Metabolite-Cycled Cardiac Proton Spectroscopy at 1.5T

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Introduction Motion leads to phase and frequency fluctuations of consecutively acquired averages in cardiac proton spectroscopy. When using water suppression (WS), respiratory gating is necessary and averages are typically phase corrected based on the low-SNR triglyceride signal. Metabolite cycling (MC) allows to perform frequency and phase correction on the high-SNR water signal[1], which might alleviate the necessity for respiratory gating. In this work metabolite cycling using a Hwang[2] asymmetric inversion pulse was implemented on a clinical 1.5T Philips scanner and results were validated with simulations.

Methods All simulations were performed using MATLAB. Dependence of transition and inversion bandwidth of the Hwang pulse on B_1, pulse length (T_p) and frequency factor (ff) was simulated; B_1=9 µT, T_p=50 ms and ff=1.4 were found optimal for our purposes. A spectrum consisting of water (W), triglycerides (TG) and creatine (Cr) was simulated, leading to an optimal frequency offset of -130 Hz for the Hwang pulse. For these parameters, the percent error in Cr/W and TG/W ratio after MC was simulated as a function of frequency shift and linewidth of the water peak. In-vivo measurements were performed on 3 healthy volunteers upon written informed consent. WS and MC measurements were performed on a clinical 1.5T Philips Achieva scanner, equipped with a five-channel cardiac receiver surface coil. Spectra in the interventricular septum were acquired using a PRESS sequence with reduced spoiler areas[3] and the following sequence parameters: spectral BW: 2000 Hz, TR: 2 s, TE: 20 ms, PB-volume shimming and ECG-triggering to end-systole. Parameters specific for WS measurements were voxel size 10×20×40 mm^3, NSA: 96 (water-suppressed) /16 (water), CHESS based water suppression BW 100 Hz, respiratory navigator (4 mm window). Parameters specific for MC measurements were voxel size 8×16×32 mm^3, NSA: 384. All averages were used for reconstruction. Effective scan durations for WS and MC scans were similar.

Results Results for simulated percent error of Cr/W and TG/W ratio are shown in Fig. 1. The percent error in Cr/W ratio can become especially large in case of a positive frequency shift. Results for in-vivo measurements are shown in Fig. 2. The percent error in TG/W ratio according to simulations is relatively stable over all measurements, whereas the percent error in Cr/W ratio varies more. MC measurements have similar SNR but better separation of peaks compared to WS measurements.

Discussion The results indicate that navigator-free cardiac spectroscopy at 1.5T is possible when using a MC scheme. The complementary simulations provide a tool to validate measurements and explain poor spectral quality. Because metabolite cycling does not rely on low-SNR TG signal for post-processing, it is suited to measure smaller voxels. This can be advantageous when comparing metabolism in an infarcted region with healthy myocardium.

References [1]Fillmer A et al. (2017), Sci Rep 7:16898 [2]Hwang T-L et al. (1999), JMR 138:173-177 [3]Weiss K et al. (2014), MRM 72:1201-1207

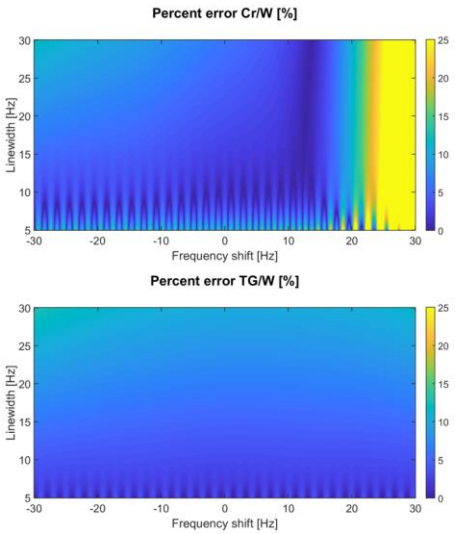

Figure 1: Simulated percent error of Cr/W and TG/W ratio as a function of linewidth and frequency shift.

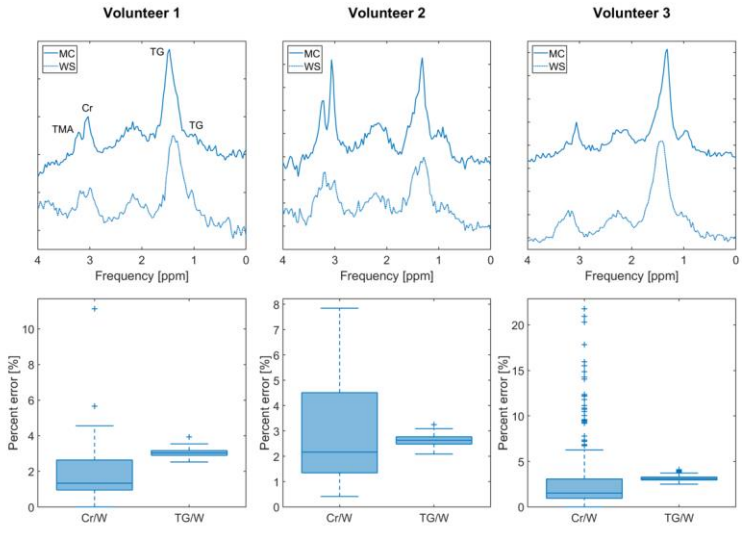

Figure 2: Metabolite-cycled (MC) and water-suppressed (WS) spectra of three different volunteers, with according box plots of the percent error of Cr/W and TG/W ratio according to simulations.