The Need for Better Imaging in EP

Wolfgang R. Bauer, M.D., Ph.D.

The aim of electrophysiological procedures is to define invasively rhythm disturbances. This is achieved by positioning electrode catheters inside the heart which stimulate and register intracardiac ECGs. At its best the arrhythmias may be cured by application of e.g. high frequency (HF) energy to the culprit substrate. The imaging modality routinely used is fluoroscopy. However more and more complex procedures as ablation of atrial fibrillation or ventricular tachycardia (VT) are performed, which definitely demand better imaging modalities. Though electroanatomical mapping systems considerably facilitate the daily work in the EP lab, they have their definite limitations, as they just show an endocardial aspect of the heart. Goals the achievement of which would considerably improve quality and success of EP procedures are

1. High resolution imaging of anatomical structures for guidance of the EP catheter
2. Tissue differentiation, e.g. scar and viable myocardium for targeting of VT ablation, or to predict success rate for Afib ablation
3. Visualization of ablation therapy in context with (1) and (2) to evaluate how successful ablation was

These goals may be accomplished by

a) performing cardiac imaging before, and after the EP procedure
b) performing real time imaging during the EP procedure

Point (a) is rather easy to fulfill, as most electroanatomical mapping systems allow image integration of CT or MR data, so that the image works as a roadmap (Dong et al.). In the talk we will show examples in which image integration and a posteriori image analysis considerably facilitates the EP procedure and allows assessing effectiveness of therapy. Nevertheless this approach has also considerable drawbacks as optimal anatomical landmarks are a prerequisite, and even if this sometimes time consuming process runs optimal the anatomical match may be insufficient. Furthermore visual evaluation of (non)effectiveness of therapy is only feasible a posteriori.

(b) is a highly ambitious aim. The imaging modality which is already used routinely for EP is ultrasound. In this talk we will give some examples. However, the imaging modality of choice to accomplish the goals (1-3) is MRI. Unfortunately many obstacles have to be overcome to use this routinely. In the talk we consider the safety issues as well as their solutions, - the problem to find the tip of the catheter by MRI as well as the challenge of real time visualization of therapy and proper ECG registration. We will show how translational research led from basic experiments to the first EP procedures performed in man inside the MR scanner (Nordbeck et al., Eitel et al.).

In summary:

I) Complex EP procedures demand imaging modalities beyond fluoroscopy
II) CT/MR image integration as a roadmap combined with electroanatomical mapping is almost clinical routine, though sometimes technically challenging
III) Real time imaging during the EP study is feasible with intracardiac echocardiography (ICE)
IV) Real time MR imaging during the diagnostic and therapeutic EP procedure is a challenge. Its feasibility has been demonstrated. Nevertheless a lot of hurdles lie ahead. Future goals are

a. A faster tracking of the catheter
b. Combination of electroanatomical mapping and real time MRI
c. A more patient and investigator friendly MR-EP suite

Dong et al. (2006), Initial Experience in the Use of Integrated Electroanatomic Mapping with Three-Dimensional MR/CT Images to Guide Catheter Ablation of Atrial Fibrillation. Journal of Cardiovascular Electrophysiology, 17: 459–466.

Nordbeck et al. (2012), Cardiac catheter ablation under real-time magnetic resonance guidance. Eur Heart J (2012) 33 (15): 1977

Eitel et al. (2012), Electrophysiology study guided by real-time magnetic resonance imaging. Eur Heart J 33 (15): 1975.