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Review article – *Special issue: Imaging in Coronary Artery Disease*

Electromechanical mapping in electrophysiology and beyond

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A B S T R A C T

In this review, we outline contemporary and upcoming electroanatomic technologies focusing on new mapping tools especially in catheter ablation for atrial fibrillation. The number of catheter ablations has been increasing exponentially in the last few years due to technological advancements enabling complex ablation strategies. The quality of the contemporary systems of electroanatomic mapping is sufficiently high in terms of both standard ablations, such as isolation of pulmonary veins, and evaluation and elimination of complex arrhythmias. New instruments and devices are coming out to facilitate the process of understanding arrhythmias and thus simplify their elimination. The trend shows a deflection from fluoroscopy towards more advanced technologies.

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Introduction

In the last decade electroanatomical mapping systems have noted a steep development. Currently they enable to generate a 3D reconstruction of any part of heart without the need for a fluoroscopic navigation. Fluoroscopy is still a fundamental instrument for displaying mapping and ablation catheters, however, for a precise imaging of those structures that are critical for eliminating complex arrhythmias it can be used only in a limited scope [1] (Fig. 1). These systems, apart from precise imaging of cardiac anatomy, position and movements of catheters, are also valuable in terms of understanding the mechanisms of arrhythmia. Thanks to integration of anatomic and electrocardiographic (ECG) data they are very useful in choosing an optimal location for ablation. Use of mapping systems contributes to reducing the time of operation, fluoroscopy and radiofrequency delivery time [2].

Nowadays there are two mapping systems available for performing catheter ablations: CARTO system (Biosense Webster, Inc., Diamond Bar, CA) and EnSite Velocity cardiac mapping system (St. Jude Medical, Inc., St. Paul, MN). In both aforementioned cases the concept is based on a 3D reconstruction of the heart chamber being examined together with imaging of mapping and ablation catheters.

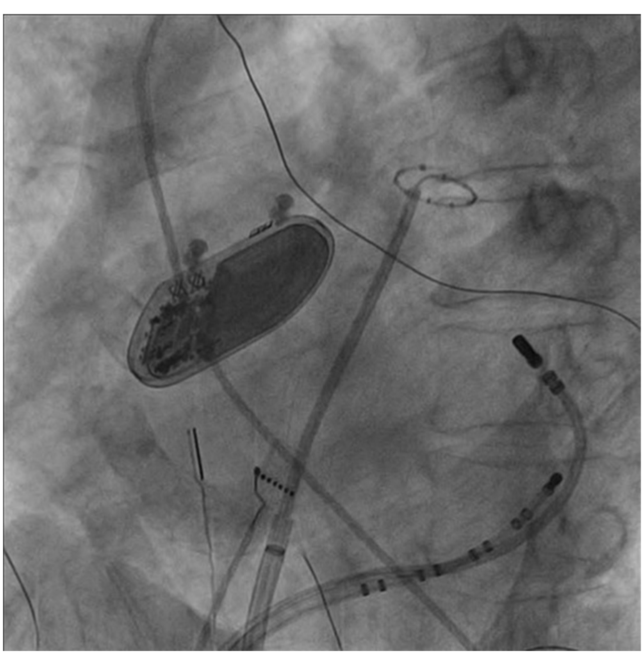

Fig. 1 – Fluoroscopy. Transseptal sheath with circular mapping Lasso catheter in pulmonary vein. Decapolar mapping catheter and ablation catheter in coronary sinus. Biomonitor (implantable ECG recorder).

CARTO

The CARTO mapping system uses low energy electromagnetic fields. The coils emitting nonhomogenous magnetic field (3 coils with different weak magnetic fields – 5×10^{-6} to 5×10^{-5} Tesla) are located in a triangle (location pad) that is placed under the table on which the patient lies during ablation procedure. A magnetic sensor is in the catheter tip. The evaluation of the magnetic field strength and orientation enables to localize catheter in space accurately. Patient's motions cause inaccuracies in the already generated map, thus previous generations of the CARTO system included a reference pad placed on a patient's back within the range of the electromagnetic field. The last generation of the CARTO system (CARTO3) combines the technology of magnetic and impedance based catheters localization. Six electrode patches, 3 on patient's chest and 3 on the back, screen the current emitted at a unique frequency from different catheter electrodes (Figs. 2 and 3). Data from magnetic sensors are rectified by impedance data to overcome distortions from non-uniform intrathoracic resistances. Furthermore, this hybrid method enhances the CARTO system accuracy and mainly enables to display more catheters at a time. A 3D reconstruction of cardiac chambers can be generated by moving a catheter in space (Fig. 4). Patient's movement or dislocation of the location pad may lead to significant map shifts that may be uncorrectable. Space maps of the heart chambers are obtained through an acquisition of points when a catheter is in touch with endocardium (or epicardium in epicardial ablations), and the greater the number of points acquired, the better the anatomical detail obtained. The new CARTO system generation is capable of creating space maps using the so-called *fast anatomical mapping (FAM)*, continuous acquisition of points by a simple movement of a catheter in individual heart chambers. A drawback of the CARTO system is seen in its closed architecture necessitating use of the original ablation catheter with the magnetic sensor (e.g. Navistar, Biosense Webster, Inc., Diamond Bar, CA, USA), since no map can be generated by a catheter other than original.

EnSite NavX

EnSite NavX (the last version entitled *EnSite Velocity*) system is based on use of body-surface patch electrodes. A high-frequency (8 kHz) alternating current electrical signal is delivered between pairs of patch electrodes. Intracardiac