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Radiofrequency catheter ablation of cardiac arrhythmias using only three-dimentional mapping systems

Ablación con catéter de radiofrecuencia de taquiarritmias usando sólo sistemas de mapeo tridimensional

Rogelio Robledo-Nolasco,* José Raymundo Leal-Díaz*

Keywords:
Catheter ablation, cardiac arrhythmias, without fluoroscopy, three-dimensional mapping.

Palabras clave:
Ablación con catéter, arritmia cardiaca, sin fluoroscopia, mapeo tridimensional.

ABSTRACT

The largest number of radiofrequency catheter ablation (RCA) procedures are performed with the help of X-rays. Ionizing radiation affects both, the patient and the electrophysiologist. Today it is a priority to reduce exposure to X-rays and this is possible with new technologies and techniques for RCA. **Objectives:** The objective of this report is to demonstrate the feasibility and safety of performing RCA of conventional and complex cardiac arrhythmias (CA) without using X-rays in a single center. **Material and methods:** Patients with different CA and with indication of RCA were included. All had an echocardiogram and the antiarrhythmic drugs were suspended 5 half-lives before the procedure. Two three-dimensional mapping systems were used. First a catheter was advanced to draw the path of the access vessels and then the cardiac cavities were reconstructed and the origin of the arrhythmia was located. RCA with conventional parameters were performed. **Results:** We included 14 patients with mean age of 46.4 ± 16.9 years, 7 (50%) women, 2 (14.3%) had heart failure. There were 11 (78.6%) common and 3 (21.4%) complex arrhythmias. In 10 (71.4%) patients, the Carto 3 system was used and in the rest the Ensite system. A mean of 334 ± 335 mapping points were performed, an irrigated catheter was used in 12 (85.7%) patients, 50 ± 82 ablation applications were performed, the duration of the procedure was 100 ± 24 minutes and 13 (92.8%) of the procedures were successful. No X-rays were used and there were no complications. **Conclusions:** It is feasible and safe to perform RCA of conventional or complex CA with a three-dimensional mapping system, without using X-rays and with 92.8% success rate.

RESUMEN

Introducción: *El mayor número de procedimientos de ablación con catéteres de radiofrecuencia (ACR) se realiza con la ayuda de rayos X. La radiación ionizante afecta tanto al paciente como al electrofisiólogo. Hoy en día, es una prioridad reducir la exposición a los rayos X y esto es posible con nuevas tecnologías y técnicas para el ACR.* ***Objetivos:*** *Demostrar la viabilidad y seguridad de realizar ACR de arritmias cardiacas (AC) convencionales y complejas sin utilizar rayos X en ningún centro.* ***Material y métodos:*** *Se incluyeron pacientes con diferentes AC y con indicación de ACR. A todos se les realizó un ecocardiograma y se les suspendió la medicación antiarrítmica cinco medias vidas antes del procedimiento. Se utilizaron dos sistemas de mapeo tridimensional. Primero se avanzó un catéter para trazar el trayecto de los vasos de acceso, y luego se reconstruyeron las cavidades cardiacas y se localizó el origen de la arritmia. Se realizó ACR con parámetros convencionales.* ***Resultados:*** *Incluimos 14 pacientes con una edad media de 46.4 ± 16.9 años, 7 (50%) mujeres, 2 (14.3%) tenían insuficiencia cardiaca. Hubo 11 (78.6%) arritmias comunes y tres (21.4%) complejas. En 10 (71.4%) pacientes se utilizó el sistema Carto 3 y en el resto el sistema Ensite. Se realizaron en promedio 334 ± 335 puntos de mapeo, se utilizó un catéter irrigado en 12 (85.7%) pacientes, se realizaron 50 ± 82 aplicaciones de ablación; la duración del procedimiento fue de 100 ± 24 minutos y 13 (92.8%) de los procedimientos tuvieron éxito. No se utilizaron rayos X y no hubo complicaciones.* ***Conclusiones:*** *Es factible y seguro realizar el ACR de la AC convencional o compleja con un sistema de mapeo tridimensional, sin utilizar rayos X y con una tasa de éxito de 92.8%.*

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INTRODUCTION

Radiofrequency catheter ablation (RCA) of tachyarrhythmias has proven effective and is widely performed worldwide. The use of X-rays has been necessary until a little over a decade ago.[1] Currently, X-rays are used to perform the conventional procedures of RCA, which are the largest number of all catheter ablations in the world. The radiation time in these procedures has been reduced by the technological improvement of the equipment of the catheters and the learning curve of the electrophysiologyts.[2] Despite the above, the harmful effects of radiation have been seen, both for the patient and for the operator and other personnel in the electrophysiology room. For the patient, harmful effects like dermatitis, burns or birth defects have been reported; while for the operators, the frequency of some types of cancer has increased.[3,4] In recent years, three-dimensional mapping in first place and intracardiac ultrasound, in second place, have evolved impressively, so that nowadays it is possible to perform RCA with nothing or minimal amounts of radiation.[4-9]The objective of this report is to demonstrate the feasibility and security of performing RCA with zero use of X-rays in a single medical center.

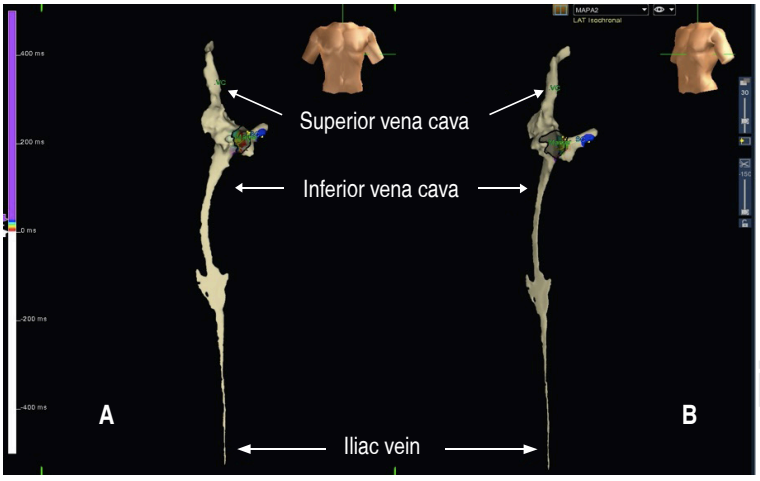

Figure 1: Panel **A**, anteroposterior view, panel **B**, left anterior oblique view. Reconstruction of the venous path from the iliac vein to the superior vena cava and the right atrium and coronary sinus. In a woman with a supraventricular tachycardia.

MATERIAL AND METHODS

Patients between 18 and 70 years old with tachyarrhythmias, undergoing radiofrequency ablation, were included. All patients signed their informed consent and the procedure was explained in detail. Most patients had no cardiac pathologies. Antiarrhythmic drugs were discontinued for a minimum of 5 half-lives prior to the procedure. Under mild sedation and local anesthesia with 2% Xylocaine venous or arterial right femoral punctures were performed by introducing two or three sheaths in the vein and one in the artery if the arrhythmia was located on the left side. A Bard polygraph (Boston Scientific) was used to perform the electrophysiological study and the Carto system (Biosense Webster, Inc.) or Ensite system (Ensite Velocity NavX, St. Jude Medical, St. Paul, MN, USA) was used to do three-dimensional mapping; in both cases the reference patches of the systems were placed in the patient in a conventional manner. When the Ensite system was used, a decapolar catheter was introduced and when we used the Carto system, an ablation catheter (Navistar or Smart Touch) was introduced first. With the first catheter inserted, the path of the vascular access to the heart (Inferior vena cava or abdominal and thoracic aorta) was drawn, then the right atrium together with the inferior vena cava and the tricuspid ring and the coronary sinus were reconstructed *(Figure 1)*. Once done the above, the decapolar catheter was placed into the coronary sinus and subsequently tetrapolar or a duodecapolar catheter was advanced for the study of arrhythmia. If the arrhythmia was on the left side, the arterial path, the aortic valve and ascending aorta were reconstructed with the ablation catheter. The same catheter was passed to the left ventricle and its anatomy was obtained, especially the mitral ring.

In case of a typical atrial flutter, a duodecapolar catheter «Halo» (Livewire Duo-Decapolar Electrophysiology Catheters) with 10 bipoles (2 mm paired spacing) separated by 1 cm distance was placed adjacent to the tricuspid annulus to record activation sequence; electrograms from the coronary sinus were recorded by a decapolar electrode and an irrigated catheter for ablation was placed within the inferior vena cava-tricuspid annulus (IVC-TA) isthmus. Successful ablation criteria

parameters were the end of the arrhythmia and bidirectional block of the IVT-TA isthmus; demostrated by an interval of 130 ms or more between both ends of the IVT-TA isthmus. In AV-nodal reentrant tachycardia (AVNRT), three catheters were introduced, one decapolar to the coronary sinus, one cuadripolar was placed in the His and the last one was the ablation catheter *(Figures 2 and 3)*. In the cases of accessory pathways, three catheters were used; one decapolar to the coronary sinus, a tetrapolar for the His or to the right ventricle and the ablation catheter *(Figure 4)*.

Statistical analysis

Categorical variables are reported as percentage (%) and continuous variables are reported as mean ± standar desviation. All analyses were performed using SPSS Statistics 25.

Figure 2: The arrows indicate the beginning of an AV-nodal reentrant tachycardia with a cycle of 322 milliseconds (186 beats per minute).

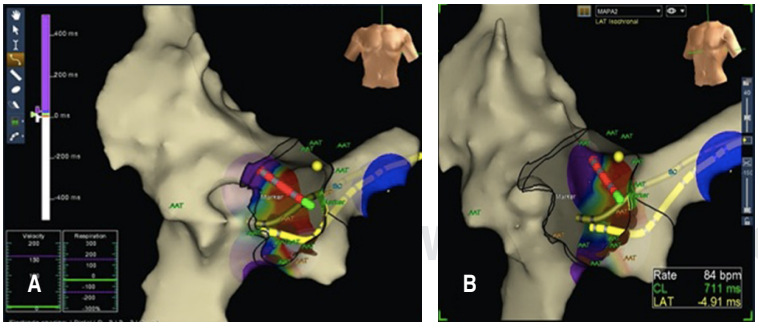

Figure 3: Panel **A**, anteroposterior view, panel **B**, left anterior oblique view of the reconstruction of the right atrium, tricuspid ring (black line outline) and in yellow point the His location. Decapolar electrode (yellow) inside the coronary sinus and the green tip catheter at the site of successful ablation.

Table 1: Clinical characteristics of the patients, n (%).

Age (years), (SD)	46.4 ± 16.9
Women	7 (50.0)
Hypertension	5 (35.7)
Diabetes	3 (21.4)
Coronary artery disease	0 (0)
Heart failure	2 (14.3)
Structural heart disease	3 (21.4)
Ejection fraction of left ventricle,(%)	58.6 ± 14.6
Cardiac arrhythmias	
- Atrial flutter	6 (42.8)
- Accessory pathways	3 (21.4)
- AVNRT	2 (14.3)
- Ventricular prematures beats	2 (14.3)
- Atypical atrial flutter	1 (7.1)

AVNRT = Atrioventricular nodal reentry tachycardia ablation, SD = standard deviation.

RESULTS

A total of 14 patients were included, aged 46.4 ± 16.9 years, 7(50%) women, 2(14.3%) had heart failure; the other demographic data are shown in *Table 1*. The indications for the ablation procedure were: in 11 (78.6%) patients, common tachyarrhythmias (6 typical Flutter, 3 accessory pathways and 2 AVNRT) and in 3 (21.4%) patients, complex tachyarrhythmias (2 ventricular premature beats and an atypical atrial flutter). In 10 (71.4%) patients the Carto 3 system was used and in the rest the Ensite system. With the chosen catheters, 334 ± 335 mapping points were performed on average, obtaining the necessary anatomy and the white zone to perform the ablation. For the ablation, an irrigated catheter was used in 12 (85.7%) patients, the number of ablation applications was 50 ± 82, the duration of the procedure was 100 ± 24 minutes and succesful ablation was obtained in 13(92.8%) patients; ablation in one patient with atypical flutter was failed *(Table 2)*. Zero minutes of radiation were used in all of the patients, there were no complications and two patients were pregnant; one in the first and another in the second pregnancy

trimesters. During the follow-up of 13.8 ± 4.0 months, no recurrences were documented and a patient who had a flutter ablation developed atrial fibrillation.

DISCUSSION

Currently, the cardiological field is responsible for indicating 45% of all studies or procedures where ionizing radiation is used.[10] Interventional cardiologists and electrophysiologists are exposed two to three times more to ionizing radiation than radiologists.[10] Usually, the average effective dose for patients undergoing these procedures is 17 mSv or 8.3 mGy per hour of fluoroscopy, with this dose there is a 0.5% higher risk of suffering from some types of fatal cancer.[11,12] There are currently several systems of three-dimensional mapping for the treatment of conventional or complex arrhythmias, such as Carto 3, Ensite and Rhytmia, with which it is possible to follow the recommendations of the American Collage of Cardiology. Today it is recommended that all electrophysiology laboratories adopt the «ALARA» principle (radiation doses «As Low As Reasonably Achievable»).[13] In our series of patients we use both Carto 3 and Ensite systems; both are equally effective, the latter allows for a more panoramic view even from the vascular puncture, allowing the drawing of vascular trayectories through which the different catheters are introduced. Stec et al.[14] reported 902 patients undergoing supraventricular tachycardia ablation, in 179 he used 0 X-rays, found no difference in procedure time, complications and success rate. In our patient group we used zero seconds of X-rays, the procedure time was 100 ± 24 minutes, our success rate was 92.8%, and we had no complications. The procedure time we report is similar to other publications, which range between 63.9 to 87 minutes.[2,14,15]

On the other hand, and with regard to pregnant patients with severe tachycardias, Demilakis et al,[15] documented that fetal exposure with lead aprons during the procedure was less than 1 mGy; despite this, it is not recommended to undergo electrophysiological studies and catheter ablation until after the 2nd trimester of pregnancy. In our series, two patients with pregnancy were included, one in the first and one in the second trimester; in both cases the indication of the procedure was the presence of severe hypotension during the episodes of tachycardia and in both cases the result was successful. It is currently possible to perform more complex arrhythmia ablation such as atrial fibrillation, ventricular or atrial tachycardias with three-dimensional mapping without using X-rays.[5,16-18]

Tabla 2: Electrophysiology study and ablation procedures n (%).

Carto 3 three-dimensional mapping system	10 (71.4)
Mapping points, SD	334 ± 335
Irrigated catheter	12 (85.7)
Number of de ablaciones	50 ± 82
Procedure time (minutes)	100 ± 24
Acute successful	13 (92.8)
Late successful	13 (100.0)
Complications	0 (0.0)
Follow-up (months)	13.8 ± 4.0

SD = standard deviation.

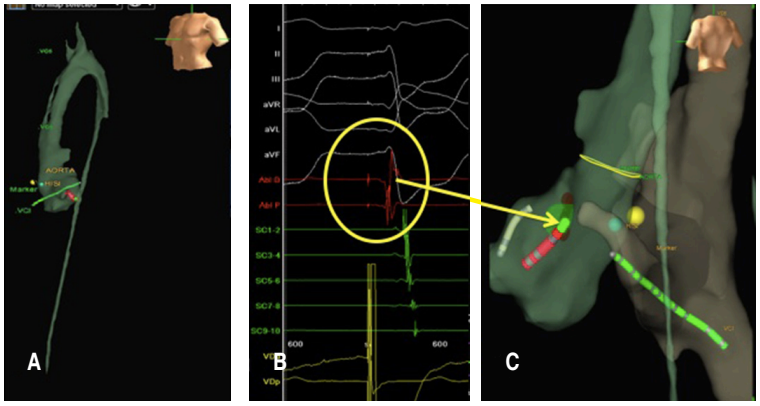

Figure 4: Panel **A**, left anterior oblique view of the aorta path (abdominal, thoracic ascending, aortic arch and descending) and aortic valve. In a patient with accessory pathway. Panel **B**, from top to bottom, electrocardiogram derivations, electrograms recording of the distal and proximal ablation catheter; registration of 5 coronary sinus electrograms and finally, right ventricle electrograms. The distal electrogram registers the location of the accessory pathway and where the ablation was successful. In panel **C**, there is the reconstruction of the aortic valve and coronary sinus that delimits the mitral ring and the green tip of the catheter is the ablation site.

CONCLUSIONS

In this case series it was demonstrated that it is feasible to perform conventional or complex catheter ablation of different tachyarrithmias with three-dimensional mapping systems, using 0 seconds of X-rays. This method of catheter ablation is safe since there were no complications and it was effective due to a success rate of 92.8% in the index procedure and during a follow-up of more than one year, there were no recurrences.

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Correspondence to:

Rogelio Robledo-Nolasco
E-mail: rogelio_robledo@hotmail.com