High resolution, non-contrast imaging of both cerebral veins and arteries by use of gradient echo T2 Star Weighted Angiography (SWAN)

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Problem

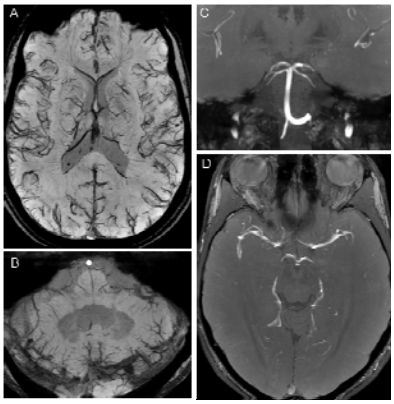
High resolution, non-contrast imaging of both cerebral veins and arteries by use of gradient echo T2 Star Weighted Angiography (SWAN) is a new method for susceptibility-weighted imaging with short acquisition times. Cerebral veins show a profoundly hypointense signal on these susceptibility-weighted images [1], while the intracranial arteries are hyperintense on the SWAN sequence. Thus, we assessed the potential of this sequence for the depiction of both cerebral veins and arteries by use of both minimum (MinIP) and maximum intensity projections (MIP).

Methods

12 healthy volunteers were included in the study. MRI was performed on a 3 Tesla MR scanner (Signa, General Electrics, USA) using the following three sequences: (1) a 3D multi-echo gradient echo T2 Star Weighted Angiography (SWAN) with 5 echos centered around 26 ms echo time (TR = 43 ms, slice thickness = 1 mm, 384 x 384 matrix, FOV = 200 mm x 200 mm, scan time 8:40 min), (2) an arterial 3D time of flight MR angiography (TOF-MRA; TR = 25 ms, TE = 3,9 ms, flip angle = 15, matrix = 384 x 320, FOV = 200 mm x 200 mm, scan time = 6:19min), and (3) a venous 2D time of flight (TOF-MRV; TR = 25 ms, TE = 4,2 ms, flip angle = 70, matrix = 224 x 224, FOV = 224 mm x 224 mm, scan time = 8:49 min).
With regard to the SWAN sequence, both MinIP and MIP images were reconstructed. The cerebral veins were assessed on the MinIPs, while the MIP images were used to analyse the intracranial arteries. Regarding the TOF-MRA and the TOF-MRV, MIP reconstructions were performed. Two readers evaluated the MinIPs and the MIPs of the three sequences, respectively, in collaboration to score the success with which the different sequences depicted the cerebral veins and arteries as continuous and homogeneous, continuous and inhomogeneous, or noncontinuous.

Results

With regard to the visualization of the cerebral veins, the MinIP reconstructions of the SWAN sequence were considerably superior compared to the TOF-MRV, especially with regard to the tributaries of the internal cerebral veins, the transmedullary veins (Fig. 1A), as well as the brainstem veins (Fig. 1B). Concerning the depiction of the main segments of the the middle, anterior and posterior cerebral arteries, and the numbers of their secondary and tertiary branches the value of the MIP reconstructions of the SWAN was comparable to that of the TOF-MRA. The value of the SWAN sequence for the evaluation of the cerebral arteries was particularly good for the posterior circulation (Fig. 1C), and limited for the divisions of the M1 segment of the middle cerebral arteries and for the cavernous segment of the internal carotid arteries (Fig. 1D).



Conclusions

SWAN allows for high-resolution visualization of both cerebral veins and arteries in one sequence without application of contrast agent. By use of either MinIP or MIP reconstructions, the arteries can be distinguished from the veins. The scan time of the SWAN sequence was significantly shortened compared to the combined scan time of TOF-MRA and TOF-MRV.
Potential clinical implications include the preoperative visualization of tumor vascularization, as well as the assessment of arterio-venous malformations, especially in patients with an impaired renal function.

Fig. 1: A,B: MinIP reconstructions of the SWAN sequence, demonstrating the transmedullary veins (A), and the brainstem veins (B). C,D: The MIP reconstructions nicely depict the arteries of the posterior circulation (C), and are limited for the divisions of the M1 segment of the middle cerebral arteries (D).

References:

1 Reichenbach JR, Venkatesan R, Schillinger DJ, Kido DK, Haake EM. Small vessels in the human brain: MR venography with deoxyhemoglobin as an intrinsic contrast agent. Radiology. 1997;204:272-7.