

Special article

Spanish catheter ablation registry. 23rd official report of the Heart Rhythm Association of the Spanish Society of Cardiology (2023)



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A B S T R A C T

Introduction and objectives: We report the results of the 2023 Spanish catheter ablation registry.

Methods: Procedural data were collected and incorporated into the REDCap platform by all participating centers through a specific form.

Results: There were 104 participating centers in 2023 compared with 103 in 2022. In 2023, the total number of ablation procedures was 26 207, indicating a stabilization of the increase observed in 2022 following the pandemic. The increase was mainly due to procedures for atrial fibrillation (AF), with a total of 9942 ablations, representing 38% of all substrates. Notably, pulse-field ablation represented 10.3% of all AF ablation procedures, leading single-shot ablation strategies to outnumber point-by-point AF ablation for the first time in the history of the registry. Cavotricuspid isthmus ablation remained the second most targeted substrate (19% of all substrates, n = 5067). The overall acute success rate remained high (97%), with a downward trend in the complication rate (1.6% vs 1.8% in 2022) and mortality rate (0.03%; n = 7). Compared with 2022, there was a significant increase in procedures performed using electro-anatomical mapping and zero-fluoroscopy techniques for cavotricuspid isthmus ablation (52% vs 26%), AV node re-entrant tachycardia (48% vs 34%), and accessory pathways (62% vs 22%). We registered 466 ablations in pediatric patients.

Conclusions: The data indicate a stabilization in the post-pandemic increase in ablation procedures, with an absolute and relative increase in AF as the predominant substrate. Success rates remained stable with a modest reduction in complication and mortality rates.

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Registro español de ablación con catéter. XXIII informe oficial de la Asociación del Ritmo Cardíaco de la Sociedad Española de Cardiología (2023)

R E S U M E N

Introducción y objetivos: Se presentan los resultados del Registro español de ablación con catéter correspondientes al año 2023.

Métodos: Registro retrospectivo de las ablaciones realizadas en los hospitales nacionales participantes incorporadas en la plataforma REDCap mediante formulario específico.

Resultados: Participaron 104 centros, respecto a los 103 participantes en 2022. En 2023 se ha estabilizado el incremento de ablaciones (n = 26.207) respecto al notable aumento de la actividad en 2022 tras la pandemia. El incremento de casos ha sido fundamentalmente a expensas del sustrato predominante, la fibrilación auricular (FA) (n = 9.942), que representa el 38% del total de sustratos. Destaca la irrupción de la electroporación (el 10,3% del total de ablaciones de FA), a expensas de lo cual el número de procedimientos de crioablación ha superado por primera vez al de punto a punto. En segundo lugar, se mantiene la ablación de istmo cavotricuspidé (el 19%, 5.067 casos). El éxito agudo global se mantiene elevado (97%), con tendencia a la baja en la tasa de complicaciones (el 1,6 frente al 1,8% de 2022) y de mortalidad (el 0,03%; n = 7). Cabe destacar un significativo porcentaje de procedimientos realizados con navegador y sin escopia para ablación del istmo cavotricuspidé (el 52 y el 26%

Palabras clave:

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Arritmia

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◇ The complete list of collaborators and participating electrophysiology laboratories is provided in [appendix 1](#).

respectivamente), taquicardia intranodular (el 48 y el 34%) y vías accesorias (el 62 y el 22%). Se realizaron 466 ablaciones pediátricas.

Conclusiones: Los datos indican una estabilización del incremento de ablaciones, con un aumento absoluto y relativo de la FA como sustrato predominante. La tasa de éxito se mantiene elevada y disminuyen ligeramente las complicaciones y la mortalidad.

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Abbreviations

AF: atrial fibrillation
 AVNRT: atrioventricular nodal re-entrant tachycardia
 CTI: cavotricuspid isthmus
 FAT: focal atrial tachycardia
 ICM-VT: ischemic cardiomyopathy ventricular tachycardia
 IVT: idiopathic ventricular tachycardia
 MAT: macrore-entrant atrial tachycardia
 NICM-VT: nonischemic cardiomyopathy ventricular tachycardia

INTRODUCTION

The Spanish catheter ablation registry has been systematically collecting data on the activity and resources of arrhythmia units in Spain for more than 2 decades. The present document comprises the latest official registry report of the Heart Rhythm Association of the Spanish Society of Cardiology (SEC). This report outlines the changes over time in the interventional management of cardiac arrhythmias in Spain.^{1–22} The objective is to provide pertinent information on each of the ablation techniques used, the available technology, and the human resources in the Spanish health care system. Finally, the document provides the data on the safety and effectiveness of each ablation target.

METHODS

The present work involves a retrospective registry of the activity of electrophysiology laboratories in Spain in 2023. Data were voluntarily obtained from participating centers using a standardized form available on the REDCap online platform, which is part of the recording platform of the Heart Rhythm Association of the SEC. The registry is continuously compiled, updated, and maintained throughout the year with the collaboration of a team consisting of full members of the Heart Rhythm Association of the SEC, as well as the technical team and coordinator of the Heart Rhythm Association registries of the SEC. The device manufacturing and marketing industry also collaborates by providing relevant data. All members contributed to data cleaning and analysis and are responsible for this publication. The data were re-anonymized for the authors of the present report.

Information was collected on the specific technical and human resources of the participating arrhythmia units, the ablation technique and modality, and the type of ablation target treated, as well as the ablation outcomes and complications. Eleven ablation targets were analyzed: atrial fibrillation (AF), cavotricuspid isthmus (CTI), atrioventricular nodal re-entrant tachycardia (AVNRT), accessory pathway (AP), atrioventricular node (AVN), macrore-entrant atrial tachycardia (MAT), focal atrial tachycardia

(FAT), idiopathic ventricular tachycardia (IVT), ischemic cardiomyopathy ventricular tachycardia (ICM-VT), nonischemic cardiomyopathy ventricular tachycardia (NICM-VT), and cardioneuroablation.

The following variables were analyzed: the number of patients and procedures (specifying the number of pediatric patients, defined as those younger than 15 years), acute success (at the end of the procedure), the type of ablation catheter used, and the number and type of in-hospital complications. Periprocedural mortality data were also recorded. The data collection permitted the inclusion of specific details on certain ablation targets (eg, vein of Marshall ethanol infusion in AF and MAT, as well as scar type and location in nonischemic cardiomyopathies). Also recorded were the use of electroanatomic mapping systems and the number of zero-fluoroscopy procedures.

RESULTS

Technical and human resources

The technical and human resources of the participating laboratories, as well as the other procedures (in addition to ablation) performed by the arrhythmia units, are detailed in [table 1](#).

The mean number of physicians per laboratory increased again to 3.7 ± 1.4 , while the number of full-time physicians per arrhythmia unit was 2.6 ± 1.8 ([table 1](#)). The percentage of centers with at least 1 full-time electrophysiologist remained at 81%. Nursing staff numbers were stable, with an average of 3.4 ± 1.9 nurses per unit. The percentage of centers with a training program for fellows was also stable at about 40% (37% in 2023), generally with 1 or 2 fellows per center (0.6 ± 1.1).

Most centers (69%) were equipped with at least 1 dedicated cardiac electrophysiology laboratory. The number of centers with 2 dedicated laboratories continued its slow increase (27 centers in 2023 vs 24 in 2022) while 1 center had 3 available laboratories, as in 2022. Once again, laboratories were available on 3.8 ± 2 days a week (median, 5).

Eleven centers (10.6%) had no electroanatomic mapping system, and the number of centers with at least 2 such systems was 51 (49%), which is similar to the figure recorded in 2022. The most common electroanatomic mapping systems were Ensite and Carto. Almost half of the centers ($n = 51$; 49%) were equipped with intracardiac echocardiography. Of the alternative energy sources to radiofrequency, cryoablation was available in a similar percentage of centers as in 2022 (80% vs 79% in 2022). No laser ablations were reported. Finally, both electroporation (pulse-field ablation [PFA], 14% of centers) and cardioneuroablation (41% of centers) showed a notable increase. Regarding procedures other than ablation, most centers implanted pacemakers, defibrillators, cardiac resynchronization devices, and Holter monitors, with percentages exceeding 90% in all centers. The percentage of centers performing left atrial appendage closure remained at about 20%.

Table 1

Variations in human resources in Spanish electrophysiology laboratories from 2014 to 2023

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Staff physicians	2.8	3.0	3.0	3.2	3.5	3.2	3.5	3.3	3.5	3.7
Full-time physicians	1.9	2.4	2.1	2.2	2.3	2.1	2.2	2.4	2.7	2.6
Fellows/y	0.6	0.8	0.7	0.9	0.6	0.6	0.6	0.5	0.6	0.6
RNs	2.3	2.7	2.7	2.8	2.7	2.8	2.9	2.8	3.4	3.4
RTs	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3

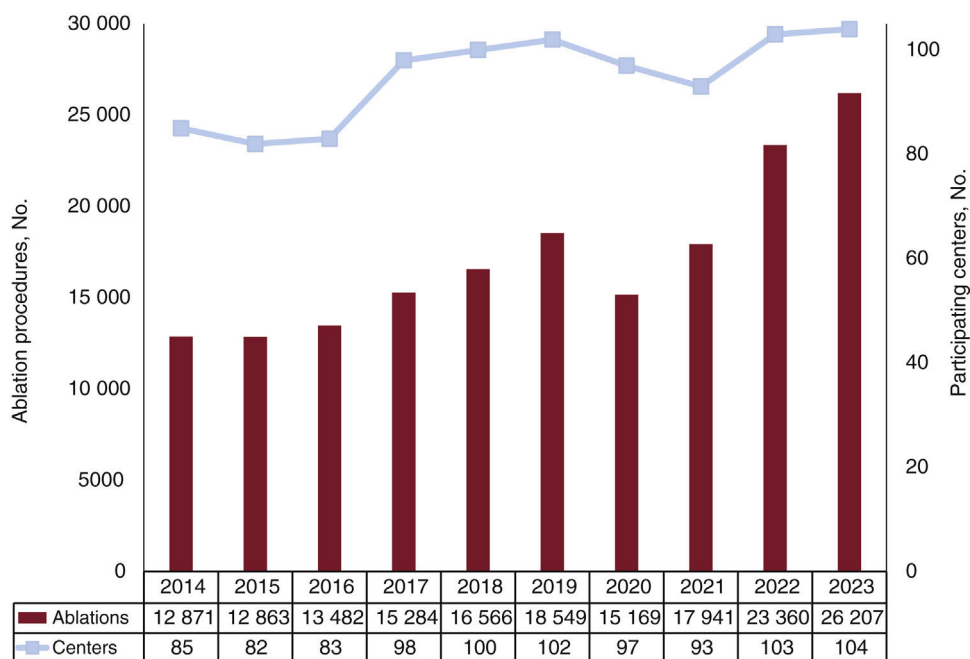
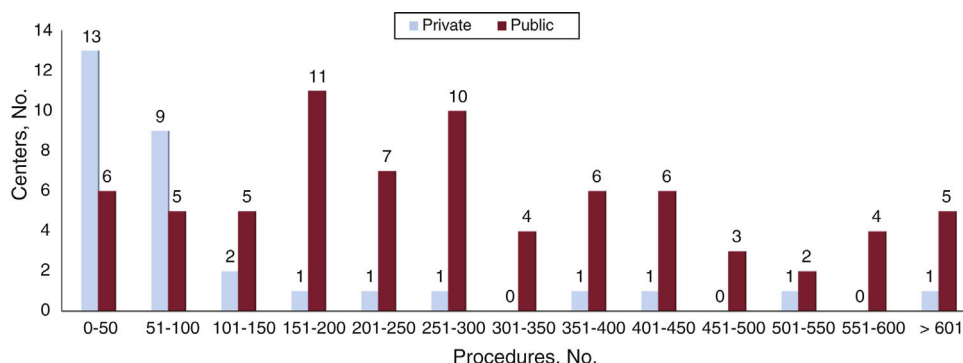
RN, registered nurse; RT, radiologic technologist.

Values represent means.

Overall results

There was a moderation in the increase in the number of ablations in 2023 vs the marked growth recorded in 2022, following 2 years of the SARS-CoV-2 pandemic (2020 and 2021). A total of 26 207 ablations were recorded, compared with 23 360 in 2022, with only 1 new center joining the registry (figure 1). The distribution of participating centers between private and publicly funded was very similar to that of previous years (74 publicly funded and 30 private).

The median number of ablations per center was 202 [inter-quartile range, 308.5]. The number of centers performing a high number of ablations increased considerably, with the number of centers conducting more than 600 ablations per year rising from 3 to 6 in just 1 year (5 of these centers were publicly funded) (figure 2). In addition, there was a marked increase in private centers performing high numbers of ablations. For example, the number of private centers performing between 51 and 100 ablations (a 50% increase in this range) rose from 6 to 9, due to a corresponding decrease in centers performing fewer than 50 ablations per year.

**Figure 1.** Changes over time in the number of procedures and centers participating in the registry from 2014 to 2023.**Figure 2.** Distribution of participating centers by annual number of procedures and by whether the center was publicly funded or private in 2023.

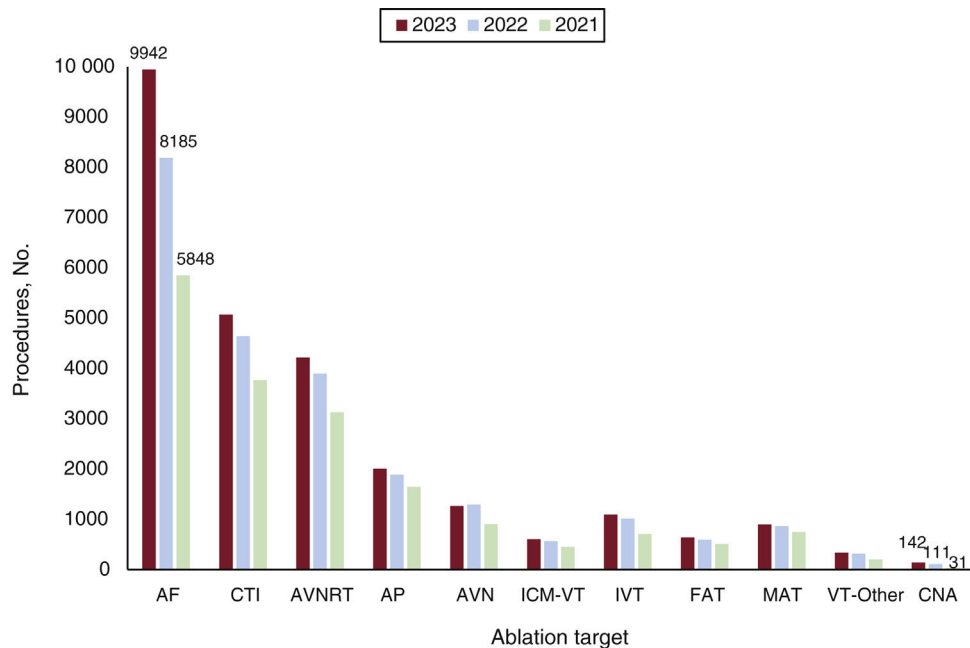


Figure 3. Distribution of the number of procedures per ablation target and year. AF, atrial fibrillation; AP, accessory pathway; AVN, atrioventricular node; AVNRT, atrioventricular nodal re-entrant tachycardia; CNA, cardioneuroablation; CTI, cavotricuspid isthmus; FAT, focal atrial tachycardia; ICM-VT, ischemic cardiomyopathy ventricular tachycardia; IVT, idiopathic ventricular tachycardia; MAT, macrore-entrant atrial tachycardia; VT, ventricular tachycardia.

The distribution of ablation targets treated was similar to that of previous years, with an increase in the predominant ablation target AF both in absolute numbers (from 8185 to 9942 ablations) and relative terms (from 35% to 38% vs the other ablation targets) (figure 3 and figure 4). There was also a sharp increase in cardioneuroablation procedures, particularly in the number of centers treating this ablation target. AP ablation continued its downward trend vs the other ablation targets, decreasing from 9% to 8% in 2023.

The overall acute procedural success rate slightly increased, from 96% to 97%, and the complication rate fell again (1.6% vs 1.8%

in 2022), as did mortality (0.03%), to levels similar to those of a decade ago (figure 5). Regarding effectiveness and complication rates by ablation target, the complication rate for VT ablations improved for both idiopathic VT and VT with underlying heart disease (figure 6). Complications associated with AF ablation fell from 2.8% (in 2022) to 2.5%.

A total of 419 complications were recorded. Vascular complications were once again the most frequent ($n = 143$), followed by pericardial effusion ($n = 111$). The distribution of complications by ablation target is presented in table 2. There were 7 procedure-related deaths, vs 10 in 2022 (0.03%); 3 of these deaths were in patients with AF (2 due to massive stroke and 1 due to refractory shock) while the remaining 4 were in patients undergoing VT ablation. The following sections detail the results for each ablation target.

Atrial fibrillation

Once again, AF ablation remained the most commonly treated ablation target and even increased, with a total of 9942 procedures (1757 more than in 2022). This ablation target was treated in 89% of the centers participating in the registry (2 percentage points higher than in 2022). Regarding clinical presentation, 60.3% of cases were paroxysmal AF, 35.7% were persistent AF, and 4% were long-standing persistent AF. These percentages are similar to those of previous years. The overwhelming majority of ablation procedures involved electrical isolation of the pulmonary veins ($n = 9240$), followed by electrogram reduction at the pulmonary vein antrum ($n = 957$) and lines in the left atrium ($n = 633$). Other ablation targets included superior vena cava isolation ($n = 83$), fibrotic area ablation ($n = 122$), and vein of Marshall ethanol infusion ($n = 174$). Reported success rates were 97% for pulmonary vein isolation and 99% for superior vena cava isolation.

Defining single-shot as the only other single-shot ablation strategy besides point-by-point ablation, a combined single-shot plus point-by-point strategy was used in 89 patients, out of a total

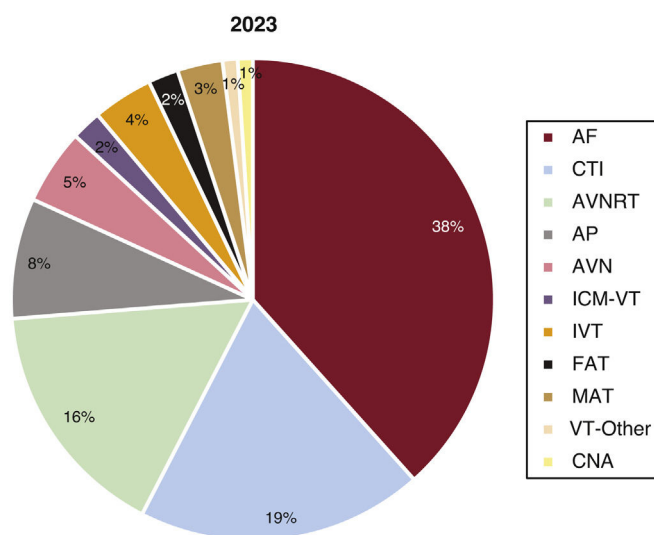


Figure 4. Relative proportions of ablation targets in 2023. AF, atrial fibrillation; AP, accessory pathway; AT, atrial tachycardia (focal and atypical flutter); AVN, atrioventricular node; AVNRT, atrioventricular nodal re-entrant tachycardia; CNA, cardioneuroablation; CTI, cavotricuspid isthmus; VT, ventricular tachycardia.

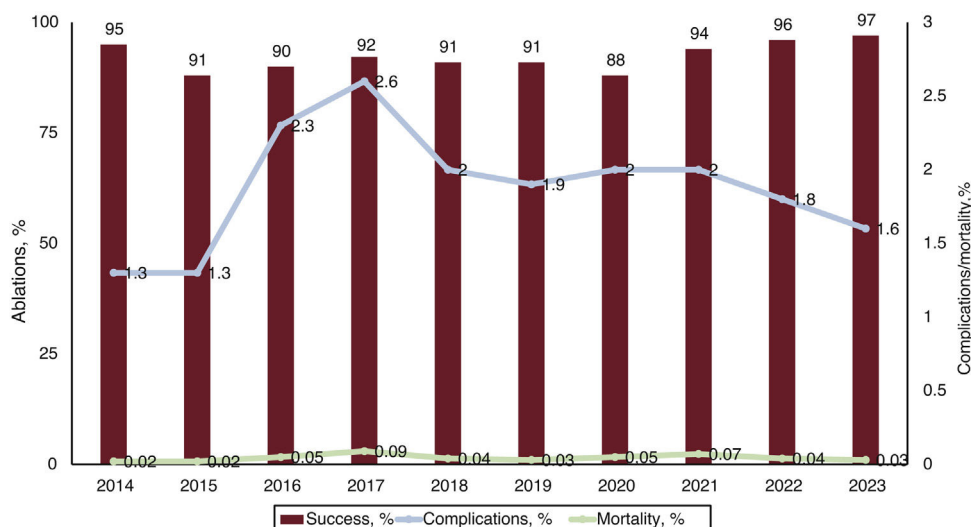


Figure 5. Variations in success, complication, and mortality rates from 2014 to 2023.

of 9942 AF ablation procedures. For the first time in the registry, the single-shot technique (50.1% of AF ablations) exceeded the point-by-point approach (49.9%) (figure 7). The point-by-point techniques included irrigated-tip catheters with contact forcesensing technology in 4775 procedures, standard irrigated catheters in 352 procedures, and other types in 56 procedures. Among the single-shot techniques, cryoablation continued to predominate (n = 3954 procedures), although there was a highly significant increase in PFA (n = 1038 procedures), which sharply increased from 3% of all AF ablation procedures in 2022 to 10.3% in 2023. Mapping systems were used in 5078 procedures (51%), and zero-fluoroscopy procedures comprised 530 (5.3%). As auxiliary instruments for ablation, steerable sheaths were used in 2683 procedures, intracardiac echocardiography in 1057, and general anesthesia in 4511.

In 2023, a total of 245 complications were recorded. This figure corresponded to 2.5% and is slightly lower than the 2.8% recorded

in 2022. The most common complications were vascular (29%), followed by pericardial effusion (27%) and phrenic nerve palsy (24%). Less frequent complications included peripheral embolism (7.6%) and heart failure/shock (2.8%). Three deaths were reported (6 in 2022): 2 due to massive stroke and 1 due to cardiogenic shock. No cases of AF ablation-related atrioesophageal fistula were reported in 2023.

Cavotricuspid isthmus

A total of 5067 CTI ablations were recorded in 2023 (427 more than in 2022). As a result, CTI was the second most commonly treated ablation target after AF (19.5% of all ablations). The trend continued toward an increased number of procedures performed with a mapping system (14% increase from 2022) and without fluoroscopy (7% increase from 2022) (table 3).

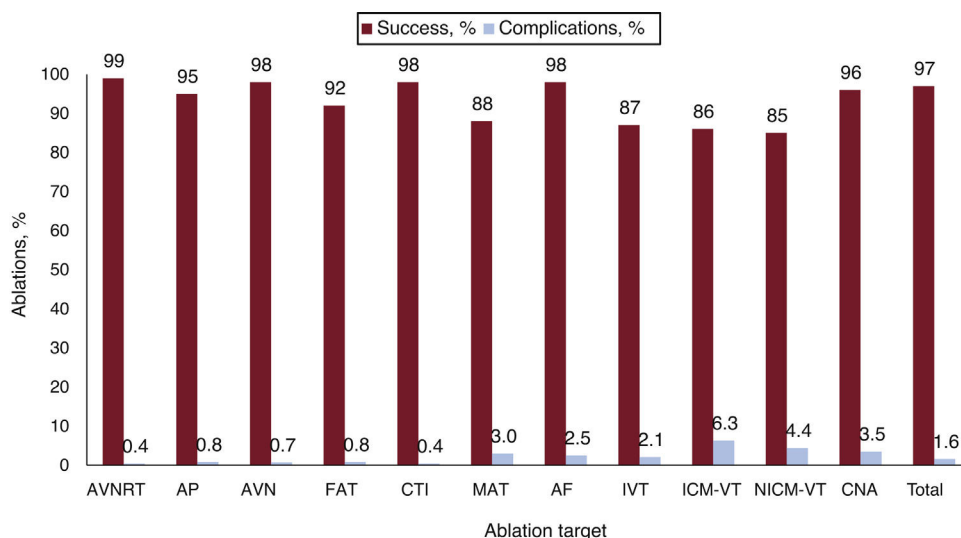


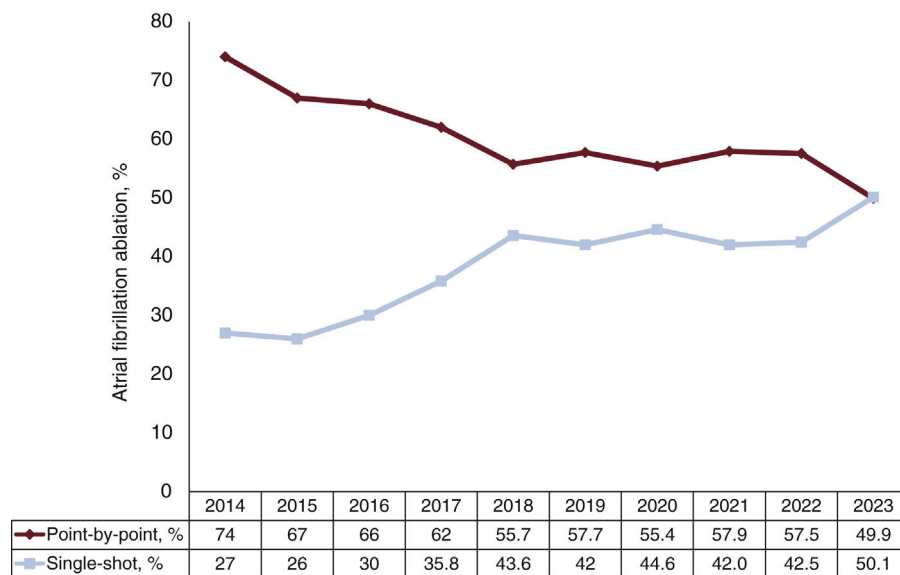
Figure 6. Variations in success and complication rates per ablation target in 2023. AF, atrial fibrillation; AP, accessory pathway; AVN, atrioventricular node; AVNRT, atrioventricular nodal re-entrant tachycardia; CNA, cardioablation; CTI, cavotricuspid isthmus; FAT, focal atrial tachycardia; ICM-VT, ischemic cardiomyopathy ventricular tachycardia; IVT, idiopathic ventricular tachycardia; MAT, macrore-entrant atrial tachycardia; NICM-VT, nonischemic cardiomyopathy ventricular tachycardia. Values represent percentages.

Table 2

Complications recorded by ablation target in 2023

	Ablations 2023	AVB	Vasc	PE	Emb	AMI	HF	PNP	Other	By substrate, n	By substrate, %
Total	26 207	25	143	111	29	6	20	58	31	265	1.6
AVNRT	4213	9	7	0	0	0	0	0	0	16	0.4
AP	2005	2	5	6	3	0	0	0	1	17	0.8
AVN	1263	-	4	1	0	0	0	0	4	9	0.7
FAT	639	2	2	1	0	0	0	0	0	5	0.8
CTI	5067	1	16	4	0	0	1	0	1	19	0.4
MAT	897	3	11	6	3	0	3	0	1	27	3.0
AF	9942	0	73	68	19	5	7	58	15	245	2.5
IVT	1095	0	10	7	2	1	0	0	3	23	2.1
ICM-VT	605	7	12	11	2	0	5	0	1	38	6.3
NICM-VT	339	1	3	5	0	0	4	0	2	15	4.4
CNA	142	0	0	2	0	0	0	0	3	5	3.5

AF, atrial fibrillation; AMI, acute myocardial infarction; AP, accessory pathway; AVB, atrioventricular block; AVN, atrioventricular node; AVNRT, atrioventricular nodal re-entrant tachycardia; CNA, cardioneuroablation; CTI, cavotricuspid isthmus; Emb, embolism; FAT, focal atrial tachycardia; HF, heart failure; ICM-VT, ischemic cardiomyopathy ventricular tachycardia; IVT, idiopathic ventricular tachycardia; MAT, macrore-entrant atrial tachycardia; NICM-VT, nonischemic cardiomyopathy ventricular tachycardia; PE, pericardial effusion; PNP, phrenic nerve palsy; Vasc, vascular complications.

**Figure 7.** Variations in point-by-point vs single-shot AF ablation techniques from 2014 to 2023.**Table 3**

Use of electroanatomic mapping systems and zero-fluoroscopy procedures by ablation target in 2023

Ablation target	With mapping system	Without fluoroscopy
AVNRT	48%	34%
AP	62%	22%
AVN	4.2%	2.7%
FAT	80%	19%
CTI	52%	26%
MAT	95%	10%
AF	51%	5.3%
IVT	88%	18%
ICM-VT	92%	5.8%
NICM-VT	87%	7.1%

AF, atrial fibrillation; AP, accessory pathway; AVN, atrioventricular node; AVNRT, atrioventricular nodal re-entrant tachycardia; CTI, cavotricuspid isthmus; FAT, focal atrial tachycardia; ICM-VT, ischemic cardiomyopathy ventricular tachycardia; IVT, idiopathic ventricular tachycardia; NICM-VT, nonischemic cardiomyopathy ventricular tachycardia; MAT, macrore-entrant atrial tachycardia.

The success rate was 98% (similar to 2022), with a similar percentage of complications vs the previous year (0.5% in 2022 and 0.4% in 2023). Most complications were vascular (n = 16) and 1 patient developed atrioventricular block (AVB). The most commonly used catheters were irrigated-tip catheters with contact forcesensing technology (41%), followed by standard irrigated catheters (31%) and 8- and 4-mm catheters (23% and 5%, respectively).

Atrioventricular nodal re-entrant tachycardia

AVNRT ablation continued to be the third most commonly treated ablation target (16%), after AF and CTI. Although the percentage relative to other ablation targets has gradually decreased in recent years, the absolute number of procedures has progressively increased (4213 procedures, representing an 8% increase vs 2022). The reported success rate was 99%, with a complication rate of 0.4%, which included 9 AVBs (0.2%) and 7 vascular complications. Both the energy source used (radio-

frequency was the most frequently used approach, while cryoablation was used in only 2.2% of procedures) and the use of mapping systems (48%) remained at figures similar to those of previous years.

Accessory pathways

AP ablation was once again the fourth most frequently treated ablation target, accounting for 8% of all ablations performed and showing a 6.2% increase in the total number of procedures vs 2022 (2005 vs 1888 in 2022). The success rate was 95% while the complication rate was 0.8%, which included 6 pericardial effusions, 5 vascular complications, 3 embolisms, and 2 AVBs. In addition, 46% of the APs showed bidirectional conduction, 19% had exclusively anterograde conduction, and 35% had exclusively retrograde conduction. Left APs continued to be the most frequent location (52.5% of procedures, with a 98% ablation success rate), followed by inferoseptal pathways (26.5%; 97% success rate), para-Hisian/anteroseptal pathways (10.6%; 80% success rate), and right free wall pathways (10.5%; 93% success rate). Epicardial ablation was necessary in 28 procedures. Transseptal access was used more frequently than retroaortic access for ablation of the left pathways (61% vs 39%). Mapping systems were used in more than half of all procedures and almost a fifth were fluoroscopy-free.

Atrioventricular node ablation

A total of 1263 AVN ablations were performed in 2023 (30 fewer than in 2022). A success rate of 98% was recorded, as well as a complication rate of 0.3% (all vascular). The most commonly used catheters were 4-mm catheters (47%), followed by standard irrigated catheters (28%) and 8-mm and irrigated contact forcesensing catheters (19% and 6%, respectively). Mapping systems and zero-fluoroscopy strategies were used in less than 5% of all procedures for this ablation target.

Macrore-entrant atrial tachycardia

In 2023, 897 procedures were performed for this ablation target (35 more than in 2022). This figure represented 3.5% of all ablations in the registry. Overall effectiveness remained similar to that of 2022 (88% in 2022 and 89% in 2023) for both right atrial ablation targets (88%) and left atrial targets (91%). Most catheters (89%) were contact forcesensing catheters. There was a notable increase in the use of electroporation ($n = 5$) and vein of Marshall ethanol infusion ($n = 18$), although the number of procedures is still very low.

All procedures were performed using a mapping system, and 90 were performed without fluoroscopy. Of the 21 complications reported, the most frequent were vascular ($n = 11$), followed by pericardial effusions requiring drainage ($n = 6$) and embolic phenomena ($n = 3$). As for AF ablation, no atrioesophageal fistula was reported after MAT ablation in 2023.

Focal atrial tachycardia

In 2023, 639 FAT ablations were performed (47 more than in 2022), representing 2.5% of all reported ablations. Of these, 65% were in the right atrium and 35% in the left atrium, with acute success rates of 95% and 89%, respectively (similar to 2022). Five complications were recorded: 2 AVBs requiring pacemaker implantation, 2 vascular complications, and 1 pericardial effusion. All procedures were performed using a mapping system, while 124 were conducted without fluoroscopy.

Idiopathic ventricular tachycardia

IVT ablation procedures in 2023 remained consistent with 2022, both as a percentage (4.2%) and in absolute numbers (1095 vs 1011 procedures in 2022). The number of centers performing these procedures was also stable, at 85, with a median of 8.5 [12] procedures per center. Regarding the locations of the tachycardias, 47% originated in the right ventricular outflow tract, 20% in the left ventricular outflow tract, and 13% in the aortic root. In addition, 6.4% were fascicular tachycardias, 3% were epicardial tachycardias, and 0.1% originated in the pulmonary artery. In 10% of procedures, the origin was located elsewhere (from most to least frequent): papillary muscle, mitral annulus, tricuspid annulus, and moderator band. The reported success rate was 87% (72% in the left ventricular outflow tract and 91% in the right ventricular outflow tract).

Mapping systems were used in 90% of procedures. The use of irrigated-tip catheters with contact forcesensing technology was standard for this ablation target (89%). The use of energy sources other than radiofrequency was rare (alcohol ablation in 3 cases and cryoablation in 2). Overall, 23 complications were recorded (2.1%), including 10 vascular complications, 7 pericardial effusions, 2 embolisms, 1 acute infarction, and 1 aortic leaflet perforation. One death occurred, caused by electromechanical dissociation in the context of arterial ethanol ablation.

Ischemic cardiomyopathy ventricular tachycardia

Although there were no major changes in the number of centers performing ICM-VT ablations ($n = 70$) or the percentage of procedures (2% of the total number of ablations performed), there was an absolute increase of 6.7% in the number of procedures ($n = 605$). The median number of procedures was 5 [8]. Mapping systems were used in most procedures, and zero-fluoroscopy procedures were rare (table 3). The acute success rate was 86% and the most commonly used ablation catheters were irrigated-tip catheters with contact forcesensing technology (97%). Six centers performed stereotactic radioablation (18 procedures). The access routes were similar to those used in 2022, with transseptal access being the common (66% of procedures). A combined endocardial/epicardial approach was used in 9% of procedures, while exclusively epicardial access was used in 2.6%. The predominant strategy was substrate ablation (68%), with conventional activation mapping applied in 18%. The complication rate was 6.3%, which is similar to that of previous years, and included 12 vascular complications, 7 AVBs, 11 pericardial effusions, 2 embolisms, and 5 cases of heart failure decompensation. Three deaths were associated with the procedure (1 electromechanical dissociation, 1 stroke, and 1 cardiogenic shock; 0.5% mortality).

Nonischemic cardiomyopathy ventricular tachycardia

The number of centers ($n = 59$) and total number of procedures ($n = 339$) in 2023 were similar to those in 2022. The median number of procedures per center was 2 [19] and the success rate was 85%. An electroanatomic mapping system was used in most procedures (87%). The main ablation targets were nonischemic dilated cardiomyopathy in 183 procedures (54%; 79% success), arrhythmogenic cardiomyopathy in 59 procedures (17%; 76% success), hypertrophic cardiomyopathy in 14 procedures (4.1%; 100% success), congenital heart disease in 30 procedures (8.8%, 93.3% success), and bundle-branch tachycardia in 9 procedures (2.6%; 87.5% success).

The use of irrigated-tip catheters with contact forcesensing technology was standard (95.5%), while the use of other energy

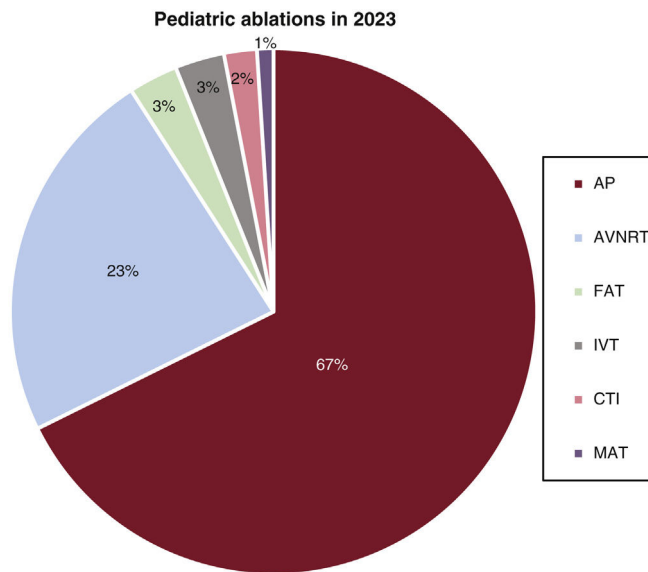


Figure 8. Relative proportion of each ablation target in pediatric patients (younger than 15 years) vs the total number of procedures in 2023. AP, accessory pathway; AVNRT, atrioventricular nodal re-entrant tachycardia; CTI, cavotricuspid isthmus; FAT, focal atrial tachycardia; IVT, idiopathic ventricular tachycardia; MAT, macrore-entrant atrial tachycardia.

sources was rare, with 9 radioablations and 1 alcohol ablation. The transseptal approach was used in 37% of procedures. A combined endocardial-epicardial approach was used in 22% of procedures while exclusively epicardial access was used in 13%.

The reported complication rate was 4.4%: 5 pericardial effusions, 4 heart failure decompensations, 3 vascular complications, and 1 pleural effusion. No deaths were associated with the procedure.

Ablations in pediatric patients

A total of 466 ablations were reported in pediatric patients, representing 3.3% of the total figure, without counting AF or VT ablations (including these ablation targets, the percentage of the total was 1.8%) (figure 8). The most frequently treated ablation target continued to be APs (67% of procedures, 313 procedures, 41 centers), followed by AVNRT (23%, 109 procedures, 29 centers) and FAT (3.4%, 16 procedures, 12 centers). Other ablation targets were much less frequently treated in this population: IVT (3.4%), ICT (1.5%), MAT (1%), NICM-VT (2 procedures), and AF (1 procedure). Thus far, no complications have been associated with ablations performed in the pediatric population.

Mapping systems and zero-fluoroscopy ablation

The percentage of ablation procedures performed with electroanatomic mapping systems was similar to that of 2022 (55% in 2022 and 54% in 2023). Notably, the use of mapping systems predominated in less complex ablation targets (CTI, AVNRT, and APs), which once again showed an increase in zero-fluoroscopy procedures (table 3). AVN ablation continued to be a less complex target that rarely involved mapping systems and zero-fluoroscopy strategies. The use of mapping systems is practically standard in MAT and VT ablations. For these targets, zero-fluoroscopy procedures are rare, although 18% of IVT ablations adopted a zero-fluoroscopy strategy. Finally, 20% of FAT ablations were performed without a mapping system.

Cardioneuroablation

In 2023, there was a significant increase in the number of centers performing cardioneuroablation, rising from 25 centers in 2022 to 41 in 2023. However, the increase in the total number of procedures for this ablation target was more modest (111 in 2022 to 142 in 2023). This indicates that the technique is becoming more established, although the indication for this type of ablation remains limited, likely due to strict patient selection.

DISCUSSION

The data from the Spanish catheter ablation registry for 2023 indicate a strong recovery in activity after the marked fall in the number of procedures in 2020 and 2021 due to the SARS-CoV-2 pandemic. In addition, only 2 years after its introduction, the REDCap online platform has been proven to effectively enable the responsible person in each center to submit data to the registry. Compared with the previous data collection method, the current approach allows for quicker data inclusion, minimizes errors, and provides the Heart Rhythm Association of the SEC with an opportunity to use the data for strategic and scientific purposes, while ensuring the impartial and anonymous use of the information gathered.

The absolute number of procedures supports the growth detected in the prepandemic years (figure 1) and even highlights a notable increase both in absolute and relative terms in AF as the predominant ablation target: AF now accounts for almost 40% (specifically, 38%) of all ablation procedures performed in the Spanish healthcare system. The number of participating centers has stabilized at around 100 ($n = 104$), allowing for a comparison with the data from 2022 and reinforcing the validity of the estimated growth in activity (particularly in AF ablation) in the arrhythmia units compared with the previous year.²²

For the first time, the absolute number of single-shot techniques has exceeded point-by-point procedures. This trend, driven largely by cryoablation over the years, has finally been confirmed by the rapid rise of PFA as the technique of choice for AF ablation, with a notable increase in its use in just 1 year, from 3% to 10.3%. It is likely that PFA will become one of the predominant single-shot techniques in the coming years. It will be interesting to observe whether this shift leads to a decline in the use of point-by-point radiofrequency catheter procedures, cryoablation, or both.

CTI and AVNRT ablation remained the second and third most common procedures, respectively. One noteworthy aspect of these 2 ablation targets is the growing number of procedures performed using a mapping system and without fluoroscopy.

AP ablation exhibited a slow decline, particularly in relative terms, now representing less than 10% of all ablations (8%). The remaining ablation targets remained largely unchanged.

Cardioneuroablation, first incorporated into the registry in 2021, continued to grow, not only in the number of procedures (from 111 in 2022 to 142 in 2023) but also in the number of centers performing it (from 25 to 41), suggesting the technique is becoming more established, despite its use being restricted to highly selected patients.

The overall procedural success rate in 2023 was comparable to that of the previous year (97% in 2023 vs. 96% in 2022). More notably, there has been a progressive reduction in the complication rate, approaching levels recorded a decade ago, when complex ablation targets were less common (eg, in 2014, AF ablation represented less than 20% of ablations vs the other targets).¹³ The complication rate has fallen to 1.6% (vs 1.8% in 2022), with a mortality rate of 0.03% (7 cases).

In terms of novel ablation strategies, alongside the increased use of PFA and cardioneuroablation, the use of mapping systems

for less complex ablation targets is also becoming more established, with a corresponding increase in zero-fluoroscopy procedures. Growth was also recorded in the use of vein of Marshall ethanol infusion for the treatment of MAT and in substrate ablation for patients with AF. The number of pediatric ablations remained stable.

Limitations

The present data come from a voluntary registry and are therefore subject to the limitations inherent in this type of report, including its retrospective nature and the inability to statistically compare the data with those from previous years.

CONCLUSIONS

The post-SARS-CoV-2 pandemic increase in activity stabilized in 2023. Registry participation remained steady, reaching a historic peak of 104 participating centers. AF continued its upward trend as the predominant ablation target in both absolute and relative terms compared with other targets, with the notable emergence of PFA. This technique appears to have become established as the leading single-shot method, surpassing point-by-point ablation, despite the increasing complexity of AF ablation strategies. The acute success rate of procedures remains very high (97%), with a sustained decline in complication rates (1.6%) and mortality (0.03%).

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AUTHORS' CONTRIBUTIONS

Both the primary author, V. Bazan, and the coauthors, E. Arana, J.M. Rubio-Campal, and D. Calvo, have fully contributed both to the design of the study and to the data analysis, manuscript drafting, and manuscript revision. D. Calvo is registry coordinator for the Heart Rhythm Association of the SEC.

CONFLICTS OF INTEREST

None of the authors have any conflicts of interest to declare.

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APPENDIX 1. SPANISH CATHETER ABLATION REGISTRY CENTERS AND COLLABORATORS FOR 2023

Center	Collaborator
Hospital Universitario Nuestra Señora de Candelaria, Santa Cruz de Tenerife	Luis Álvarez Acosta
Hospital San Juan de Dios, Santa Cruz de Tenerife	Julio Hernández Afonso
Clínica Universidad de Navarra, Pamplona, Navarra	Pablo Ramos Ardanaz
Hospital Universitario Virgen de la Arrixaca, Murcia	Pablo Peñafiel Verdú
Hospital Universitario Puerta del Mar, Cádiz	Lucas R. Cano Calabria
Hospital Universitario Virgen de la Victoria, Málaga	Alberto Barrera Cordero
Hospital QuirónSalud, Málaga	Alberto Barrera Cordero
Hospital QuirónSalud Marbella, Málaga	Alberto Barrera Cordero
Hospital Vithas Málaga, Málaga	Alberto Barrera Cordero
Hospital Vithas Xanit Internacional Benalmádena, Málaga	Alberto Barrera Cordero
Hospital Vithas Sevilla, Seville	Ernesto Díaz Infante/Rocío Cózar León
Hospital Ramón y Cajal, Madrid	Vanesa Cristina Lozano Granero
Hospital Clínico Universitario de Santiago de Compostela, Santiago de Compostela, A Coruña	José Luis Martínez Sande
Hospital Universitario Dexeus, Barcelona	Àngel Moya Mitjans
Hospital Universitario Marqués de Valdecilla, Santander, Cantabria	Felipe Rodríguez Entem
Hospital Clínico San Carlos, Madrid	Ricardo Salgado Aranda
Hospital Severo Ochoa, Leganés, Madrid	Ricardo Salgado Aranda
Hospital Universitario Santa Lucía, Cartagena, Murcia	Ignacio Gil Ortega
Hospital Álvaro Cunqueiro, Vigo, Pontevedra	Pilar Cabanas Grandío
Hospital Universitario de Navarra, Pamplona, Navarra	Óscar Alcalde Rodríguez
Hospital Universitario de Burgos, Burgos	Francisco Javier García Fernández
Hospital Sant Joan de Déu, Esplugues de Llobregat, Barcelona	Georgia Sarquella-Brugada
Hospital Puerta de Hierro-Majadahonda, Majadahonda, Madrid	Víctor Castro Urda
Hospital Universitario de León, León	María Luisa Fidalgo Andrés
Complejo Hospitalario Universitario de Badajoz, Badajoz	J. Manuel Durán Guerrero
Hospital Universitario Reina Sofía, Córdoba	Francisco Mazuelos Bellido
Hospital Universitario Fundación Alcorcón, Alcorcón, Madrid	Jose Amador Rubio Caballero

APPENDIX 1. SPANISH CATHETER ABLATION REGISTRY CENTERS AND COLLABORATORS FOR 2023 (Continued)

Center	Collaborator
Hospital Universitario General de Castellón, Castellón	Víctor Pérez Roselló
Hospital Clínico Universitario Lozano Blesa, Zaragoza	Mercedes Cabrera Ramos
Fundación Jiménez Díaz, Madrid	José Manuel Rubio Campal
Hospital Universitario General de Villalba, Collado Villalba, Madrid	José Manuel Rubio Campal
Clínica Sagrada Família, Barcelona	Andreu Porta Sánchez
Complejo Hospitalario Universitario de Albacete, Albacete	Víctor M. Hidalgo Olivares
Hospital Universitario Central de Asturias, Oviedo, Asturias	José Manuel Rubín López
Hospital del Mar, Barcelona	Jesús Jiménez López
Hospital Universitario Son Espases, Palma de Mallorca, Baleares	Carlos Eugenio Grande Morales
QuirónSalud Sagrado Corazón, Seville	Juan Manuel Fernández Gómez
Hospital Universitario de Salamanca, Salamanca	Javier Jiménez Candil
Hospital QuirónSalud Infanta Luisa, Seville	Rafael Moreno Garrido
Hospital Juan Ramón Jiménez, Huelva	María Teresa Moraleda Salas
Hospital Universitario 12 de Octubre, Madrid	Daniel Rodríguez Muñoz
Complejo Hospitalario Universitario de A Coruña, A Coruña	Iván Vázquez Esmorís
Hospital General Universitario Dr. Balmis, Alicante	José Luis Ibáñez Criado
Clínica HLA Vistahermosa, Alicante	Alicia Ibáñez Criado
Hospital de Basurto, Bilbao, Vizcaya	María Fe Arcocha Torres
Hospital Virgen Macarena, Seville	Pablo Bastos Amador
Hospital Universitario Lucus Augusti, Lugo	Juliana Elices Teja
Hospital Universitario Virgen de Valme, Seville	Ricardo Pavón Jiménez
Hospital Universitario Virgen de las Nieves, Granada	Miguel Álvarez López
Unidad Funcional Territorial de Electrofisiología Camp de Tarragona, Tarragona	Gabriel Martín Sánchez
Hospital La Luz, Madrid	Juan Benezet Mazuecos
Hospital Universitario Rey Juan Carlos, Móstoles, Madrid	Federico Gómez Pulido
Clínica HLA Santa Isabel, Seville	Alvaro Arce León
Hospital General Universitario de Valencia, Valencia	Aurelio Quesada Dorador
Hospital Universitario de Gran Canaria Dr. Negrín, Las Palmas de Gran Canaria, Las Palmas	Haridian Mendoza Lemes
Hospital Universitario Río Hortega, Valladolid	Benito Herreros Guilarte
Hospital Universitario La Fe, Valencia	Joaquín Osca Asensi
Hospital Universitario QuirónSalud Madrid, Madrid	Tomás Datino Romaniega
Complejo Hospitalario Ruber Juan Bravo (equipo Dr. Datino), Madrid	Tomás Datino Romaniega
Hospital Universitari Germans Trias i Pujol, Badalona, Barcelona	Axel Sarrias
Complejo Hospitalario Universitario de Canarias, Santa Cruz de Tenerife	Julio Jesús Ferrer Hita
Hospital Clínico Universitario San Cecilio, Granada	José Miguel Lozano Herrera
Hospital Universitario de Toledo, Toledo	Miguel Ángel Arias
Hospital Universitari Vall d'Hebron, Barcelona	Nuria Rivas Gandara
Hospital San Pedro La Rioja, Logroño	Pepa Sánchez Borque
Hospital Universitario de Álava, Vitoria	Enrique García Cuenca
Hospital Universitario de la Ribera, Alzira, Valencia	Bruno Bochard Villanueva
Hospital de Manises, Manises, Valencia	Pau Alonso Fernández
Hospital Universitario de Cabueñes, Gijón, Asturias	Irene Valverde André
Hospital QuirónSalud Huelva, Huelva	María Teresa Moraleda Salas
Hospital Clínico Universitario de Valladolid, Valladolid	María de Gracia Sandín Fuentes
Hospital Universitario de Getafe, Madrid	Agustín Pastor Fuentes
Hospital de Cáceres, Cáceres	Javier Portales Fernández
Hospital Perpetuo Socorro, Las Palmas de Gran Canaria	Pablo M. Ruiz Hernández
Hospital Clínic de Barcelona, Barcelona	Eduard Guasch Casany
Hospital Virgen del Rocío, Seville	Alonso Pedrote
Hospital Universitario Miguel Servet, Zaragoza	Antonio Asso Abadía
Clínica Corachán, Barcelona	Jose Maria Guerra Ramos
Hospital Universitario de Bellvitge, L'Hospitalet de Llobregat, Barcelona	Ignasi Anguera
Hospital Universitario Arnau de Vilanova, Lleida	Javier Cantalapiedra
Hospital de Cruces, Barakaldo, Vizcaya	Íñigo Sainz Godoy
Hospital Clínico Universitario de Valencia, Valencia	Eloy Domínguez Mafé
Hospital de la Santa Creu i Sant Pau, Barcelona	Enrique Rodríguez Font
Centro Médico Teknon, Barcelona	Julio Martí Almor

APPENDIX 1. SPANISH CATHETER ABLATION REGISTRY CENTERS AND COLLABORATORS FOR 2023 (Continued)

Center	Collaborator
Hospital Universitario San Juan de Alicante, San Juan de Alicante, Alicante	José Moreno Arribas
Hospital Universitario La Paz, Madrid	José Luis Merino Llorens
Hospital Viamed Santa Elena, Madrid	José Luis Merino Llorens
Complejo Hospitalario Ruber Juan Bravo (equipo Dr. Merino), Madrid	José Luis Merino Llorens
Hospital Clínica Benidorm, Alicante	Vicente Bertomeu González
Hospital Universitari Josep Trueta, Girona	Eva María Benito Martín
Hospital HM Modelo, A Coruña	Ignacio Mosquera Pérez
Hospital La Inmaculada, Granada	Miguel Álvarez López
Hospital Universitario Dr. Peset, Valencia	Antonio Peláez González
Hospital General Universitario de Ciudad Real, Ciudad Real	Francisco Javier Jiménez Díaz
Hospital Arnau de Vilanova, Valencia	Assumpció Saurí Ortiz
Hospital Universitario Donostia, San Sebastián, Guipúzcoa	Antonio Óscar Luque Lezcano
Hospital Universitario Insular de Gran Canaria, Las Palmas de Gran Canaria	Federico Segura Villalobos
Hospital Universitario HM Montepíncipe, Madrid	Jesús Almendral Garrote
Hospital Universitario de Torrejón de Ardoz, Torrejón de Ardoz, Madrid	Óscar Salvador Montañés
Hospital Universitario Príncipe de Asturias Alcalá de Henares, Madrid	Juan José González Ferrer
Hospital Universitario Infanta Elena, Valdemoro, Madrid	Federico Gómez Pulido
Hospital Universitario La Paz, Madrid	Rafael Peinado Peinado
Hospital IMED, Valencia	Óscar Fabregat Andrés
Hospital General Universitario Gregorio Marañón, Madrid	Ángel Arenal
Hospital Central de la Defensa Gómez Ulla, Madrid	Sara Moreno
Hospital Universitario Sanitas La Zarzuela, Madrid	Álvaro Marco del Castillo

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