Validation of 3D Multi-Contrast Black Blood Sequences with Large Coverage for One-Stop Neurovascular Screening

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Introduction: Multi-contrast Black Blood (BB) MRI is an effective technique to detect and measure the atherosclerotic plaque morphology and components. Currently, 2D T1W and T2W BB imaging sequences are widely used in intracranial and extracranial clinical applications respectively to diagnose the plaque burden. However, these methods are limited to the lesion detection range and partial volume effect which might give rise to missed or false diagnosis. Recently, several 3D BB techniques[1-3] have been proposed to improve the coverage by either the whole brain or the whole carotid arteries and overcome the partial volume effect to some degree. In this study, we suppose to apply the 3D multi-contrast BB techniques including MERGE[1] (T1W/T2W), VISTA[2] (T2W) and SNAP[3] (T1W) to cover the intracranial and extracranial segments and investigate the blood suppression effectiveness and image quality for diagnosis in this large-coverage scenario.

Methods: These 3D multi-contrast BB sequences use different BB principles to suppress the blood signal. MERGE exploits MSDE based BB technique whose blood suppression effectiveness will basically not be violated if the first gradient moment is sufficient large. VISTA takes advantage of variable low flip angle TSE sequence whose flowing void effect and potential dephasing gradient like readout and slab selection gradient in terms of T2W imaging can provide the BB effect. SNAP is the modified PSIR sequence whose blood suppression effect is arisen from the blood's relatively long T1 value. In this study, we further enlarge the FOV of the traditional coronal imaging to cover the major intracranial and the entire carotid arteries and a dedicated 36-channel coil is therefore employed[4] as shown in Fig. 1. ***MR imaging***: 24 patients with recent ischemic stroke undertook these 3D multi-contrast BB sequences at Philips Achieva 3.0T system. All of these 3D sequences were sharing the same FOV FH/RL/AP = 250/160/40 mm and 0.8 mm isotropic spatial resolution. The BB module for each 3D sequence was appropriately optimized and the other primary sequence parameters included: SPGR acquisition with TR/TE = 9.2/4.3 ms and FA = 6° for 3D MERGE, SPGR acquisition with TR/TE = 10/4.8 ms and FA = 11° for 3D SNAP and variable flip angle TSE with TR/TE = 2500/268 ms for 3D T2W-VISTA. ***Data Analysis***: The CNR between vessel wall and lumen of the middle cerebral artery and the carotid bifurcation were regarded as the quantitative criterions to compare the intracranial and extracranial blood suppression effectiveness because the atherosclerotic plaque once progressed on these 2 vasculature beds might be highly correlated with stroke and also these lumen areas might be simply contaminated with the flow artifacts. Besides, the image quality score given by an experienced reviewer was evaluated to indicate the image quality for diagnosis.

Results and Discussions: The result of CNR analysis (Table 1) shows that all of these 3 BB techniques can provide relatively effective blood suppression and this result can also be simply visualized by the curve reconstruction result illustrated in Fig 2. Since VISTA sequence primarily depend on the flowing void effect to suppress the blood signal, the blood signal might not be fully suppressed around the carotid bifurcation while it outperforms others in the intracranial artery because VISTA sequence can better preserve the vessel wall in this particular segment. MERGE sequence can suppress the blood with nearly the same performance because the dephasing gradient can work similarly in these different segments. If we only consider the blood signal in lumen area, SNAP performs much better than others since the lumen signal can be negative with respect to the background signal. However, this T1 dependent blood suppression method may bear the cost of vessel wall signal reduction. Based on qualitative analysis, VISTA has statistically superior grades in the intracranial segment and this further demonstrates the previous CNR analysis. For the extracranial segment, all of these 3D multi-contrast BB sequence can provide the similarly diagnostic image quality. Since these 3D multi-contrast BB sequences are implemented with further augmented coverage and robust blood suppression effectiveness, the plaque burden and components distributed along the intracranial and extracranial vascular beds, especially after the curve reconstruction (Fig. 2), can be detected and measured.

Figure 1: The dedicated 36-channel neurovascular coil.

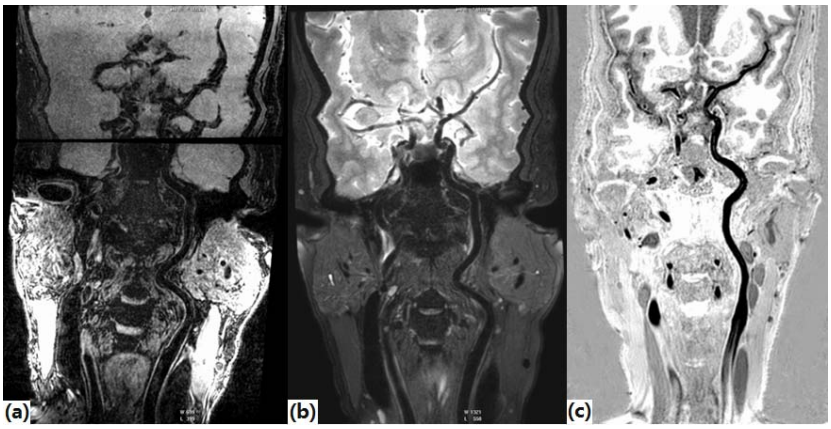

Figure 2: The curve reconstruction results of the left extracranial and intracranial arteries for 3D MERGE (a), 3D VISTA (b) and 3D SNAP (c).

Table 1: Comparison of CNR between vessel wall and lumen

	CNR between vessel wall and lumen		
	MERGE	VISTA	SNAP
Intracranial	8.134±1.951	10.838±1.553	9.275±3.530
Extracranial	7.905±2.679	6.949±1.900	10.040±4.517

Table 2: Comparison of Image Quality Score

	Image Quality Score (1-4)		
	MERGE	VISTA	SNAP
Intracranial	2.583±0.493	2.833±0.373	2.667±0.514
Extracranial	2.875±0.525	2.854±0.456	2.875±0.331

Conclusion: In this study, we investigated the blood suppression effectiveness and diagnostic image qualities for a set of 3D multi-contrast BB sequences in a large coverage application. These 3D multi-contrast large coverage BB techniques can be used as a promising tool to screen the atherosclerotic plaque distribution in the range of major intracranial and the entire carotid arteries and this will further promote our understanding on the association between atherosclerotic plaques within these segments and ischemic stroke.

References: [1] Balu Niranjan, et al. Magn Reson Med. 2011 Mar;65(3):627-37. [2] Qiao Ye, et al. J Magn Reson Imaging. 2011 Jul;34(1):22-30. [3] Wang Jinnan, et al. Magn Reson Med. 2012 Mar 22 Epub. [4] Wang Xinyuan, Proc. Intl. Soc. Mag. Reson. Med. 20, page 2787, 2012