Towards Quantification of Tissue Sodium Concentration in Mice with Acute Myocardial Infarction

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Introduction: Myocardial sodium concentration is known to increase rapidly following acute ischemia (infarction) [1]. As a result, tissue sodium levels are an early marker of electrophysiological disruption and myocardial injury. Little has been published on quantifying ^{23}Na in the mouse heart [2] and, to our knowledge, nothing in the mouse model of acute myocardial infarction. The high spatial resolution required, the rapid cardiac motion and the extremely short T2 of ^{23}Na render *in vivo* measurement of ^{23}Na technically demanding. We sought to measure myocardial tissue sodium concentration in normal and acutely infarcted mouse hearts *in vivo* and to confirm infarct size and location using late gadolinium enhancement.

Methods: C57Bl/6 mice with and without permanent occlusion of the left coronary artery were subjected to MR examination 24 h post surgery (n=3 each). Experiments were carried out on a 9.4 T/210 mm bore Magnex magnet with Varian direct drive console (Agilent, US). ^{1}H short axis anatomical scout images (128x128, 4 slices, 1.5 mm thick, short axis, 25x25 mm FOV) were acquired using 39 mm quadrature birdcage resonator (Rapid Biomedical, Germany). Corresponding Hanning weighted ^{23}Na chemical shift images (CSI) were acquired (44x44, 4 slices, 1.5 mm thick, 0.96x0.96 mm nominal resolution, effective TR ~460 ms). Using a 39 mm actively decoupled ^{23}Na quadrature birdcage resonator (Rapid Biomedical) for transmit and a 14 mm square actively-decoupled surface coil for receive. A late gadolinium enhanced (LGE) T1 weighted short axis GE3D image was acquired to assess infarct volume [3]. Infarcted hearts were also excised immediately following the procedure for histological examination. CSI data were fitted using in-house software. In order to minimize the effects of the non uniform receive profile of the surface coil, the ratio of myocardial/blood tissue sodium concentration was calculated for adjacent myocardial:blood voxels. High resolution B1 maps have been acquired to allow for correction of flip angle and receive profile effects enabling calculation myocardial/infarct:blood ^{23}Na ratios for the entire myocardium.

Results: Example data from a healthy and infarcted mouse are shown (Figures 1 and 2); ^{23}Na levels are scaled identically in both images. Total myocardial:blood tissue ^{23}Na concentration ratio was markedly increased in the anterior wall (infarcted tissue; 1.01±0.50) relative to the septum (remote tissue; 0.65±0.23) whilst both regions had a similar ratio in healthy mice (0.45±0.12, 0.53±0.18). Elevated ^{23}Na signal was also observed in the region of the surgical incision in the chest wall.

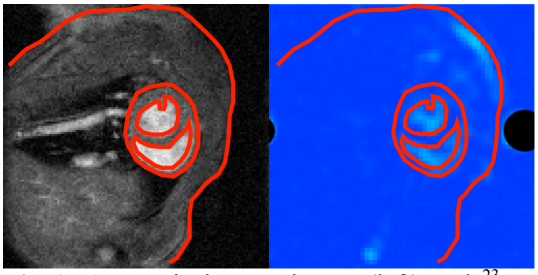

Fig 1: Anatomical scout image (left) and ^{23}Na CSI magnitude image of a healthy mouse. The sphere used for pulse calibration is masked.

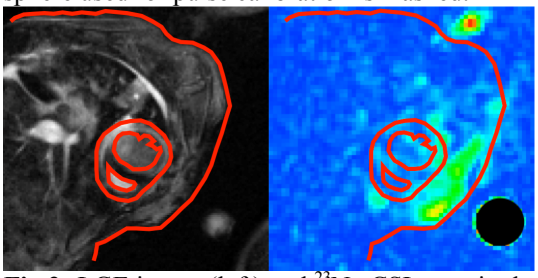

Fig 2: LGE image (left) and ^{23}Na CSI magnitude image of an acutely infarcted mouse. The sphere used for pulse calibration is masked. Tissue ^{23}Na concentration is markedly higher in the infarcted anterior wall than in the remote septum.

Conclusion: Elevated tissue sodium concentrations can clearly be observed in acutely infarcted myocardium in the mouse for the first time. Work is in progress to combine the MRS data with high resolution B1 maps for both transmit and receive coils and will, along with a concentration reference phantom, enable quantification of the ^{23}Na signal from the mouse heart. Absolute quantification will for the first time allow direct study of *in vivo* changes of cardiac sodium levels in the mouse.

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References: [1] Weidensteiner *et al.*, Magn Reson Med, 48, 89-96 (2002), [2] Neuberger *et al.*, MAGMA, 17, 196-200 (2004), [3] Bohl *et al.*, Am J Physiol Heart Circ Physiol, 296, H1200-1208 (2009)