TIME OF FLIGHT MAGNETIC RESONANCE VENOGRAPHY OF THE INTERNAL JUGULAR VEIN: APPLICABILITY TO CHRONIC CEREBROSPINAL VENOUS INSUFFICIENCY

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PURPOSE

Recently, a role for abnormalities in extra-cranial veins in pathogenesis of multiple sclerosis (MS) has been proposed (1). This so-called chronic cerebrospinal venous insufficiency (CCSVI) involves putative occlusion of one or both of the internal jugular veins (IJVs). While diagnosis of CCSVI requires studies with ultrasound, this modality is foreign to the conventional assessment of MS. MRI on the other hand is used routinely in the diagnosis and monitoring of MS. Time of flight (TOF) magnetic resonance venography (MRV) can be used to produce three-dimensional venograms and is capable of determining the presence of vascular lesions (2). In addition to a reduced dependence on operator performance compared to ultrasound, non-contrast TOF MRV is an acceptable addition to CCSVI studies on the basis of safety for control subjects. We hypothesized that metrics of IJV anatomy (cross-sectional area, CSA) derived from TOF MRV are sufficiently reproducible across serial venograms to permit their inclusion in CCSVI research protocols. The purpose of this study is to classify typical values and errors of IJV CSA obtainable from TOF MRVs in healthy controls. A second objective is to address the challenge of co-registration of serial (in time) MRVs in order to follow disease progresison.

METHODS

<u>MR Imaging</u> Nine healthy volunteers were scanned on a 3T MR scanner with a 12-channel head coil and 4-channel neck coil. Two-dimensional MRV was performed in the axial plane using the following parameters: TR/TE = 39/4.99 ms; flip angle, 50º; slice thickness, 2 mm; gap, -0.4 mm; matrix, 640 x 303; readout field of view, 400 mm; number of slices, 110. An inferior saturation slab was used to null arterial signal. This sequence was performed three times for each volunteer. Between scans, volunteers were instructed to rotate their head and neck and then return to a comfortable position in order to introduce variation between scans similar to what might be observed in serial scans within a longitudinal study.

<u>Measurements of CSA</u> Left and right IJVs were segmented in each slice. Area profiles were plotted as CSA versus slice number for each acquisition. Trends in CSA were assessed at three positions of interest along each IJV that were commonly observed in volunteers: (**I**) a local minimum in area near the transverse process of the first cervical vertebrae (C1), (**II**) a local maximum in area where the common facial vein enters the IJV, and, (**III**) a local maximum in area at the level of the inferior bulb. The average CSAs of the right and left IJVs were also computed by taking the mean of CSA of all slices.

Due to repositioning between scans, images were not intrinsically co-registered. An optimal method to align slices to facilitate slice-wise comparisons between serial volumes was not obvious. Two different paradigms were evaluated to address this challenge:

<u>One-dimensional translation (1DT)</u> Volumes from the second and third acquisitions were translated an integer number of slices in the superior/inferior direction. The number of slices translated was determined such that there was optimal alignment of major features between the three area profiles according to visual inspection.

<u>Rigid body registration (RBR)</u> All prominent neck veins were segmented using a 3D region-growing tool. The segmentation masks from the second and third scans were co-registered to that of the first scan using rigid body registration. Registration parameters were then applied to the original, un-segmented volumes of the second and third scan. In contrast to 1DT, this registration may involve re-slicing of images as opposed to simple translation of slices.

RESULTS

Grand means and root-mean-square standard deviations (SDs) across all subjects are summarized at right for all CSA metrics made following both allignment paradigms. It is readily clear that these metrics of IJV CSA tend to be larger on the right than the left. Also shown are P-values from Wilcoxon signed-rank test between left and right measurements made following 1DT.

	1DT	RBR	1DT	RBR	P (L vs R)
	Left		Right		1DT
Average CSA					
Mean (mm^2)	44.9	45.0	66.8	66.6	0.0078
SD (mm^2)	2.0	2.2	4.4	4.4	
Position I					
Mean	17.9	18.0	29.5	29.5	0.0742
SD	2.8	3.1	3.6	3.6	
Position II					
Mean	84.8	83.5	101.5	99.4	0.0234
SD	10.8	14.6	15.1	9.1	
Position III					
Mean	81.7	82.5	122.9	122.2	0.0625
SD	4.3	3.4	8.1	9.5	

DISCUSSION & CONCLUSION

Future studies of CCSVI must consider normal left/right differences in order to avoid false positive for occlusion. For example, we report a grand mean cross-sectional area of the minimum near C1 of the left and right IJV to be approximately 0.2 cm^2 and 0.3 cm^2, the former being considerably smaller than the ostensibly pathological CSA described by Zamboni and colleagues of 0.3 cm^2 (1). At the minimum near C1, rms SD never exceeds 3.6 mm^2, an order of magnitude smaller than this value, suggesting our CSA metrics are sufficiently precise for classification of stenosis. With respect to co-registration: both paradigms yield comparable means and SDs. Therefore, we recommend use of the 1DT paradigm given its relative simplicity yet comparbale results to RBR.

REFERENCES (1) Zamboni et al, J Neurol Neurosurg Psychiatry 2009;80. (2) Rollins et al, Radiology 2005;235.