Clinical Radiology xxx (2017) 1–7

Contents lists available at ScienceDirect

Clinical Radiology

journal homepage: www.clinicalradiologyonline.net

Diagnostic capability of feature-tracking cardiovascular magnetic resonance to detect infarcted segments: a comparison with tagged magnetic resonance and wall thickening analysis

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ARTICLE INFORMATION

Article history:
Received 23 December 2016
Received in revised form
11 May 2017
Accepted 15 May 2017

AIM: To examine the diagnostic capabilities of feature-tracking cardiovascular magnetic resonance (FT-CMR), tagged cine magnetic resonance (MR), and wall thickening (WT) analyses to detect infarcted segments in patients with established myocardial infarction (MI).

MATERIALS AND METHODS: Twenty patients with established MI were selected retrospectively and the peak endocardial circumferential strain (CS) was quantified based on the 16-segment model. According to CMR with late gadolinium enhancement, segments were categorised as transmural MI, subendocardial MI, and no MI.

RESULTS: A total of 320 segments (62 transmural MI, 50 subendocardial MI, and 208 no MI) were analysed. Peak endocardial CS was significantly lower for transmural MI compared with subendocardial MI ($p<0.05$) and no MI ($p<0.001$). Cut-off values of −11.2% for CS by FTCMR, −10.9% for CS by tagged MR, and 23.8% for %WT, differentiated between infarcted and non-infarcted segments with a sensitivity of 72%, 71%, and 56%; specificity of 71%, 75%, and 67%; accuracy of 72%, 73%, and 63%; positive predictive value of 57%, 60%, and 48%; negative predictive value of 83%, 83%, and 74%; and an area-under-the-curve of 0.77, 0.79, and 0.64, respectively.

CONCLUSIONS: FT-CMR was diagnostically superior to %WT, and could differentiate between subendocardial and transmural MI. Unlike tagged MR, FT-CMR did not require the acquisition of additional sequences.

Introduction

Quantification of left ventricular (LV) wall motion is a fundamental issue for assessment of cardiac function. Myocardial infarction (MI) reduces regional wall motion, and causes a decrease in the LV ejection fraction as an index of global cardiac function. The ratio of wall thickening (% WT), which evaluates contractility of the entire wall thickness, has been widely used as a conventional quantitative parameter of regional wall motion in cardiovascular imaging.

Cardiac magnetic resonance (CMR) allows for comprehensive assessment of the LV wall motion and tissue characterisation in patients with acute and old MI.[1] Cine images

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http://dx.doi.org/10.1016/j.crad.2017.05.010
0009-9260/

and late gadolinium enhancement (LGE) images quantify % WT and the transmural extent of MI, predicting future cardiac function and cardiac events.

Myocardial strain refers to myocardial deformation, which can be used to analyse the LV wall motion, precisely. In echocardiography, some studies showed that myocardial strain using speckle tracking imaging may provide more detailed information beyond global cardiac function.[2,3] Meanwhile, in CMR, tagged MR, which evaluates the tag patterns superimposed within the myocardium, can be used to assess myocardial strain.[4] Previous studies reported the diagnostic capability of tagged MR in assessment of myocardial ischaemia and MI.[5–7]

Feature-tracking (FT-) CMR, which analyses tissue voxel motion, quantifies myocardial strain by using standard cine MR images.[8] Recent studies have shown the reliability and feasibility of myocardial strain assessment using FT-CMR in healthy volunteers[9] and in acute MI.[10] Recently, dedicated FT-CMR software has been developed that uses a similar algorithm for FT-CMR-based myocardial strain.

It was hypothesised that the assessment of MI in the chronic phase was suitable for assessing whether the software-derived FT-CMR values could differentiate between normal and infarcted myocardium in patients with established MI. The purpose of this study is to investigate the diagnostic capability of FT-CMR to detect infarcted myocardium in patients with established MI in comparison with tagged MR.

Materials and methods

Study population

The study was approved as a retrospective observational study by the institutional review board of the university. The requirement for informed consent was waived. Thirty-three patients with MI who underwent comprehensive CMR examination using a 3-T MR system between April 2011 and October 2012 were selected retrospectively from the clinical database. The clinical diagnosis of MI was performed in accordance with the standard definition,[11] using clinical data such as electrocardiography, echocardiography, CMR, coronary computed tomography angiography, single-photon emission computed tomography, and cardiac catheterisation results. Among 33 patients with MI who underwent a comprehensive 3-T CMR examination, with comprehensive diagnosis, patients with acute MI (n=6, within a month from the onset, International Classification of Diseases, Tenth Revision, Clinical Modification codes I21) or MI complicated with cardiomyopathy (hypertrophic cardiomyopathy [n=2], dilated cardiomyopathy [n=4], cardiac sarcoidosis [n=1]) were excluded. No patient who was diagnosed with ischaemic cardiomyopathy without LGE was seen in this study. The remaining 20 stable patients with prior MI (at least a month after onset), who did not have recurrence of MI, were classified as established MI and analysed in this study.

CMR imaging protocol

All studies were performed using a whole-body 3-T MR system (Achieva 3 T Quasar Dual; Philips Healthcare, Best, Netherlands) equipped with a dedicated cardiac software package and a 32-element cardiac phased-array coil (16 anterior elements and 16 posterior elements); a four-lead vector cardiogram was used for cardiac gating. After the acquisition of scout images, retrospective electrocardiographic gating cine imaging was performed using a steady-state free precession sequence with continuous short-axis views spanning the entire LV from the base to apex. The imaging parameters for cine images were as follows: 3.3 ms repetition time, 1.4 ms echo time, 45° flip angle, 7 mm section thickness, 3 mm inter-slice gap, 360 mm field of view, 128×128 matrix size, SENSE factor=2.4; and 20 cardiac phases (or R−R intervals) on an electrocardiogram. After the acquisition of cine images, three corresponding tagged images of the short-axis of the LV (basal, mid, and apical) were obtained using a two-dimensional turbo field-echo sequence, as described previously.[6] Imaging parameters were as follows: 4.7 ms repetition time, 2.8 ms echo time, 12° flip angle, 8 mm section thickness, 380 mm field-of-view, 288×195 matrix size; SENSE factor=2.5 6 mm tag grid, and 20 cardiac phases (or R-R intervals) on an electrocardiogram. After the acquisition of cine and tagged images, a gadolinium-based contrast agent (gadopentetate dimeglumine, Magnevist; Schering, Germany) was administered intravenously at 0.1 mmol/kg body weight. LGE images were obtained using an inversion-recovery three-dimensional T1 turbo field-echo sequence. The imaging parameters were as follows: 3.5 ms repetition time, 1.7 ms echo time, 400−500 ms inversion time (adjusted to the null signal of the normal myocardium using the Look-Locker sequence), 15° flip angle, 6 mm section thickness, 350 mm field-of-view, 224×157 matrix size, and SENSE factor=2.

MR image analysis

All strain data were analysed using a commercially available workstation (Ziostation2, Ziosoft, Tokyo, Japan). Two radiologists who were blinded to all other information evaluated peak endocardial circumferential strain (CS) by FT-CMR using the dedicated software (work in progress, Ziosoft, Tokyo, Japan). A 16-segment model based on the standard 17-segment model excluding the apex was used, which was independent from the anatomy of coronary arteries.[12] Epicardial and endocardial borders were manually drawn in the end-diastolic images, and automatically propagated through all phases of a single cardiac cycle. The values of CS per segment were automatically calculated (Fig 1).

Each segment was divided into an endocardial and epicardial side, and both sides of CS were automatically calculated. In the present study, the peak endocardial CS was used as an investigation item to assess the infarcted myocardium. The peak endocardial CS by tagged MR was also automatically calculated with three short-axis tagged images using dedicated software and was used as well as

Please cite this article in press as: Ogawa R, et al., Diagnostic capability of feature-tracking cardiovascular magnetic resonance to detect infarcted segments: a comparison with tagged magnetic resonance and wall thickening analysis, Clinical Radiology (2017), http://dx.doi.org/10.1016/j.crad.2017.05.010