Non-enhanced MR angiography of the external carotid artery and its branches using true steady-state free-precession (SSFP) sequence with time spatial labeling inversion pulse (T-SLIP) technique

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Introduction:

Detailed anatomical information of the external carotid artery system is important for less-invasive treatment approaches to head and neck disorders, including selective arterial embolization and intraarterial infusion chemotherapy. Recently balanced steady-state free-precession (SSFP) sequence has been applied for non-enhanced head and neck MR angiography and has shown relatively good visualization of the external carotid branches (1), but veins and salivary gland ducts also show high signal intensity on this sequence. The time spatial labeling inversion pulse (T-SLIP) method is an arterial spin-labeling technique that can selectively visualize arteries with good background suppression, and this technique can control the extent of inflowing arterial signal and background signal suppression by changing the inversion time (TI). The purpose of this study was to evaluate the visibility of the external carotid artery system using true SSFP with T-SLIP, and to provide the optimal TI value.

Materials and Methods:

MR examinations were performed in 20 healthy volunteers (14 men and 6 women; mean, 24 years; range, 18-31 years). Peripheral-pulse-gated coronal 3D true SSFP images with fat saturation were obtained using a 1.5-T MR scanner (EXCELART Vantage, Toshiba Medical Systems, Tokyo, Japan). Imaging parameters were as follows: slice thickness of 1.5 mm, slice number of 54, field-of-view of 180x320 mm, matrix size of 144x256, speeder factor of 2x1. T-SLIP method with four different TIs (600, 900, 1200, and 1500 ms) was applied, and the acquisition time ranged from 1 min 50 sec to 4 min 15 sec. For the qualitative analysis, two radiologists separately evaluated the visibility of the main external carotid artery, eight first-order branches (the superior thyroid, lingual, facial, ascending pharyngeal, occipital, posterior auricular, maxillary, and superficial temporal artery), and two second-order branches (the middle meningeal and deep lingual artery) using the coronal source images and MIP images. Visualization quality was scored on a 4-point scale, and the Friedman rank test and the Wilcoxon signed rank test with Bonferroni correction were conducted using an average score of two readers for each vessel. For the quantitative analysis, the average signal intensity (SI) of the external carotid artery and sternocleidomastoid muscle was measured by applying oval region-of-interest on the coronal source images, and the relative SI was calculated by the following equation: relative SI = (SIartery - SImuscle) /SIartery. Comparison was performed using one-way repeated-measures analysis of variance followed by Scheffe's test.

Results:

The scores of the visibility of the external carotid artery system are summarized in Table 1. The images with TI of 600 ms revealed lower visibility compared with the other TIs. The scores with TI of 900 ms also showed significant deterioration in comparison with TI of 1200 and 1500 ms, but there was no significant difference between the visibility with TI of 1200 and 1500 ms. The relative SI values were 0.97 ± 0.02, 0.87 ± 0.02, 0.81 ± 0.02, and 0.76 ± 0.02 for TI of 600, 900, 1200, and 1500ms, respectively. There was a significant difference between any two pairs of the four different TIs.

Discussion and Conclusion:

True SSFP with T-SLIP showed favorable visibility of the external carotid artery system with considerably short acquisition times. The images with TI of 1200 and 1500 ms showed higher visibility compared with TI of 600 or 900 ms, and better background suppression was observed in the images with TI of 1200 ms in comparison with TI of 1500 ms. We suggest a TI of 1200 ms to be optimal for true SSFP MR angiography with T-SLIP for the evaluation of the external carotid artery system.

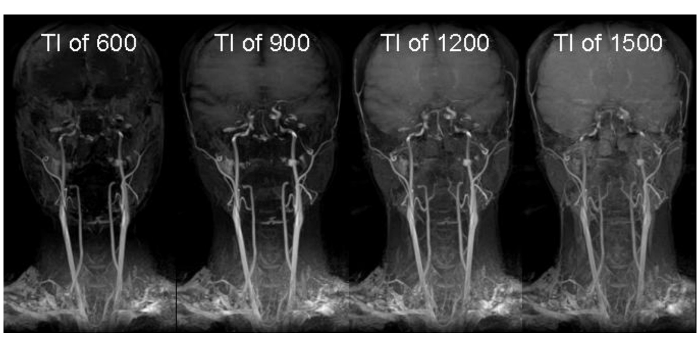

Figure 1. Coronal MIP images in a 25–year-old man with four different TIs

Table 1. Visibility of the external carotid artery and its branches (1-4 points)

TI	600 ms	900 ms	1200 ms	1500 ms
External carotid	3.9 ± 0.2	4.0 ± 0.0	4.0 ± 0.0	4.0 ± 0.0
Superior thyroid	2.6 ± 0.6	3.3 ± 0.6	3.6 ± 0.6	3.7 ± 0.6
Lingual	2.6 ± 0.5	3.7 ± 0.4	4.0 ± 0.2	4.0 ± 0.1
Facial	3.1 ± 0.7	3.8 ± 0.5	3.9 ± 0.3	4.0 ± 0.3
Ascending pharyngeal	1.6 ± 0.6	2.5 ± 0.9	2.9 ± 1.0	2.6 ± 1.1
Occipital	4.0 ± 0.1	4.0 ± 0.0	4.0 ± 0.0	4.0 ± 0.0
Posterior auricular	2.3 ± 1.1	3.4 ± 0.9	3.7 ± 0.7	3.6 ± 0.9
Maxillary	2.6 ± 0.6	3.6 ± 0.5	3.9 ± 0.3	4.0 ± 0.1
Superficial temporal	2.9 ± 0.6	3.8 ± 0.5	4.0 ± 0.0	4.0 ± 0.0
Middle meningeal	1.8 ± 0.7	3.3 ± 0.8	3.8 ± 0.5	3.6 ± 0.6
Deep lingual	1.1 ± 0.3	2.5 ± 1.1	3.7 ± 0.6	3.9 ± 0.3
Average Friedman rank	1.42	2.56	3.03	3.00

References:

1. Sumi T, et al. Parallel imaging technique for the external carotid artery and its branches. J Magn Reson Imaging 2007; 25(5):1028-1034.