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Role of Preprocedural Imaging in Catheter Ablation of Atrial Fibrillation

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Abstract

Catheter ablation is a well established and widely used therapy option of atrial fibrillation. The use of 3D mapping systems to aid the ablation process has become standard in most centers. Whether preprocedural imaging is an asset to catheter ablation procedures is of debate. Available methods and the existing evidence are outlined in this article.

Introduction

Catheter ablation of atrial fibrillation has evolved into a widely accepted therapy approach and has been incorporated in current guidelines.[1]

In the setting of paroxysmal atrial fibrillation it may be considered a therapy option even prior to antiarrhythmic drug treatment. Limited three-dimensional visualization of the complex three- dimensional structures in the left atrium poses a major limitation, especially when procedures are performed using fluoroscopy alone. Another unsolved problem is the limited durability of lesions sets performed with radiofrequency ablation resulting in suboptimal long-term ablation results, as well as fluoroscopy exposition of patient and operator, required for safe catheter manipulation.

Preprocedural imaging is frequently obtained using Cardiac Magnetic Resonance Imaging (CMR) and Computed Tomography (CT). Several studies have been performed to evaluate, whether these imaging strategies help to improve peri-interventional parameters or procedural outcome data and will be discussed in the following.

In recent years we have gained substantial insight with respect to arrhythmia mechanisms. At the same time new technology and ablation protocols have become available to improve catheter ablation results.

The present article summarizes available options with respect to three-dimensional mapping including CMR/CT image integration.

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Left Atrial Anatomy

It has been shown in the past that the use of three-dimensional mapping can help to reduce fluoroscopy times in patients undergoing catheter ablation for various arrhythmias.[2-5] The largest body of evidence exists for catheter ablation of atrial fibrillation, including data for conventional as well as robotically / magnetically guided procedures.[6,7] In one report by Reddy et al, the authors were able to perform an entire AF ablation procedure without fluoroscopy, guided solely by intracardiac ultrasound along with three-dimensional mapping.[8]

Several studies strived to evaluate, whether image acquisition prior to ablation is able to improve the ablation procedure either with respect to outcome or periprocedural parameters such as procedure duration or fluoroscopy times. In general, magnetic resonance imaging should be preferred since radiation exposure of computed tomography can be extensive depending on the imaging acquisition and processing. Imaging prior to ablation procedures enables the operator to appreciate anatomical variants, potentially influencing the ablation procedure. Furthermore, the three-dimensional geometry derived from CMR/CT can be integrated in most three-dimensional mapping systems potentially resulting in a less time consuming anatomy acquisition process and a more accurate delineation of the respective anatomy.

Among other systems such as EPLogix™ (BARD EP, C. R. Bard, Inc., Lowell, MA, USA), LocaLisa™ (Medtronic Inc, Minneapolis, MN, USA) and Rhythmia™ (Boston Scientific, Natick, MA, USA), there are two systems that are most commonly used for three-dimensional mapping also providing the ability of image integration. One is the CARTOMERGE™ (Biosense-Webster, Diamond Bar, CA, USA) the other is the NavX™Fusion system (St. Jude Medical, St. Paul, MN, USA) (example in figure 1. and 2.). There is limited data on the comparison of both systems. One report showed that image

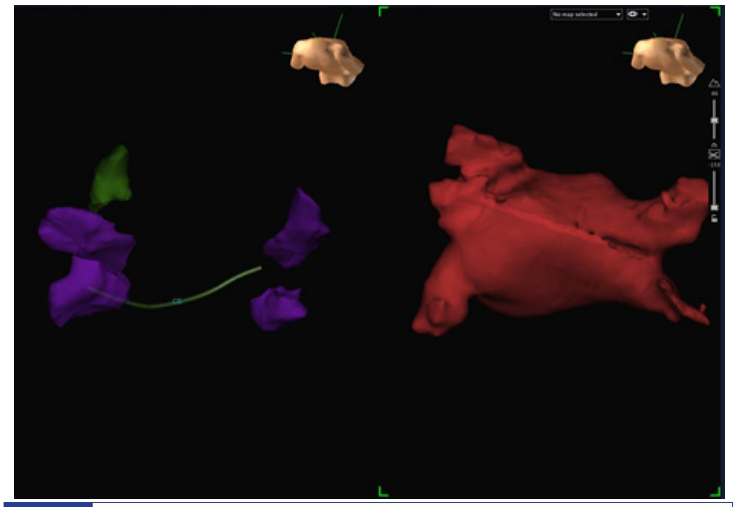

Figure 1: Intraprocedural geometry with pulmonary vein anatomy and the CS catheter on the left. Left atrial anatomy acquired by cMRI on the right. Image from the NavX™ Fusion system.

integration with CARTOMERGE™ appeared to be somewhat faster using less fluoroscopy as compared to the NavX™ system.[9] However, no differences in clinical outcome or other procedural parameters were evident.

Data in the literature regarding the influence on image integration on both, procedural parameters and mid-term success are somewhat contradictory. In 2009 Bertaglia and colleagues provided data from a relatively large Italian registry including 573 patients. These patients underwent catheter ablation for atrial fibrillation using fluoroscopy guided segmental ablation alone in one group, CARTO™ and CARTO Merge™ guided ablation in two other groups.[10] The authors report, that clinical outcomes were significantly improved using image integration. However, procedural parameters between groups did not show a significant difference. The data of this study are difficult to interpret, since various levels of experience along with different approaches for ablation in various centers were compared.

In an additional study by Della Bella and colleagues, conventional ablation without three-dimensional mapping was compared with CARTOMERGE™ indicating a higher long-term success (p=0.046) along with higher fluoroscopy times and radiation exposure in the CARTOMERGE™ cohort.[11] Also, in this study CT scan was used for preprocedural imaging.

The most structured evidence to answer the question on the impact of image integration on post- and periprocedural parameter comes from Kistler and colleagues. In an initial non-randomized study, they evaluated their patients undergoing catheter ablation with and without image integration.[12] They were able to show that atrial fibrillation (AF) recurrence and fluoroscopy times were reduced using image integration and that the endpoint of sinus rhythm restoration was achieved more frequently. However, in the consecutive randomized prospective trial published two years later, they were not able to reproduce this effect.[13] The randomized trial failed to show any effect on periprocedural data such as fluoroscopy times or procedure duration. No difference with respect to outcome was observed, leading the authors to the conclusion that electrophysiological endpoints rather than employed tools predict the postprocedural outcome. These results have recently been supported by a meta-analysis published last year.[14]

Phrenic Nerve Anatomy

Diaphragmatic paralysis has been encountered during catheter ablation using both, radiofrequency energy delivery and cryoablation. Damage to the phrenic nerve (PN) is a rare complication but may result in respiratory insufficiency and in rare cases gastroparesis after catheter ablation. The course of the phrenic nerve along the left lateral atrium and along the right atrium puts it at risk, especially during ablation of the right atrium, mainly the right free wall. High output pacing prior to RF delivery may help to avoid damage to the PN. However, since the individual course of the PN may vary, imaging techniques such as CT may be of use to delineate the anatomical location relative to potential ablation sites. Implementing this information into a 3 dimensional mapping system is of interest. Fukumoto and coworkers were able to show that CT is feasible to detect the course of the PN prior to ablation procedures.[15] The authors conclude that delineation of the PN prior to ablation may be of value to avoid PN damage in case of unexpected anatomic variants of the course of the PN. In their study, the course of the PN as detected by high output pacing was well in line with the anatomical findings of the imaging study. Furthermore, Schmidt et al. were able to show that the course of the phrenic nerve can be reconstructed on a three-dimensional mapping system in a reasonable time frame and therefore can be used to prevent phrenic nerve palsy.[16]

Intracardiac Ultrasound

In addition to electroanatomic mapping a preprocedural image acquisition, intracardiac ultrasound (ICE) is used by an increasing number of operators. It has potential benefit with regard to safety, when used to guide transseptal puncture and has been shown to reduce fluoroscopy time. However, since cost effectiveness plays a major role in countries outside the United States, the routine use of ICE in Europe has been limited.

Regarding available evidence, there is some data on preprocedural image integration compared to CARTOSOUND™ using a phased-array ultrasound catheter. Brooks et al published some sixty patients in whom ICE was compared with merging preprocedural CT imaging.[17] CARTOSOUND™ was able to reduce the total fluoroscopy times significantly without impact on procedural outcome. However, it has to be considered that reimbursement as well additional vascular

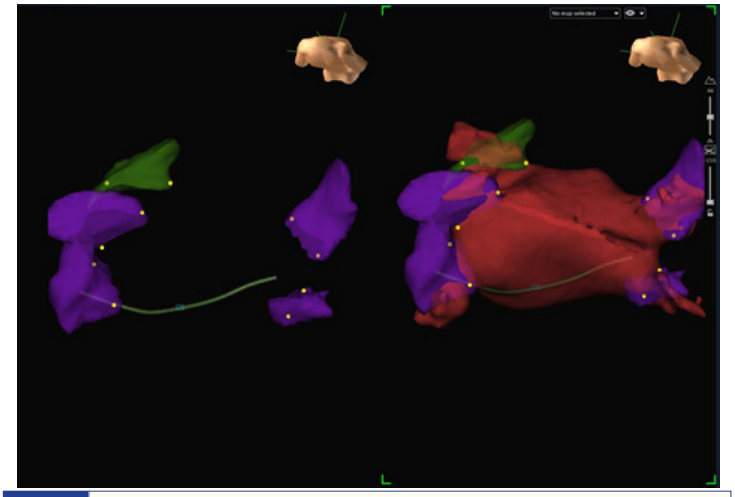

Figure 2: Merging process of pulmonary vein anatomy and cMRI date through NavX™ Fusion. Reference points set in yellow.

access for positioning an additional ICE catheter in the right heart are limitations using ICE in every country and every patient.

Electrophysiological Parameters

Most electrophysiological information superimposed on three-dimensional maps has to be gathered independently from previously acquired anatomical shells. However, some information such as structural abnormalities can be derived from imaging such as CMR/CT. With respect to catheter ablation of ventricular tachycardia, studies have been performed integrating scar information from CMR into the three dimensional map to guide catheter ablation. On the atrial level, very promising data regarding atrial distribution of fibrosis in the context of ablation outcome and atrial scar have been published.[18] However, signal processing to achieve this kind of information is rather complex and only few centers were able to reproduce this important information from CMR data.

Rotational Angiogram

A recent study[19] compared conventional 3-dimensional anatomy using the NavX system during ablation of atrial fibrillation with a group of patients in whom LA anatomy was acquired through rotational angiography and merged with NavX™ Fusion. Despite additional radiation and time spent on the angiography, the total procedure time, radiation dose and fluoroscopy time were significantly lower in the NavX™ Fusion group. Clinical outcome was similar in this small group of patients, confirming rotational angiography as a useful and beneficial addition during AF ablation procedures.

Overall, preprocedural imaging has evolved as an important part of modern electrophysiological studies and may help to reduce risks of the individual procedure. However, no general recommendation can be given about how preprocedural imaging should be performed. At the end of the day, the operator can chose form a variety of possibilities to assure that the patient undergoes a safe and reliable ablation procedure.

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