Cardiac catheter ablation under real time MR guidance: initial clinical application

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Introduction: Malignant arrhythmia is one of the leading causes of morbidity and mortality. Even though over the last decades interventional electrophysiology (EP) and catheter ablation have revolutionized the diagnosis and therapy of cardiac arrhythmias, one of its main shortcomings is the inability to generate sufficient soft tissue contrast for intraprocedural visualization of the myocardium and the surrounding tissue using conventional imaging techniques. Intraprocedural magnetic resonance (MR) guidance has the potential to address the weaknesses of conventional EP.[1] Essential for clinical adoption of MR-guided EP interventions is the development of EP devices which are both fully MR-functional and MR-safe.[2] That is, despite recent technical improvements to surmount many of these problems,[3,4] successful catheter ablation in patients under real-time MR-guidance has not been reported up to the present. In the following we report on the first clinical utilization of catheter ablation under real-time MR guidance in our hospital as an advanced alternate approach in patients with arrhythmia resistant to conventional therapy.

Methods: An enhanced configuration of a recently described custom MR-EP setup[5] was utilized, including a 1.5 T Magnetom Avanto MR scanner (Siemens Healthcare, Erlangen, Germany) as the platform for imaging, and a Cardio Lab EP console (GE Medical, Little Chalfont, UK) as the platform for the EP setup. In-room equipment of the EP setup and leads were individually replaced by non-magnetic and/or MR-conditional components, including the equipment for surface ECG, patient surveillance, in-room monitors for the interventionalist, ECG and IEGM registration, neutral electrode, and catheters. MR imaging sequences for real-time visualization and tracking of the catheters, myocardium, surrounding tissue, and lesion development after ablation therapy[6] were developed and adjusted first in vitro and then in a large animal model. After extensive ex-vivo and in-vivo testing and validation of EP setup functionality and patient safety was followed by the first clinical applications of diagnostic EP and ablation therapy under real-time MR guidance in selected patients.

Results: The customized in-room equipment with dedicated radiofrequency (RF) filters and adapted MR imaging sequences allowed minimization of interference between the MR surrounding, imaging sequences, and EP equipment. Irrigated steerable 7F catheters which had been specially designed and fabricated for use in the MRI were capable of sensing, pacing, and RF delivery for ablation in the MR environment. Procedural safety was shown prior to the clinical applications in vitro and in vivo. First clinical utilization of interventional EP under real-time MR guidance using the described setup was performed in two patients with atrial arrhythmia refractory to conventional ablation therapy. Passive catheter visualization with operator-guided real-time MR catheter tracking was used. In both patients, successful ablation therapy under real time MR guidance could be confirmed by immediate post-procedural lesion imaging. No adverse effects occurred during the intervention. Both patients experienced no further arrhythmia episodes after ablation therapy.

Conclusion: Interventional cardiovascular MRI aims to provide decisive improvements to the diagnosis and treatment of cardiac arrhythmia. This might be particularly crucial for complex EP interventions which are currently often performed under fluoroscopy with the support of electroanatomic mapping systems. In addition to the benefit of the absence of ionizing radiation, interventional cardiovascular MRI has the potential to be suitable to directly visualize the arrhythmogenic substrate and therapeutic effects. Most important, MRI allows for immediate intraprocedural access to the whole myocardium and surrounding tissue beyond the cardiovascular cavities and endocardium. The combination of advanced imaging techniques for simultaneous tissue and catheter visualization and tracking, monitoring of ablation, and assessment of the ablation lesions will presumably provide significant advantages compared to conventional EP in the near future.

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Acknowledgements: This work was supported by the Bayerische Forschungsstiftung (Bavarian Research Foundation).