Assessment of Microcirculation in Murine Myocardium: A Retrospective Method for Quantification of Perfusion and Regional Blood Volume

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Introduction: A retrospectively triggered Look-Locker Arterial Spin Labeling (ASL) method for the quantification of perfusion in murine myocardium as demonstrated in [1] was extended for Regional Blood Volume (RBV). The method is based on T_1 measurement after global and slice selective inversions before and after the administration of intravascular contrast agent [2, 3, 4]. Usually a prospectively triggered Inversion Recovery Snapshot FLASH [5] (IRSF) is used. Due to the long measurement time changes in the heart phase can cause problems since pre and post contrast agent T_1 maps are compared voxel by voxel. The introduction of retrospective triggering enables the reconstruction of arbitrary time points in the heart cycle. Therefore this problem can be mitigated by choosing matching positions in the heart cycle for reconstruction. Furthermore the continuous measurement of a non-triggered IRSF retains strict Look-Locker.

Method: Experiments were carried out on a 7 T small animal imaging system using a 72 mm quadrature birdcage and a 4-channel coil array [6]. NMRI-Mice (Charles River Laboratories) are anesthetized with Isoflurane (1.5-2%). Gd-DTPA-Albumin (0.7 µmol kg^{-1}) serves as intravenous contrast agent. Breath and heart activity are recorded using ECG and a pressure based sensor.

The retrospective IRSF sequence and a model based reconstruction as reported in [1] has been employed. The sequence uses prospective triggering only for inversion pulses, readout pulses are assigned to their heart cycle retrospectively by evaluating the recorded ECG data. Specific sequence parameters were: 3 cm by 2 cm FOV, isotropic resolution (294 µm)², imaging slice thickness 1.6 mm, inversion slice thickness 6mm, bandwidth 38 kHz, TR 3.85 ms, 3000 readout pulses per inversion, waiting period of 7 s between inversions adding up to a measurement time of 20 min. Quantification of T_1 and perfusion maps is performed following [4]. After intravenous administration of the contrast agent the protocol is started a second time. The contrast agent reduces the blood T_1 time by approximately 1 s. From the resulting scans the RBV can be calculated [3]. T_1 maps are reconstructed for several points in the heart cycle for the pre and post contrast agent measurements. The best match is chosen manually so far.

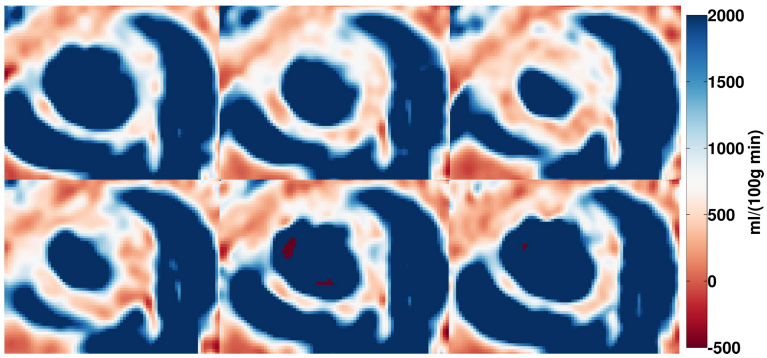

Fig 1 Perfusion maps reconstructed on 6 equidistant positions in the heart cycle starting from end diastole

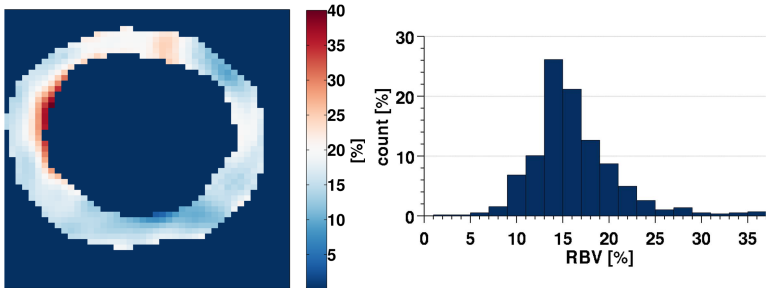

Fig 2 Map of RBV and histogram over RBV values.

Results and Discussion: Exemplary perfusion maps are shown in fig. 1. The perfusion values are in good agreement with literature values [4]. The maps are reconstructed to different points in the heart cycle. Variations in perfusion values can be attributed to partial volume effects and motion artifacts. An RBV map is shown in fig 2. The RBV values are slightly higher than reported in [4] which can most likely be explained by the vasodilating effect of Isoflurane.

Conclusion: A retrospectively triggered protocol has been demonstrated. Quantitative T_1, perfusion and RBV maps can be reconstructed on arbitrary positions in the heart cycle. Retrospectively triggered acquisition is strongly beneficial for RBV measurements as conventional triggering can drift over time especially after the administration of contrast agent.

References:

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