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Original Article

# Ablation of cardiac arrhythmias using a three-dimensional electro-anatomical mapping system in the Instituto Nacional Cardiovascular-INCOR

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## ABSTRACT

**Objective.** To describe the initial experience in ablation of cardiac arrhythmias using 3D mapping at the Instituto Nacional Cardiovascular INCOR (Lima, Peru). **Methods.** A retrospective descriptive study was carried out. During February 2020, data was collected from the medical records of all patients in whom ablation was performed using 3D mapping from July 2017 to December 2019. This procedure was performed in patients with symptomatic arrhythmia refractory to antiarrhythmic therapy. **Results.** Data were collected from 123 patients (median age: 46 years, 64.2% male), who had a median time of illness of 6 years. Among the arrhythmias treated, 19% had atrial fibrillation, 17.5% atrial tachycardia, 17.5% idiopathic ventricular arrhythmias, 16.6% Wolf Parkinson White syndrome / Atrioventricular reentrant tachycardia, 11.1% ventricular arrhythmias of the His-Purkinje conduction system, 9.5% scar related ventricular tachycardia associated, 6.4% atrial flutter and 2.4% intranodal tachycardia. The median fluoroscopy time was 26 minutes. Ablation was acutely successful in 95.9% of cases, acute complications were observed in 4.8%, and recurrence-free survival during the first year of follow-up was 74%. **Conclusions.** Our experience in ablation of cardiac arrhythmias using 3D mapping had a high acute success rate, low frequency of complications, and one-year recurrence-free survival of 74 %.

**Keywords:** Cardiac arrhythmia; Catheter ablation; Peru (source: MeSH NLM).

## Introduction

The treatment of cardiac arrhythmias has passed through important advances in the last 40 years [1 - 4]. Ablation is a percutaneous invasive procedure, involving the insertion of catheters into the heart. These procedures were initially guided conventionally by fluoroscopy, allowing mapping, recording endocardial electrical activity, and performing maneuvers to understand the mechanism and locate the origin or critical area of arrhythmias. Conventional ablation guided only by fluoroscopy is used for the treatment of different arrhythmias; however, it has limitations in the treatment of complex cardiac arrhythmias such as atypical atrial flutter (AF), atrial tachycardia (AT), atrial fibrillation (AF), and ventricular arrhythmias [5]. In this scenario, radiofrequency ablation using a three-dimensional electroanatomic mapping system (3D mapping) emerges as an alternative that may have advantages over conventional pharmacological or invasive strategies [5]. The 3D mapping system emits low-intensity magnetic fields or electric fields generating an axial voltage gradient, which allows detecting the spatial position of the mapping catheter, which has an integrated sensor in its tip that acquires electrical information at each point of contact between the catheter and the myocardial tissue, which is recorded in the form of electrograms that are then analyzed to construct electroanatomic maps of voltage, activation, and propagation. These maps, together with the maneuvers and the analysis of the electrograms, help the specialist to understand with greater precision the mechanism, the presence of the arrhythmic substrate, and the location of the critical zone of the cardiac arrhythmia [6].

Evidence suggests that radiofrequency ablation using 3D mapping may be an effective and safe alternative in the management of cardiac arrhythmias [7], due to its adequate reproducibility in experimental animal studies [8], and the lower recurrence of atrial arrhythmias compared to antiarrhythmic drugs in patients with atrial fibrillation found in randomized clinical studies [9]. This method has expanded in different countries so that in 2015 its use extended to 49% of specialized centers in Latin America [10]. The Instituto Nacional Cardiovascular (INCOR) began its experience in radiofrequency ablation using 3D mapping in July 2017 and is currently the center with the greatest number of procedures performed in Peru.

Because this method achieves the resolution of a large group of arrhythmias, and because there are no reports published on its use in our country, we conducted this study to describe the characteristics and results obtained in patients who underwent ablation of cardiac arrhythmias employing 3D mapping in a high specialty hospital in Peru.

## Materials and Methods

### Design and population

We performed a descriptive, retrospective study that included patients who underwent radiofrequency ablation employing 3D electroanatomic mapping to treat cardiac arrhythmias at the Instituto Nacional Cardiovascular INCOR (Lima, Peru) from July 2017 to December 2019. We excluded patients with focal arrhythmias, in whom clinical arrhythmia was not induced during the procedure.

### Collection of variables

The data were collected from medical records on a previously prepared sheet in February 2020, we recorded the epidemiological and clinical characteristics, the procedure performed, the final result of radiofrequency ablation using 3D mapping, complications, and the last clinical follow-up. The definition of ablation success depended on the type of arrhythmia, as detailed below:

- **Atrial fibrillation:** electrical isolation achieving inflow and outflow block between the pulmonary veins and the left atrium, and no induction of AF by atrial overstimulation [11].
- **Atrial flutter:** bidirectional block of the ablation line over the critical isthmus of the macro re-entry circuit and non-induction of AF by atrial overstimulation [12].
- **Focal atrial and ventricular arrhythmias:** application of radiofrequency (RF) in the area of origin, with the elimination of the focal arrhythmia and non-induction through overstimulation maneuvers [13].
- **Ventricular tachycardia (VT) associated with a scar:** modulation of the arrhythmic substrate by different techniques such as homogenization of the ventricular scar, ablation of fragmented late potentials, or the isthmus of the VT reentry circuit and non-induction of monomorphic VT by ventricular overstimulation maneuvers [14].
- **Wolf-Parkinson-White syndrome or atrioventricular reentrant tachycardia (AVRT):** elimination of the accessory pathway during RF application, documented through loss of ventricular pre-excitation and ventricular-atrial dissociation [15].
- **Intranodal reentrant tachycardia (INRT):** the application of RF over the slow pathway of the atrioventricular node with the

presence of nodal beats during RF application, with no evidence of two or more nodal echoes or induction of tachyarrhythmia during post-ablation overstimulation [16].

Acute complications were defined as those occurring during the procedure or within 24 h post-procedure [17]. Major complications were defined as those adverse events that, according to the opinion of the treating specialist, were related to the ablation procedure and required intervention for their treatment, causing longer recovery time and longer hospitalization [18].

Recurrence was defined as the reappearance of the treated clinical arrhythmia after ablation. In patients with post-ablation AF/AFL, we defined recurrence as the reappearance of the clinical arrhythmia 3 months after ablation, which had to be reported in the clinical history by electrocardiographic recording or Holter study.

The present study was approved by the Ethics Committee of the Instituto Nacional Cardiovascular INCOR before its execution. No variables were collected to identify the patients.

### Description of the ablation procedure

In patients with complex arrhythmias, symptomatic and refractory to antiarrhythmic therapy, radiofrequency ablations were performed using 3D mapping with the CARTO 3 system (Biosense Webster, Johnson & Johnson) and irrigated 3.5 mm ablation catheters (Navistar Thermocool, Biosense Webster, Johnson & Johnson), with an inter-electrode distance of 1 mm. Bipolar electrograms were recorded between distal and proximal electrode pairs, filtered between 16 to 500 Hz. Unipolar electrograms were recorded between each electrode of the ablation catheter and the central Wilson terminal, filtered between 2 to 240 Hz.

The procedures were performed in a cardiovascular interventional suite, under sedation or general anesthesia. Patients under general anesthesia were those whose procedure required a transseptal approach guided by transesophageal echocardiography or an epicardial approach following the technique described by Sosa et al [19].

Depending on the type of arrhythmia, different diagnostic catheters and stimulation protocols were used to induce and understand the tachyarrhythmia mechanism, then the ablation catheter was inserted for 3D anatomical reconstruction, activation map, propagation, unipolar, and bipolar voltage map. The application of radiofrequency in the critical zone was titrated with different power values, according to the operator's criteria. Once the desired result was achieved for each type of arrhythmia, acute success was considered the absence of recurrence of the clinical arrhythmia within 30 min of observation [20].

Clinical follow-up was performed within the first week post-procedure, then at one, three, and six months, and every year, including face-to-face or telephone consultation, electrocardiogram, and 24-h Holter study.

### Statistical analysis

Statistical analysis was performed using the Stata package (v.15). Univariate analysis was performed using measures of central tendency, and dispersion, absolute and relative frequencies. Overall recurrence-free survival was analyzed using the Kaplan Meier curve.

## Results

Between July 2017 and December 2019, 133 patients underwent radiofrequency ablation employing 3D mapping at INCOR to treat cardiac arrhythmias. Ten patients with focal arrhythmias were excluded because clinical arrhythmia was not induced during the procedure; therefore data from 123 patients were analyzed.

The median age of the patients was 46 years; 64.2% were male, and the median time of disease was six years. All patients were symptomatic, and palpitations were the most frequent form of presentation (93.5%). All patients were refractory to pharmacological treatment, and 86.9% had no structural heart disease. One hundred twenty-six arrhythmias were treated. **(Figure 1)** shows the frequency and type of arrhythmia; the characteristics of the population, the intervention approach, type of ablation, and outcomes are detailed in **(Table 1 and Table 2).**

In 24 patients with AF, 20 were paroxysmal and 4 were persistent. The endpoint was to electrically isolate the four pulmonary veins from the left atrium by point-to-point circumferential antral isolation, achieving this in 95.8% of cases. In 4 patients it was necessary to perform ablation lines in the posterior wall of the left atrium, superior vena cava or cavotricuspid isthmus, recurrence was 33.3% and complications reached 8.3%.

Of the 22 patients with idiopathic ventricular arrhythmias, 11 were located in the right ventricular outflow tract, and 4 were in the infundibular region. The median arrhythmic load was 32% and acute ablation success was achieved in 95.5% of cases with a recurrence of 23.8%.

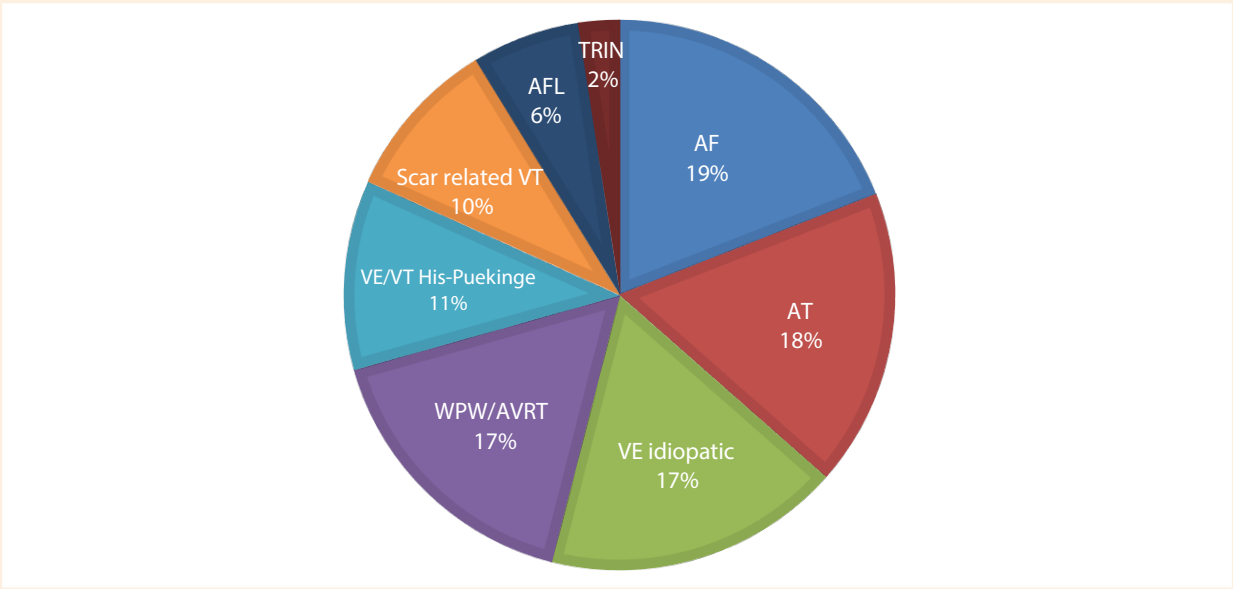



**Figure 1.** Arrhythmias treated with 3D electroanatomic mapping system (N= 126).

Frequency and percentage of clinical arrhythmias treated by ablation with 3D electroanatomic system, AF: atrial fibrillation. AT: atrial tachycardia. VE: ventricular extrasystole. WPSW/ AVRT: Wolf-Parkinson-White syndrome/Atrioventricular reentrant tachycardia. VT: ventricular tachycardia. AFL: atrial flutter. INRT: intranodal reentrant tachycardia.

Of 14 patients with ventricular arrhythmias associated with the His-Purkinje conduction system, 13 had left posterior fascicular VT and one patient had His related VT. All presented acute ablation success, documenting 7.1% post-ablation recurrence. Twelve patients with scar-associated VT had underlying structural heart disease. In this group, the etiology was ischemic heart disease (50%), idiopathic dilated cardiomyopathy (33.3%), and arrhythmogenic right ventricular cardiomyopathy (16.7%). The ablation procedure, in this case, was successful in 91.6% with recurrence in 25%. We performed an epicardial approach in four cases, due to post-ablation recurrence and endocardial ablation failure. The endo-epicardial approach was performed only in patients with non-ischemic cardiomyopathy (3 with idiopathic dilated cardiomyopathy and 1 with arrhythmogenic right ventricular cardiomyopathy).

Overall, 95.9% of patients who underwent radiofrequency ablation using 3D mapping **(Figure 2)** had acute success and 4.8% had some complication. The estimated survival free of arrhythmic recurrence at one year was 74% **(Figure 3)**.

## Discussion

Our initial experience in cardiac arrhythmia ablation using 3D electroanatomic mapping found a high rate of acute successful ablation and low frequency of complications. Radiofrequency ablation of cardiac arrhythmias using 3D mapping has become a common therapeutic tool for the treatment of complex cardiac arrhythmias. This technique allows a more precise definition of the anatomy and mechanism of the arrhythmia and has advantages over other methods, which is why it has become an invasive strategy widely used for different types of cardiac arrhythmias [7,9].

The prolonged period of illness leading up to the procedure is mainly due to the recent incorporation of this technology in our country. The indication for this procedure was based on international guidelines and those of our institution [21], prioritizing the presence of symptoms and refractoriness to antiarrhythmic therapy. The acute success rate was similar to that described in different international registries, which report acute success rates between 91 and 95.4% [10,22,23].

Our experience shows that AF ablation had a recurrence of 33%. Studies evaluating the efficacy and safety of AF ablation, using technology comparable to our center, reported a recurrence-free survival between 63 to 86% at 9 - 12 months of follow-up in paroxysmal AF [24,25], from 60 to 74% in persistent AF [26,27] with a major complication rate of 4.5% and mortality of 0.15% [28].

In patients with idiopathic ventricular arrhythmias, we recorded a success rate similar to other registries showing

**Table 1.** Clinical characteristics of patients who underwent ablation with a 3D mapping system at INCOR (N= 123).

| Clinical characteristics | n (%) |
|---|---|
| Age – median (IQR) | 46 (24-62) |
| Male | 79 (64,2) |
| Time of disease in years - median (IQR) | 6 (2-10) |
| **Symptoms** | |
| Palpitations | 115 (93,5) |
| Dyspnea | 22 (17,8) |
| Syncope | 6 (4,8) |
| Thoracic pain | 19 (15,4) |
| **Pharmacological therapy** | |
| Betablockers | 61 (49,5) |
| Calcium channel blockers | 19 (15,4) |
| Digoxin | 1 (0,81) |
| Propafenone | 45 (36,5) |
| Amiodarone | 45 (36,5) |
| **Comorbidities** | |
| Arterial hypertension | 16 (13,0) |
| Diabetes mellitus | 3 (2,4) |
| Ischemic cardiopathy | 7 (5,6) |
| Cerebro-vascular event | 6 (4,8) |
| **Structural cardiopathy** | |
| None | 107 (86,9) |
| Ischemic cardiomyopathy | 6 (4,8) |
| Idiopathic cardiomyopathy | 6 (4,8) |
| Right ventricle arrhythmogenic cardiomyopathy | 2 (1,6) |
| Ebstein anomaly | 2 (1,6) |
| Left ventricular ejection fraction % - median (IQR)[1] | 64 (58-68) |
| Previous ablation | 28 (22,7) |

IQR: interquartile range.

**Table 2.** Characteristics of the procedure

| Characteristics of the procedure | Median (IQR) |
|---|---|
| Procedure time in minutes | 225 (180-300) |
| Fluoroscopy time in minutes | 26 (14-37) |
| Radiation dose in mGy | 470 (165-1092) |
| Radio frequency time in seconds | 684 (317-1351) |
| Radiofrequency points | 29 (12-97) |
| Type of approach | n (%) |
| Right | 52 (42,0) |
| Transeptal | 38 (30,8) |
| Retro aortic | 29 (23,5) |
| Endo-epicardial | 4 (3,2) |
| Type of ablation performed | n (%) |
| Focal | 66 (53,6) |
| Isolation | 28 (22,7) |
| Substrate modulation | 9 (7,3) |
| Lineal | 20 (16,2) |
| Outcomes | n (%) |
| Acute successful ablation | 118 (95,9) |
| Acute complications | 6 (4,8) |
| Vascular complications | 3 (2,4) |
| Pericardial effusion | 2 (1,6) |

IQR: interquartile range.

an acute success rate of 85 to 90%, with long-term recurrence-free survival of 75.80% and a complication rate of 2% [29,30]. The incorporation of new technologies will allow us to improve our efficacy and safety and at the same time address with better results arrhythmias of more complex locations among them LV Summit, papillary muscle, or moderator band.

The ventricular arrhythmias of the His-Purkinje conduction system reported in our study were mainly composed of left posterior fascicular ventricular tachycardia. We recorded a success rate similar to other reports of fascicular VT ablation (100% success) reporting 85% recurrence-free survival at 4.5 years of follow-up [31].

Clinical studies of recurrent VT ablation in postinfarction patients show a recurrence-free survival at six months of 54% and a mortality rate of 18% at 1-year follow-up [32]. Studies of VT ablation in patients with nonischemic heart disease are heterogeneous and usually observational from a single center. The acute success rates reported were between 38 to 74% and recurrence rates between 29 to 58% with a mean follow-up of 9 to 22 months [33 - 35].

No mortality associated with the procedure was recorded. Acute complications occurred in 4.8%, most of which were vascular (2.4%) followed by pericardial effusion with the need for drainage (1.6%), these findings are similar to other registries that have found between 2 and 4.5%, with vascular complications being the most frequent [10,22,23,28].

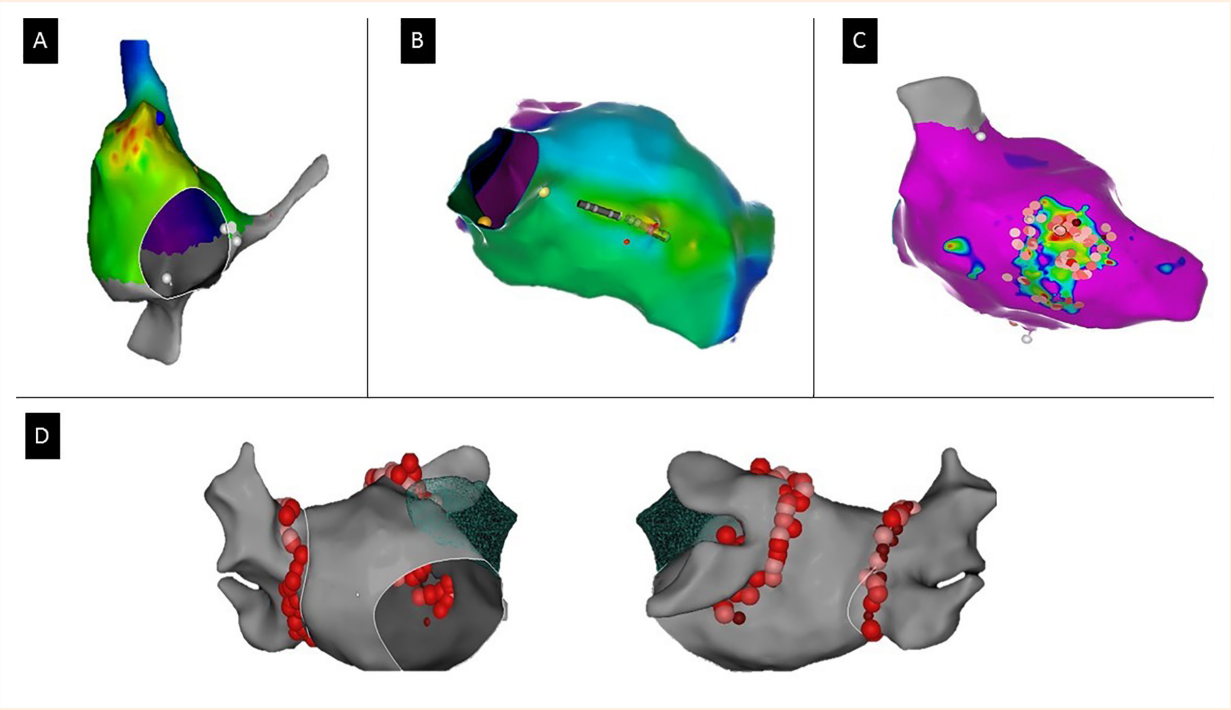



**Figure 2.** 3D electroanatomical map for ablation of complex arrhythmias

A. Activation map in right atrial appendage focal atrial tachycardia. B. Activation map in focal ventricular extrasystole of the left ventricular posterior papillary muscle. C. Modulation of arrhythmic substrate for scar-associated ventricular tachycardia defined by bipolar voltage map with areas of low voltage in mid-septal region D. Circumferential antral electrical isolation of pulmonary veins.

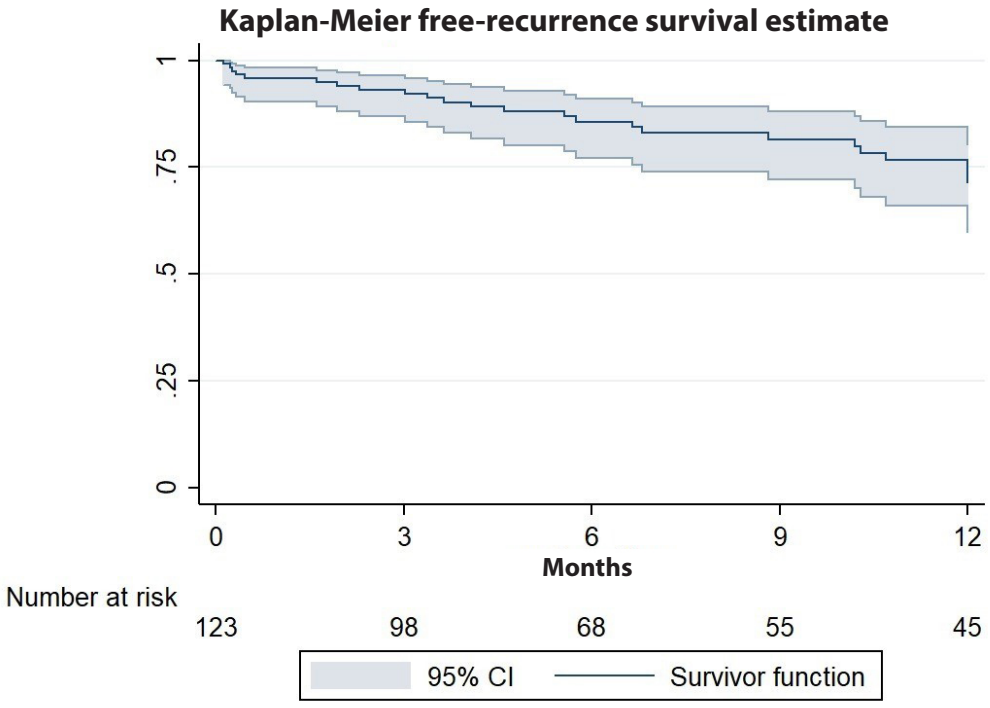
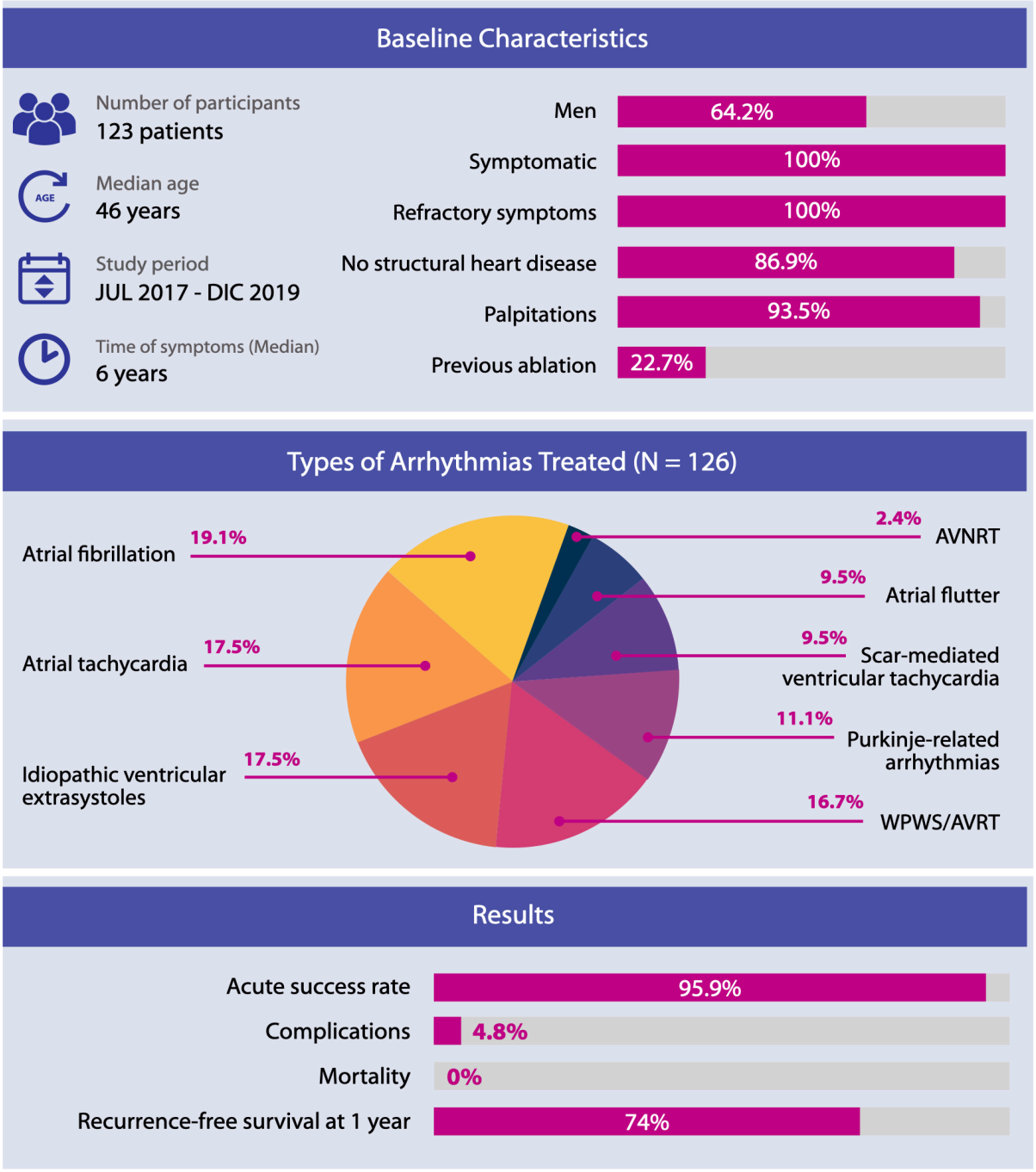



**Figure 3.** Recurrence-free survival of patients who underwent ablation with 3D electroanatomic mapping system (N= 123)

Estimated recurrence-free survival using Kaplan Meier in the clinical follow-up of patients with acute post-procedural success, 74% are estimated to be free of recurrences at one year follow-up

**Figure 4. Central figure: Ablation of cardiac arrhythmias using a three-dimensional electro-anatomical mapping system in the Instituto Nacional Cardiovascular-INCOR**

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AVNRT: Atrioventricular nodal reentry tachycardia. WPWS: Wolf-Parkinson-White syndrome. AVRT: Atrioventricular reentrant tachycardia

We consider that it is important to continue collecting data on radiofrequency ablations using 3D electro-anatomical mapping in our center, since this will allow us to identify variables on which to intervene to improve our results. The incorporation of new strategies approaches and new technology such as catheters with contact force sensors, multielectrode catheters for high-density mapping, intracardiac echocardiography, and new software within the 3D mapping system will help to increase the frequency of acute success and reduce complications and recurrences.

### Limitations and strengths

It is necessary to take into account some considerations of the present study when interpreting its results: 1) It is an observational study carried out through the review of medical records, so it was necessary to rely on what was recorded in these documents. 2) At the time of data collection, an important group of patients had less than 12 months since they underwent the procedure; therefore, at 12 months after the procedure we only had information on 21 patients with recurrence and 45 without recurrence (that is, 66 patients [53.7%] of 123); this may bias the result of recurrence, so future studies with a lower frequency of losses are required. 3) These results were obtained in a specialized national referral center, so they may not be extrapolated if performed in other centers with lower resolution. However, this is the first report of ablation with 3D mapping in Peru, in which the procedure performed in INCOR is presented in detail. In this way, we provide a baseline on the use of this procedure in our context.

## Conclusions

Data from our initial experience with symptomatic patients with cardiac arrhythmia, refractory to antiarrhythmic therapy, who underwent radiofrequency ablation using 3D electro-anatomic mapping in our institution were evaluated. We found a high frequency of successful acute ablation and a low frequency of complications, as well as an estimated 74% recurrence-free survival at 1-year follow-up.

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### Authors' contributions

RSB, MCS, CGC, PZC, and RZC proposed the research idea. RSB, JMM, RHR, and WJG collected the study data. RSB, OAT, and ATR analyzed the data. RSB and RZC drafted the first version of the manuscript. All authors participated in the writing and accepted the final version of the study.

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