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1136 Cardiovascular radiofrequency (B_1) field maps using HASTE

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Introduction

Quantitative cardiovascular magnetic resonance (CMR) imaging assumes spatially uniform excitation of spins. Heterogeneities in the radiofrequency (B_1) field due to effects such as coil loading, conductivity, and dielectric resonance violate this assumption and may result in apparent changes in tissue properties. Previous CMR B_1 mapping approaches have relied heavily on custom pulse sequences [1] and have not included the lungs.

Purpose

To develop a robust B_1 field mapping approach that is applicable to the heart and lungs.

Methods

The double angle method for B_1 field mapping [2] utilizes two images acquired with different flip angles: θ_1 and commonly $\theta_2 = 2\theta_1$. Signal intensities from the two images are compared to solve for the true achieved θ_1. We used a single shot fast spin echo (HASTE) pulse sequence with excitation flip angles of 60° and 120° for the double angle experiment (refocusing pulses not modified). This rapid acquisition alleviates the need for breath-holding as a means of eliminating respiratory motion in the chest.

Representative heart coverage was achieved using short axis and four chamber view slice prescriptions. Images can be acquired during a single breath-hold or during free breathing. For free breathing, each image acquisitions was repeated 10 times and the position of the diaphragm and heart was used to select images of similar respiratory phase.

All data was acquired on a Siemens Sonata 1.5 T MRI scanner. Typical HASTE scan parameters are: body coil reception, cardiac gating (diastolic imaging), black blood preparation, 360 × 250 mm FOV, 8–12 mm slice thickness, 192 × 70 matrix, 12–22 ms TE, 2.75 ms inter-echo spacing, ~4–5 seconds TR, and 10 repetitions (if free breathing). Each slice was acquired in ~10 seconds (breath-hold) or ~80 seconds (free breathing). Heart and lung tissue were manually segmented and averaged within regions of interest (~3.5 cm^2).

Results

In Figure 1, a four chamber view shows a significantly varying B_1 field across both lungs and the heart. Results are expressed as actual flip angles for prescribed 90° RF pulses. For this volunteer, flip angles in the left lung closely matched the prescribed flip angles, while the right lung flip angles were 10°–20° lower. In the heart, the flip angle ranged from > 90° in the free wall to ~75° in the septum to as low as ~60° in the right ventricle and nearby chest. There are no large variations in the longitudinal direction. Parallel short axis slices (e.g. Fig. 2) confirm these findings. The B_1 field varies smoothly within the heart and into the lungs (Fig. 2 – inset). Similar trends were observed in other volunteers. The HASTE approach was validated by comparison to the conventional GRE double angle method in phantom experiments (not shown).

Conclusion

HASTE imaging can be used with the double angle method to map the B_1 field in the heart and lungs. Images can be acquired in a short breath-hold or during free

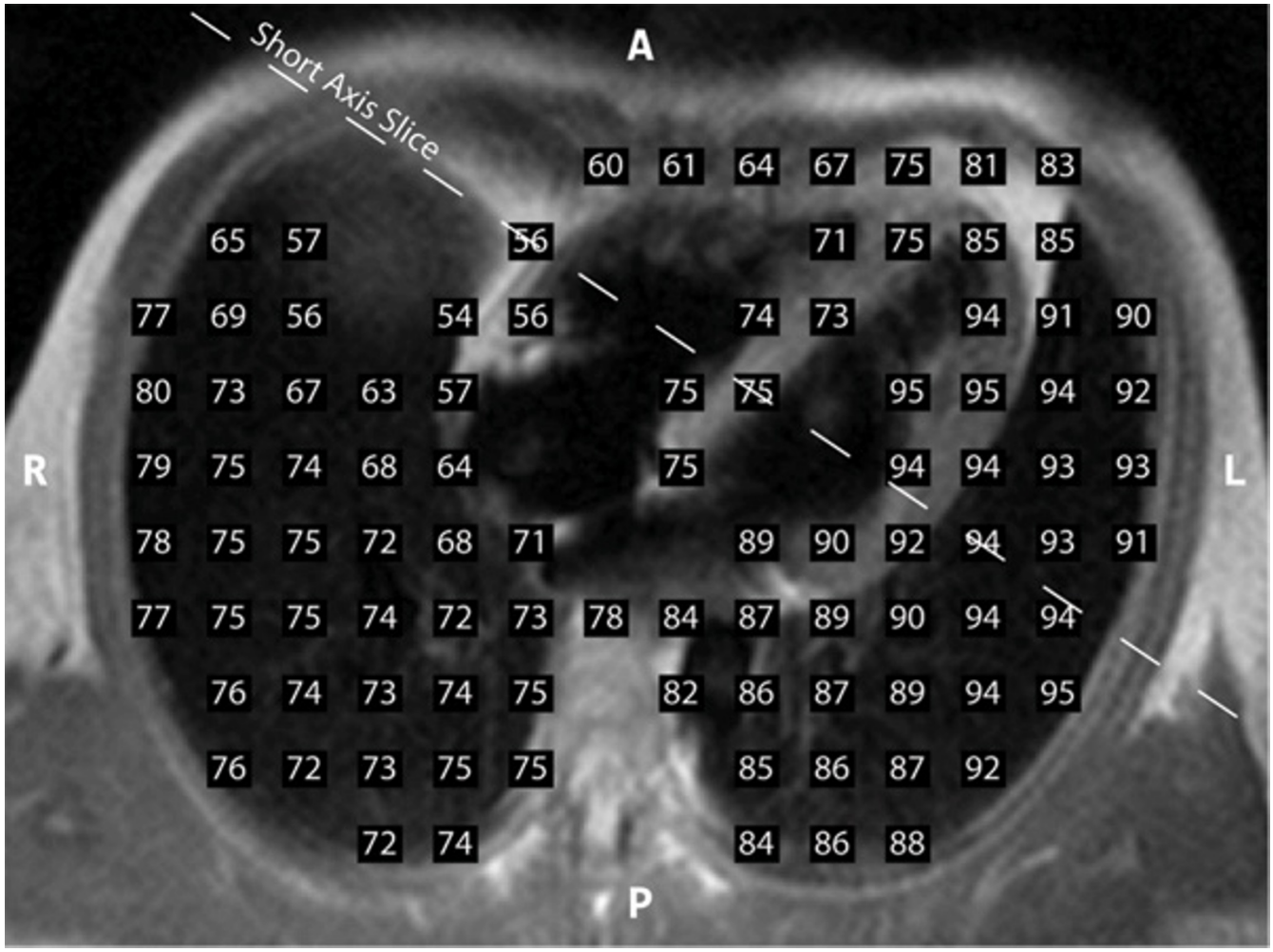

Figure 1
Four chamber view of the heart.

breathing. Even at 1.5 T, the calculated RF flip angles deviate up to 40° from a nominal 90°. Comparably large variations in the B_1 field were previously observed in the human pelvis at 1.5 T [2]. At 3 T, cardiac B_1 maps were found to have larger variations with different spatial patterns [3]. We have validated the HASTE approach for B_1 field mapping at 4.7 T in the brain. SAR limitations, which normally preclude fast spin echo imaging at high fields, were overcome using low refocusing flip angles [4].

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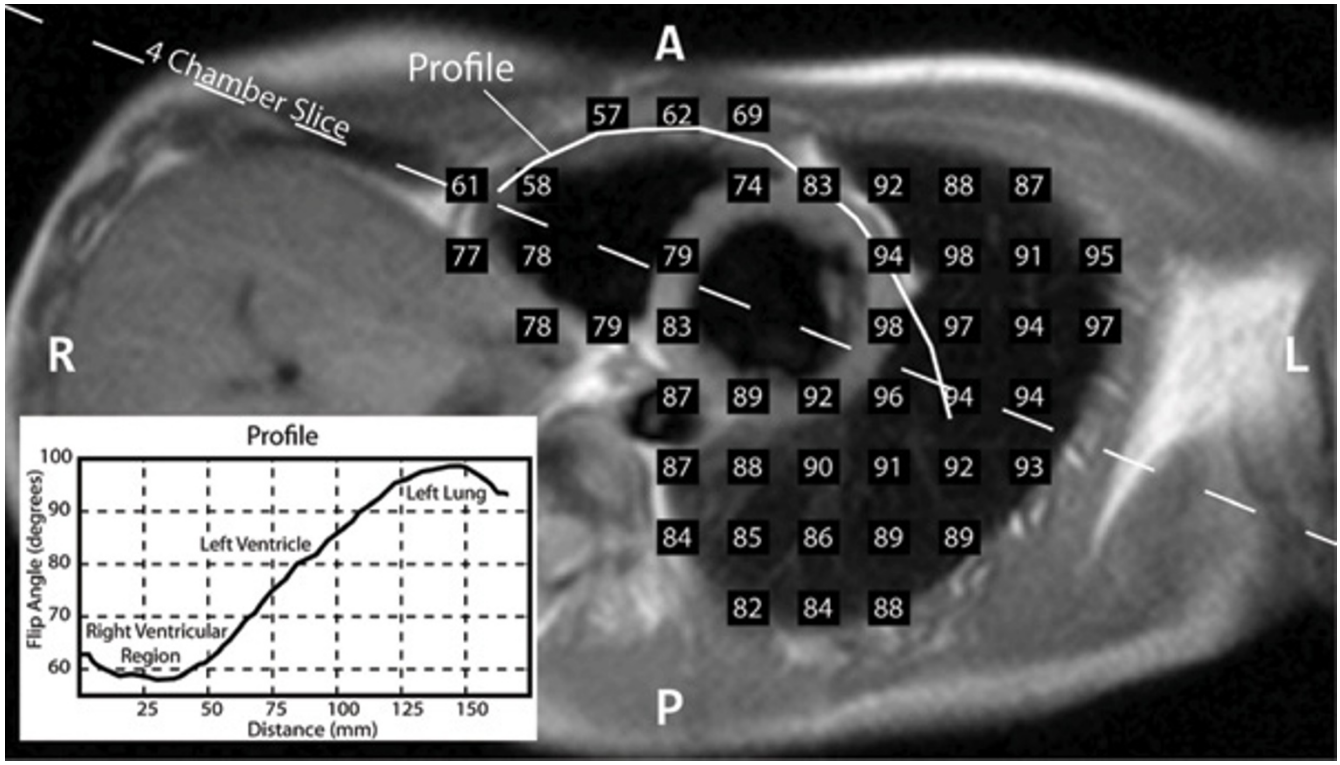

Figure 2
Short axis view of the heart. Inset: profile through heart and lung.