

An Interleaved Lipid/Water Acquisition Method for Improved Detection of Lipid Infiltration in the Heart

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Introduction: Arrhythmogenic right ventricular dysplasia (ARVD) is a condition characterized by progressive lipid infiltration in the right ventricular free wall leading to ventricular malfunction and death [1-2]. Black-blood MRI techniques are often used for the non-invasive detection of lipid infiltration in ARVD. Current protocols use a double-inversion fast spin-echo (DIR-FSE) method to acquire a combined lipid/water image and a lipid-suppressed image (each image acquired in a separate breath hold) to assign regions of lipid infiltration in the right ventricle (RV). The relatively long ETL, as well as artifacts from unsuppressed flow, introduce blurriness making it difficult to detect the signal from lipid within the myocardium [3]. In this work, we introduce a method for obtaining a lipid- and water-only image from data acquired in a breath hold by interleaving the acquisition of lipid- and water-suppressed k-space data. These images can be combined to generate a lipid/water image with optimal lipid-to-myocardium contrast and reduced effects due to flow and motion.

Methods: The method uses an electrocardiographically gated (ECG) DIR-FSE technique where water- and lipid-suppression is alternated every TR period (Fig. 1). On each pair of odd and even consecutive TR periods, the same k-space lines are collected. On each TR period, lipid or water data are collected on-resonance. The interleaved DIR-FSE method produces a lipid- and water-only image without misregistration due to chemical shift or motion. Thus, a colorized lipid map can be overlaid onto the water image to generate a combined lipid/water image with optimal lipid-to-myocardium contrast-to-noise ratio.

All imaging was performed on a 1.5T GE Signa NV-CV/i MRI scanner equipped with 40 mT/m gradients. Images of ex vivo tissue were acquired with 300 μm^2 in-plane resolution (FOV=14 cm², acquisition matrix = 512x256) and slice thickness= 5 mm. High spatial resolution was needed to better correlate the MR images with gross anatomical findings. Other imaging parameters for ex vivo tissue were: TR=2R-R (set with an external ECG device operating at 60 bpm), BW= ± 32 kHz, ETL=4, and NEX=2. In vivo images were acquired with FOV=26 cm² and slice thickness = 6 mm, BW= ± 32 kHz, TR=2R-R, ETL=16, and NEX=1. In order to fit the acquisition of in vivo data to a breath hold, the acquisition matrix for the lipid- and water-only data was 256x128. Parallel imaging methods were used to attain an in-plane resolution of ~ 1 mm².

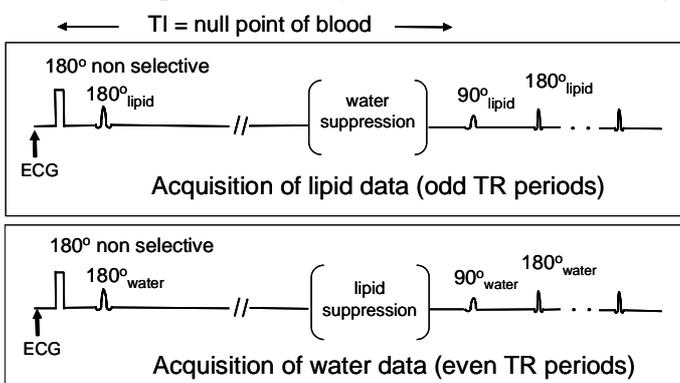


Fig. 1. DIR-FSE for collecting interleaved lipid- and water-only data.

In vivo images of a patient diagnosed with ARVD are shown in Fig. 3. The lipid-only image obtained with the interleaved DIR-FSE method (Fig. 3a) is free of flow or motion artifacts and lipid structures are clearly seen. Note that there are regions of lipid infiltration into the myocardium that can be mapped to the outflow tract when the lipid and water images are combined (Fig. 3b). Lipid infiltration is better delineated in the images obtained with the interleaved DIR-FSE method than in the DIR-FSE image shown in Fig. 3c, where lipid and water are acquired simultaneously (i.e., conventional acquisition strategy). In the latter, the poor contrast between lipid and myocardium and blurriness impairs the visualization of lipid infiltration.

Conclusion: A method has been developed for obtaining a lipid and a water image of the heart in one breath hold. With this method the detection of lipid structures is independent of flow or other artifacts present in the water image. Furthermore, a combined lipid/water image can be generated with optimal lipid-to-myocardium contrast. The method can improve the diagnosis of pathologies that involve lipid infiltration such as ARVD.

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References: (1) Fontaine G, et al *Ann Rev Med*, 50, 17, 1999; (2) Richardson P, et al, *Circulation*, 93, 841, 1996; (3) Castillo E, et al, *Radiology*, 232, 38, 2004.

Results: High resolution images of ex vivo tissue (RV) where fatty infiltration was characterized by pathology are shown in Fig. 2. Lipid infiltrations are seen in the gross anatomical slice (arrows in Fig. 2a), as fingerlike yellowish structures that extend from the epicardium to the myocardium. These structures are clearly seen in the images generated with the interleaved DIR-FSE method as bright or dark structures in the lipid-only (Fig. 2b) and water-only (Fig. 2c) images, respectively. The lipid structures are clearly seen in the combined lipid/water image (Fig. 2d), where the contrast between lipid and myocardium is enhanced by overlaying a colorized lipid map onto the water image.

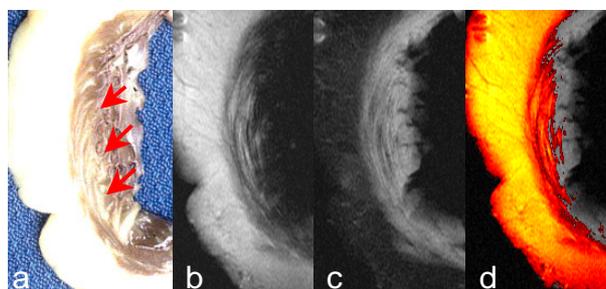


Fig. 2. (a) Gross pathological slice and (b-d) MR images of ex vivo tissue.

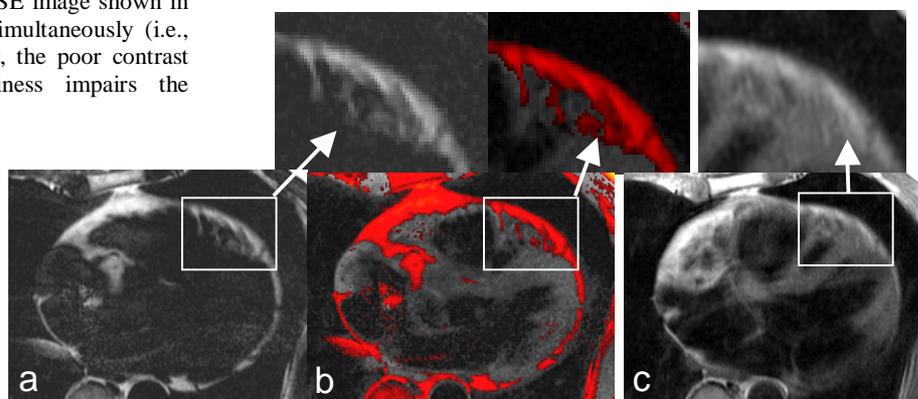


Fig. 3. In vivo images of a patient diagnosed with ARVD.