Reproducibility of Secondary Vessel Segmentation on Magnetic Resonance Venography

Matthew Toposki[1], Kana Kimura[1], Dejan Jakimovski[1], Niels Bergsland[1], Jesper Hagemeier[1], Robert Zivadinov[1,2]

[1]Buffalo Neuroimaging Analysis Center, Department of Neurology, Jacobs School of Medicine and Biomedical Sciences, University at Buffalo, State University of New York, Buffalo, NY, USA;
[2]Translational Imaging Center at Clinical Translational Research Center, University at Buffalo, State University of New York, Buffalo, NY, USA

Background

- . Magnetic resonance venography (MRV) is a non-invasive tool for imaging the vasculature, however, obtaining absolute cross-sectional area (CSA) measurements remain technically challenging. Previous study has shown that patients with multiple sclerosis (MS) have been shown to display higher numbers of secondary vessels in the neck, while simultaneously displaying a lower cross-sectional area (CSA) of the main arterial vasculature when compared to healthy controls (HC).

Multiple Sclerosis

- Multiple sclerosis is a chronic autoimmune-mediated demyelinating disease of the central nervous system (CNS). Demyelination of neuronal axons in the CNS reduces propagation of action potentials. This can result in a wide variety of symptoms from numbness in the extremities to a loss of visual acuity (optic neuritis).

Figure 1. Graphic representation of the T-cell mediated autoimmune attack of the neuronal myelin sheath.
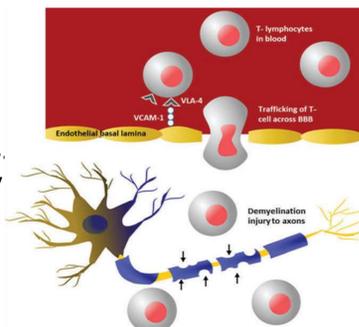
Objective

- To asses and validate the intra- and inter-rater accuracy of MRV-derived vessel CSA quantification.

Materials and Methods

- The reproducibility examination was performed on subset of 10 HCs which were part of a larger cardiovascular, environmental, and genetic effects in MS (CEG-MS) study.
- In addition to the conventional images, the 3T MRI protocol also included MRV of the neck.
- The secondary vessels of predetermined MRV slices at each cervical level (C1/C2, C2/C3, C4, C4/C5, C5/C6, C6/C7, and C7/T1) were segmented by two trained operators using the Java Image Manipulator (JIM) software.
- All vessels except the internal jugular vein, common carotid, and vertebral artery were classified as secondary vessels.
- Intra- and inter-rater intraclass correlation coefficients (ICC) with a 95% confidence interval (CI) were calculated.

Interrater

Figure 2. MRV image as viewed by JIM neuroimaging software. Red lines mark OPERATOR 1's segmentation of secondary vessels. This image was taken at cervical level C1/C2.
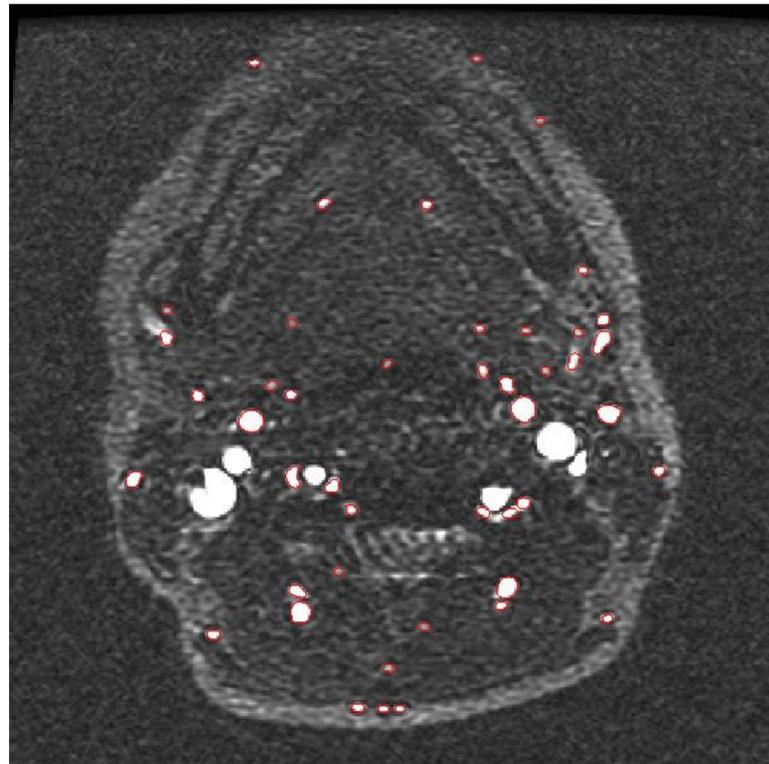
Figure 3. Same MRV-derived image as seen in Figure 2. However, red displays OPERATOR 2's segmentation of the same slice at cervical level C1/C2.
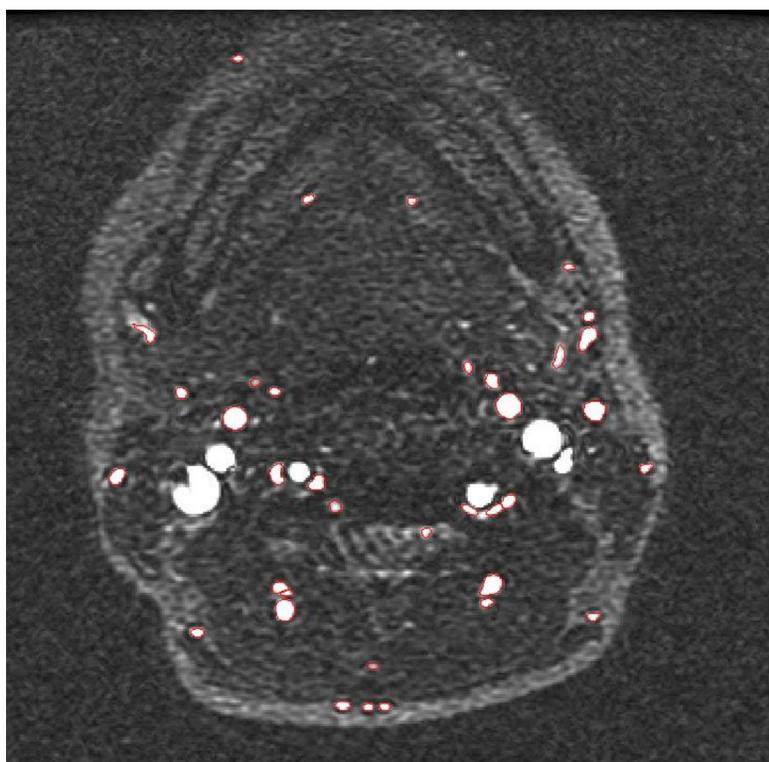
Results

Table 1. Intrarater and interrater intraclass correlation coefficients

Collateral Vessel Level	Intrarater ICC		Interrater ICC	
	ICC (95% CI)	P value	ICC (95% CI)	P value
C1/C2	.843 (-.509-.984)	0.05	.971 (.719-.997)	0.002
C2/C3	.888 (-.079-.988)	0.029	.998 (.982-1.00)	<.001
C4	.924 (.269-.992)	0.014	.844 (-.497-.984)	0.05
C4/C5	.909 (.125-.991)	0.02	.979 (.802-.998)	0.001
C5/C6	.882 (-.130-.988)	0.031	.988 (.883-.999)	0.123
C6/C7	.972 (.734-.997)	0.002	.992 (.926-.999)	<.001
C7/T1	.920 (.228-.992)	0.016	.967 (.680-.997)	0.003
Average	.935 (.872-.967)	<0.001	.972 (.944-.986)	<.001

Legend: ICC- intraclass correlation coefficient, data is presented with a 95% confidence interval (CI). Data for intrarater and interrater ICC were obtained from 10 scans, 5 for each data set.

An average intra-class ICC for all segmented slices was 0.935 (0.872-0.967), p<0.001. The highest intra-class ICC was measured at the C6/C7 level 0.972 (0.734-0.997), p=0.002 and the lowest ICC was measured at the C1/C2 level 0.843 (-0.509-0.984) p=0.050. Similarly, the inter-class ICC for all segmented slices was 0.972 (0.944-0.986) p<0.001. The highest inter-class ICC was measured at the C2/C3 level 0.998 (.982-1.00), p<.001 and the lowest ICC was measured at C4 0.884 (-0.497-0.984) p=0.050.

Conclusion

- The ICC analysis showed highly reliable intra- and inter-class results. Previous anatomical knowledge, software training, and familiarization with image contrast are warranted for ensuring reliable and accurate MRV-derived vessel segmentation.

References

- Belov, P., Jakimovski, D., Krawiecki, J., Magnano, C., Hagemeier, J., Pelizzari, L., Weinstock-Guttman, B., Zivadinov, R. 2018. Lower Arterial Cross-Sectional Area of Carotid and Vertebral Arteries and Higher Frequency of Secondary Neck Vessels Are Associated with Multiple Sclerosis. American Journal of Neuroradiology, 39(1), 123-130
- Gandhi, S., Jakimovski, D., Ahmed, R., Hojnacki, D., Kolb, C., Weinstock-Guttman, B., Zivadinov, R. 2016. Use of natalizumab in multiple sclerosis: current perspectives. Expert Opinion on Biological Therapy, 16 (9), 1151-1162