4D Magnetic Resonance Velocity Measurements in the Internal Jugular Veins of Healthy Subjects and MS Patients

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Introduction: There is considerable interest in the anatomy and physiology of the large veins in the head and neck due to the theory that chronic cerebrospinal venous insufficiency (CCSVI) is related to multiple sclerosis (MS). One source for this interest is the study of Zamboni et al. (2009) who used extracranial color-Doppler and transcranial color-coded Doppler sonography to distinguish healthy control subjects from MS patients using criteria indicative of abnormal blood flow in veins of the neck and head. The position of the cerebrospinal veins make such ultrasound measurements difficult and other researchers have had difficulty reproducing their results making these methods not ideal for general application in diagnosing and potential treatment. An alternative method for looking at blood flow is sought. Magnetic resonance imaging (MRI) is an imaging modality that can provide anatomic and hemodynamic information for the entire neck and head. Several studies including the recent one by Wattjes et al. (2010) have used MRI to look at vein anatomy and blood flow through 2D slices through the cerebrospinal veins. Wattjes looked for abnormal flow reflux reported by Zamboni in the deep cerebral veins but found no reflux and no difference between healthy and MS subjects. It may be that MRI with its limited spatial and temporal resolution may not detect the abnormal flow signatures Zamboni detected. However, it stands to reason that if MS is related to CCSVI, there should be differences in the blood flow of the MS patients. In an attempt to investigate these differences, time-resolved 3D phase-contrast MRI measurements were made in healthy control and MS subjects. Flow rate waveforms were measured several places along the length of the internal jugular (IJ) veins and compared.

Materials & Methods: Cohorts of gender and age-matched healthy controls (HC) (n=15) and MS patients (n=10) underwent MRI exams in a 3T GE MRI scanner. Time-resolved 3D velocity data were taken using 5 mm axial slices and a field of view of 24 cm with 1 mm in-plane resolution. Total coverage ranged from below the top of the aortic arch to above the straight sinus. Temporal resolution for the HC data was 78 msec (4 views/segment) and 156 msec (8 views/segment) for the MS data. Data were reconstructed to produce 20 phases in a heart beat. Plethysmograph triggering was used. The flow rates in the right and left IJs were measured at three levels: low - above the

valve at the IJ-brachiocephalic vein junction, mid - around the carotid artery bifurcation, and high - just below the jugular bulb (see Figure 1).

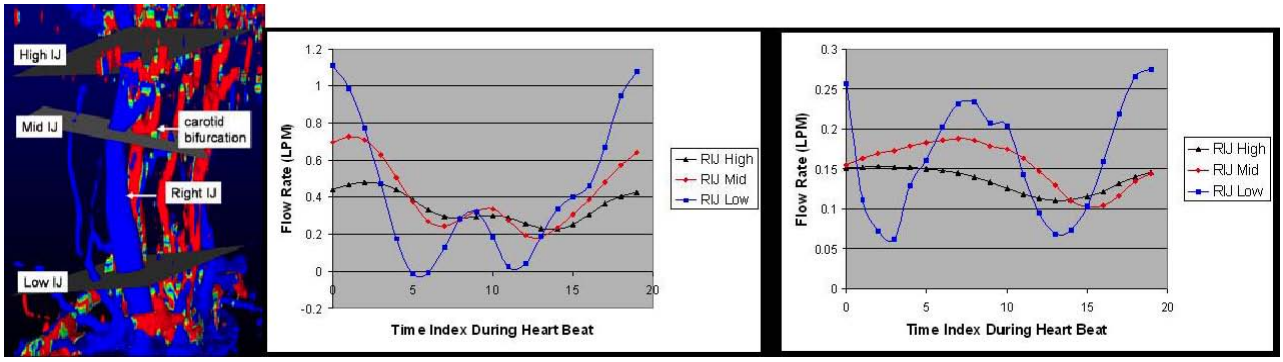

Figure 1: measurement sites. Figure 2: Flow rate waveforms at three levels in the RIJ of HC (left) and MS (right) subjects.

Results: Figure 2 shows illustrative waveforms from the right IJ in HC and MS data. These waveforms can be analyzed for their amplitude variations and relative phase shifts in order to determine the functional characteristics of the IJ veins.

Discussion & Conclusion: One goal of this study is to determine what is normal venous flow in healthy people. The left set of waveforms illustrates normal flow. In the lower IJ, the flow rate waveform has two peaks and two troughs which relate to the action of the right atrium and ventricle. This shape persists higher in the IJ although the amplitude is damped, there is a phase delay, and the mean flow rate decreases. Note that significant variations exist in the exact shape of the waveform from person to person, but normal flow rates share these three characteristics. The flow rates in the MS case differ: the double pulse is lost between the low and mid IJ, the mean flow rates are considerably lower, and the phase delay progression is inconsistent. These are early results, and much work must be done to understand the reasons for these changes and to potentially relate them to symptoms of MS.

References:

Zamboni P, Galeotti R, Menegatti E, et al. J Neurol Neurosurg Psychiatry 2009:80:392-9 Wattjes MP, van Oosten BW, de Graaf WL, et al. J Neurol Neurosurg Psychiatry 2010 online doi:10.1136/jnnp.2010.223479