Carotid Atherosclerotic Lesion Distribution in Patients with Cerebrovascular Events: A 3.0 Tesla Magnetic Resonance Vessel Wall Imaging Study Using Three-dimensional, Isotropic, Fast Sequence with Large Coverage

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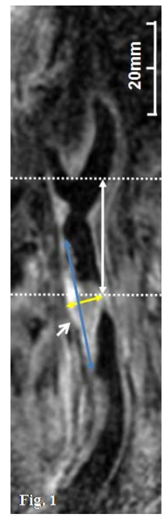
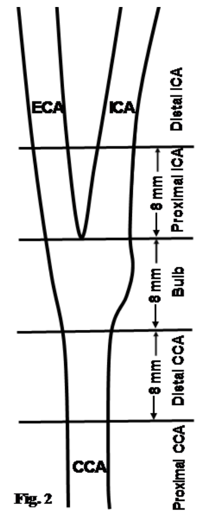
Introduction: Carotid atherosclerotic disease is the major cause of transient ischemic attack (TIA) or ischemic stroke [1]. Early identification of vulnerable plaques in carotid arteries will be helpful for prevention of cerebrovascular events. Carotid multicontrast vessel wall magnetic resonance (MR) imaging has been demonstrated to be capable of characterizing atherosclerotic plaques accurately [2,3]. However, the limited imaging coverage (32-40 mm) centered in carotid bifurcation could not provide the full spectrum of lesion distribution along the longitudinal dimension. Therefore, vulnerable lesions occurred in more proximal or more distal carotid segments cannot be captured using the current multicontrast MR protocol. Additionally, multicontrast imaging may not be an ideal screening approach for vulnerable plaques due to the long scan times. Recently, researchers have developed a new sequence '**M**otion-sensitive Driven **E**quilibrium Prepared **R**apid **G**radient **E**cho (MERGE)' with 3D acquisition, isotropic matrix size, larger longitudinal coverage (> 80 mm), and shorter scan time (2 minutes) [4]. The 3D MERGE technique for vessel wall imaging can be potentially used for fast assessment of plaque morphology and compositions [4,5].

Purpose: This study sought to determine carotid lesion distribution in patients with cerebrovascular symptoms using 3D MERGE sequence with large coverage.

Methods: Ninety-one patients (76 males. mean age 64.5 years) with TIA or stroke underwent carotid black-blood MRI using a Philips 3.0T scanner ((Achieva, Philips Medical System, Best, Netherlands) with dedicated 8-channel phase-array carotid coil. ***MR imaging:*** Carotid MRI was performed using 3D MERGE sequence with the following parameters: TR/TE 10/4.8 ms, FOV 250x160x70 mm^3, isotropic resolution 0.7x0.7x0.7 mm^3, effective foot-head coverage > 80 mm, scan time 2 minutes. The MR imaging was centered in carotid bifurcation. ***Data analysis:*** The 3D MERGE data were reconstructed at the Philips MR work station using curved algorism. Carotid lesions were defined as local wall thickening. Fig. 1 showed how to measure the maximum wall thickness (MaxWT, yellow double-arrow), length (blue double-arrow), distance from bifurcation to location of MaxWT (white double-arrow), and stenosis for each lesion. Presence or absence of calcification, lipid-rich necrotic core (LRNC), intraplaque hemorrhage (IPH), and surface disruption was identified. Carotid artery was partitioned into 5 segments (Fig. 2): distal internal carotid artery (ICA), proximal ICA, bulb, distal common carotid artery (CCA), and proximal CCA. Lesion distribution in different carotid segment was determined by distance from bifurcation to MaxWT.





Results: Of 178 carotid arteries with accepted image quality, 115 arteries had 151 lesions in total. Of the 151 lesions, 11 (7.3%) were in distal ICA, 21 (13.9%) were in proximal ICA, 66 (43.7%) were in bulb, 16 (10.6%) were in distal CCA, and 37 (24.5%) were in proximal CCA (Fig. 3). Benefited from 3D MERGE's large coverage and fast acquisition, near one fourth of the lesions (lesions at proximal CCA) that cannot be detected using traditional carotid scanning protocols (40mm of longitudinal coverage), were identified in this study. The mean value of MaxWT, length, stenosis of lesions and prevalence of plaque compositions in different carotid segment were detailed in Table 1. Proximal CCA lesions showed larger length, more LRNCs, less calcification, and lower stenosis among all carotid segments (Table 1). A substantial number of proximal CCA lesions developed high risk features, such as IPH and surface disruption (Table 1).

Table 1. Lesion distribution in different segment of carotid artery.

	Mean ± SD or %				
	Distal ICA	Proximal ICA	Bulb	Distal CCA	Proximal CCA
MaxWT, mm	3.5 ± 0.9	3.2 ± 0.9	3.8 ± 1.4	3.0 ± 0.7	3.2 ± 1.4
Length, mm	15.0 ± 7.7	10.1 ± 5.2	11.3 ± 5.5	13.5 ± 9.8	17.7 ± 10.5
Stenosis, %	31 ± 30.2	19.7 ± 23.8	22.2 ± 22.4	20 ± 26.1	19.3 ± 17.7
Calcification	36.4%	57.1%	39.4%	31.3%	24.3%
LRNC	81.8%	23.8%	60.6%	43.8%	62.2%
IPH	9.1%	0%	3%	0%	5.4%
Surface disruption	0%	9.5%	4.5%	0%	2.7%

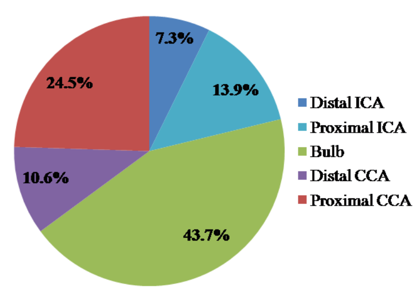


Fig. 3

Discussion and Conclusions: This study investigated the spectrum of carotid atherosclerotic lesion distribution in patients with cerebrovascular symptoms using 3D MERGE imaging sequence. Without increasing the scan time, the 3D MERGE sequence provides large coverage MR data (> 80 mm) which enable depicting the lesion distribution from distal internal carotid artery to proximal common carotid artery. According to the results of this study, near one fourth of carotid lesions occur in proximal common carotid arteries. These lesions could not be captured by multicontrast MR imaging protocol but can be detected by 3D MERGE sequence due to large longitudinal coverage. In addition, we found that the lesions in proximal common carotid segments appear low grade luminal stenosis but large plaque burden with more lipid components. This phenomenon may be due to the positive remodeling which cannot be detected by angiographic approach. The results of this study suggest that 3D MERGE vessel wall imaging technique with isotropic acquisition, large longitudinal coverage, and short scan time might be a useful tool for screening carotid vulnerable plaques. However, the signal to noise ratio of more distal or more proximal carotid segments is limited by the coverage of current carotid coil. We planned to design a new neurovascular coil with dedicated carotid artery component to potentially acquire the vessel wall images for the whole carotid artery tree.

References:

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