Simultaneous Acquisition of MR Angiography and Venography (MRAV)

Y. P. Du[1], and Z. Jin[2,3]

[1]Psychiatry, Radiology, University of Colorado Denver School of Medicine, Aurora, CO, United States, [2]Automation, Hangzhou Dianzi University, Hangzhou, Zhejiang, China, People's Republic of, [3]Biomedical Engineering, Zhejiang University, Hangzhou, Zhejiang, China, People's Republic of

Introduction: MR susceptibility weighted imaging (SWI) has recently demonstrated great clinical significance in the diagnosis of several intracranial venous diseases (1,2). SWI utilizes the relative phase and magnitude changes in the venous vasculature introduced by the susceptibility difference between venous blood and parenchyma. MR angiography (MRA) using the time-of-flight (TOF) contrast, on the other hand, provides excellent details of the arterial vasculature and has been routinely used in clinical brain exams. MRA and MRV can reveal different neuronal and vascular abnormalities and provide complementary diagnostic assessments of brain vascular diseases. In this study, we present a novel technique in which the data acquisition of MRV is incorporated into the 3D TOF MRA scan: the first echo is used for MRA and the second echo is used for MRV. This approach of simultaneous acquisition of MR angiography and venography (MRAV) yields additional MRV images without increasing the typical scan time for MRA at 3T.

Methods: In a conventional 3D TOF pulse sequence, a short echo time (TE) (e.g., TE=3-5ms) is used to reduce flow artifacts. The sequence is in an "idle" state after the readout and phase rewinders. The duration of the "idle" state is typically in the range of 10-20ms, depending on the TR selected for in-flow effect. In MRV, a relatively long TE (e.g., TE=28ms at 3T) is used to achieve optimal venous contrast. In the MRAV technique, the acquisition of a second echo is added to a conventional multiple overlapped thin slab acquisition (MOTSA) of a 3D TOF pulse sequence (see the dashed rectangular area in Fig. 1). A fly-back gradient is placed in the middle of two readouts to refocus the second echo and restore flow-compensation in the second echo. In this study, partial echo acquisition for the second echo is used because it allows a shortened TR for a selected echo time of the second echo (TE2). The MRAV data were acquired on a GE 3T scanner with TE1/TE2/TR/α=4.1ms/24.5ms/32ms/20^o, a matrix size of 384x310x32, a FOV of 20cm$\times$16cm, and a slice thickness of 1.6mm. The in-plane resolution was 0.52$\times$0.52mm^2 and the voxel volume was 0.43mm^3. Two partially overlapped slabs with 32 slices per slab were acquired. High-order autoshim was applied prior to the scans to improve the field inhomogeneity. A 66.7% partial echo was used in the acquisition of both echoes. Flow compensation was applied along the slice-selection and frequency encoding directions to reduce flow artifacts. The total scan time was 10 minutes and 46 seconds.

Results: Both MRV and MRA data were simultaneously acquired with the dual-echo MRAV technique. Figure 2a shows the minimum-intensity projection (mIP) of MRV of 16 slices in the inferior slab with a thickness of 25.6mm. Figure 2b shows the mIP of MRV of 20 slices in the superior slab with a thickness of 32.0mm. These venograms depict excellent details of the venous vasculature. Figure 2c shows the maximum-intensity projection (MIP) of the concatenated MRA slabs acquired at TE1.

Discussion: The dual-echo MRAV technique enables us to acquire additional MRV images in an MRA scan without increasing scan time at 3T. Simultaneous acquisition of MRA and MRV data also eliminates possible misregistration between MRA and MRV due to inter-scan patient motion if the data are acquired separately. The MRAV technique can also be applied at 1.5T. Because a twice longer TE is needed to achieve the same susceptibility effect at 1.5T than at 3T, a longer TR is required for simultaneous MRAV acquisition. The increased TR would affect the vascular contrast in MRA because of the competing effects of the increased in-flow and weakened saturation of the stationary tissue. Careful selection of TR is necessary for optimal balance of vascular contrast in MRA and MRV at 1.5T.

References: 1) Reichenbach, JR et al., Radiology 1997;204:272-7. 2) Haacke, EM, et al., MRM 2004;52:612-8.

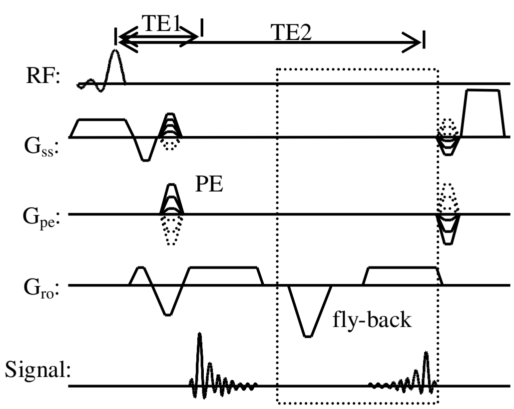
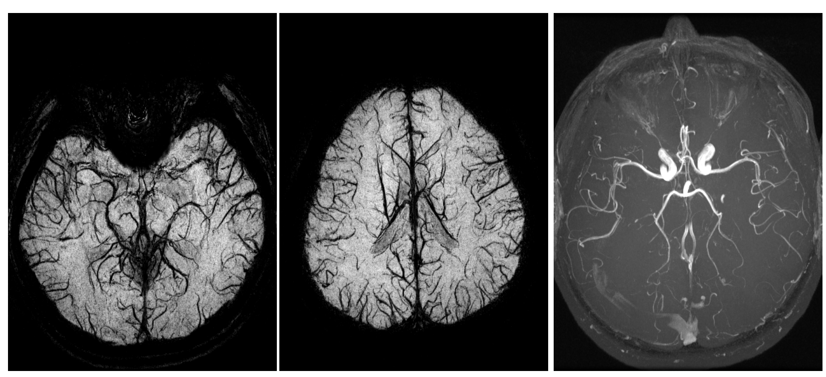


Fig. 1. The diagram of the MRAV pulse sequence. The acquisition of the second echo, as shown inside the dashed rectangular area, is added to the 3D TOF MRA sequence for MR venography.



(a) (b) (c)

Fig. 2. The mIP of MR venography of the inferior slab (a), and the superior slab (b). These 2 slabs were acquired at the second echo of the MRAV pulse sequence. Figure 2c shows the MIP of MRA of both slabs acquired at the first echo of the same pulse sequence.