Detection of infarcted myocardium by peak-combination HARP

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Introduction

Since the publication of Tennant and Wiggers in 1935 [1], which describes the effects of regional ischemia on left ventricular function, many studies have been performed on the topic of left ventricular dyssynergy. Smalling et al [2] investigated the regional contraction pattern during ischemia in dogs instrumented with segmental shortening sonomicrometers. Magnetic resonance myocardial tagging combined with HARP [3] allows for a non-invasive quantification of myocardial motion also on a regional level. In our study, four patients with a history of myocardial infarctions were examined. In a late-enhancement measurement [4, 5] the infarcted myocardial segments were identified. On CSPAMM [6] data circumferential shortening was analyzed and compared for infarcted and non-infarcted regions and to data obtained in healthy volunteers.

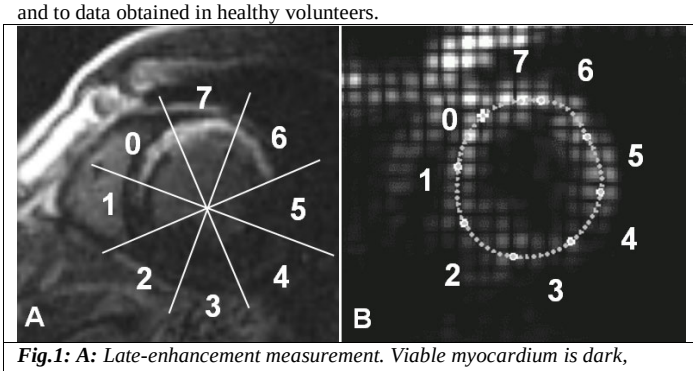


Fig.1: A: *Late-enhancement measurement. Viable myocardium is dark, infarcted myocardium bright. An infarct is visible in the sectors 0, 7, and 6.* ***B****: Corresponding CSPAMM image with centerline divided into eight sectors.*

Methods

Data acquisition:

Four patients (all male, age: 55 ± 9 years) and four healthy volunteers (all male, age: 30 ± 4 years) were recruited for this study. CSPAMM tagging images were acquired on five short-axis levels (slice thickness: 8 mm, gap: 15 mm) on a 1.5 T scanner (Gyroscan Intera, Philips Medical Systems). For imaging, an EPI sequence was used (TE: 7.5 ms, EPI factor: 13, spatial resolution: 3x3mm^2, temporal resolution: 35ms, 20 frames). In one case, where the patient was not able to hold his breath long enough, a fast TFEPI sequence was applied (TE: 2.9 ms, EPI factor: 9, turbo factor: 4). Only in patients, late-enhancement images were acquired also on a 1.5 T system (CV/i, GE Medial systems) during clinical routine. Twenty minutes after administration of 0.25 mmol/kg of the extravascular contrast medium Gd-DTPA-BMA (Omniscan, Amersham Health), images were acquired with an inversion recovery pulse sequence (TR: 6.4 ms, TE: 1.6 ms, spatial resolution: 1.7x1.7mm^2, inversion time nulling: normal myocardium). Short-axis views of the entire left ventricle were acquired (thickness: 8 mm, gap: 0.5 mm).

Data analysis: The CSPAMM images were evaluated with peak-combination HARP [7]. The centerline was divided circumferentially into eight equal sectors (Fig.1), relative to the position of the anterior junction of right and left ventricle (reference point) and tracked over all heart phases. Circumferential fiber-shortening (cFS in %) was calculated over the cardiac cycle for each sector. In order to correct for different heart rate, temporal resolution and number of frames, all shortening-, displacement- and rotation curves were resampled and normalized to end systole. On the late-enhancement images, the infarcted sectors were identified. Circumferential shortening values were compared for the infarcted sectors and the contralateral sectors. The same sectors were also evaluated on the volunteer data.

Results

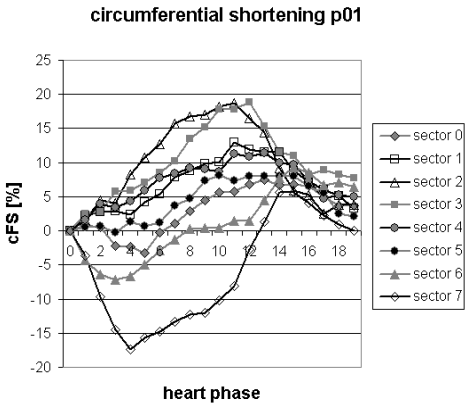


Fig 2: *Circumferential shortening over the cardiac cycle for all sectors in one patient. The infarct sectors (sectors 0, 7, 6) show a different contraction pattern than the other sectors.*

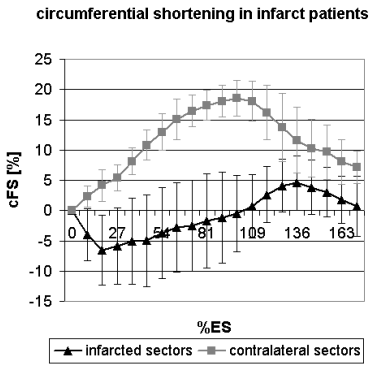
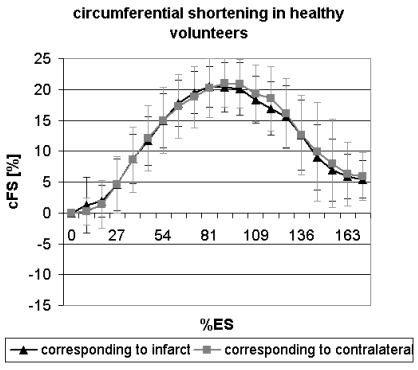


Fig 3: A: *Circumferential shortening of the infarct sectors and the contralateral sectors averaged over all patients. The infarct region is characterized by an initial stretching and then contraction during diastole.*



B: *The same sectors evaluated in healthy volunteers.*

Discussion

The assessment of functional parameters in various segments by HARP allows for studying the intraventricular mechanics. Regions classified as infarcted on late-enhancement images clearly show a different contraction pattern in the HARP analysis than intact myocardium. After an initial stretching of the myocardium post-systolic shortening occurs which might be a passive phenomenon. The contraction of adjacent vital myocardium could lead to the stretching of the infarct region. The observation of a delayed onset of contraction is in accordance with earlier findings [3, 8]. In contrast, the contraction curves in healthy volunteers for the corresponding sectors do not differ from each other.

Conclusion

The combination of CSPAMM myocardial tagging with HARP analysis yields myocardial motion parameters on a regional level. Infarcted regions clearly show a different motion pattern than vital myocardium (Fig. 2, Fig. 3A) or myocardium in healthy volunteers (Fig. 3B). This sensitivity to identify dysfunctional myocardium on a regional level is a prerequisite to an automatic and observer independent detection of ischemic myocardium by HARP that would allow for monitoring of patients during stress measurements.

References

[1] Tennant, R et al., *Am J Physiol*, 112:351-61(1935). [2] Smalling, RW et al., *J Am Coll Cardiol*, 7:1335-46(1986). [3] Osman N,et al.,*MRM* 42:1048-60(1999). [4] Kim, RJ et al., *N Engl J Med*, 343:1445-53(2000). [5] Knuesel, PR et al., *Circulation*, 108:1095-100(2003). [6] Fischer SE, et al., *MRM* 30:191-200(1993). [7] Ryf, S et al., *J Magn Reson Imaging*, 20:874-80(2004). [8] Wiegner, AM et al., *Am J Physiol*, 235:H776-83(1978).