Real-time magnetic resonance imaging-guided cardiac electrophysiology: the long road to clinical routine

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This editorial refers to ‘Clinical workflow and applicability of electrophysiological cardiovascular magnetic resonance-guided radiofrequency ablation of isthmus-dependent atrial flutter’, by I. Paetsch et al., pp. 147–156.

For patients suffering from symptomatic tachyarrhythmia, catheter ablation has become standard of care for many years. Current guidelines therefore give a Class I or IIa recommendation for use of catheter ablation in a growing number of indications when treating patients with atrial as well as ventricular tachycardia (VT). Greatly improved treatment success rates going along with expanding indications have led to exponentially rising numbers of interventions over the last decade. Very recently, first studies even suggested improved outcomes after rhythm control of complex arrhythmia such as atrial fibrillation by catheter ablation, a task medical therapy largely failed to prove. On the other hand, complex interventions such as atrial fibrillation ablation are currently still accompanied with relatively poor outcome regarding both procedural success and occurrence of complications when compared to other interventional routine procedures.

Without question, magnetic resonance imaging (MRI) in this regard offers great potential in improving both efficacy as well as safety of cardiac catheter ablation. Most important, MRI excels in terms of soft tissue contrast, a feature potentially useful in all phases of the procedure, including planning, execution, and post-procedural care. Therefore, not surprisingly, first attempts of real-time cardiovascular MRI-guided interventions started early after implementation of catheter ablation into clinical routine. First reports on successful diagnostic electrophysiology procedures in animal models and preliminary patient investigations under real-time MR-guidance reach back as far as 2008, followed only shortly after by the first successful treatment of cardiac arrhythmia in the MRI without any fluoroscopic aid as early as in 2011. While these techniques have been expanded Afterwards both regarding patient workflow, as well as technical aspects, further progress in clinical use over the last years at first site appears to be rather marginal. Specifically, spreading the technique to new groups in the field has been revealed a complicated issue.

In this context, it must be emphasized that electrotherapy within the MR scanner is especially from the technical side extremely challenging. Even very basic techniques essential to cardiac electrophysiology such as 12-channel electrocardiography are hard to utilize, here mainly due to the magneto-electrocardiography effect hampering signal quality. In addition, safety issues related to heating of the catheter tip within the MR-radiofrequency field have to be considered. The imperative to transmit high ablation energy impedes approaches relying on high resistances, e.g. as inductive decoupling. Possible solutions are temporally mechanical interruption of the energy transmit line during MR-imaging, alterations in device insulation, or use of adapted imaging protocols with direct cooling of the catheter tip. Another important challenge is the interference of the induced ablation high frequency field with MR image formation. Though the frequency of the MR HF field differs from that of the generator (~64 MHz for 1.5 T vs. 0.5 MHz), the rectangular shaped profile of the ablation signal provides higher harmonics which requires sophisticated filtering. MR-guided electrophysiology, however, not only requires sophisticated electrophysiology (EP) devices, but equally important also specific spatial and personal conditions in order to allow implementing this new approach into clinical routine.

In their current work, Paetsch et al. expanded their prior work in this regard. In a non-randomized pilot study patients with isthmus-dependent atrial flutter were referred to MRI-guided cavotricuspid isthmus ablation. The authors suggest a protocol, which makes procedure duration and success rate comparable to data obtained from conventional ablation procedures. A whole heart sequence combined with a 3D surface reconstruction was applied to construct a roadmap of the heart and relevant vessels. Pre- and post-procedural T2 weighted imaging demonstrated ablation-related oedema formation, and gadolinium enhanced imaging showed severe tissue damage by contrast enhancement and presence of microvascular obstruction. Keeping in mind the complexity of the MRI-EP set up and

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its interface with the MRI scanner, the restricted mobility of the operator and the unaccustomed catheter handling within the MR-unit, the authors’ protocol must be appreciated when enabling to achieve procedure times comparable with those of the conventional approach.

Despite obvious improvements presented in the current study, MRI-guided ablation of atrial flutter certainly can still only represent a first step towards more complex procedures, which really demand and benefit from the whole amount of information MRI can provide. As one example, VT ablation in the presence of structural heart disease still represents a major clinical challenge. In order to achieve acceptable results, the complex structure of scar and viable myocardium—constituting the substrate of VT—must be captured, as well as the therapeutic effects of ablation. In this field, MRI without doubt carries the potential to be superior to approaches relying on conventional electroanatomical mapping systems, which mainly provide information at the endocardial site. This equally relates to the arrhythmogenic substrate as well as therapeutic effects.

As by 2019, MRI-guided EP therefore still has a long way to go in order to evolve its full potential. One major issue certainly relates to use of imaging techniques. Recent imaging of therapy effects focused on either contrast agent enhanced imaging—ultimately requiring highly problematic repeated gadolinium contrast agent applications—or T2 weighted imaging, largely reflecting myocardial oedema but not necessarily permanent scar tissue.

In order to overcome all remaining practical issues listed above, MR vendors and EP companies certainly must share a common interest in order to allow growing real-time MRI guidance of cardiovascular interventions from a theoretically highly attractive but practically extremely narrow pre-clinical (research) field to a mature clinical application and tracking. Heart Rhythm 2013;10:938–9.


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References


