Fluoroscopy-Free Electrophysiology Study Using 3D Electroanatomic Mapping System: A Case Report and Review of Literature

Linle Hou1,2, Zohaib Shaikh1, and Todd J. Cohen1,2*

1Department of Medicine, Winthrop University Hospital, USA
2Stony Brook University School of Medicine, Stony Brook, USA

Abstract

Due to the use of fluoroscopy in the electrophysiology lab, long and complex procedures to diagnose and treat cardiac arrhythmias can lead to radiation exposure to both patients and the laboratory staff. In this report, we present a case in which a diagnostic electrophysiology study was conducted on a 41 year-old patient with atrial tachycardia without the use of fluoroscopy. The diagnostic component of the procedure was successfully completed exclusively utilizing a 3D nonfluoroscopic electroanatomic mapping system to guide catheters into the heart and determine the mechanism of the arrhythmia. The patient then underwent a successful mapping and ablation procedure using a robotic remote catheter system and the electroanatomic mapping system, with minimal use of fluoroscopy.

ABBREVIATIONS

EAM: Electroanatomic Mapping; AV: Atrio Ventricular

INTRODUCTION

The length and complexity of modern interventional procedures to treat cardiac arrhythmias has generated major concern regarding radiation exposure for both the patients and the medical professionals involved [1,2]. The vast majority of intracardiac electrophysiological studies are fluoroscopy-guided procedures [2]. Radiation exposure to the patient and operator can vary from 5 to 46 Gy cm² depending on the fluoroscopic dose and exposure [3,4]. Prolonged fluoroscopy exposure during radiofrequency ablation procedures has been linked to an increased lifetime risk of malignancy, particularly in the lungs [5]. In this report, we present a successful fluoroscopy-free electrophysiology study, which diagnosed the mechanism of supraventricular tachycardia in an adult patient, followed by a robotic remote catheter ablation which primarily utilized nonfluoroscopic 3D electroanatomic mapping (EAM).

CASE PRESENTATION

A 41-year-old Caucasian woman with a history of a previous radiofrequency catheter ablation of atrial tachycardia presented with recurrent rapid palpitations and was referred for ablation of atrial tachycardia. The patient was prepped and draped in usual sterile fashion for the procedure. She was deeply sedated by the anesthesia team and the procedure was initiated. Femoral venous sheaths were inserted and upon placement of the electrophysiology catheters, the standard fluoroscopy system became inoperable. After a number of attempts to reboot the system, a decision was made to proceed with the diagnostic component using solely the nonfluoroscopic EnSite™ NavX™ 3D mapping system (St. Jude Medical, Saint Paul, MN) for catheter guidance and navigation.

This methodology permitted advancement of the catheter via the venous tract into the cardiac silhouette (Figure 1). Using the nonfluoroscopic system, mapping images were created of the right atrium and its intracardiac structures, including the coronary sinus vein, the inferior and superior vena cavae, and the crista terminalis. The catheters themselves were also visualized. Using the catheters’ mapping capability, a full conduction study was performed and programmed electrical stimulation (A1A2) induced a nonsustained atrial tachycardia at a cycle length of 380
msec (Figure 2). An isoproterenol intravenous infusion along with ventricular overdrive pacing sustained the tachycardia, which facilitated mapping. An OEC 9900 Elite mobile C-arm fluoroscopic system (GE Healthcare, Chicago, IL) was transported into the room for use following the diagnostic electrophysiology study. The patient underwent successful mapping and ablation with the Amigo™ Remote Catheter System (Catheter Precision, Inc., Ledgewood, NJ) using predominantly 3D nonfluoroscopic mapping and occasional fluoroscopy and subsequently received an implantable loop recorder.

The tachycardia was mapped to the superior vena cava near where it meets the crista terminalis (Figure 3). The red dots in the figure are the areas where radiofrequency energy was delivered. The Amigo™ system provided no direct radiation exposure to the operator, who remained in a separate lead-shielded control room, while he operated the remote handle controller of the Amigo™. The fluoroscopy time for the electrophysiology study was zero minutes, while the fluoroscopy time for the ablation procedure was 4.5 minutes.

**DISCUSSION**

Radiofrequency ablation has evolved over the years as a curative measure for a number of heart rhythm pathologies [6]. As the number and complexity of arrhythmias with indication for catheter ablation increases, there is mounting concern over cumulative radiation exposure due to these procedures. Fluoroscopy-free ablation is more commonly practiced in children and in pregnant women due to the higher inherent risk from radiation exposure in these populations [7-9]. In the adult population, efforts to reduce radiation exposure include the utilization of real-time transesophageal echocardiography and magnetic resonance imaging as adjunctive technologies to eliminate or reduce fluoroscopy time. However, the efficacy of these efforts is limited due to the invasiveness of these imaging modalities.

In contrast, 3D EAM is a technology that enables one to record intracardiac electrical signals in relation to anatomic location in the patient during arrhythmia mapping. When applied properly, 3D EAM can significantly reduce fluoroscopy time and radiation exposure [10-16]. A study investigating focal atrial tachycardia originating in the right atrial appendage reported a mean fluoroscopy time of 29 ± 12 minutes for completed radiofrequency catheter ablations [17]. Though the case presented here found the tachycardia to originate in the crista terminalis rather than the atrial appendage, the ablation procedures are comparable. In our case presentation, the fluoroscopy time of the ablation component was merely 4.5 minutes, which represents a reduction of 84.5 percent compared to conventional atrial tachycardia ablation procedures. A meta-analysis of radiofrequency catheter ablation of atrial fibrillation reported an average fluoroscopy time of 33 minutes for cases using EAM systems [18], which is still significantly higher than the fluoroscopy time observed in this case. Fluoroscopy time for a given procedure can depend on both operator experience and arrhythmia complexity. Although fluoroscopy time is highly variable from case to case, the reduction in radiation exposure...
**Figure 2** Surface and intracardiac electro grams from the electrophysiology study, which was performed solely with the use of 3D nonfluoroscopic electroanatomic mapping. The intracardiac electro grams show catheters placed in the atrium and near the His bundle which demonstrate an atrial tachycardia at a cycle length of 380 msec.

**Figure 3** A three-dimensional map of the right atrium following the placement of ablation lesions near the superior vena cava junction where it meets the crista terminalis. The image to the left displays the right anterior oblique projection while the image to the right displays the left anterior oblique projection. Red dots convey the location of the ablation lesions. The duodecapolar catheter placed in the coronary sinus is highlighted in light blue. The bundle is indicated as a yellow sphere. The region in white is the site of earliest activation time.
Several studies have confirmed comparable success rate of the EAM-guided approach when measured against the conventional fluoroscopy-guided approach in AV-nodal reentry, atrial flutter and bypass tract-mediated arrhythmias [10-14]. In addition, an EAM-guided approach has the advantage of marking and isolating important anatomic structures, such as the AV node. EAM has been used to achieve an equiproval effect and reduce fluoroscopy time when compared to conventional methods without prolonging procedure duration [15]. However, EAM-guided approaches are also linked to as much as a 50 percent increase in expenses when compared to the traditional fluoroscopy approach [13].

There is very little reported data on the utilization of robotic ablation along with nonfluoroscopic mapping. Although this procedure did not intend to restrict the use of fluoroscopy, its utilization was limited due to its unavailability during an already initiated procedure in a sedated patient. The electrophysiology study was safely performed without fluoroscopy, and the addition of fluoroscopy contributed less than five minutes of radiation exposure to the patient and scattered radiation to the lab staff. Nonfluoroscopic robotic ablation requires further testing to evaluate its safety and efficacy. This approach has the potential to bring ablative therapy to the bedside, in more confined areas outside of a lead-shielded laboratory.

CONFLICT OF INTEREST

Dr. Cohen is the co-inventor of the Amigo™ Remote Catheter System. He does not have any current financial ties to Catheter Precision, Inc. nor does he receive any royalties from the relevant patent. The other authors have no conflicts of interest to disclose.

REFERENCES


