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Patency of the infarct-related artery and time-dependant infarct transmurality on cardiovascular magnetic resonance in patients with ST-segment elevation myocardial infarction treated by primary percutaneous intervention

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ABSTRACT

Background: Outcome in ST-segment elevation myocardial infarction (STEMI) is affected by patency of the infarct-related artery (IRA) on the initial angiogram. Therefore we decided to assess the relation between patent IRA and time-dependent infarct transmurality.
Materials and methods: The study included 62 patients with first STEMI (age 61 ± 9 years, 76% male) undergoing primary percutaneous coronary intervention (PCI). All patients underwent cardiovascular magnetic resonance (CMR) in the sub-acute phase to assess infarct transmurality. Infarction was considered as transmural if mean infarct transmurality exceeded >75%. IRA patency was defined as TIMI flow 2 or 3 on the initial angiogram.
Results: Patent IRA at baseline was found in 23 patients (37%) and was related to lower infarct transmurality in comparison to IRA occlusion (46.9 ± 27.3% vs. 82.4 ± 21.3%, $p < 0.0001$). Patients were divided into three groups according to time-to-PCI (≤2 h, >2–6 h, >6–12 h). Infarct transmurality increased with increasing time-to-PCI in patients with occluded IRA on the initial angiogram ($p = 0.0006$), but not in patients with initially patent IRA ($p = 0.07$). Similarly, the frequency of transmural infarctions increased with longer time-to-PCI in patients with occluded IRA ($p = 0.01$), but not in patients with initially patent IRA ($p = 0.12$).
Conclusions: Cardiovascular magnetic resonance demonstrated the relation between initial IRA patency in STEMI and time-dependant infarct transmurality. After 6–12 h from the onset of symptoms transmural infarctions were found in all patients with initially occluded IRA and only in about a third of patients with initially patent IRA.

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Introduction

The prognosis in ST-segment elevation myocardial infarction (STEMI) is affected by initial patency of the infarct-related artery (IRA) [1–3]. Patients who arrive in the cath-lab with patent IRA are more likely to have successful primary percutaneous coronary intervention (PCI), lower infarct size and better survival in comparison to those with initially occluded IRA [1–3].

Infarct transmurality and size in STEMI depend on the time-to-reperfusion as demonstrated consequently by previous studies with the use of cardiovascular magnetic resonance (CMR) [4–8]. Although this is true for all STEMI patients and for patients who present with occluded IRA there are no sufficient data analyzing the same concept in patients with initially patent IRA [8].

Therefore we decided to assess the relation between patency of the IRA on the initial angiogram and time-dependent infarct transmurality.

Materials and methods

Study population

The study group included 62 patients with first STEMI (age 61 ± 9 years, 76% male) treated with primary PCI. All patients received loading doses of 300 mg of aspirin and 600 mg of clopidogrel in the pre-hospital phase (in the referring hospital or in the ambulance) and unfractionated heparin (in the pre-hospital phase or in the ambulance). None of the patients received thrombolytics. Maintenance doses of aspirin and clopidogrel were 75 mg daily. CMR examination was performed in the sub-acute phase of AMI (days 3–5) in all patients.

STEMI was defined as (1) presence of continuous chest pain for at least 30 min, (2) ST-segment elevation in 2 or more contiguous ECG leads (≥1 mm for the arm leads and ≥2 mm for precordial leads), (3) presence of coronary artery occlusion or significant coronary artery stenosis on the initial coronary angiogram in the territory corresponding with ECG changes. Each case of STEMI had to be eventually confirmed with the presence of elevated troponin I (TnI). The STEMI onset time was obtained from the referral charts and was verified by the patient. Time-to-PCI was defined as time between the onset of STEMI and balloon expansion (recorded from the procedure timing chart). Patency of the IRA was based on the TIMI flow and defined as TIMI flow 2 or 3 [9].

All patients with contraindications to CMR in the sub-acute phase of STEMI were excluded. These included: critical clinical condition, acute or chronic renal failure defined as estimated glomerular filtration rate <50 ml/min (value suggested by the local ethics committee as a contraindication to gadolinium-based contrast agents), severe form of claustrophobia and the presence of temporary or permanent pacemakers or some other metallic foreign objects in the body.

Informed consent was obtained from each participating patient. The study was approved by the local ethics committee.

Cardiovascular magnetic resonance

CMR studies were performed with the use of 1.5 Tesla scanner (Magnetom Avanto, Siemens, Erlangen, Germany). Scout images and electrocardiographic gated breath-hold steady state free precession (SSFP) cine images in 2- and 4-chamber views were registered to set up final short axis imaging planes. Short-axis SSFP cine images were obtained from the mitral valve insertion point to the apex with 8 mm thick slices and 2 mm gap between subsequent slices to encompass the entire left ventricle (LV). The same short-axis and long-axis slice positions were used to obtain dark-blood T2-weighted short-tau inversion-recovery (STIR) fast-spin echo sequences. Finally, a 0.1 mmol/kg of body weight of gadolinium contrast (gadobutrol – Gadovist®, Bayer Schering Pharma AG, Berlin, Germany) was administered via the antecubital vein and flushed with 30 ml of isotonic saline. Delayed enhancement (DE) images were performed with a breath-hold segmented inversion recovery sequence 10 min after contrast injection and acquired in the same orientation as the cine images. The inversion time was adjusted to completely null normal myocardium.

Image analysis

Cine images were analyzed with the use of a dedicated software (MASS 6.2.1, Medis, Leiden, the Netherlands). Initially, short axis images were previewed from the base to the apex in a cinematic mode, then endocardial and epicardial contours for end-diastole and end-systole were manually traced. Delineated contours were used for the quantification of end-diastolic and end-systolic volumes normalized to body surface area (LVEDVI, LVESVI) and ejection fraction (LVEF).

Intramyocardial hemorrhage was defined as a hypointense zone within the area at risk defined as myocardial tissue with signal intensity of 2 standard deviations (SD) above mean signal obtained in the remote myocardium on STIR images [10]. Infarct size was defined as area above 50% of the maximal signal intensity within DE (full-width at half maximum – FWHM) and expressed in grams (absolute infarct size) and as a percentage of LV mass (relative infarct size) [11]. Mean infarct transmurality was calculated as a sum of infarct transmurality in each segment divided by the number of segments with subendocardial DE and presented as percent. Infarction was labeled as transmural if mean infarct transmurality exceeded >75%. Microvascular obstruction (MVO) was defined as dark areas of absent contrast surrounded by DE [12].

All images were analyzed by a single cardiologist with 6 years of training in CMR (ŁAM) and supervised by a senior expert with 10 years of experience in CMR (JM).

Statistical analysis

All results for categorical variables were expressed as number and percentage and for continuous variables as mean and standard deviation (SD) or median and interquartile range (IQR), depending on the normality of distribution assessed with the use of a Kolmogorov–Smirnov test. Chi-square test or