MR imaging of mouse heart in vivo at 4.7T using the homebuilt RF probehead and gradient system

S. Heinze-Paluchowska[1], T. Skorka[1], A. Jasinski[1,2], R. Wiertek[1], P. Skora[1], J. Kiczek[1], P. Borowiec[1]

[1]H. Niewodniczanski Institute of Nuclear Physics PAS, Krakow, Poland, [2]Department of Dielectric and Biophysics, Pedagogical University, Krakow, Poland

Introduction and Purpose:

Animal models of cardiovascular diseases have an increasing importance in basic cardiovascular research. Transgenic mice with cardiac-specific overexpression of αq subunit of protein G (Tgαq*44) represent a unique model of heart failure. Overexpression of αq subunit mimics chronic stimulation of neurohormonal pathways, which play a key role in development of heart failure in human [1].

Magnetic resonance imaging (MRI) is suitable to face the requirements of the small sized and rapidly beating mouse heart measurements, and allows for quantification of left ventricle (LV) volume and mass. However, specialized hardware is needed to achieve required temporal and spatial resolution. MRI of small animals (i.e. mice) with fast imaging techniques requires gradient coil system with high gradient strength and short rise-time, appropriate RF probehead and animal handling system.

The aim of this work was to image very small and rapidly beating (500 beats/min) mouse heart using homebuilt, dedicated hardware components such as gradient system, RF probehead and animal handling system for the 4.7T/310 MRI system with MARAN DRX console (Resonance Instruments).

Subjects and Methods:

Unshielded gradient coils [Fig.1] with water-cooling system were designed and constructed for the 4,7T/310 magnet [2]. Inner diameter of the gradient system was set at 60 mm to maximize gradient at the field of view (FOV) optimized to the mouse size. The gradient system is able to produce gradients of 500 mT/m at a current of 100 A, with a risetime of less than 100 μs, driven from Techron 7700 amplifiers.

The probehead, constructed to fit the gradient system, consists of the RF birdcage coil and the animal handling system. For NMR signal transmission and reception an 8-rung shielded, high-pass quadrature driven and inductively matched birdcage coil, with inner diameter of 40 mm was constructed [Fig.2] [3].

The animal handling system allows for precise positioning and monitoring the animal during examination. It is equipped with an animal positioning pad, gas anesthesia delivery, temperature controller and cardiac gating (SA Instruments) for investigation of mice heart *in vivo*.

For the MR imaging of the mouse heart an ECG triggered fast gradient echo (FLASH with flow-compensation and multiphase option) sequence with the following imaging parameters was used: echo time (TE) 2,5ms; repetition time (TR) depends on the distance between R-R waves and number of images per cardiac cycle (~5ms), acquisition matrix 128×128; slice thickness 1 mm, number of scans (NS) 8, and a flip angle was set to achieve the best contrast between myocardium and blood pool (about 50 degrees). The examination starts from the sagittal image to locate the position of the heart in a chest. The coronal image was then obtained to visualize a long-axis of the mouse heart. From this view short-axis was defined and MRI data acquisition was performed in multiple contiguous short-axis slices to cover the entire left ventricle (LV) [4]. All animal experimental procedures were in accordance with institutional guidelines.

Fig.1. The homebuilt gradient system

Fig. 2 The homebuilt high-pass birdcage coil

Results:

The homebuilt system is efficient, easy to operate and allows achieving good quality, ECG triggered images of the mouse heart *in vivo*. MR images of the mouse heart, obtained using the homebuilt probehead in midventricular short-axis orientation are shown in Fig.3.

The homebuilt hardware components enabled achieving 20-30 frames per cardiac cycle for both wild-type mice (FVB) and transgenic mice with heart failure (Tgαq*44). Multislice MR imaging in different phases of the cardiac cycle, with a good contrast between myocardium and flowing blood allow calculating the end-diastolic (EDV) and end-systolic (ESV) volumes.

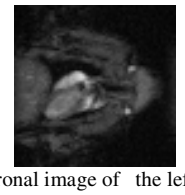

Fig.3. Coronal image of the left ventricle of the wild-type mouse

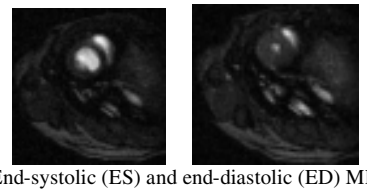

Fig.4. End-systolic (ES) and end-diastolic (ED) MR image of the left ventricle of the wild-type mouse.

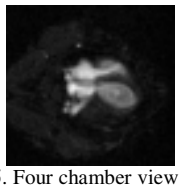

Fig.5. Four chamber view of the mouse heart

Conclusions:

The homebuilt probehead and gradient system enabled us to achieve good quality cardiac MR images of mice. Morphological and functional changes can be studied non-invasively applying homebuilt hardware components. Our *in vivo* studies show that this system is capable of operating successfully in an MR environment without generating electrical interference that would affect image quality.

Acknowledgements:

This work was supported by the Polish Ministry of Science and Informatics (MNiI), grants No P05A 003 25 and PBZ-KBN-101/T09/2003/6.

References:

1. U. Mende, C. et all. *J. Mo.l Cel.l Cardiol.* 2001; **33**: 1477-1491.
2. Turner R. *J.Phys.E:Sci.Instrum.* 1998; **21:** 948-952.
3. Chin Ch., et all. *Concepts Magn. Reson. (Magn. Reson. Eng.)*. 2002; **15**: 156-164.
4. Wiessman F, et all. *Circ. Res*. 2001**; 88**: 563-569