International Journal of Cardiology 183 (2015) 162–170

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Prediction of functional recovery by cardiac magnetic resonance feature tracking imaging in first time ST-elevation myocardial infarction. Comparison to infarct size and transmurality by late gadolinium enhancement

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ARTICLE INFO

Article history:
Received 14 October 2014
Received in revised form 23 December 2014
Accepted 4 January 2015
Available online 7 January 2015

Keywords:
Myocardial infarction
STEMI
Cardiac magnetic resonance
Left ventricular function
Two dimensional strain imaging
FTI
Late gadolinium enhancement

ABSTRACT

Purpose: To investigate whether myocardial deformation imaging, assessed by feature tracking cardiac magnetic resonance (FTI-CMR), would allow objective quantification of myocardial strain and estimation of functional recovery in patients with first time ST-elevation myocardial infarction (STEMI).
Methods: Cardiac magnetic resonance (CMR) imaging was performed in 74 consecutive patients 2–4 days after successfully reperfused STEMI, using a 1.5 T CMR scanner (Philips Achieva). Peak systolic circumferential and longitudinal strains were measured using the FTI applied to SSFP cine sequences and were compared to infarct size, determined by late gadolinium enhancement (LGE). Follow-up CMR at 6 months was performed in order to assess residual ejection fraction, which deemed as the reference standard for the estimation of functional recovery.
Results: During the follow-up period 53 of 74 (72%) patients exhibited preserved residual ejection fraction ≥50%. A cut-off value of −19.3% for global circumferential strain identified patients with preserved ejection fraction ≥50% at follow-up with sensitivity of 76% and specificity of 85% (AUC = 0.86, 95% CI = 0.75–0.93, $p < 0.001$), which was superior to that provided by longitudinal strain (ΔAUC = 0.13, SE = 0.05, z-statistic = 2.5, p = 0.01), and non-inferior to that provided by LGE (ΔAUC = 0.07, p = NS). Multivariate analysis showed that global circumferential strain and LGE exhibited independent value for the prediction of preserved LV-function, surpassing that provided by age, diabetes and baseline ejection fraction (HR = 1.4, 95% CI = 1.0–1.9 and HR = 1.4, 95% CI = 1.1–1.7, respectively, $p < 0.05$ for both).
Conclusions: Estimation of circumferential strain by FTI provides objective assessment of infarct size without the need for contrast agent administration and estimation of functional recovery with non-inferior accuracy compared to that provided by LGE.

1. Introduction

Since the introduction of percutaneous coronary interventions (PCI) the clinical outcomes of patients with ST-elevation myocardial infarction (STEMI) have considerably improved [1,2]. However, despite modern interventional and pharmacologic therapeutic regimes, prognosis remains limited in a subset of patients with severe left ventricular dysfunction and chronic heart failure after myocardial infarction.

Therefore, the identification of the extent and degree of contractile dysfunction and myocardial scar in patients with STEMI has important prognostic implications and may help tailoring current or future therapeutic regimes [3]. Several imaging techniques have been previously used for the evaluation of myocardial viability, such as echocardiography and nuclear scintigraphy (reviewed in [4]). However, limited echogenic windows and radiation exposure, respectively may limit the precision and serial applicability of these modalities. Cardiac magnetic resonance (CMR) imaging, on the other hand, is a non-invasive imaging technique that allows accurate assessment of myocardial function and viability with high spatial and temporal resolution and without radiation exposure for the patients [5–8]. Due to its tomographic nature, CMR allows for assessment of myocardial function and scar in identical

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http://dx.doi.org/10.1016/j.ijcard.2015.01.022
0167-5273/

myocardial slices, providing excellent reproducibility of the acquired results.

In previous studies, we demonstrated the ability of strain encoded magnetic resonance (SENC) for the quantification of myocardial strain in patients with stable coronary artery disease (CAD) and after STEMI [9–11]. In the present study, we used the (feature tracking imaging) FTI algorithm, which can be applied to cine sequences from different vendors and field strengths and obviate the need for dedicated pulse sequences [12–16]. Using FTI we sought to investigate whether quantification of circumferential and longitudinal strains can be used to estimate infarct size by late gadolinium enhancement (LGE) and clinical outcomes in patients with first time STEMI. The results were compared to standard clinical and conventional CMR parameters such as LV-ejection fraction.

2. Methods

2.1. Patient cohort

We prospectively enrolled 74 consecutive patients with first time STEMI who were admitted to chest pain unit of our department in the University Hospital Heidelberg. We included patients who had typical chest pain lasting >20 min within 12 h before their presentation and ST segment elevation of >0.2 mV in at least two contiguous ECG leads.

Exclusion criteria were ECG signs or history of previous infarction. Thus, we included only patients with first-time acute myocardial infarction with a clearly identified culprit coronary vessel. Patients with severe hemodynamic compromise or patients requiring inotropic support were excluded from the study. In addition patients with other contraindications to CMR such as pacemaker and renal diseases (GFR < 30 ml/min/1.73 m^2) and patients with claustrophobia were excluded from the study.

All patients underwent cardiac catheterization and were treated with primary angioplasty and stent placement. CMR was performed at days 2–4 (baseline) and at 6 months after STEMI (Fig. 1).

All procedures complied with the Declaration of Helsinki and were approved by our local ethic committee and all patients gave written informed consent.

2.2. Biochemical markers

Cardiac troponin T (cTnT) was typically collected on presentation and at 72–96 h of follow-up to estimate the extent of myocardial damage [17–20] and was determined by a commercially available enzyme linked immunosorbent assay (Cardiac Reader, Roche, Mannheim, Germany). Creatine kinase was collected on presentation and serially up to the forth day of follow-up. Enzyme activity was determined in a Synchron LX-20® clinical chemistry system (Beckman Coulter, Krefeld, Germany) at 25 °C.

2.3. Cardiac catheterization

Angiograms were performed in a standardized fashion, and at least two orthogonal views of every major coronary vessel and its side branches were obtained. The degree of stenosis was expressed as the percent reduction of the internal luminal diameter. TIMI flow grades were assessed visually as described previously after coronary angioplasty [21].

2.4. CMR examination

Patients were examined in a clinical 1.5-T whole-body CMR-scanner Achieva system (Philips Medical Systems, Best, The Netherlands) using a dedicated cardiac phased-array receiver coil. A standardized protocol was followed 2–4 days after STEMI, aiming 1) at the assessment of baseline parameters of the left ventricle (LV-diameters, wall thickness, ejection fraction) using cine imaging, 2) the quantification of infarct size and infarct transmurality using late enhancement CMR and 3) the quantification of circumferential and longitudinal strains using feature tracking imaging (FTI) (details for cine imaging, LGE and FTI are provided in the supplementary Methods section).

6 months after STEMI CMR was repeated for the assessment of residual LV-ejection fraction (Fig. 1).

2.5. Study end points

Follow-up ejection fraction ≥50% (6 months after first time STEMI) was the primary endpoint of this study because this is an important clinical goal [21]. Secondary end

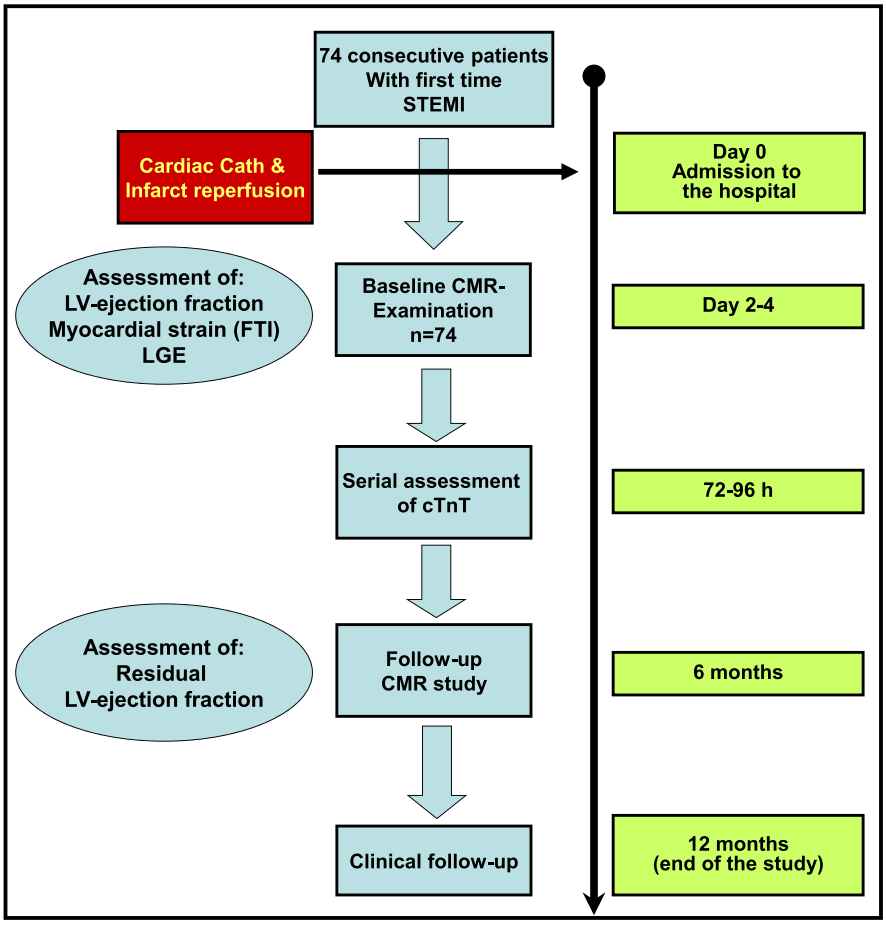

Fig. 1. Study flow chart and procedures during the study duration.