

Original Research

Radiofrequency Ablation Procedures in Greece: Initial Experience and Results from the National Registry 2008-2010

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Introduction: In 2008 the radiofrequency ablation procedures (RFA) registry of the Hellenic Cardiological Society (HCS) was created. This is a dynamic, web-based application, which acts as the interface for storing and retrieving patients' demographic data and ablation procedures. Access to the site is permitted only to registered users. The purpose of this study is to report the results of RFA procedures performed in Greece over the 2008-2010 period.

Methods: There are 27 centers in 24 hospitals that are licensed to perform RFA in Greece. During the period 2008-2010, 3541 RFA procedures were performed in 3344 patients in 23 centers. Four centers did not contribute data at all for various reasons. It is interesting that nearly 50% of the total number of procedures were performed at 3 high volume centers (> 100 cases/year).

Results: The most common procedure was slow pathway ablation for atrioventricular reentrant tachycardia, the second was ablation of accessory pathway related tachycardias, and the third was ablation of atrial fibrillation. Success rates were high (92.1%), the complication rate was 3% (serious complications <1%) and total relapse rate was 8.7% at six months' follow up.

Conclusions: The electronic RFA registry in Greece confirmed that all RFA procedures are performed in Greece with high success and low complication rates, comparable to the European and US standards. The experience and results from the first three-year period using the registry are very interesting and encouraging, thus indicating the need for development of similar databases at the national level.

Radiofrequency ablation (RFA) is a well-established and effective method for the treatment of tachycardias. Since the first successful application of the method in 1987,¹ more than 100,000 procedures have been performed worldwide. It has been applied in almost all types of supraventricular and ventricular tachycardias, including atrial fibrillation (AF). The success rate is very high, ranging from 85-100% depending on the type of the arrhythmia.² The recurrence rate is 2-8% and the complication rate is low.³ Among the complications, the late occurrence of complete heart block is an issue, especially in patients who have undergone slow pathway ablation for atrioventricular reentrant tachycardia (AVNRT),⁴⁻⁶ or ablation in the posteroseptal area.⁷ Patients frequently complain of palpitations after a successful procedure, but in the majority this is due to benign arrhythmias, as has been confirmed by long-term remote monitoring.⁸ Additionally, inappropriate sinus tachycardia can be recorded in 10% of patients who have had AV nodal modification.

Although there are various published studies about the efficacy and safety of this technique from individual centers, data regarding the experience at the national level were lacking in Greece. Therefore, we organized a web-based national registry for all RFA procedures performed in Greece, under the auspices of the Working Group of Pacing and Electrophysiology of the Hellenic Cardiological Society (HWGPE).

Methods

In Greece, at the time the database was designed, there were 27 centers, located in 24 hospitals, which were licensed by the Ministry of Health to perform RFA procedures. The project was started in August 2008 as part of an MSc thesis under the postgraduate program of the Medical School of Thessaloniki, and was eventually funded by the Hellenic Cardiological Society (HCS). Experience from organizing databases at the national level in the past suggested that data should be limited to the essential items, thus avoiding the collection of excessive, usually unnecessary information. Completion of the relevant form should be very easy and clear, with dropdown menus, it should be quick and easy for the average user, and all data should be stored directly in a central electronic database. The latter was very important because in the past, although in most centers the relevant paper forms were filled in, there was insufficient secretarial

support to enter the data in the database, and eventually the system was never complete and functional.

The registry of the HCS is a dynamic, web-based application, which acts as the interface for storing and retrieving patients' demographic data and ablation procedures (internet address: <http://hcs-registry.com>). Access to the site is permitted only to users registered with the HWGPE, who can enter, edit and delete patient data. Patients' names are not stored in the database and each patient is assigned a 10-digit unique identifier, thus ensuring data anonymity and privacy protection.

Statistical analysis

Continuous data are presented as mean \pm standard deviation, and categorical data as number and percentage. Lower and upper margins of values are indicated where appropriate.

Results

Among the 27 centers licensed for ablation procedures in Greece, 18 centers (66.7%) contributed to the National Registry in 2008, 22 centers (81.5%) in 2009 and 19 centers (70.4%) in 2010 (Figure 1). The data collected comprised a total of 904 procedures (874 patients) in 2008, 1317 procedures (1244 patients) in 2009, and 1320 procedures (1226 patients) in 2010 (Figure 2). It is important to note that almost 50% of the total number of procedures were per-

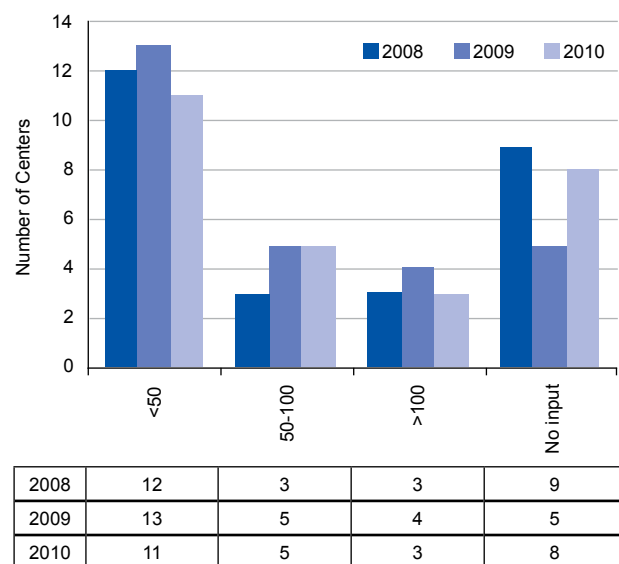


Figure 1. Distribution of centers according to procedures performed per year.

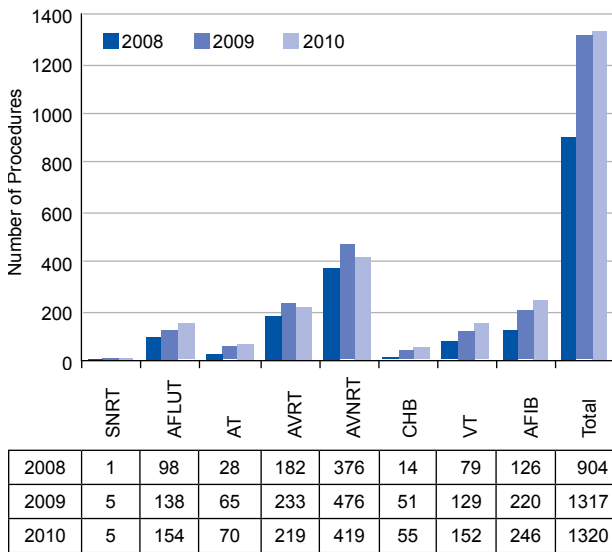


Figure 2. Number of ablation procedures per arrhythmia type in 2008-2010. SNRT – sinus node reentrant tachycardia; AFLUT – atrial flutter; AT – atrial tachycardia; AVRT – atrioventricular reentrant tachycardia; AVNRT – atrioventricular nodal reentrant tachycardia; CHB – ablation of the AV node and implantation of a pacemaker; VT – ventricular tachycardia; AFIB – atrial fibrillation.

formed in 3 and 4 centers in 2008 and 2009, respectively, whereas in 2010 >50% of the total number of procedures were performed in 3 centers (406 cases, 44.9% for 2008, 628 cases, 47.7% for 2009, and 663 cases, 50.3% for 2010). Conversely, 12 centers contributed <50 cases/year for 2008, 13 for 2009 and 11 for 2010 (Figures 1 & 3).

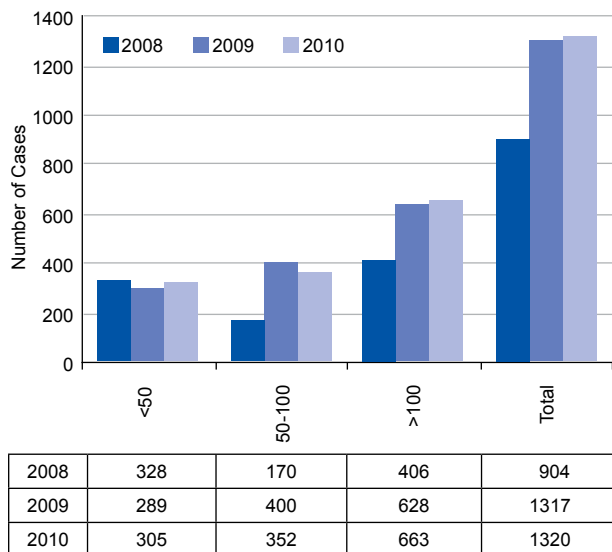


Figure 3: Number of cases performed per center category.

The demographic characteristics of the patients are presented in Table 1. The most common procedure was AVNRT ablation, accounting for 41.6%, 36.1% and 31.7% of the procedures in 2008, 2009 and 2010, respectively. The second most common procedure was for atrioventricular reentrant tachycardia (AVRT); cases with overt pre-excitation were most common. Atrial fibrillation (AF) was the third most common arrhythmia and it seems that RFA procedures are gradually increasing (Table 1, Figure 2).

The majority of the patients (85.6%) were free of structural heart disease and 92.3% had a left ventricular ejection fraction >50%. Syncope as manifestation of the tachycardia was present in 6% of the total population (Table 1).

Overall success rates were 93.1% for 2008, and 91.9% and 91.5% for 2009 and 2010, respectively. Success rates per procedure type are presented in Figure 4. The observed complication rate was 3%, while major complications were <1% (Figure 5). Overall relapse rate was 8.7% at 6 months. Relapse rates per type of procedure are shown in Figure 6. Complete heart block with implantation of a pacemaker and AVNRT had the lowest relapse rates (ranging from 0-2%), followed by AVRT (8-10%). Atrial tachycardia, ventricular tachycardia, atrial flutter and AF relapse rates ranged from 8-27%. A three-dimensional electroanatomic navigation system was used in 38.2% of the procedures (36.9%, 39% and 39.4%, respectively, in 2008, 2009 and 2010; Table 2). This increasing tendency is attributed to the increased use of the CARTO system (12.8%, 19% and 21.7% for years 2008-2010) by a single center, which doubled the number of AF ablations using that system. The percentage of cases performed with the NAV-X system declined from 2008, but remained stable in 2009 and 2010. The ENSITE system was used in 7.7% of cases in 2008, but declined in 2009 and 2010 (Table 2).

Mean radiation and procedure times are shown in Figures 7 and 8, respectively. The shortest times were observed for complete heart block induction and placement of a pacemaker, and the longest times were observed for AF ablation. AVNRT was the second shortest procedure in duration.

AVNRT ablation

A total of 1271 AVNRT ablation procedures were registered, accounting for 35.9% of the total. Success

Table 1. Epidemiological characteristics of registry patients.

	2008	2009	2010
Number of patients	874	1244	1226
Number of procedures	904	1317	1320
Age (years), (range)	51.3 (5-90)	50.1 (6-90)	49.8 (2-90)
Gender (male/female, %)	53.8 / 46.2	56.3 / 43.7	58.7 / 41.3
Structural heart disease (%):			
None	85.7	86.4	84.5
MI	2.4	4.7	7.1
COCM	1.1	2	2.4
HOCM	0.6	0.7	0.4
Other	10.2	6.3	5.5
Syncope (%)	6.4	5.1	6.8
Ejection Fraction (%):			
>50%	93.7	92.4	91
35-50%	4.6	3.7	4.3
<35%	1.7	3.9	4.6
Tachycardia type (%):			
SNRT	0.1	0.4	0.4
AT-R	2	3	3.1
AT-L	1.5	1.8	3.1
AFLUT-R	10.2	10	11.1
AFLUT-L	0.6	0.6	0.3
AFIB	16.4	21.2	22.3
AVRT-WPW	12.6	9.6	9.1
AVRT-CONC	7	7.3	7.1
AVNRT	40.9	36.5	32
VT	8.6	9.6	11.5
VF	0.1	0	0

MI – myocardial infarction; COCM – congestive cardiomyopathy; HOCM – hypertrophic cardiomyopathy; SNRT – sinus node reentrant tachycardia; AT-R – right atrial tachycardia; AT-L – left atrial tachycardia; AFLUT-R – right atrial flutter; AFLUT-L – left atrial flutter; AFIB – atrial fibrillation; AVRT-WPW – atrioventricular reentrant tachycardia involving an overt accessory pathway; AVRT-CONC – atrioventricular reentrant tachycardia involving a concealed accessory pathway; AVNRT – atrioventricular nodal reentrant tachycardia; VT – ventricular tachycardia; VF – ventricular fibrillation.

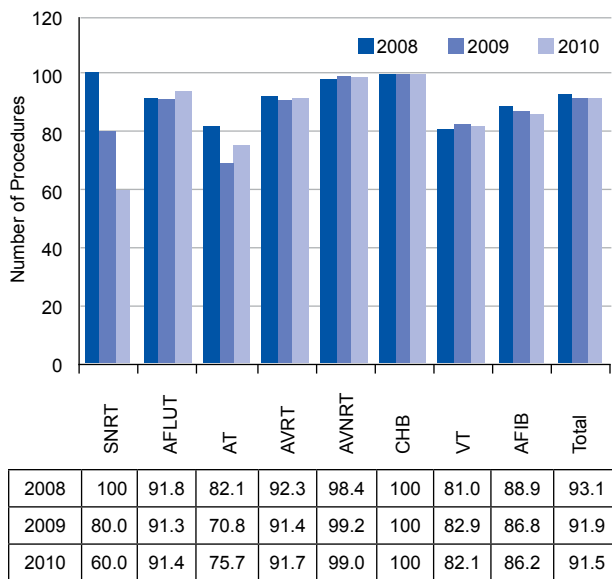


Figure 4. Success rates (%) per procedure category. Abbreviations as in Figure 2.

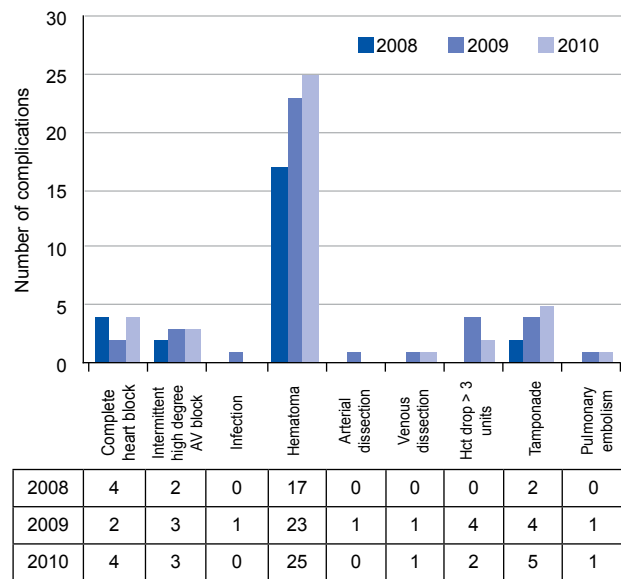


Figure 5. Total reported complications, regardless of procedure type.

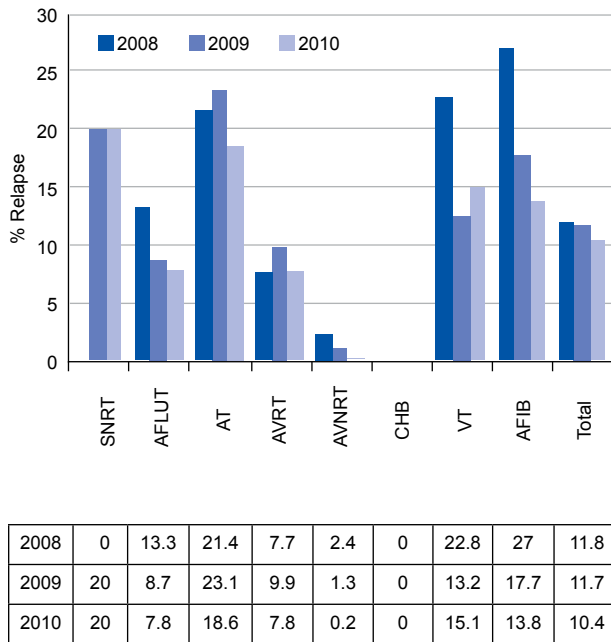


Figure 6. Relapse rates per procedure. Abbreviations as in Figure 2.

rates were 98.4% in 2008, 99.2% in 2009 and 99% in 2010 (Figure 4). Relapse rates at 6 months were 2.4%, 1.3% and 0.2% in 2008, 2009 and 2010, respectively (Figure 6).

Atrial fibrillation ablation

There were 592 (16.7%) cases of AF ablation. In most cases, the isolation of pulmonary veins was performed for each individual vein (66.6% of total cases; Figure 9). Although in 2008 in almost 50% of cases the left atrial roof and mitral isthmus were targeted, in 2009 and 2010 these techniques were applied less frequently (Figure 9). The reported acute successful isolation rate for the pulmonary veins was reported as up to 88%, but the 6-month relapse rate of the arrhythmia was 27%, 17.7% and 13.8% for 2008, 2009 and 2010, respectively (Figures 4 & 6).

Table 2. Distribution of mapping systems. CARTO, NAV-X and ENSITE are three-dimensional electroanatomical systems.

(%)	2008	2009	2010
CARTO	12.8	19	21.7
NAV-X	16.4	13.3	13.4
ENSITE	7.7	6.7	4.3
Other	63.1	61	60.6

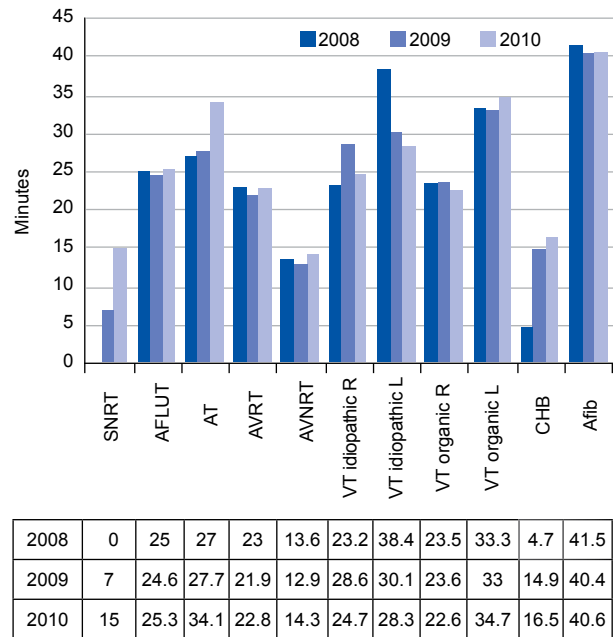


Figure 7. Radiation times per procedure in minutes (including the radiation time of the basic electrophysiology study).

VT idiopathic R – idiopathic ventricular tachycardia originating from the right ventricle; VT idiopathic L – idiopathic ventricular tachycardia originating from the left ventricle; VT organic R – organic ventricular tachycardia originating from the right ventricle; VT organic L – organic ventricular tachycardia originating from the left ventricle. Other abbreviations as in Figure 2.

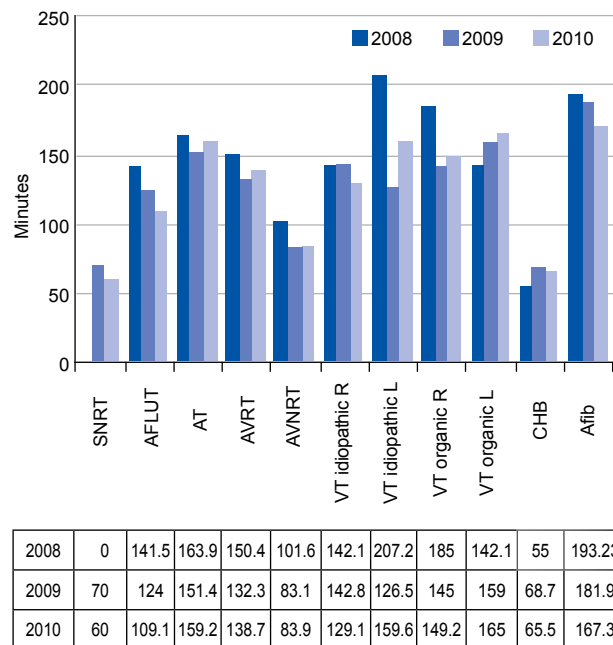
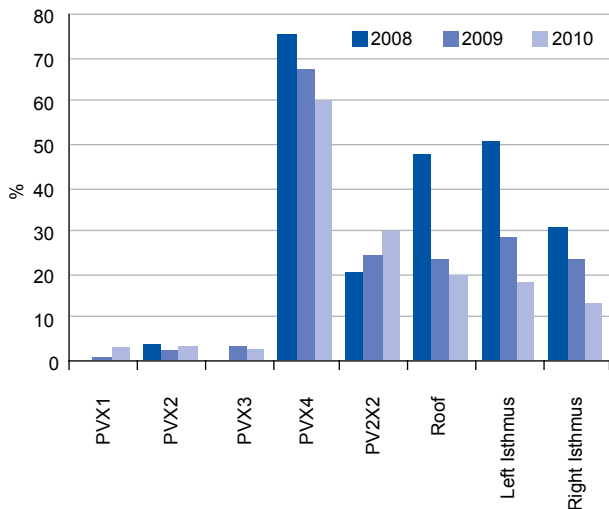


Figure 8. Procedure times per procedure in minutes (including the procedure time of the basic electrophysiology study). Abbreviations as in Figures 2 & 7.



	2008	2009	2010
0	0	0.9	3.3
4	4	3.2	3.7
0	0	3.6	2.8
75.4	75.4	68.6	60.2
20.6	20.6	23.6	30.1
49.2	49.2	23.2	20.3
50.8	50.8	29.5	18.3
31	31	23.2	13.4

Figure 9. Percentage of atrial fibrillation ablation procedures per technique used. PVX1 – isolation of one pulmonary vein; PVX2 – isolation of two pulmonary veins; PVX3 – isolation of three pulmonary veins; PVX4 – isolation of all four pulmonary veins independently; PV2X2 – isolation of all four pulmonary veins in pairs; Roof – ablation line at the roof of left atrium; Left isthmus – ablation line at the mitral isthmus; Right isthmus – ablation line at the tricuspid isthmus.

Accessory pathways

Atrioventricular reentrant tachycardia (AVRT) ablation procedures (n=634) accounted for 17.9% of the total; 468 (73.8%) of them were associated with Wolff-Parkinson-White (WPW) syndrome. Among the WPW cases, the most common location of the accessory pathway was left lateral (40.6%), followed by right posteroseptal (23.7%), left posteroseptal (17.1%), right anteroseptal (9.8%) and right lateral (8.8%) (Table 3). AVRT ablation was successful in 92.3%, 91.4% and 91.7% of cases for years 2008-2010

Table 3. Distribution of different types of accessory pathways. Numbers are percentages.

%	2008	2009	2010	Total (%)
Left lateral	42.7	42.8	36.2	40.6
Right anteroseptal	7.3	10.8	11.2	9.8
Right lateral	6.7	6	13.8	8.8
Right posteroseptal	23.3	22.9	25	23.7
Left posteroseptal	20	17.5	13.8	17.1

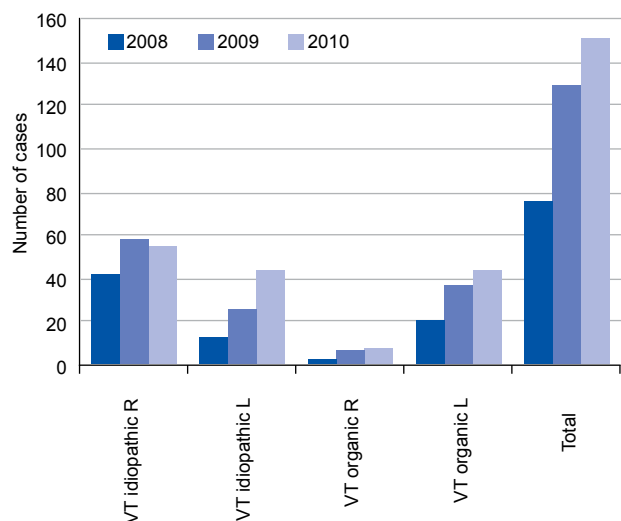
(Figure 4). Relapse rate was 7.7% in 2008, 9.9% in 2009 and 7.8% in 2010 (Figure 6).

Atrial flutter

There were 390 cases of atrial flutter ablation (11% of total procedures), the majority of which (92.3%) originated from the right atrium. Success rates were 91.8%, 91.3% and 94.1% for years 2008-2010 (Figure 4), and the 6-month relapse rates were 13.3%, 8.7% and 7.8%, respectively (Figure 6).

Ventricular tachycardia

Ablation of ventricular tachycardias (VT) (n=360) accounted for 10.2% of the total procedures. The most common type of VT was idiopathic VT originating from the right ventricle (43.1%), followed by VT due to structural left ventricular disease (28.6%) (Figure 10). The overall success rate of VT ablation was 81%, 82.9% and 82.1% respectively in 2008-2010, but success rates varied from 66.7% to 89.7% according to VT type (Figure 11). The 6-month relapse rate after VT ablation dropped from 22.8% in 2008 to 13.2% in 2009 and 15.1% in 2010, and varied among different types of VT, with the highest relapse rates



	2008	2009	2010
42	42	58	55
13	13	26	44
3	3	7	9
21	21	38	44
79	79	129	152

Figure 10. Ventricular tachycardia (VT) ablation procedures per type of tachycardia. Abbreviations as in Figure 7.

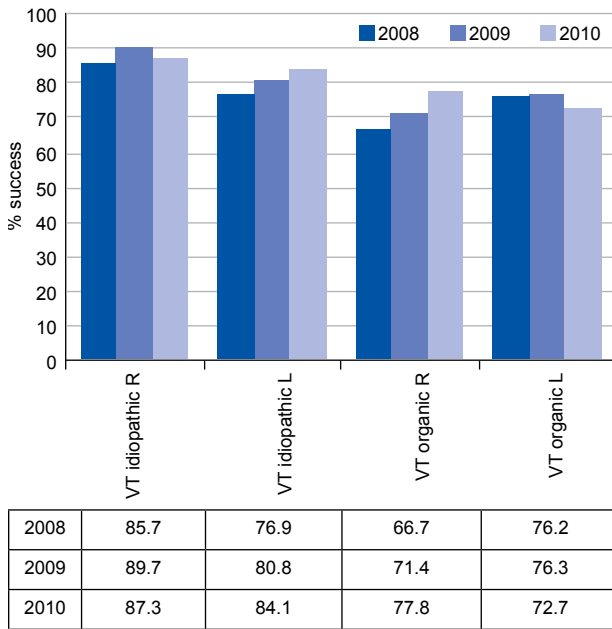


Figure 11. Success rates (%) per type of VT ablation procedure. Abbreviations as in Figure 7.

observed in cases of VT associated with right ventricular structural disease (Figure 12).

Atrial tachycardia

There were 163 cases of atrial tachycardia ablation (4.6% of total). Success rates were 82.1% in 2008, 70.8% in

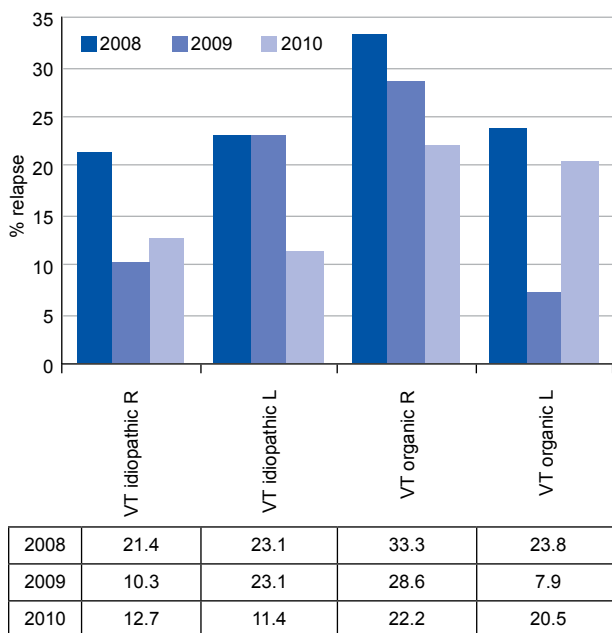


Figure 12. Ventricular tachycardia relapse rates (%) after successful ablation. Abbreviations as in Figure 7.

2009 and 75.7% in 2010 (Figure 4). Relapse rates were among the highest, ranging from 18-24% (Figure 6).

Sinus node reentrant tachycardia

Ablation for sinus node reentrant tachycardia was very uncommon (1 case in 2008, 5 cases in 2009 and 5 cases in 2010) and was associated with a 72.7% success rate and a 18.2% relapse rate (Figures 4 & 6, respectively).

Atrioventricular nodal ablation and pacemaker implantation

There were 120 cases of AV nodal ablation (3.4% of total procedures). As expected, all were successful with no relapse.

Discussion

This is the first report of the National Registry for all ablation procedures, presenting data from 3541 ablations performed in 3344 patients (including children)⁹ in 23 centers during the period 2008-2010 in Greece. Similar registry data in Europe have been reported by Spain,¹⁰ Portugal,¹¹ and Italy.¹² The number of participating centers and the procedures registered met the initial expectations of the designers of the program. The feedback from the users was positive, reporting ease in entering and editing the data. The precision and clarity used in coding and the limitation of the required data to essential items contributed to the acquisition of a consistent data set with few missing values, which made all analyses easy and reliable. Furthermore, the number of ablation procedures registered was the largest ever reported in Greece. A previous study by Theodorakis et al¹³ reported a total of 1513 ablations for the years 1993-1998 in Greece.

At the time of writing, there are 27 centers, located in 24 hospitals, licensed for performing RFA procedures in Greece (8 university, 8 NHS, 2 military, 2 semi-private, and 7 private). Over the 2008-2010 period, 4 centers (2 public and 2 private) out of the 27 centers licensed to perform RFA procedures consistently did not enter data. This can be attributed to the lack of an electrophysiologist over the specified time period, to the small number of cases performed, or to technical reasons. In addition, in 2008 and in 2010 two high-volume centers did not register their procedures. This could account for an additional estimated number of 200-250 cases, especially for the year 2008.

(The estimated number of ablations performed in 2008 and reported in the 2009 EHRA White Book¹⁴ was 1213, with 164 AF ablation cases, based on data obtained from the industry: i.e. ablation catheters sold by the major catheter ablation makers.) This discrepancy between the data reported in the White Book and the data entered in the National Registry for the year 2008 was due to the fact that in 2008, which was the first year of data collection, most centers delayed significantly in entering their cases in the database, and therefore the deadline for the 2009 EHRA White Book could not be met (which is why the industry-derived data were submitted to the 2008 EHRA White Book). Also, for the 2009 period, 1192 procedures were registered initially, and at the time the Hellenic Working Group reported this number for the 2010 EHRA White Book.¹⁵ In 2010, five centers added additional data for the 2009 period, which increased the total number of procedures for that year. It is important to point out that entering data into this new National Ablation Registry is not obligatory by law, although this has been suggested, as part of the training requirements in Electrophysiology proposed to the Ministry of Health by the Hellenic Working Group of Pacing and Electrophysiology.¹⁶

More than half of the procedures reported in 2008 and in 2010 were performed in three centers, two from Athens (Evangelismos, Henri Dunant) and one from Thessaloniki (AHEPA). These centers consistently registered more than 100 cases/year. Two high-volume centers were merged and appeared as a single center in 2010 (Henri Dunant and Red Cross hospitals). In contrast there were 12 low-volume centers, which reported a mean of less than 50 procedures per year (Figure 1).

The most frequent procedure was AVNRT ablation, followed by accessory pathway mediated tachycardia. The distribution of tachycardia ablation types in our series is similar to the published Greek¹³ and European Registries' data.¹⁰⁻¹²

Regarding AF ablation, all centers reported low numbers of procedures compared to the European standards. Although the number of cases performed almost doubled in two centers in 2009, it still remains low. A possible explanation for this is the portion of the clinical workload of the electrophysiologists that is relevant or non-relevant to electrophysiology (clinical work in cardiology wards and follow up of patients), their involvement in all electrophysiology cases (EP studies, ablations of all kinds, implantation of devices), and the lack of dedicated EP laboratories for AF ablation. The

majority of the cases were paroxysmal AF cases. The 4 pulmonary veins were targeted independently (most cases) or in pairs 2 by 2. Three centers in almost half of the cases targeted, in addition to the pulmonary veins, the roof and the left isthmus, one almost never used this technique, and one center used additional ablation lines as routine. This was more pronounced in 2008, but was less used in years 2009 and 2010 (Figure 9). In recent years it has become clear that simple pulmonary vein isolation as the initial procedure for paroxysmal AF cases is enough, leaving the addition of more lines for redo or persistent or permanent AF cases. The majority of AF cases performed were paroxysmal and this explains the change of practice in years 2009 and 2010 in the main AF ablation centers in Greece.

The procedures performed were in line with current recommendations for ablation procedures.^{17,18} The success and complication rates were satisfactory and similar to those previously reported in the USA and Europe,^{3,10-12,19} reflecting the high level of electrophysiology expertise in Greece – although in a recent survey in our country it was reported that general practitioners and internists were more reluctant to refer patients for ablation therapy.²⁰ Similar trends in the management of AF have been recorded in another survey performed by our group in Greece.²¹ AF ablation was characterized by a high success rate, higher than the average from high-volume European and American centers. The reported number in our series refers to the acute isolation of the pulmonary veins, and not the actual clinical outcome, hence the higher number. In contrast the 6-month relapse rate was relatively high. However, relapse after AF ablation has been reduced in 2009 and 2010 compared to 2008, which is most probably related to the learning curve of the procedure. The VT ablation success rate was also among the lowest, with high relapse rates, especially in cases with structural heart disease.²²

Limitations

Participation in this National Registry is not obligatory by law, and therefore the reported numbers represent data from only 70% of the licensed centers in Greece. Our initial experience, though, is very satisfactory, since all but one of the high-volume centers contributed their cases to the database, thus minimizing the amount of missing data.

Another potential problem one might point out is the reliability of the original data, since there is no other way to check their correctness. This is a

common problem in almost all registries. Since the electrophysiology community in Greece is relatively small, we believe that the data are accurate, because most senior operators have a good idea about the approximate number of cases performed in neighboring centers, thus this may work as a feedback “reliability” mechanism. The accuracy of the data could be improved further if a central quality control mechanism was implemented. The Working Group has proposed the latter to the Ministry of Health.¹⁶

Conclusions

The three first years of the implementation of the National Registry of ablation procedures in the routine clinical practice of licensed electrophysiology laboratories across Greece have been successful regarding the number of participating centers and the volume of the information collected. Key points in achieving these favorable results were the easy-to-use interface of the electronic application and the previously described need for a national documentation of the ablation procedures performed in Greece. The initial report of the Registry has revealed a high-volume and high-quality practice of various ablation procedures. Further analysis of the data collected and future reports of the Registry are expected to expand ablation performance and improve its results in Greece.

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Appendix

This is the list of electrophysiologists to whom a password and access to the Registry for data input was provided at the time of the database design. During the 3-year period, some of them did not activate their passwords, and in some centers where more than one person was authorized, a single person using one password entered the relevant data. All clinically active electrophysiologists from each center are not included in this list. Also during the 3-year period some electrophysiologists changed their place of work. They are listed according to their place of work in 2008.

AHEPA University Hospital, 1st Cardiology Division, Medical School of Thessaloniki, Thessaloniki	S. Paraskevaidis , V. Vassilikos
Alexandra University Hospital, Medical School of Athens, Athens	S. Chatzidou, S. Rokas
Attikon University Hospital, 2nd Cardiology Division, Medical School of Athens, Athens	N. Dargres, P. Flevari, D. Lefteriotis, E. Simeonidou
Chatzikosta University Hospital, Medical School of Ioannina, Ioannina	T. Kolettis
Henri Dunant Hospital, Athens	G. Theodorakis
Euroclinic Hospital, Athens	D. Katritsis
Evangelismos Hospital, 1st Cardiology Division, Athens	G. Andrikopoulos, K. Kappos, A. Manolis
Evangelismos Hospital, 2nd Cardiology Division, Athens	M. Efremidis, A. Sideris
Geniko Kratiko Hospital, Athens	S. Defteraios, N. Michelekakis, I. Rendoukas,
Hygeia Hospital, Athens	T. Apostolopoulos, C. Vassilopoulos
Iatriko Athinon, Athens	I. Gialafos
Ippokraton University Hospital, 1st Cardiology Division, Medical School, University of Athens, Athens	K. Gatzoulis
Ippokraton University Hospital, 2nd Cardiology Division, University of Thessaloniki, Thessaloniki	G. Sakadamis
Ippokraton University Hospital, 3rd Cardiology Division, Medical School of Thessaloniki, Thessaloniki	V. Skeberis
Metropolitan Hospital, Athens	P. Ioannidis, X. Kosteas, T. Mesiskli
Mitera Childrens' Hospital, Athens	J. Papagiannis
Nikaia General Hospital, Piraeus	A. Kotsakis
Onassis Cardiothoracic Center, 1st Cardiology Division, Athens	T. Maounis
Onassis Cardiothoracic Center, 2nd Cardiology Division, Athens	E. Livanis
Papanikolaou General Hospital, Thessaloniki	N. Frangakis, K. Polymeropoulos
Peripheral University Hospital, Medical School, University of Crete, Heraklion	E. Kanoupakis, E. Manios
Red Cross Hospital, Athens	A. Katzivas
Rio University Hospital, Medical School of Patras, Patras	J. Chiladakis
St. Lukas Hospital, Thessaloniki	E. Chatzinikolaou
1st IKA hospital, Athens	S. Gaitanidou
251 General Air Force Hospital, Athens	J. Kourgianidis
401 General Military Hospital, Athens	D. Kalpakos