Black-Blood Restricted Field of View Sequence for Pre-Ablation Imaging of the Atria

C. Stehning[1], D. Caulfield[2], B. R. Knowles[2], S. Weiss[1], and T. Schaeffter[2]
[1]Philips Research Europe, Hamburg, Germany, [2]Division of Imaging Sciences, King's College, London, United Kingdom

Introduction

Pre-ablation MR imaging of atria in patients with atrial fibrillation (AF) or flutter (AFL) is one of the most challenging applications of cardiac MRI [1]. However, knowledge of the atrial anatomy, in particular the wall thickness, is important for the subsequent ablation procedure; suboptimal ablation settings may entail a re-connection of tissue, or bear the risk of a puncture of the thin (2mm) atrial wall. A restricted FOV MR sequence which allows exclusive imaging of the atria was evaluated in the present study. The targeted imaging sequence provides a clear depiction of the atrial wall thickness with submillimeter resolution in a clinically acceptable scan time and mitigates motion artifacts, particularly in patients in AF.

Methods

Localized images of the left atrium were acquired in 9 healthy adult volunteers and in 11 patients with either atrial fibrillation (AF) or flutter (AFL) referred for an interventional RF ablation procedure. The experiments were conducted on a 1.5T clinical MR scanner (Achieva, Philips Healthcare) equipped with a cardiac coil array. A cine scan was employed to detect a quiescent period of the atrial walls. Next, a targeted volume multislice black blood, fat suppressed spin echo sequence as sketched in Fig. 1 was employed. The imaging sequence involves perpendicular slice selection and refocusing gradients [2], which restrict the FOV in two dimensions and thus reduces the scan time for a given spatial resolution. The imaging parameters were as follows: FOV=330×110×83mm³, measured resolution = 0.8×0.8×6mm³, 8 slices (5mm gap), 16 echoes per cardiac cycle (77ms AQ window). Data were acquired ECG-triggered on every 2nd heartbeat to maintain efficient blood suppression in patients with irregular RR intervals, and respiratory navigators were employed to allow for free breathing. A respiratory gating level drift was allowed in between the acquisition of individual slices to cope with respiratory drifts. NSA=2 averages were acquired with a pseudo-stochastic phase encoding order to destroy the coherence of motion artifacts and improve SNR. The resulting total scan time was 4-6 minutes, depending on the breathing pattern and severity of arrhythmia.

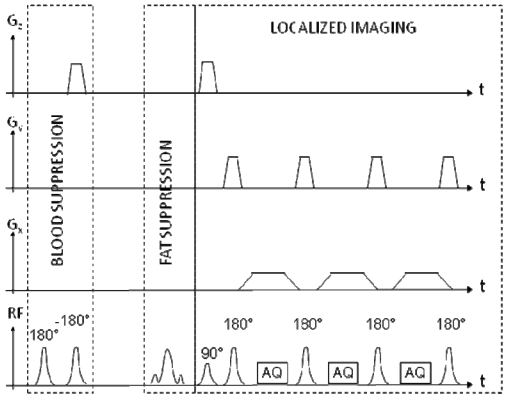

Fig. 1 Black blood, fat suppressed localized MR imaging. Perpendicular slice selection and refocusing gradients restrict the FOV in two spatial dimensions and reduce the number of phase encoding steps for a given spatial resolution

Results and Discussion

Selected *in vivo* results obtained in a volunteer and a patient in sinus rhythm are shown in Fig 2 [a,b], respectively. A clinical example acquired in a patient in the presence of AF is shown with a full FOV and the proposed restricted FOV method in [c] and [d], respectively. A clear depiction of the thin (approx. 2mm) atrial wall with submillimeter spatial resolution and efficient blood suppression were achieved within a clinically acceptable scan time. A clear delineation of the atrial wall thickness was achieved. In the clinical example [c] and [d], a superior image quality was observed with the restricted FOV, which may be attributed to the fact that the ventricles, which may reveal an abnormal motion pattern in patients in AF, do not contribute motion artifacts during the localized imaging of the atria.

Conclusion

The present sequence is a promising candidate to provide volumetric, blood-suppressed images of the atrial wall with good image quality and submillimeter spatial resolution. The targeted volume approach is appealing for two reasons; due to the restricted FOV, sufficient spatial resolution to image the thin atrial walls can be obtained in a clinically acceptable scan time. Furthermore, localized imaging of the atria mitigates motion artifacts originating from the arrhythmic ventricles, which may reveal a substantially different motion pattern than the atria. A 3D acquisition may provide improved SNR and isotropic spatial resolution, which may ease the planning procedure. However, the here employed multislice acquisition was found to offer optimal blood suppression and keeps the acquisition time to complete each slice minimal, which reduces motion artifacts and allows to cope better with respiratory drifts. In conclusion, the anatomy of the thin atrial wall could be evaluated in a clinically acceptable scan time even in patients with AF, who represent a very challenging patient group in cardiac MR imaging. A clear delineation of the atrial wall thickness was achieved, which may provide additional information for the subsequent ablation procedure, and improve the accuracy of computer models of the atria.

Ref: [1] Peters DC et al, Radiology (2007) [2] Bottomley PA, Ann N Y Acad Sci (1987)

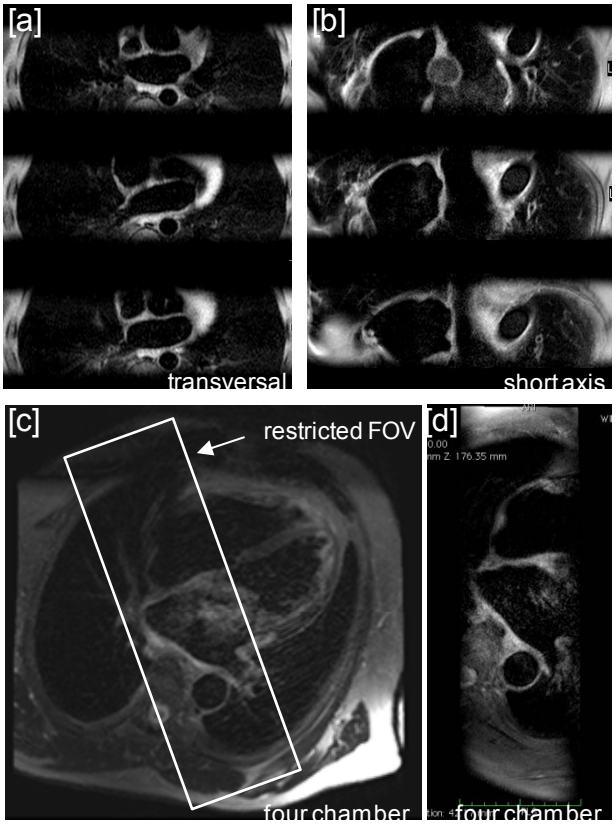

Fig. 2 Selected atrial wall images in a volunteer [a] and a patient in sinus rhythm [b]. Images with full and restricted FOV are shown for comparison in [c] and [d], respectively. A substantially improved delineation of the atrial wall was obtained in [d]