the spine in pixels and x-axis represents time).

REFERENCES

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