Journal of Cardiovascular Magnetic Resonance

Technologist presentation

Distinguishing type I and type II hemorrhage by gradient echo based MR sequence in carotid atherosclerotic plaques

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from 13th Annual SCMR Scientific Sessions
Phoenix, AZ, USA. 21-24 January 2010

Published: 21 January 2010

Journal of Cardiovascular Magnetic Resonance 2010, **12**(Suppl 1):T12 doi:10.1186/1532-429X-12-S1-T12

This abstract is available from: http://jcmr-online.com/content/12/S1/T12

Introduction

Previous studies have demonstrated that carotid intraplaque hemorrhage (IPH) is highly associated with neurovascular events[1] and type I (fresh) hemorrhage is more prevalent in symptomatic arteries compared to asymptomatic arteries[2]. The IPH is identified successfully using T1 weighted image[3]. However the age of IPH is difficult to depict using existing techniques.

Purpose

This study sought to distinguish type I (fresh) and type II (recent) hemorrhage in ex vivo carotid atherosclerotic plaques using a gradient echo (GRE) based MR sequence.

Methods

Five ex vivo carotid endarterectomy (CEA) specimens were imaged on a 3T MR scanner (Philips Achieva) after formalin fixation. Firstly, a GRE sequence was optimized with different echo time (from 4.1ms to 9.1ms) to obtain the greatest contrast between type I and type II hemorrhages which were verified by histology. Secondly, four contrast MR weightings including T1 weighted (T1W), T2 weighted (T2W), Proton density weighted (PDW) and GRE with optimized parameters (Table 1) were acquired. Histology specimens were stained using hematoxylin and eosin (H&E) and Mallory's trichrome at the location according to MRI slices. The histologist, blinded to the MR images, outlined IPH regions. Morphological features of lumen, vessel wall, and the relative position of external carotid and internal carotid on histology were used for registration. The regions on MR images corresponding to type I and type II hemorrhage on histological slides were mapped by a trained reviewer. The CNR was compared between these regions.

Results

For optimizing the parameters of GRE sequence, we found that regions of type I hemorrhage grew darker as echo time increased (Figure 1). This indicates that type I hemorrhage has a shorter T2* than other tissues in atherosclerotic plaque. Considering the susceptibility effect due to long echo time, an echo time of 9.1ms was used to balance the image contrast and quality. Sample images acquired by T2, PD, T1 and GRE sequences are shown in

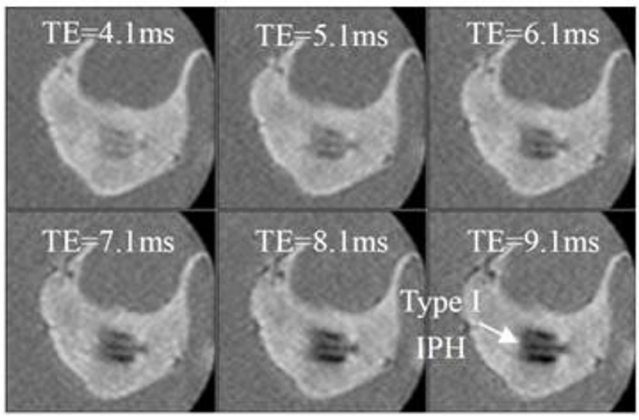

Figure 1

Table 1: Main parameters of T1, T2, PD weighted SE sequence and GRE sequence

	FOV(mm)	TH(mm)	Matrix	SlcNum	TR(ms)	TE(ms)	FA	Scan Time
T2	24*24	1	150*150	32	4000	60	90	3m28s
PD	24*24	1	150*150	32	4000	11.9	90	3m28s
T1	24*24	1	150*150	32	550	11.9	90	3m5s
GRE	24*24	1	150*150	32	921	9.1	60	2m6s

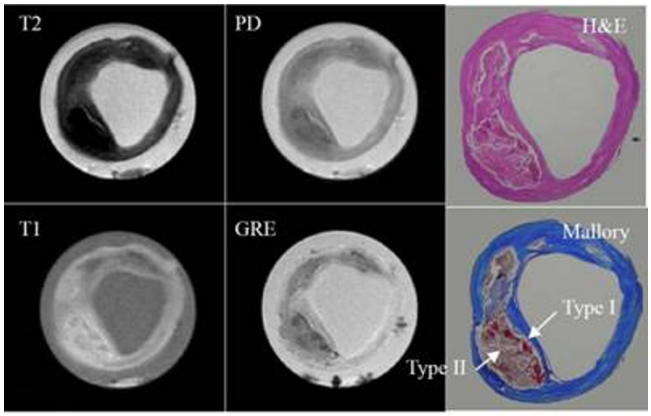

Figure 2

Figure 2, with corresponding H&E and Mallory stained slices. The images obtained by the GRE sequence show the best correspondence to histology for tissue boundaries and delineation. 37 type I hemorrhage regions and 14 type II hemorrhage regions were identified to calculate the CNR between type I and type II hemorrhage. CNR for different image contrasts is listed in Table 2. The GRE sequence obtained the best CNR for all protocols. This sequence should be verified in vivo in the future.

Table 2: Contrast noise ratio of different contrast image

	T2W	PDW	T1W	GRE
SNR (Type I)	12.7	55.7	73.4	40.9
SNR (Type II)	19.5	71.2	89.4	61.1
CNR	6.8	15.5	16.0	20.2