A 3D HYBRID-SHOT SPIRAL FOR HYPERPOLARIZED ^{13}C IMAGING (3D-HYSS)

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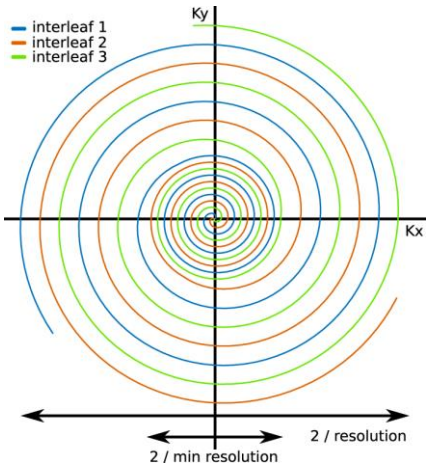
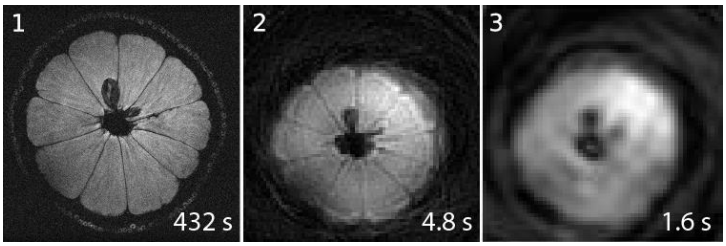
Introduction: The first hyperpolarised ^{13}C images of the human heart were acquired using a single-shot spiral k-space encoding trajectory [1]. Spiral-out trajectories are signal efficient, but for a given FOV, the achievable resolution is limited by readout duration, constrained by T_2*. Multi-shot spirals retain greater signal at higher spatial frequencies by shortening the readout length at the expense of temporal resolution.

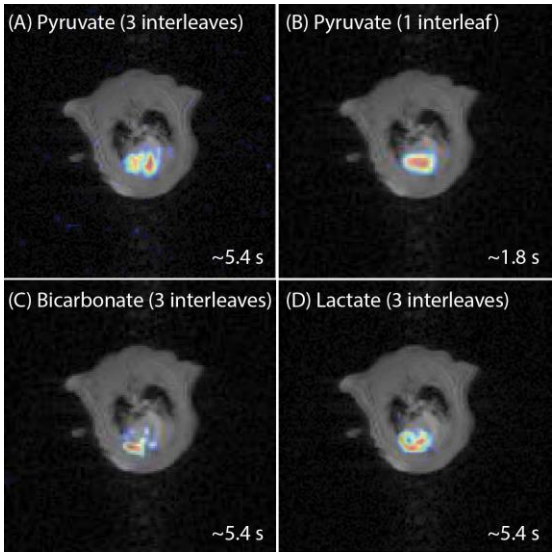
Sequence design: A hybrid-shot spiral regime is proposed to sample k-space at single-shot density within the central region corresponding to a desired minimum resolution. Higher spatial frequencies are sampled at *N*-shot density. By combining data within an adaptive window of *N* time points, higher resolution images can be generated at lower temporal resolution. The Hargreaves algorithm [2] was modified to generate hybrid-shot spiral trajectories, such as those shown on the right for *N* = 3.



^{1}H imaging: A lemon was imaged using a 72 mm birdcage coil on a Varian 7T preclinical scanner (G_{max} = 1000 mT/m, S_{max} = 5000 mT/m/ms) with the *N* = 3 hybrid-shot trajectory. The central slice shown below was reconstructed from the full extent of sampled k-space by combining 3 interleaves (2) and from only the single-shot portion of a single interleaf (3). A conventional 3D gradient echo acquisition of the same slice (1) is shown for comparison. Scan times are indicated in the lower right corner.



^{13}C imaging: A ~600 g Wistar rat was placed on a 2-channel ^{13}C receive array in a ^{1}H/^{13}C birdcage transmitter, injected with 2 mL of hyperpolarised [1-^{13}C]pyruvate. A cardiac-gated *N* = 3 hybrid-shot sequence (one TR per R-R interval ~ 150 ms) with an interleaved spectral-spatial excitation scheme was used to image pyruvate, bicarbonate, and lactate. Axial images of the rat heart are shown on the right. Reconstruction combining 3 interleaves (A) reveals the cardiac chambers with clear delineation of the myocardium at 2 mm resolution compared to the corresponding single interleaf reconstruction of the central region of k-space with 10 mm resolution (B). Bicarbonate (C) and lactate (D) were also well resolved with the reconstruction combining 3 interleaves. Approximate scan times are indicated in the lower right corner.



Discussion and Conclusions: The applicability of 3D-HYSS to ^{13}C cardiac imaging was demonstrated in vivo. Future work will implement this trajectory on a clinical scanner to perform adaptive spatio-temporal resolution imaging of the human heart.

References: [1] C.H. Cunningham et al, *Circ Res*, 119, 1177 (2016). [2] J.H. Lee et al, *Magn Reson Med,* 50, 1276 (2003).