Single voxel spectroscopy with cycled water-suppression in cardiac ^{1}H MRS

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Introduction: Cardiac ^{1}H magnetic resonance spectroscopy (MRS) can be used to quantify in vivo myocardial lipids,[1] and potentially other metabolites. However, motion-induced phase and frequency shifts can result in incoherent averaging, making the detection of low level metabolites, e.g. creatine (Cr), challenging. Recently, a cycled water-suppression scheme (WC) has been suggested to correct for these shifts in each FID for ^{1}H MRS in the brain.[2] This work aims to evaluate the performance and reproducibility of this method in measuring myocardial Cr at 3 T in vivo.

Methods: All measurements are performed on a 3 T scanner (Prisma, Siemens) using an 18-channel body-array coil (Siemens). 10 healthy volunteers (3 females, age = 29.3 ± 4.0 yrs) were scanned in 2 sessions on the same day. In the first session, 3 acquisitions were run consecutively: 150 measurements over 30 breath-holds (BH) for STEAM with WET water-suppression (STEAM WET) to establish the 'gold' standard, 60 measurements over 10 BH each for STEAM with WC (STEAM WC) and PRESS with WC (PRESS WC). A non-suppressed data set was obtained (1 BH, 3 measurements) after each acquisition. In the second session, 30 BH STEAM WET and 10 BH PRESS WC were repeated. MRS data were obtained at end expiration using ECG triggering from a 12.6 cm^3 voxel centred on the interventricular septum. The residual water peak was used for phase and frequency correction before averaging. Signal peaks were fitted using the OXSA toolbox.[3] For comparison, 60 measurements from 12 random BH were also analysed for STEAM WET. SNR and Cramer-Rao lower bounds (CRLB) of the Cr CH_3 peaks were compared for all. Reproducibility data were analysed for 30 BH STEAM WET and 10 BH PRESS WC.

Results and discussion: Fig. 1 depicts a set of representative spectra. Although there was a slight decrease in SNR, the implementation of the WC in STEAM greatly improves the fitting of the spectra (lower CRLB value) allowing for better Cr quantification. This fitting is further improved with PRESS WC (Fig. 2). The coefficient of repeatability of 30 BH STEAM WET and 10 BH PRESS WC are 8.85 µmol/g and 3.42 µmol/g respectively showing that despite the reduced number of BH, 10 BH PRESS WC displayed improved reproducibility compared to 30 BH STEAM WET (Fig. 3). Thus, PRESS WC might be able to detect smaller changes in myocardial Cr levels in shorter scan times.

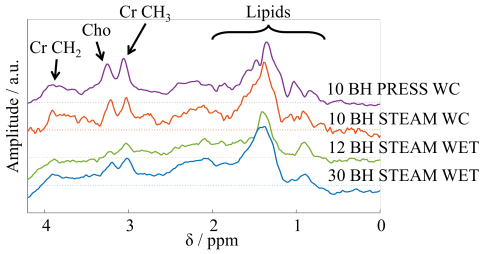

Figure 1: Representative cardiac ^{1}H spectra acquired with the sequences.

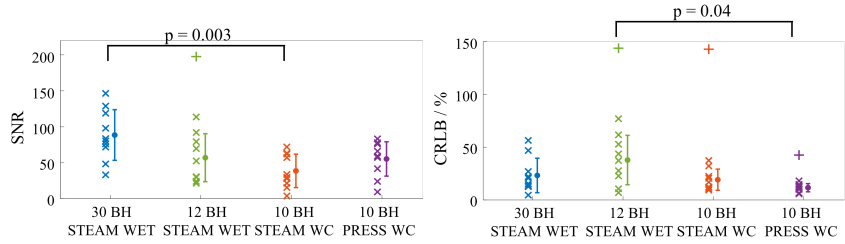

Figure 2: Plots of SNR (left) and CRLB (right). '+' represent outlier data.

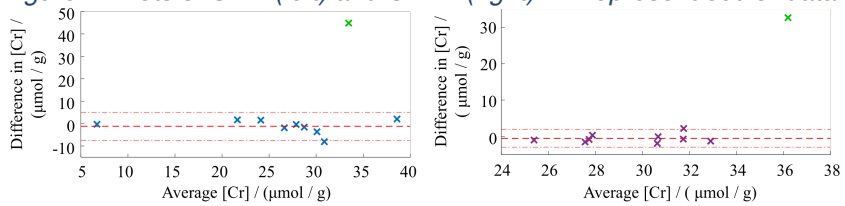

Figure 3: Bland-Altman plot of [Cr] comparing reproducibility of 30 BH STEAM WET (left) and 10 BH PRESS WC (right). Red dotted lines represent limits of agreement, the red dashed line represents bias.

Conclusion: The decrease in CRLB and increase in reproducibility makes PRESS WC a promising technique to use in cardiac ^{1}H MRS at 3 T. We believe that it may help to decrease the number of BH currently required to assess cardiac Cr levels.

References: [1] Rial et al. Magn Reson Med. 2011; [2] Ernst and Li. Magn Reson Med. 2011; [3] Purvis et al. PLOS. 2017