A fast black blood sequence for 4D cardiac MEMRI of mouse heart

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Introduction :

The increasing number of mouse models of cardiac diseases requires improvements of non-invasive imaging methods adapted to small animals. Cardiac MRI methods currently used are cine 2D imaging with T1-weighted gradient echo sequences and bright blood contrast. However, the obtained images are sensitive to artifacts that arise from flowing blood which limits accuracy for the measurements of myocardial parameters [1]. The aim of this study was also to develop a fast time-resolved cine 2D and cine 3D (4D) black blood imaging of mouse heart. After implementation, this sequence has been applied to Manganese-Enhancement MRI (MEMRI) studies *i.e.* with Mn^{2+} infusion to improve contrast [2].

Materials and methods :

The images have been performed at 9.4T with a Bruker DPX 400 system (Ettlingen, Germany) using a mouse-dedicated birdcage resonator probe. Acquisitions were synchronized with cardiac rhythm. The imaging sequence was T1-weighted gradient echo in which a module of cancellation of blood signal has been introduced, made up of bipolar gradient (TE/TR = 2.3/9.6 ms ; flip angle = 40° ; field of view = 22 x 21 x 10 mm ; matrix size = 128 x 105 x 48 ; resolution = 172 x 200 x 208 µm ; total acquisition time = 30 minutes). For contrast enhancement, MnCl2 (60 µL ; 105 mM) was injected in the tail vein.

Results :

The blood suppression module was efficient and enabled to obtain black blood cine 2D images within less than one minute. The time course of contrast enhancement of the cardiac wall upon manganese injection was measured. Black blood images in 4D permitted to image the moving heart at 10 periods of the cardiac cycle within 30 minutes only. This represents a three-fold reduction in the total experimental time compared to current black blood sequences. The 4D data were segmented and permitted an accurate measurement of myocardial volumes with manganese injection ; CNR up to 55 were measured in myocardium tissue.

Conclusion :

This new method provides time- and space-resolved 3D images, respectively $(200\ \mu m)^3$ and one image every 12 ms. These resolutions and the high contrast enable an accurate volumetry. Lastly, associated to manganese infusion, this sequence appears to be particularly suitable for studying cardiac diseases such as ischemia on animal models.

References :

[1] Schneider JE et al., *Journal of Cardiovascular Magnetic Resonance* 2006, **Vol. 8**, 613-701.
[2] Wendland et al., *NMR in biomedecine* 2004, Vol. 17, 581-594.

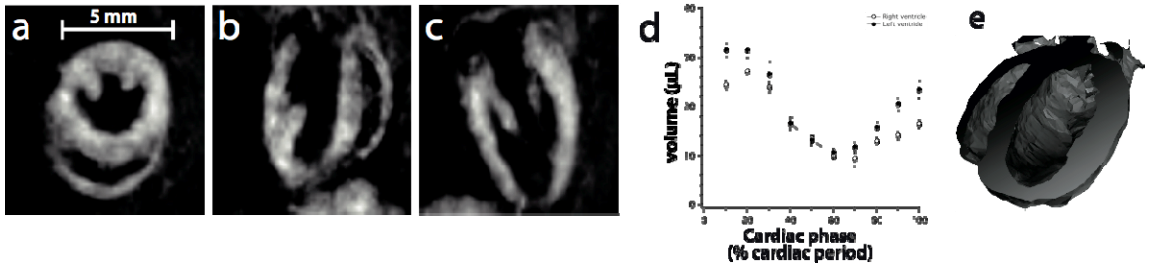

Figure 1 : Anatomical and functional data obtained by 3D black blood MEMRI. Short axis (a), long-axis two chambers (b) and long-axis four chambers (c) slices at end diastole with 3D black blood MEMRI at 9.4T. (d) Left and right cavity volumes assessed throughout the cardiac cycle on 5 mice. (e) 3D reconstruction of the mouse heart at end diastole after computer segmentation of the myocardium and the cavities.

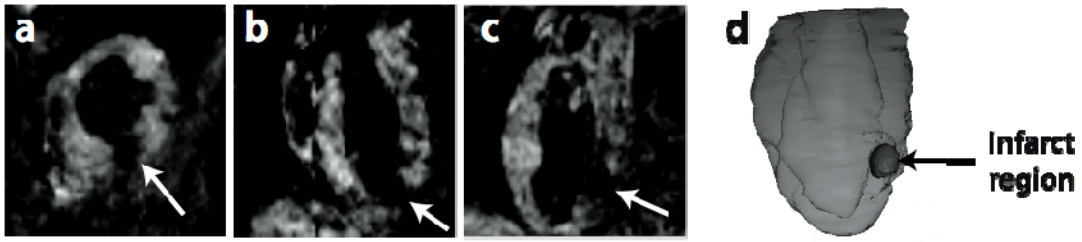

Figure 2 : Assessment of infarct region on mouse heart by 3D black blood MEMRI. (a, b and c) The infarct appears as a hyposignal (arrows). (d) 3D reconstruction of the infarcted mouse heart, the cavities and the infarct region in hyposignal (arrow).