High-risk mid-cerebral artery atherosclerotic disease detection using Simultaneous Non-contrast Angiography and intraPlaque hemorrhage (SNAP) imaging

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Introduction

Intracranial artery disease (IAD) is an important but often overlooked contributor to the onset of stroke. Previous studies indicated that ~10% of the stroke incidences are caused by the intracranial lesions[1], and this number is even higher for certain racial groups[2]. Besides the commonly inspected luminal stenosis, intraplaque hemorrhage (IPH), as indicated by studies based on carotid artery lesions, has also been associated with increased lesion progression rate and the incidence rate of clinical events[3]. The impact from IPH (alone or in combination with luminal stenosis) is still poorly understood in the intracranial area mainly because of the lack of a proper imaging technique for IPH detection in this area. In this study, we will validate a newly optimized Simultaneous Non-contrast Angiography and intraPlaque hemorrhage (SNAP) technique[4] suitable for joint stenosis and IPH lesion detection for IAD patients. We focus only on the mid-cerebral artery (MCA) area in the validation, as it is the most frequent target of IAD in the region.

Methods

Sequence Optimization The SNAP technique was previously developed for carotid atherosclerotic disease detection. Benefited from the phase-sensitive (PS) reconstruction, SNAP can offer simultaneous IPH and non-contrast MRA in the same dataset. The resulting IPH contrast is much improved compared to the traditional MP-RAGE technique[5].

To adapt the SNAP sequence for intracranial artery imaging, the key is to optimize the flow suppression for improved lumen analysis. This was done by meeting the conditions proposed before[4] with the intracranial artery flow knowledge reported from previous studies[6].

Study Population 15 patients with angiographically diagnosed intracranial artery disease were consecutively recruited in the local hospital after obtaining local IRB approved consent forms.

MR scan All scans were conducted using a 3T whole body scanner (Philips Achieva, the Netherlands) with 8-ch phase array brain coil. Geometry and matrix size matched SNAP and TOF scans were added onto a regular clinical evaluation protocol. The imaging parameters were: SNAP: PSIR enabled 3D IRTFE, IRTR 1970ms, TR/TE 10/5.5ms, FA: 11º, FOV 160×160×50mm³, acquired matrix size: 1×1×1mm³, interpolated to 0.5×0.5×0.5mm³, scan time 2min40sec; TOF uses the same parameters except: 3D FFE, TR/TE 26/3.5ms, FA 20º, scan time 1min40sec.

Image Analysis The SNAP images were first processed for MRA visualization as described before[4]. The presence or absence of MCA stenosis was then evaluated on both SNAP and TOF images by an experienced neuroimaging radiologist. 3D MIP images were used to evaluate both sides of the MCA arteries. The smallest visible MCA branch level of the mid-cerebral arteries was also recorded for both sides of the arteries. The SNAP images were also processed and used for IPH detection using the method described before[4].

Statistics Both the stenosis level and smallest visible segments comparisons between SNAP and TOF were evaluated by Cohen's Kappa. Both evaluations were made on the artery level.

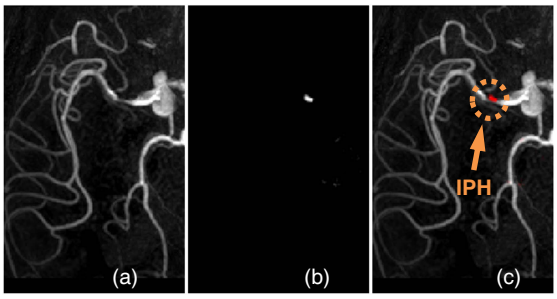

Fig. 1 SNAP imaging of the intracranial artery: the SNAP MRA view (a), IPH view (b) and color-coded joint view (c). As they are from the same dataset, no registration error is expected.

Results

The optimized SNAP sequence has an inversion slab thickness of 30cm and TI 500ms. All 15 patients completed both scans and image quality on all images was found to be satisfactory except one TOF image with motion artifact. SNAP detected IPH lesions on 3 arteries (10%). As the IPH lesions share the same dataset with the non-contrast MRA scans, a color-coded 3D SNAP (Fig.1c) allows for easy evaluation of both luminal stenosis and IPH in a same review session.

The reconstructed 3D SNAP MRA provided improved visualization of the intracranial artery vascular tree, particularly on small branches, as compared to the matched TOF MRA images (Fig.2).

Quantitatively, 3 arteries were found to present complete occlusion on both SNAP and TOF and consequently excluded from the following quantitative comparison. Excellent agreement on the presence of stenosis comparison was found between SNAP and TOF (κ=1.0). The smallest visible branch detected by SNAP was also found to be in an overall good agreement with TOF (κ=0.87), as detailed in Table 1.

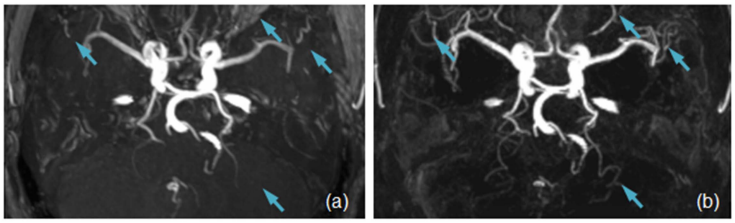

Fig. 2 The MIP image comparison between TOF(a) and SNAP-MRA (b). SNAP was found to provide better visualization of the entire artery tree, especially the visualization of the smaller branches (arrows).

Conclusion

The SNAP was successfully optimized for intracranial artery imaging. As shown in this study, the optimized SNAP allows for simultaneous evaluation of luminal stenosis and IPH at the same time for IAD patients. SNAP MRA was found to provide great agreement for MCA stenosis and small artery evaluation, as compared to TOF technique. Combined the high sensitivity IPH detection rate and the time efficiency, SNAP has the potential to become the first-line imaging tool for IAD evaluation.

Table 1 Smallest visible segment agreement between SNAP and TOF

Smallest segments visible (n=26)		SNAP		
		M1	M2	M3
TOF	M1	0	0	0
	M2	0	4	1
	M3	0	0	21

Reference

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