MR tagging on healthy and MI mice model, an EF vs strain study

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Introduction

For the non-invasive detection of coronary artery disease (CAD) the assessment and quantification of regional myocardial wall motion may provide additional diagnostic information compared to global functional and volumetric indices and may be useful for the investigation of transgenic and knockout mice (1). This is especially true in studies of myocardial infarction (MI) (2) and left ventricular (LV) remodeling (3). Regional cardiac contraction can be examined qualitatively, or quantitatively from MR tagging images. Spatial modulation of the magnetization (SPAMM) (4) is the most commonly used MR technique to generate tag lines across the myocardium in order to follow regional deformation. By analyzing the data with dedicated software such as HARP (5) it is feasible to assess mechanical parameters such as strain or circumferential shortening. In this study we sought to investigate radial and circumferential strain in a mouse model of myocardial infarction (MI) 3 weeks post left anterior diagonal (LAD) coronary artery ligation and healthy control mice using 2D SPAMM technique. Strain was correlated with ejection fraction (EF) and left ventricular (LV) infarct size.

Method

Ten healthy C57Bl6 and eight mice 3 weeks post MI (permanent LAD ligation), were imaged using a cine-FLASH and a Black-Blood-SPAMM-cine-FLASH sequence in order to compare functional/volumetric parameters with myocardial strain. After sedation of the animal by isoflurane-oxygen mixture, images were acquired on a 7 T horizontal-bore MR scanner (Varian, USA) with a gradient strength of 1000mT/m and a 39mm RF coil (Rapid, Germany). Imaging parameters included: FOV of 25x25mm; 1mm thickness; matrix size of 128x128 for standard cine, 192x192 for the Black-Blood-SPAMM; 9 slices; 9 frames for cine, 10 for SPAMM; TR=11ms for cine, TR=2-heart-beats for Black-Blood-SPAMM; TE=1ms; 3 averages; flip angle=20°. Cine-FLASH acquisition time was 8 minutes. Black-Blood-SPAMM-cine-FLASH acquisition time was 40 minutes. The cardiac cycle was on average between 110-140ms while the respiration cycle was 1000-1600ms. ECG triggering and respiratory gating was achieved using an external trigger device (SA Instruments, NY, USA). EF and infarct size analysis was performed using semi-automated software developed in C++. Strain analysis was performed using Tag Track (Gyrotools, Zurich, CH) that allowed for semi-automatic tracking of the epi and endocardial borders. Strain results were derived from end-systolic and end-diastolic frames of each slice.

Results

Table1 reports EF and infarct size values assessed by standard cine-FLASH images of MI model. The first 3 animals reported an EF higher than 30% resulting in low infarct size percentage. The remaining 5 animals had an EF lower than 30% resulting in a larger infarct size and extensive remodeling. Figure1 shows end-systolic and end-diastolic frames of a mid equatorial slice of healthy and MI mice acquired with the Black-Blood-SPAMM-cine-FLASH technique. The good image quality, achieved for all slices and animals, makes it easy to distinguish LV epicardium and endocardium. Fig2 reports the radial and circumferential strain for healthy and MI mice. Eight slices were required to cover the myocardium of MI mice whereas 6 slices were sufficient in healthy mice. This is due to extensive myocardial remodeling and LV expansion. In addition, contraction appears highly affected in the apex area reporting statistically difference between MI and healthy models. In the mid area, radial and circumferential endocardial strain followed different patterns depending on the amount of EF and infarct size, while the circumferential epicardial strain remained mostly unchanged between healthy and MI mice model. Although the basal slices did not present infarcted areas, some strain differences between healthy and MI models were observed.

Discussion and conclusions

MR tagging analysis provided important information on LV regional contraction and allowed assessment of wall motion alterations in MI mice. While the apex was most affected by remodeling, contractility was dependent on infarct size in the mid ventricular slices. Consistent with previous studies, EF values of <30% resulted in strain which was always lower compared to healthy control mice. For 40%< EFs >30%, strain values in the apex area were as small as the previous MI model, but in the mid and basal zone, contraction patterns followed an irregular path most likely due to compensate for myocardial dysfunction.

Table1. EF and infarct size for the 3 weeks post MI mice model. Red above 30% EF. Blue below 30% EF.

Animal	EF (%)	Infarct size (%)
1	32.1	20.7
2	36.8	17.5
3	39.5	16.6
4	14.8	55.3
5	20.7	42.0
6	17.7	35.2
7	25.7	37.0
8	23.5	40.9

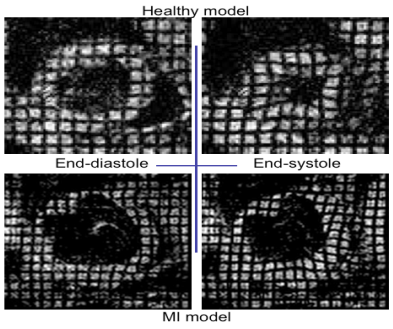

Fig1. Tagging MRI image of a Mid slice at A) end-systole and B) end-diastole for an MI mouse EF below 30%.

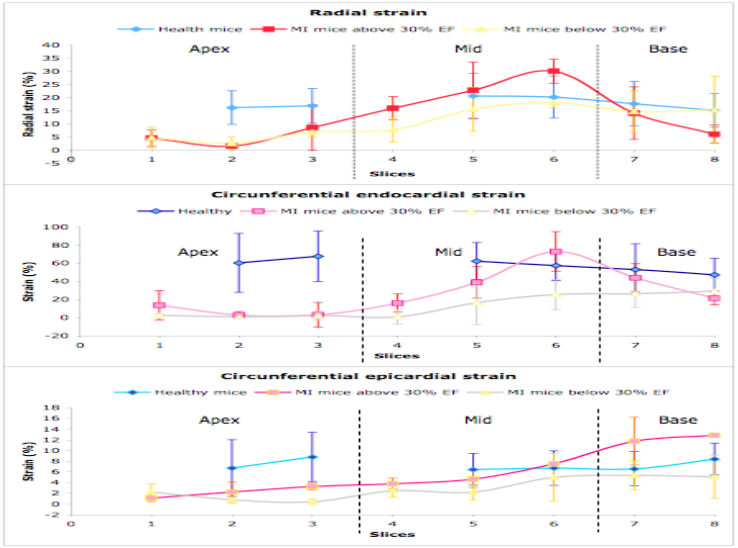

Fig2. Radial and circumferential strain for healthy mice, MI mice above and below 30% EF in the apex, mid and base. The strain was reported as an average over the 10 healthy and 8 MI mice. A) Radial strain. B) Circunferential endocardial strain. C) Circunferential enpicardial strain.

References

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