^{23}Na Microscopy of the Mouse Heart in vivo

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Introduction:

Localization of myocardial infarcted areas can be performed by observing changes in the sodium signal [1]. Due to the poor sensitivity of 23Na in vivo studies have been limited to humans [2], dogs [1,3] or rabbits [1]. Since the mouse has become the most important animal model for human cardiac disease sodium imaging of the mouse heart is of outstanding interest. In this work we present cardiac sodium images at a voxel resolution of 1 µl, acquired at 17.6 Tesla. A comparison with proton CINE-images is presented.

Subjects & Methods:

Experiments were performed on a Bruker 17.6 T widebore Avance System with a maximum gradient strength of 200 mT/m. After positioning the mouse in the magnet standard CINE-imaging was performed (15 frames/heartbeat; res=0.3x0.3x0.8mm; NS=8 ; T_{tot}=6min) to enable the correlation of proton with sodium images. The sodium images are obtained by using a purely phase-encoded, density-weighted 3D localization method (denCSI) [4] in which the k-space sampling scheme combines an optimized shape of the spatial response function (SRF), minimal T_{exp} and high SNR. With a non selective short excitation pulse (80µs) and an adapted gradient switching the effective echo-time was minimized (< 0.75 ms) and the spatial resolution was maximized to a 1 µl voxel size. Due to respiratory and ECG triggering of the anesthesized mice the sodium experiment took about 2 hours (2 scans/heartbeat; 64k total scans).

Results:

Proton images of healthy mice allowed identification of the anatomy of the heart and major vessels in the animal. Figure 1 shows a short axis cut through a mouse heart from the CINE data sets. The ventricles and the myocardium are shown with a good contrast to noise ratio. Six short axis cuts from the 3D ^{23}Na denCSI dataset of the same mouse are shown in figure 2. The resolution of the shown dataset is 0.9 x 0.9 mm^2 in plane and 1.5 mm in the third dimension. The signal to noise ratio in the septum in the sodium images is approximately 60% less than in the ventricles which is due both to differential relaxation times and the calculated myocardial/blood sodium concentration ratio of 0.45 [2].

Discussion:

In this study we have shown for the first time sodium images of the mouse heart with a resolution of 1 µl. The ventricles, the septum and most of the myocardium are clearly distinguishable. As the sodium concentration in infarcted areas of the heart increases by about 200% [3] infarcted mice should be easily visible with our setup. Therefore, application of denCSI with optimized instrumentation at high magnetic fields allows for investigation of mouse cardiac models by sodium imaging. This adds a valuable tool to cardiac diagnosis that has so far only been available for models in dogs or rabbits.

Acknowledgement:

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References:

[1] Kim RJ et al [1997] Circulation 95 : 1877-1885
[2] Pabst et al [2001] MRM 45 :164-166
[3] Kim RJ et al [1999] Circulation 100 : 185-192
[4] Greiser A et al [2001] Proc. ISMRM 9: 718

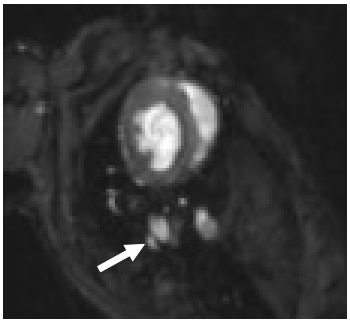

Figure 1: Short axis slice from a healthy mouse heart (CINE-^{1}H dataset, frame 7). The image has the same orientation as the isotropic plane of the 3D sodium dataset. Arrow indicates aorta.

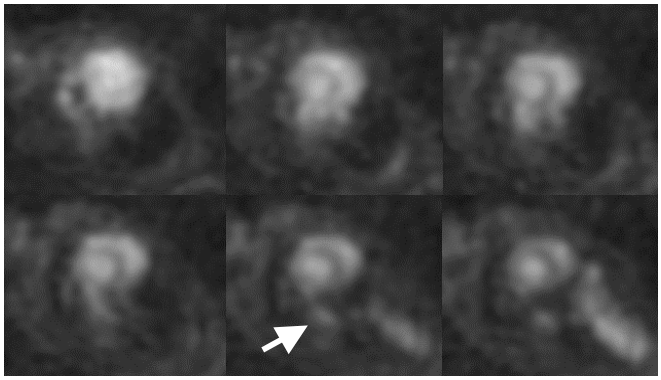

Figure 2: Six slices from the 3D ^{23}Na denCSI data set. The whole heart from the atrium (upper left) to the apex cordis (lower right) can be seen. The septum can be clearly distinguished. The arrow indicates the aorta.