Cycled water-suppression single voxel spectroscopy in cardiac ^{1}H MRS

***Belinda Ding*[1], *Ferenc Mózes*[1], *Ladislav Valkovič*[1], *Christopher Rodgers*[1, 2]**

[1]Oxford Centre for Clinical Magnetic Resonance Research, University of Oxford, UK

[2] Wolfson Brain Imaging Centre, University of Cambridge, UK

Introduction: In vivo cardiac ^{1}H magnetic resonance spectroscopy (MRS) has been widely used to quantify myocardial lipids,[1] and potentially other metabolites. However, it is sensitive to motion, and motion-induced phase and frequency shifts can result in incoherent averaging. Thus, detection of low concentration metabolites, e.g. creatine (Cr), in the heart is very 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] It has been demonstrated previously that SVS sequences with WC remained sensitive to Cr concentrations in phantom. This work aims to test the performance and evaluate the reproducibility of this technique 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, mean age = 29.3 ± 4.0 years) were scanned in two sessions on the same day. In the first session, three acquisition schemes were run consecutively: STEAM with WET water-suppression (STEAM WET), STEAM with WC module (STEAM WC) and PRESS with WC module (PRESS WC). 150 measurements were acquired for STEAM WET over 30 breath-holds (BH) to establish the 'gold' standard, while 60 measurements each were acquired over 10 BH for STEAM WC and PRESS WC. A subsequent non-water-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 to estimate their reproducibility. All MRS data were obtained at end expiration using ECG triggering from a 12.6 cm^3 voxel centred on the interventricular septum. Weighting and the phase correction factor for coil combination were calculated from the non-water-suppressed data. The residual water peak was used for phase-correction and frequency alignment before signal averaging. Signal peaks were fitted using the OXSA toolbox.[3] For comparison, 60 measurements from 12 randomly selected BH were also analysed for STEAM WET. SNR and Cramer-Rao lower bounds (CRLB) of the Cr CH_3 peaks were compared between the 4 sequences. [Cr] were obtained by correcting the Cr/water peak ratios by T_1, T_2 and number of protons. 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.

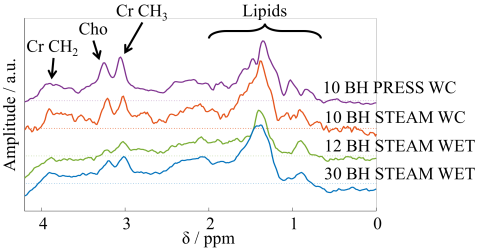

Figure 1: Representative cardiac ^{1}H spectra acquired with the sequences.

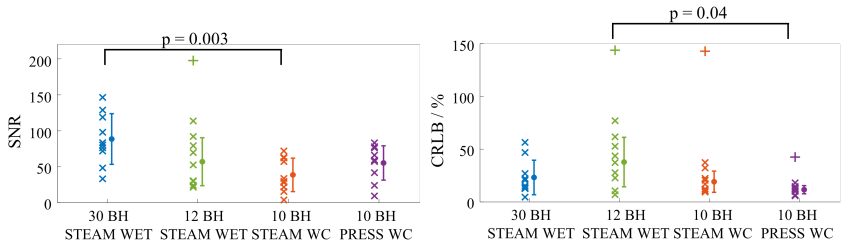

Figure 2: Plots of SNR (left) and CRLB (right). '+' represent outlier data.

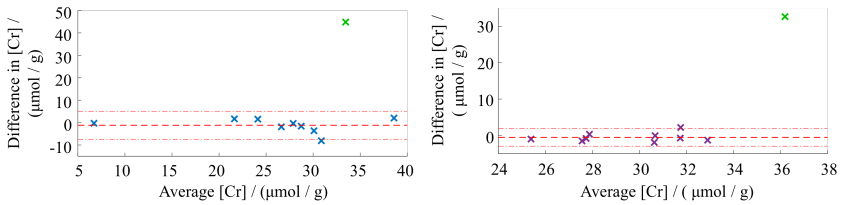

Figure 3: Bland-Altman plot of [Cr] comparing reproducibility of 30 BH STEAM WET (left) and 10 BH PRESS WC (right). Green 'x' represent outlier data. Red dotted lines represent limits of agreement, the red dashed line represents bias.

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. PRESS WC could be potentially used in conjunction with a liver dome navigator to allow for free-breathing acquisition to further improve patient compliance with the acquisition protocol.

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