ATRIAL WALL THICKNESS IMAGING FOR CAVOTRICUSPID ISTHMUS ABLATION

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Purpose

Radiofrequency (RF) ablation is an effective treatment for patients with atrial fibrillation and atrial flutter showing less recurrence of arrhythmia than antiarrhythmic medications. The success of the RF-ablation procedure depends on the creation of transmural lesions that block unwanted conduction pathways. The RF-ablation power has to be adjusted to create transmural lesions, while avoiding perforation of the heart. This is challenging since the patient's individual local atrial wall thickness is unknown. MR wall thickness imaging (WTI) may provide this information and contribute to increased success rates and safety [1]. In this work a fully integrated WTI procedure as input for cavotricuspid isthmus (CTI) ablation is described. The technique is validated in a phantom study and applied in healthy volunteers and an atrial flutter patient.

Methods

WTI was performed in five steps. **1)** A 3D whole heart scan ($400 \times 280 \times 165$ mm^3, resolution $2 \times 2 \times 3$ mm³, acquisition window: 130 ms, TE / TR = 2.7 / 5.3 ms, ECG triggered at mid diastole) was acquired (Fig. 1A). **2)** Based on the 3D scan, a model-based, automatic segmentation of the different heart chambers was performed [2] (Fig. 1B). **3)** The two spatial endpoints of CTI (tricuspid valve (TV) and inferior vena cava (IVC)) were selected manually on the segmentation surface of the right atrium. A corresponding scan geometry including CTI and read-out direction perpendicular to the atrial wall was generated without user interaction (Fig. 1C). **4)** In this scan geometry, a 2D black-blood single shot turbo spin echo (TSE), fat suppressed zoom image, with perpendicular slice selection and refocusing gradients [3], which restrict the FOV in two dimensions was applied (FOV=$300 \times 120 \times 3$mm³, voxel size = $0.5 \times 0.8 \times 3$mm³, 98ms acquisition window, TE_{eff} = 4.9 ms, ECG triggered at mid diastole, Fig. 1D). **5)** Wall thickness was defined as the FWHM of the central signal intensity profile peak. Wall thickness was calculated for all positions along the CTI.

The accuracy of WTI imaging was tested in a resolution phantom with defined wall sizes (1mm – 18mm, Fig. 1E). The effect of partial volume on WTI was investigated by diverting the imaging angle from the optimal perpendicular position (0-50°). The WTI procedure was performed in five healthy volunteers and one atrial flutter patient. All experiments were performed with a 32-channel cardiac coil on a 1.5T scanner (Philips, Best, The Netherlands) connected to the Interventional MRI Suite (Philips Research, Hamburg, Germany) to implement the WTI workflow.

Results & Conclusion

The phantom study revealed, that WTI can reach submillimetre accuracy if planned perpendicular to the atrial wall (<10° deviation, Fig. 2). A representative wall thickness profile along CTI is shown in Fig. 3. The local wall thickness along CTI varied from on average 1.9mm near the TV to 5mm near the IVC. In future studies the study population should be increased to investigate how atrial wall thickness changes between individuals.

References: [1] Koken, Proc.ISMRM 2011, p3734. [2] Heese, Proc.ISMRM 2009, p4681 [3] Stehning C, Proc.ISMRM 2010, p1409
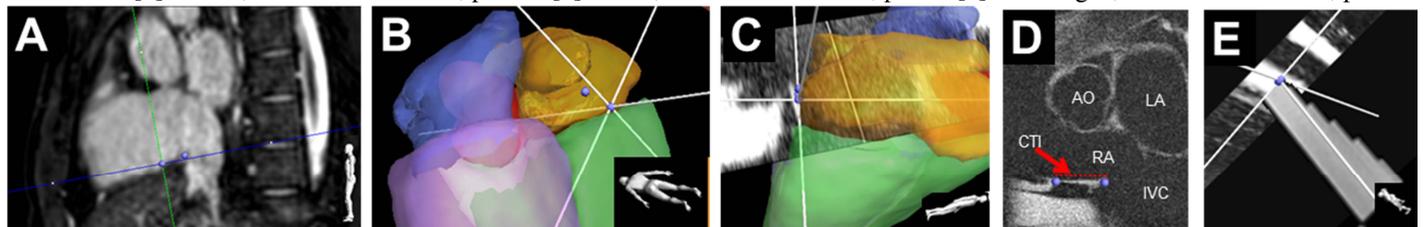
Fig 1 (top): Wall thickness imaging process as proposed in this study. A) 3D whole heart scan. B) Automatic segmentation of the heart (based on A). CTI endpoints are selected manually on the surface C) Perpendicular scan geometry on the surface of the right atrium (RA). D) Zoom image of CTI showing aorta (AO), left atrium (LA), IVC and RA. E) Phantom and zoom image from validation study.

Fig 2 (right): Errors in WTI due to partial volume effects measured in a phantom. WTI performed perpendicular to the atrial wall (0°) as in this study can achieve submillimetre accuracy.
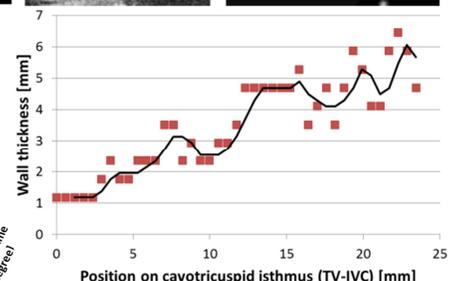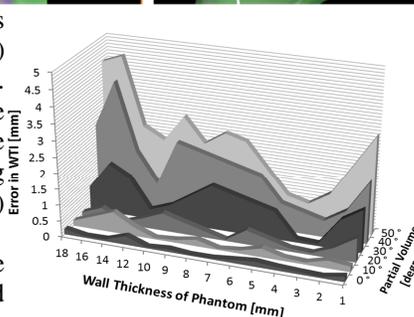
Fig 3: Wall thickness profile measured along CTI, starting from tricuspid valve. A moving average is shown.