Original Article

Catheter Ablation of Arrhythmias Exclusively Using Electroanatomic Mapping: A Series of Cases

Leonardo Martins Pires, Tiago Luiz Luz Leiria, Marcelo Lapa Kruse, Rafael Ronsoni, Caroline Saltz Gensas, Gustavo Glotz de Lima

Instituto de Cardiologia/Fundação Universitária de Cardiologia, Porto Alegre, RS - Brazil

Abstract

Background: Catheter ablation is a treatment that can cure various cardiac arrhythmias. Fluoroscopy is used to locate and direct catheters to areas that cause arrhythmias. However, fluoroscopy has several risks. Electroanatomic mapping (EAM) facilitates three-dimensional imaging without X-rays, which reduces risks associated with fluoroscopy.

Objective: We describe a series of patient cases wherein cardiac arrhythmia ablation was exclusively performed using EAM.

Methods: Patients who presented with cardiac arrhythmias that were unresponsive to pharmacological therapy were prospectively selected between March 2011 and March 2012 for arrhythmia ablation exclusively through EAM. Patients with indications for a diagnostic electrophysiology study and ablation of atrial fibrillation, left atrial tachyarrhythmias as well as hemodynamically unstable ventricular arrhythmia were excluded. We documented the procedure time, success rate and complications as well as whether fluoroscopy was necessary during the procedure.

Results: In total, 11 patients were enrolled in the study, including seven female patients (63%). The mean age of the patients was 50 years (SD ±16.5). Indications for the investigated procedures included four cases (35%) of atrial flutter, three cases (27%) of pre-excitation syndrome, two cases (19%) of paroxysmal supraventricular tachycardia and two cases (19%) of ventricular extrasystoles. The mean procedure duration was 86.6 min (SD ± 26 min). Immediate success (at discharge) of the procedure was evident for nine patients (81%). There were no complications during the procedures.

Conclusion: This study demonstrates the feasibility of performing an arrhythmia ablation exclusively using EAM with satisfactory results. (Arq Bras Cardiol. 2013;101(3):226-232)

Keywords: Arrhythmias, Cardiac / therapy; Arrhythmias, Cardiac / diagnostic; Catheter Ablation; Fluoroscopy.

Introduction

Recently, technologies available for treating cardiac arrhythmias have rapidly advanced. The indications for catheter ablation have expanded and now include more patients with greater severity that are often unresponsive to other forms of therapy (pharmacological and implant devices)[1].

X-ray fluoroscopy has been used to position catheters in the heart to diagnose and treat cardiac arrhythmias[1]. This form of mapping has low spatial resolution and interferes with ablations that require substrate modification in which it is imperative to locate scar tissue and maintain an electrically active isthmus in the atrial or ventricular myocardium.

X-ray exposure may negatively affect the patient and medical staff. Exposure increases the incidence of diseases, such as dermatitis, cataracts, birth defects and cancer[2,3]. Pediatric patients are also at risk, especially from gonad and thyroid irradiation[4]. Electrophysiological procedures may involve a significant duration for the fluoroscopy, especially during atrial fibrillation ablation[5,6]. Therefore, lead aprons are worn by the medical team as well as placed over patient thyroid and gonads, and acrylic plates as well as special glasses are used to block radiation and reduce such risks[7].

Recently, non-fluoroscopic mapping, including electroanatomic mapping (EAM), has altered percutaneous treatment of arrhythmias, such as atrial flutter (AFL), atrial fibrillation (AF) and ventricular tachycardia (VT)[8,9]. The currently available models include the EnSite (NAVx)®, Localiza® and Carto® systems. This technology measures the difference between the electrical potential detected on the patient surface and from the catheter in the patient's vascular structure. Therefore, the three-dimensional shape of the cavity where the catheter is located can be reconstructed with pinpoint accuracy[10]. Thus, structures, such as veins, arteries and heart chambers, can be visualized and manipulated to discern localization of arrhythmogenic points, which can be treated using ablation.

EAM can be exclusively used to treat cardiac arrhythmias. However, studies investigating the therapeutic efficacy and

procedure time have not been reported. Therefore, we describe herein a series of patient cases for cardiac arrhythmia ablation exclusively using EAM without fluoroscopy.

Methods

For this study, patients who were referred for arrhythmia ablation at the Cardiology Institute, University Cardiology Foundation [Instituto de Cardiologia - Fundação Universitária de Cardiologia (IC-FUC)] from the arrhythmias outpatient clinic were selected for the first ablation procedure and had tachyarrhythmias recorded using a 12-lead electrocardiogram or 24-hr electrocardiographic monitoring. Patients who had indications for a diagnostic electrophysiological study as well as ablation of atrial fibrillation, left atrial tachyarrhythmia and hemodynamically unstable ventricular arrhythmia were excluded from the study. Patients referred by physician assistants outside the clinic or by other hospitals were also excluded. The study was approved by the local committee for ethics, and the participating patients who underwent the procedure signed an informed consent form.

The examinations were performed in the electrophysiology laboratory at IC-FUC. During the procedures, a Prucka polygraph for electrophysiology, a Medtronic stimulator and an EnSite electroanatomic mapping system (St. Jude Medical) were used. The patients were sedated using intravenous propofol (100-150 mcg/kg/min), midazolam (0.02-0.04 mg / kg) and fentanyl (0.5-2 μg/kg). Patients undergoing ventricular arrhythmia ablation in the outflow ventricles did not receive propofol. Venous right femoral punctures were performed by introducing three introducer sheaths. Through such sheaths, the multipolar diagnostic catheters and/or ablation were placed in the cardiac cavities. To place the catheters in the right chambers, their displacement was followed via images collected by EnSite system (St. Jude Medical) from the inferior vena cava, and X-rays were not necessary during the procedure. This system facilitates visualization of more than one catheter projection simultaneously and identification of such based on color. Typically, the first catheter inserted is positioned in the His bundle region using the hisian potential measurements. Catheters were placed in the right atrium, coronary sinus and right ventricle as necessary for each patient using the same technique. To indicate reference points, the catheter position was also shaded such that the catheter's original position was well-marked if the catheter was dislodged. For the left bundle branch, we performed a right femoral artery puncture and inserted the catheter ablation in a retrograde manner through the aorta using the technique described above. For each patient, atrial and ventricular stimulation were performed to diagnose the arrhythmias. When such maneuvers were unsuccessful, isoproterenol (2-10 mcg/min) was also used intravenously.

The database was maintained in Microsoft Excel 2004. The data were used to calculate means and percentages. Statistical analyses were performed using SPSS v. 12.

Results

Eleven of the 365 patients referred for an ablation between March 2011 and March 2012 were selected; seven were female (63%), and the mean age was 50 years (SD ±16.5). Medication was used to control the arrhythmias in seven patients (63%). The indications for the procedure included four cases (35%) of atrial flutter (AFL), three cases (27%) of pre-excitation syndrome (WPW), two cases (19%) of paroxysmal supraventricular tachycardia (PSVT) and two cases (19%) of ventricular extrasystoles (VES).

On the day of the exam, patients with a history of AFL, WPW and one with VES presented with their respective arrhythmias. The patients diagnosed with PSVT and one patient with a history of VES were in sinus rhythm (SR). Three catheters (two diagnostic catheters and an ablation catheter) were used in the examination except for the patient with VES, for whom one diagnostic and one ablation catheter was used. In the three patients with AFL, ablation catheters with an 8 mm tip were used, whereas 4 mm catheters were used for the remaining patients. The average AH time interval for the procedure (excluding the AFL patients) was 73 ms (SD ± 13 ms), and the HV interval (including the AFL patients) was 37 ms (SD ± 15 ms). Nodal reentrant tachycardia (NRT) was induced in two patients with a history of PSVT. The WPW patients presented with left lateral bundles and anterograde conduction. Isoproterenol was used to induce arrhythmia in two patients (18%), a PSVT and a VES patient. Both VES patients had a focused arrhythmia in the right ventricle outflow. The mean total duration for the procedure was 86.6 min (SD ± 26 min); the average door-to-puncture time (patient entry through the initial punctures), puncture time (puncture completion time) and examination time (the end of puncturing through the end of the procedure) were, respectively, 17 min (SD ± 4.4 min), 7 min (SD ± 2.7 min) and 61.7 min (SD ± 25 min). The mean number of radio frequency energy applications was 15.9 (SD ± 18) ranged from one application in a WPW patient to 62 applications in an AFL patient). The immediate success of the procedure (at discharge) was evident in nine patients (81%). Table 1 shows a summary for such data. In one AFL patient who presented with a left atrial arrhythmia, ablation was not performed. In our center, consent is not routinely required to perform a transseptal puncture in all cases. In such instances, the left side was not approached, and the patient was informed after examination that a left catheterization was necessary, which is a procedure that was scheduled for another time. Another AFL patient presented with an SR arrhythmia reversal. However, the ablation line in the cavotricuspid isthmus was not bidirectionally blocked even after numerous lines were performed in the isthmus region with low voltage. One reason for this observation may be lower-loop reentry. However, the activation map under atrial stimulation did not unequivocally demonstrate such an event. There were no complications during the procedures; the patients were also discharged without complications.

Original Article

Table 1 - Case descriptions

	Gender	Medication	Indication	Induced arrhythmia	No. RF	Success	Door-to-Puncture Time (min)	Puncture time (min)	Exam Time (Min)	Total time (min)
1	M*	None	AFL	AFL - L	9	No	13	6	56	74
2	F	Sotalol	PSVT	NRT	8	Yes	17	4	42	63
3	F	None	AFL	AFL	32	Yes	21	6	43	70
4	F	Sotalol	WPW LE	WPW LE	8	Yes	27	5	87	119
5	F	None	PSVT	NRT	5	Yes	14	10	55	79
6	M	Sotalol	VESRVOT	VESRVOT	11	Yes	19	11	83	113
7	M	Beta blocker	AFL	AFL	5	Yes	11	11	103	125
8	F	Propafenone	VESRVOT	VESRVOT	2	Yes	12	6	76	94
9	F	None	AFL	No	62	No	16	4	79	99
10	M	Beta blocker	WPW LE	WPW LE	1	Yes	20	5	2	47
11	F	Beta blocker	WPW LE	WPW LE	3	Yes	17	9	33	59

VESRVOT: extrasystoles from the right ventricle outflow tract, F: female; AFL: atrial flutter; AFL-L: left atrial flutter, M: male, min: minutes; NRT: Nodal reentrant tachycardia; PSVT: paroxysmal supraventricular tachycardia, and WPW LE: left lateral pre-excitation.

Fluoroscopy was not used for the cases herein. Figures 1-4 are examples of slow pathway ablation for AV nodes in patients with NRT, left lateral bundle ablation during tachyarrhythmia, extrasystole ablation of the right ventricle outflow and cavotricuspid isthmus ablation in patients with classic counterclockwise AFL, respectively.

Discussion

The evolution of electrophysiology diagnostic and therapeutic procedures has progressed in important ways in recent years. EAM systems have introduced new diagnostic and therapeutic potential for patients with complex arrhythmias. In a study of 21 pediatric patients referred for right accessory pathway ablation, fluoroscopy use was reduced by 90% with concomitant EAM use following experiences from seven cases; fluoroscopy was then abandoned after five new cases[11]. EAM was effective for a pediatric population in another study, wherein it reduced the children's X-ray exposure during ablation for NRT and atrioventricular reentrant tachycardia (AVNRT)[12]. Forty pediatric patients with NRT and AVNRT were divided into two procedural groups, one where fluoroscopy was exclusively used and the other where fluoroscopy and EAM were used. The X-ray exposure time was lower in the group that concomitantly used EAM[13]. A group of 11 patients with accessory bundles on the right lateral wall who underwent unsuccessful ablation fluoroscopy then underwent a new EAM procedure, which was successful in each case[14]. Nine pregnant patients with supraventricular tachycardias that were not controlled through medication were ablated using EAM and minimal fluoroscopy time; the patients did not have recurrences following the procedure[15]. In another study, fluoroscopy and EAM (using two different systems, the Carto® and Ensite systems [NAVx®]) were compared with fluoroscopy-only NRT, AVNRT and AFL ablations for 145 patients. The fluoroscopy and EAM use yielded shorter radiation exposure times. However, the total procedure time, short and long-term success, complication rate and absence of symptoms were similar between the groups[16]. AFL ablation using fluoroscopy and EAM with fluoroscopy were compared in a randomized, multicenter clinical trial involving 210 patients. Both techniques were effective, but the fluoroscopy time was lower in the group using EAM at a higher cost[17]. Recently, paroxysmal AF ablation exclusively using EAM and intracardiac ultrasound was 97% successful in 20 patients without complications[18].

Currently, the procedural complexity of arrhythmia ablation extends the exam times. Therefore, the fluoroscopy time is increased, which includes the inherent X-ray risks. EAM is used concomitantly in such tests to both assist in arrhythmia diagnosis and treatment as well as reduce the risks from radiation in procedures that involve fluoroscopy.

In this study, we studied a series of patients who underwent an arrhythmia ablation exclusively using EAM. The results demonstrate this procedure can be performed with satisfactory results for both procedure time and success rate upon discharge. Fluoroscopy was unnecessary for the EAM cases, and none of the patients had major complications. The catheters were positioned without complication. The distinction between catheters with different colors and greater than one projection view provides adequate spatial information during catheter positioning. After points of reference were established, such as intracavitary electrogram identification, including the His signal, atrial and/or ventricular cavity reconstruction and the exam dynamics yielded better results. Images were used to distinguish important points, such as the His bundle region, the coronary sinus and areas of previous ablations as shown in Figures 1-4. For the mitral annulus accessory pathway, the ablation catheter passage through the aortic valve was easy to follow, and the shortest AV or VA intervals were identified as could be with conventional tests, without additional difficulty.
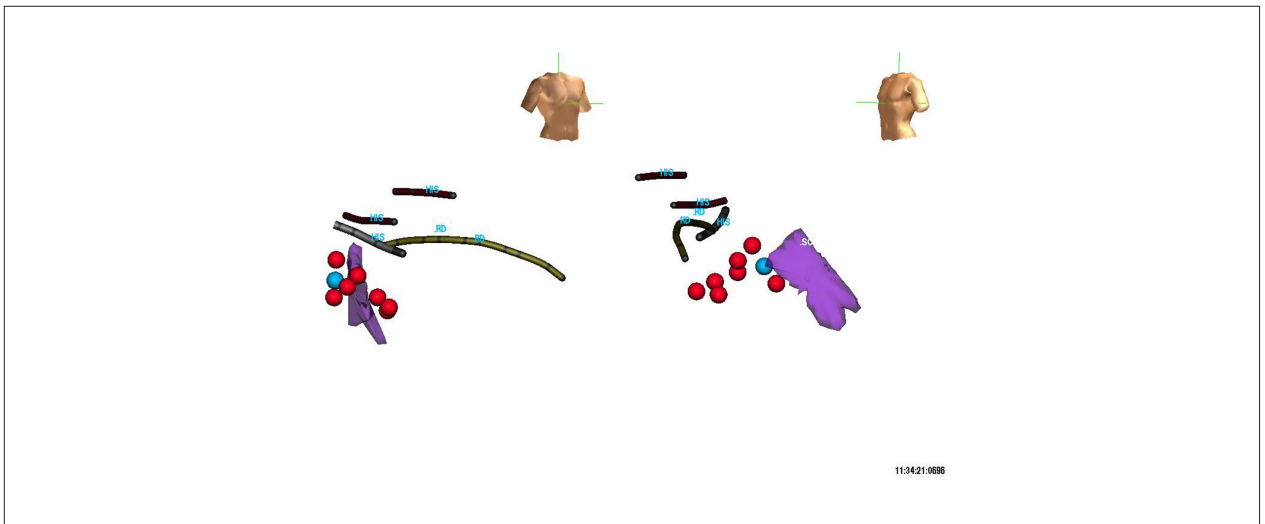
Figure 1 - *Catheter positioning during nodal reentrant tachycardia ablation. The left image (right anterior oblique view) shows the catheter shadows that identify the right branch and His bundle region. Notably, the His potential was identified in a region up to 1 cm high. Such is noted in the right image (left anterior oblique view), and three levels of His were observed; one was more caudal, one was intermediary, and the third was more cranial. In part, such observations may be due to heart movement and altered thoracic impedance during deep inspiration. However, it is important to define this region for safe radiofrequency application. The structure in lilac is the coronary sinus. The blue point (near the coronary sinus entrance) shows the location where we measured the slow junctional rhythm. Additional regions where energy application (15 s) did not induce slow junctional rhythm are marked in red.*
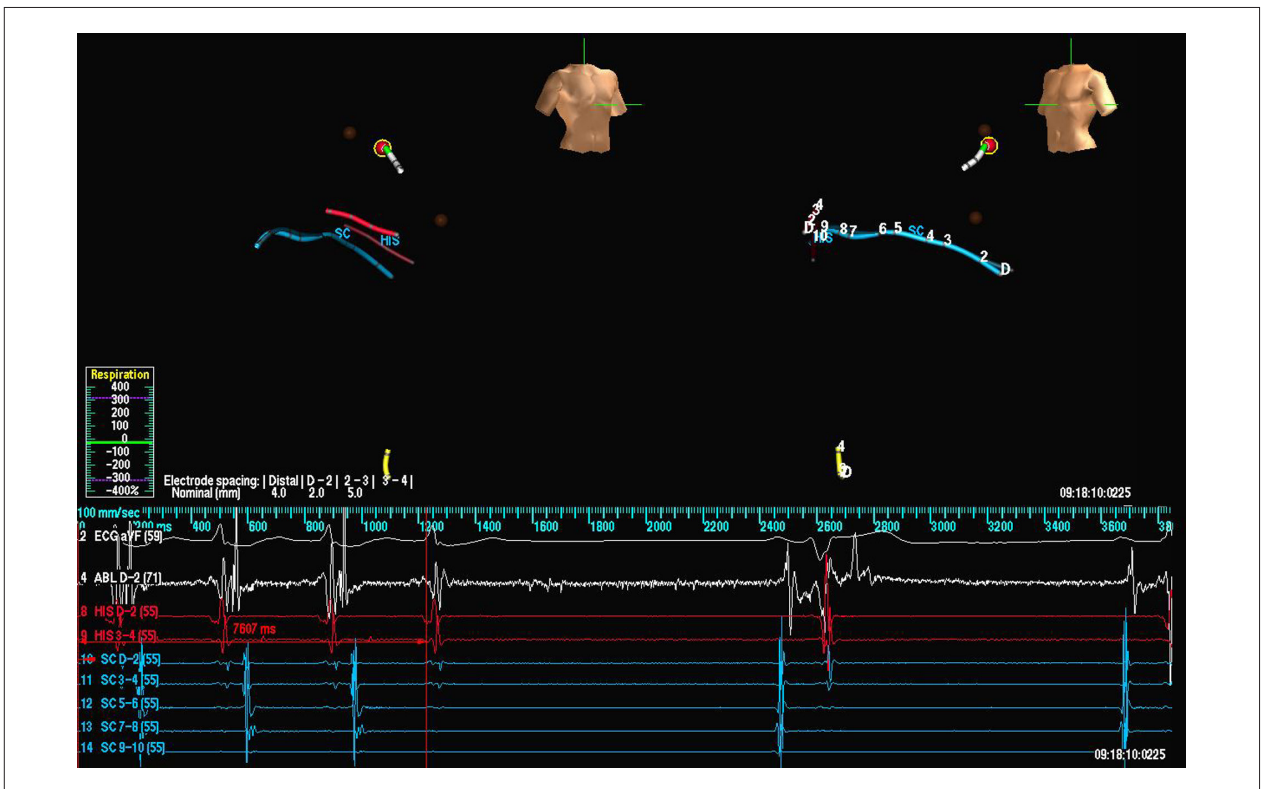

Figure 2 - *Left lateral bundle ablation during atrioventricular reentrant tachycardia. The images on the left (right anterior oblique view) and right (left anterior oblique view) show catheter shadows used to identify the His bundle, coronary sinus and ablation catheter. The ablation catheter was introduced in a retrograde manner through the aorta. In brown are two early points where radiofrequency energy was applied for 10 s without arrhythmia termination. The point marked in red shows the location of the earliest VA signal during tachyarrhythmia, which was observed for the endocardial tracings below the figures. After 7.6 s of a radiofrequency energy application, the arrhythmia was terminated. After this application, new induction was no longer possible.*
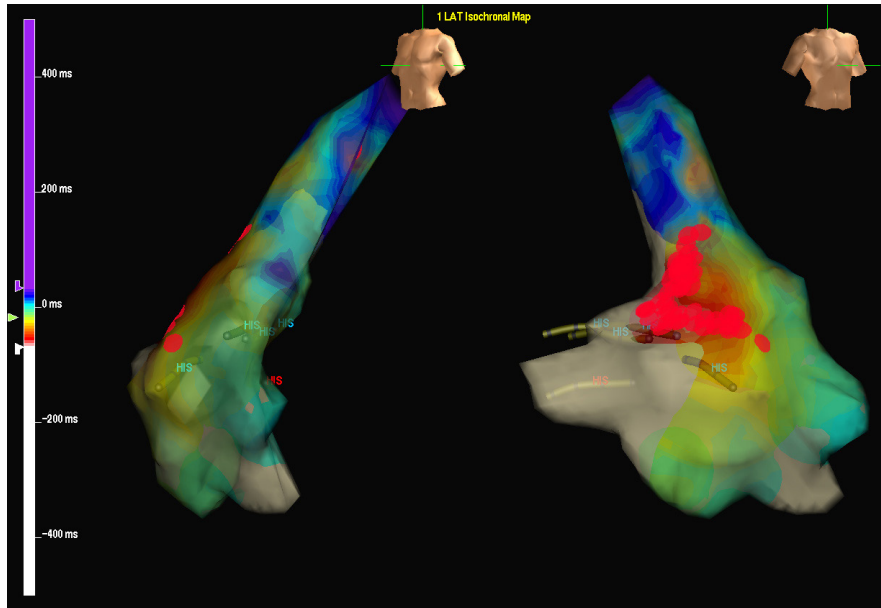
Original Article

Figure 3 - *Extrasystole ablation from the right ventricle tract outflow. The images on the left (left anterior oblique view) and right (right anterior oblique view) show a map from a three-dimensional reconstruction of a right ventricular and catheter shadow for the His. The earliest activity point observed in the extrasystole map was located in the lateral region of the right ventricle tract outflow. After the radiofrequency energy was applied, extrasystole was no longer observed (red points).*
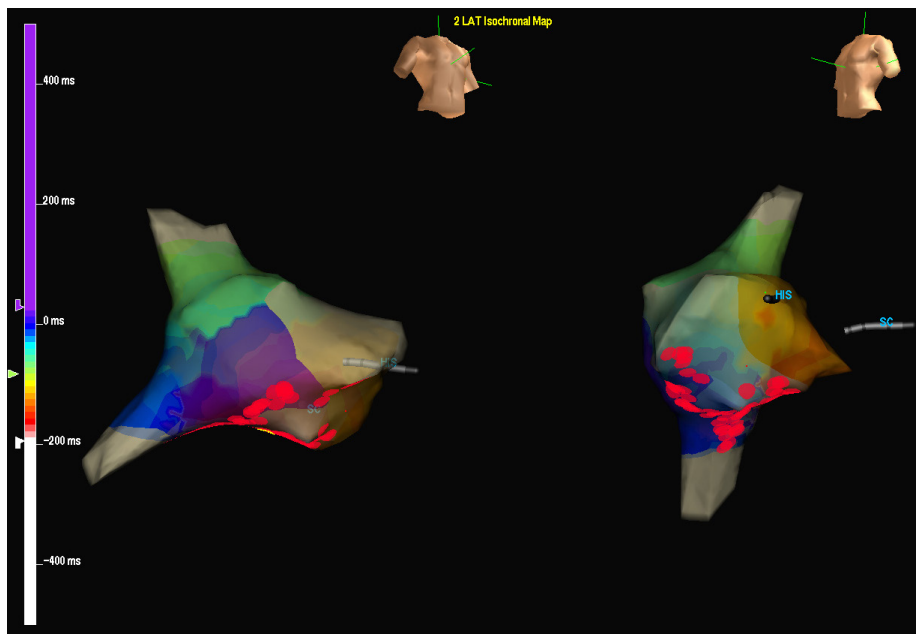

Figure 4 - *Cavotricuspid isthmus (CTI) ablation for a classical AFL. The images on the left (right anterior oblique view) and right (left anterior oblique view) show a three-dimensional reconstruction map of the right atrium, the inferior and superior vena cava and catheter shadows in the His bundle region as well as the coronary sinus. From the mapping, a flutter with a counterclockwise circuit dependent on the CTI with at the front of a depolarization wave is in orange for the septal region. Two block lines that abolished the arrhythmia were produced (in red dots; one is from the coronary sinus to the CTI, and the other is at the CTI-level). After ablation, the block line effectiveness was measured via septolateral and laterosseptal activation times longer than 120 ms.*

However, our study has certain limitations. It was designed as a case series study. The follow-up time is an additional limitation because the study results were only noted at discharge. Despite such limitations, we demonstrate that this procedure can be performed without fluoroscopy.

EAM has introduced new therapeutic potential for arrhythmia patients. EAM is used to improve spatial orientation for the catheter in the heart and reduce the risks associated with radiation. A randomized study that compares exclusive EAM and fluoroscopy use should provide more consistent data.

Conclusion

This study is the first to demonstrate the feasibility of performing an ablation exclusively using EAM with satisfactory results.

Author contributions

Conception and design of the research, Statistical analysis and Obtaining funding: Pires LM, Leiria TLL, Kruse ML, Ronsoni R, Lima GG; Acquisition of data, Analysis and interpretation of the data, Writing of the manuscript and Critical revision of the manuscript for intellectual content: Pires LM, Leiria TLL, Kruse ML, Ronsoni R, Lima GG, Gensas CS.

References

1. Guidelines for Clinical Intracardiac Electrophysiological and Catheter Ablation Procedures. A report of the American College of Cardiology/ American Heart Association task force on practice guidelines. (Committee on Clinical Intracardiac Electrophysiologic and Catheter Ablation Procedures). Developed in collaboration with the North American Society of Pacing and Electrophysiology. Circulation. 1995;92(3):673-91.

2. Lin EC. Radiation risk from medical imaging. Mayo Clin Proc. 2010;85(12):1142-6.

3. Austin LM, Frush DP. Compendium of national guidelines for imaging the pregnant patient. AM J Roentgenol. 2011;197(4):W737-46.

4. Linet MS, Kim KP, Rajamaram P. Children's exposure to diagnostic medical radiation and cancer risk: epidemiologic and dosimetric considerations. Pediatr Radiol. 2009;39 Suppl 1:S4-26.

5. Rosenthal LS, Mahesh M, Beck TJ, Saul JP, Miller JM, Kay N, et al. Predictors of fluoroscopy time and estimated radiation exposure during radiofrequency catheter ablation procedures. AM J Cardiol. 1998;82(4):451-8.

6. Lickfett L, Mahesh M, Vasamreddy C, Bradley D, Jayam V, Eldadah Z, et al. Radiation exposure during catheter ablation of atrial fibrillation. Circulation. 2004;110(19):3003-10.

7. Grobe H, Sommer M, Koch A, Hietschold V, Henniger J, Abolmaali N. Dose reduction in computed tomography: the effect of eye and testicle shielding on radiation dose measure in patients with beryllium oxide-based optically stimulated luminescence dosimetry. Eur Radiol. 2009;19(5):1156-60.

8. Gepstein L, Hayam G, Ben-Haim SA. A novel method for nonfluoroscopic catheter-based electroanatomical mapping of the heart. In vitro and in vivo accuracy results. Circulation. 1997;95(6):1611-22.

9. Wittkampf F, Wever E, Derksen R, Wilde A, Ramanna H, Hauer R, et al. LocaLisa: new technique for real-time 3-dimensional localization of regular intracardiac electrodes. Circulation. 1999;99(10):1312-7.

10. Gepstein L, Hayam G, Shpun S, Cohen D, Ben-Haim AS. Atrial linear ablations in pigs: chronic effects on atrial electrophysiology and pathology. Circulation. 1999;100(4):419-26.

11. Drago F, Silvetti MS, Di Pino A, Grutter G, Bevilacqua M, Leibovich S. Exclusion of fluoroscopy during ablation treatment of right accessory pathway in children. J Cardiovasc Electrophysiol. 2002;13(8):778-82.

12. Smith G, Clark JM. Elimination of fluoroscopy use in a pediatric electrophysiology laboratory utilizing three-dimensional mapping. Pacing Clin Electrophysiol. 2007;30(4):510-8.

13. Papagiannis J, Tsoutsinos A, Kirvassilis G, Sofianidou I, Koussi T, Laskari C, et al. Nonfluoroscopic catheter navigation for radiofrequency catehter ablation of supraventricular tachycardia in children. Pacing Clin Electrophysiol. 2006;29(9):971-8.

14. Chen ML, Yang B, Ju WZ, Chen HW, Chen C, Hou XF, et al. Right-sided free wall accessory pathway refractory to conventional catheter ablation: lessons from 3-dimensional electroanatomic mapping. J Cardiovasc Electrophysiol. 2010;21(12):1317-24.

15. Szumowski L, Szufladowicz E, Orczykowski M, Bodalski R, Derejko P, Przybylski A, et al. Ablation of severe drug-resistant tachyarrhythmia during pregnancy. J Cardiovasc Electrophysiol. 2010;21(8):877-82.

16. Earley MJ, Showkathali R, Alzetani M, Kistler PM, Gupta D, Abrams DJ, et al. Radiofrequency ablation of arrhythmias guided by non-fluoroscopic catheter location: a prospective randomized Trial. Eur Heart J. 2006;27(10):1223-9.

17. Hindricks G, Willems S, Kautzner J, De Chillou C, Wiedemann M, Schepel S, et al; EuroFlutter Investigators. Effect of electroanatomically guided versus conventional catheter ablation of typical atrial flutter on the fluoroscopy time and resource use: a prospective randomized multicenter study. J Cardiovasc Electrophysiol. 2009;20(7):734-40.

18. Reddy VY, Morales G, Ahmed H, Neuzil P, Dukkipati S, Kim S, et al. Catheter ablation of atrial fibrillation without the use of fluoroscopy. Heart Rhythm. 2010;7(11):1644-53.