

Editorial

Current Situation of the Treatment of Arrhythmias in Children in Spain. Finding a Place of its Own

Estado actual del tratamiento de las arritmias en la edad pediátrica en España. Buscando su espacio

Ferran Rosés-Noguer^{a,b,c,d,*} and Ángel Moya-Mitjans^{c,d}

^a Servei de Cardiologia Pediàtrica, Hospital Universitari Vall d'Hebron, Barcelona, Spain

^b Paediatric Cardiology Department, Royal Brompton Hospital, NHS Foundation Trust, London, United Kingdom

^c Unitat d'Arrítmies, Servei de Cardiologia, Hospital Universitari Vall d'Hebron, Barcelona, Spain

^d Instituto de Medicina y Cardiología, Unitat d'Arrítmies, Hospital Universitari Dexeus, Barcelona, Spain



Article history:

Available online 9 August 2018

Cardiac arrhythmias are relatively common in the pediatric age. The yearly estimated incidence of supraventricular tachycardia in persons younger than 19 years is 13 cases per 100 000 population.¹ Currently, the safety and effectiveness of percutaneous ablation treatment in this population is considered comparable to that of adults undergoing cardiac ablation, although the number reported is considerably smaller. Most literature on pediatric cardiac ablation is from multicenter registries in the United States,²⁻⁴ where these patients are treated in referral units with a large volume of cases, exceeding 100 per year. This factor has been associated with better clinical outcomes.⁵ Nonetheless, some recent reports from European countries have shown similar effectiveness and safety results, even though the number of cases treated is significantly smaller.^{6,7}

Regardless of the health care setting, ablation in pediatric patients, particularly those younger than 12 years, involves specific clinical characteristics, technical requisites, and management requirements. Hence, the professionals attending these patients should be well prepared to carry out the procedure with guaranteed safety and resolve any unforeseen complications that may arise.

TREATMENT INDICATIONS

The guidelines for the diagnosis and treatment of arrhythmias in pediatric patients and those with congenital heart disease (CHD) from AEPC/EHRA in 2013¹ and PACES/HRS in 2016⁸ provide specific information on the etiology, epidemiology, diagnosis, and treatment strategies for cardiac ablation in patients 0 to 18 years of age (Table).

Although these 2 guidelines are similar in general terms, there are some slight differences in the indications provided. For example, the class I indications for patients with Wolff-Parkinson-White syndrome: although both guidelines include as a class I indication the presence of this syndrome in patients with an

episode of resuscitated sudden cardiac death and in patients with syncope and an RR interval < 250 ms during atrial fibrillation (corresponding to a heart rate of 240 bpm) or an accessory conduction pathway effective refractory period < 250 ms, the American guidelines also include syncope with more than 1 accessory pathway as a risk factor. Furthermore, the guidelines differ regarding the treatment of paroxysmal supraventricular tachycardia (PSVT) without pre-excitation in patients with no heart disease. In these cases, the AEPC/EHRA guidelines only include PSVT associated with severe ventricular dysfunction as a class I indication. In the HRS/PACES guidelines, apart from ventricular dysfunction, a class I indication is also given to cases of recurrent or incessant PSVT in which medication is ineffective or poorly tolerated in patients weighing more than 15 kg, in patients with hemodynamic deterioration with syncope as a symptom associated with PSVT, and in cases with an electric cardioversion requirement for initial treatment in patients weighing more than 15 kg. Lastly, family preference is also included as a class I indication in patients with weight higher than 15 kg.

For the treatment of ventricular arrhythmias, the guidelines show no relevant differences. Both have a class I indication for patients with symptomatic ventricular tachycardia (VT) when drug therapy is ineffective in controlling the arrhythmia. The HRS/PACES guidelines also include a class I indication for intolerance to medication and for family preference as an alternative to medical therapy in patients weighing more than 15 kg.

Specific indications for arrhythmia ablation treatment in patients with CHD are only provided in the American guidelines. These include a class I indication for patients with PSVT related to specific CHDs, such as twin atrioventricular nodes or other CHD-related accessory pathways when medication is not effective or produces intolerable adverse effects. A class I indication is also assigned to ablation of multiple accessory pathways in patients with Ebstein anomaly, and to ablation of atrial arrhythmia outside the immediate postoperative period (3-6 months following surgery) when medical treatment is not effective and produces important adverse effects. Finally, a class I recommendation is included for VT in CHD patients with an implantable automatic defibrillator experiencing several episodes of tachycardia despite drug therapy and adequate device reprogramming, with the aim of avoiding activation of multiple shocks.

SEE RELATED CONTENT:

<https://doi.org/10.1016/j.rec.2018.01.007>

* Corresponding author: Servei de Cardiologia Pediàtrica, Hospital Universitari Vall d'Hebron, Pg. de la Vall d'Hebron 119-131, 08035 Barcelona, Spain.

E-mail address: froses@vhebron.net (F. Rosés-Noguer).

<https://doi.org/10.1016/j.rec.2018.07.004>

1885-5857/© 2018 Sociedad Española de Cardiología. Published by Elsevier España, S.L.U. All rights reserved.

Table

Comparison of the Class I Indications for Ablation Between the European and American guidelines

Patient group	AEPC/ESC 2013 class I recommendations	HRS/PACES 2016 class I recommendations
Indications for patients with WPWS	<ol style="list-style-type: none"> 1. Patients with WPWS and a resuscitated sudden death episode 2. Patients with WPWS and syncope with an RR interval < 250 ms during atrial fibrillation, or an accessory pathway effective refractory period < 250 ms 3. Patients with WPWS and palpitations with inducible and sustained PSVT on EPS 	<ol style="list-style-type: none"> 1. Patients with WPWS and a resuscitated sudden death episode 2. Patients with WPWS and syncope with an RR interval < 250 ms during atrial fibrillation, or an accessory pathway effective refractory period < 250 ms, or the presence of multiple pathways
Indications for PSVT	<ol style="list-style-type: none"> 1. PSVT associated with severe ventricular dysfunction 	<ol style="list-style-type: none"> 1. PSVT associated with severe ventricular dysfunction in patients > 15 kg 2. Recurrent or incessant PSVT when medication is not effective or poorly tolerated in patients > 15 kg 3. Documented recurrent or incessant PSVT when the family wishes to avoid chronic drug therapy in patients > 15 kg 4. Documented recurrent PSVT that poses an emergency for the patient or requires electric cardioversion in patients > 15 kg
Indications for VT	<ol style="list-style-type: none"> 1. Monomorphic VT with hemodynamic compromise treatable by catheter ablation 	<ol style="list-style-type: none"> 1. Focal VT or VE causing ventricular dysfunction when medication is not effective or causes intolerable adverse effects, as an alternative option in patients > 15 kg 2. PFVT, OTVT, or VT with syncope when medication is not effective or causes intolerable adverse effects, as an alternative option in patients > 15 kg
Indications for patients with CHD		<ol style="list-style-type: none"> 1. PSVT related to specific CHDs, such as twin atrioventricular nodes or other CHD-related accessory pathways when medication is not effective or causes intolerable adverse effects 2. A Wolff-Parkinson-White pattern and multiple risk pathways in patients with Ebstein anomaly weighing > 15 kg 3. Ablation of atrial arrhythmias outside the immediate postoperative period (3-6 months following surgery) if medical therapy is not effective and causes important adverse effects 4. VT in patients with CHD and an implantable automatic defibrillator with multiple VT episodes despite drug therapy and appropriate device reprogramming

AEPC/ESC, Association for European Paediatric and Congenital Cardiology/European Society of Cardiology; CHD, congenital heart disease; EPS, electrophysiology study; HRS/PACES, Heart Rhythm Society/Pediatric and Congenital Electrophysiology Society; OTVT, outflow tract ventricular tachycardia; PFVT, posterior fascicular ventricular tachycardia; PSVT, paroxysmal supraventricular tachycardia; VE, ventricular extrasystoles; VT, ventricular tachycardia; WPWS, Wolff-Parkinson-White syndrome

Both guidelines include a specific mention regarding cardiac ablation in lactating infants and children younger than 5 years, as there is sufficient evidence to consider the patient's weight as an independent risk factor for severe complications, including some reported deaths.⁹ Up to now, the AEPC/EHRA guidelines have defined these as patients weighing < 15 kg, but in the latest American guidelines this limit has been slightly modulated, with smaller patients being referred to as those weighing less than "approximately 15 kg". Despite this slight difference in the definition, there is consensus that professionals should be more restrictive with the indications in this age group, and attempt to optimize medical therapy by including several drug combinations to delay cardiac ablation. In addition, the following measures are recommended: 1) that these procedures should be carried out by electrophysiologists with experience in pediatric patients; 2) that ablation should be performed with a tailored strategy that minimizes the number of applications; and 3) that cryoablation should be used before radiofrequency in substrates carrying an elevated risk of atrioventricular block. Finally, special mention is made of the subgroup of smallest patients, weighing between 3 and 7 kg or younger than 6 months, in whom ablation should only be performed for life-threatening cardiac arrhythmia after failure of several combinations of antiarrhythmic drugs.

EFFECTIVENESS AND COMPLICATIONS OF PEDIATRIC CARDIAC ABLATION

Data on the effectiveness of ablation mainly come from retrospective and prospective registries in the United States,

which have shown a rise in the rate of effective ablations from 90.4% in the 1991 to 1996 period to 95.2% from 1996 to 1999.^{2,3} These results are very similar to those observed in a prospective registry including 2761 patients from 41 centers, reporting an overall effectiveness rate of 93%.⁴ To date, there are 2 population registries of pediatric ablation procedures in Europe, 1 in Finland⁶ and 1 in the Czech Republic,⁷ which show an overall final effectiveness rate similar to the values in the American registries, specifically 91% and 96%, respectively. Recent nonpopulation studies have reported very high effectiveness (> 98.5%) in both pediatric patients (< 12 years) and adolescents, although with a higher complication rate in the group younger than 12 years of age (5.4%) and a slightly higher recurrence rate (25.5% vs 17.6%).¹⁰ Furthermore, the effectiveness of ablation varied according to the substrate treated: highest in ablation of nodal reentrant tachycardia (effectiveness 95%-99%), followed by ablation of left lateral pathways (effectiveness > 95% in all series), and focal atrial tachycardias (effectiveness 93%). In contrast, the right lateral, right septal, and left septal pathways show lower effectiveness values ranging from 80% to 90%, similar to those obtained in VT ablation (effectiveness around 75%-80%).

Cryoablation use for the treatment of various substrates has been described in several studies in pediatric patients, with immediate effectiveness rates of 83% to 98% for nodal reentrant tachycardia, which is somewhat lower than the values obtained with radiofrequency (95%-100%). These procedures are also associated with a higher rate of recurrent arrhythmias than radiofrequency ablation: between 0% and 28%, depending on the series. These data concur with those reported in a recent meta-analysis comparing radiofrequency ablation and cryoablation for

the treatment of nodal reentrant tachycardia. Specifically, initial overall effectiveness was nonsignificantly lower with cryotherapy (relative risk [RR] = 1.44; 95% confidence interval [95%CI], 0.91-2.28), but cryotherapy had a higher associated recurrence rate (RR = 3.66; 95%CI, 1.84-7.28).¹¹

In patients with CHD, ablation of accessory pathways provides slightly poorer results than those reported for patients without CHD (effectiveness 80%-85%¹²). The effectiveness of ablation for macroreentrant atrial tachycardia is also lower in pediatric patients with CHD than in those without (66%-97%), and recurrence rates are higher (10%-60%). The results seem to be poorer in patients with transposition of the great arteries repaired using the Senning/Mustard techniques, in those with single ventricle heart defects, patients undergoing surgical repair at advanced ages, and those treated with procedures involving nonirrigated catheters. These data are similar to those obtained in adult patients with CHD undergoing atrial arrhythmia ablation.¹³

The most severe immediate adverse effects are permanent atrioventricular block, an acute coronary lesion, cardiac perforation, vascular lesions, and even procedure-related death. Stochastic effects of radiation are included in the long-term adverse effects. Considering that medical therapy is avoided or discontinued in more than 60% of pediatric patients who have undergone ablation and that the majority have no other comorbidities,⁷ a severe complication could have particularly dramatic consequences for the quality of life of these children. Thus, it is especially important to prioritize drug therapy for the smallest patients, maximize safety measures during the ablation procedure, use electroanatomic navigation systems, and render the technique less aggressive by nonirrigated catheter use, cryoablation therapy in substrates near the conduction system, and limiting the number, duration, and energy of the applications.¹⁴

CURRENT SITUATION OF PEDIATRIC ABLATION IN SPAIN

Although the use of ablation techniques in the pediatric age has a long history in Spain, data have been available from only a few centers up to now.^{15,16} The initial experience with ablation in 5 infants younger than 1 year was reported in 1997,¹⁵ and in 1998, an initial experience in a larger case series was described: 117 patients younger than 18 years, with an immediate effectiveness rate of 93% and a recurrence rate of 8%.¹⁶ The recent article by Alonso-García et al.¹⁷ published in *Revista Española de Cardiología* is very welcome for several reasons, but particularly because it includes a large population and describes a 12-year experience in a referral center. The findings emphasize the importance of performing these procedures in centers equipped with an arrhythmia unit with extensive experience in all substrates in CHD patients, a pediatric cardiology department with special dedication to arrhythmias, a pediatric surgery department, a pediatric anesthesia department particularly devoted to pediatric cardiology, and a stable program of collaboration between all these units. The authors should be congratulated for their excellent success and complication rates, which are in accordance with data from the literature. Without a doubt, this study supports the idea that pediatric ablation can be implemented successfully, but always in centers meeting these characteristics.

As one of the differential aspects between ablations performed in the adult and pediatric populations is the indications, it is interesting to note the small percentage of treated patients weighing less than 15 kg, which account for only 7.6% of cases in the reported series. These data are in line with the current recommendations regarding these patients. Even so, it would be interesting to have information on the indications for these ablations and the drug therapy used before ablation was indicated.

One relevant factor in the article by Alonso-García et al.¹⁷ is the use of cryoablation in 35.5% of the patients. In this study and in the literature, the effectiveness and recurrence rates associated with cryoablation are higher than with radiofrequency; hence, it would have been interesting to have a description of the indications for the use of one or other energy source, as well as some details regarding the selection of the energy source in the discussion, considering that the authors report a very low atrioventricular block rate in ablations for nodal reentrant tachycardia. It would also have been of interest to have additional information on the indications for using navigation systems.

Of special note, pediatric ablations, including this series, have been recorded separately in the Spanish ablation registry for the last 2 years. Data from the 2016 registry¹⁸ show that pediatric procedures accounted for only 2.3% of the total and were performed in numerous centers. The professionals responsible for the ablation registry and the centers that carry out these procedures and record the results should be congratulated for this initiative, which raises awareness that the indications for children should be differentiated from those of adults. It also underscores the need to separately consider the success and complication rates in the 2 populations. Another fact reflected in the registry is the dispersion regarding care for pediatric patients in our country, with 369 ablation procedures carried out in 35 centers. Considering the importance of having a sufficient case volume to minimize the potentially negative effect of the learning curve in these patients,¹⁹ perhaps we should consider centralizing these procedures in referral centers. These should have fully equipped electrophysiology units and a high volume of cases, cardiology departments for pediatric patients and adults with teams experienced in CHD and equipped for radiofrequency ablation, cryoablation and electroanatomic navigation, a pediatric surgery team available 24/7, and pediatric intensive care units with experience in the management of patients with heart disease.

CONFLICTS OF INTEREST

None declared.

REFERENCES

1. Brugada J, Blom N, Sarquella-Brugada G, et al. Pharmacological and non-pharmacological therapy for arrhythmias in the pediatric population: EHRA and AEP-Cardiac Arrhythmia Working Group joint consensus statement. *Europace*. 2013;15:1337-1382.
2. Kugler JD, Danford DA, Deal BJ, et al. Radiofrequency catheter ablation for tachyarrhythmias in children and adolescents. *The Pediatric Electrophysiology Society. N Engl J Med*. 1994;330:1481-1487.
3. Kugler JD, Danford DA, Houston KA, Felix G. Pediatric Radiofrequency Ablation Registry of the Pediatric Radiofrequency Ablation Registry of the Pediatric Electrophysiology Society. Pediatric radiofrequency catheter ablation registry success, fluoroscopy time, and complication rate for supraventricular tachycardia: comparison of early and recent eras. *J Cardiovascular Electrophysiol*. 2002;13:336-341.
4. Van Hare GF, Javitz H, Carmelli D, et al. Prospective assessment after pediatric cardiac ablation: demographics, medical profiles, and initial outcomes. *J Cardiovasc Electrophysiol*. 2004;15:759-770.
5. Triedman JK, Pfeiffer P, Berman A, et al. COMPASS: a novel risk-adjustment model for catheter ablation in pediatric and congenital heart disease patients. *Congenit Heart Dis*. 2013;8:393-405.
6. Hiippala A, Happonen JM. Population-based single-center outcome for pediatric catheter ablation of common supraventricular tachycardias. *Pacing Clin Electrophysiol*. 2015;38:115-119.
7. Kubuš P, Vít P, Gebauer RA, et al. Long-term results of paediatric radiofrequency catheter ablation: a population-based study. *Europace*. 2014;16:1808-1813.
8. Philip Saul J, Kanter RJ, et al. WRITING COMMITTEE. PACES/HRS expert consensus statement on the use of catheter ablation in children and patients with congenital heart disease: Developed in partnership with the Pediatric and Congenital Electrophysiology Society (PACES) and the Heart Rhythm Society (HRS). Endorsed by the governing bodies of PACES, HRS, the American Academy of Pediatrics (AAP), the

- American Heart Association (AHA), and the Association for European Pediatric and Congenital Cardiology (AEPC). *Heart Rhythm*. 2016;13:e251-e289.
9. Blafox AD, Felix GL, Saul JP. Radiofrequency catheter ablation in infants ≤ 18 months old: when is it done and how do they fare?.: short-term data from the Pediatric Ablation Registry. *Circulation*. 2001;104:2803-2808.
 10. Chen TH, Tsai ML, Chang PC, et al. Risk factors of recurrence and complication in radiofrequency catheter ablation of atrioventricular reentrant tachycardia in children and adolescents. *Cardiol Young*. 2013;23:682-691.
 11. Hanninen M, Yeung-Lai-Wah N, Massel D, et al. Cryoablation versus RF ablation for AVNRT: A meta-analysis and systematic review. *J Cardiovasc Electrophysiol*. 2013;24:1354-1360.
 12. Chetaille P, Walsh EP, Triedman JK. Outcomes of radiofrequency catheter ablation of atrioventricular reciprocating tachycardia in patients with congenital heart disease. *Heart Rhythm*. 2004;1:168-173.
 13. Roca-Luque I, Rivas Gándara N, Dos Subirà L, et al. Intra-atrial re-entrant tachycardia in patients with congenital heart disease: factors associated with disease severity. *Europace*. 2017. Disponible en: <https://doi.org/10.1093/europace/eux180>.
 14. Blafox AD, Paul T, Saul JP. Radiofrequency catheter ablation in small children: relationship of complications to application dose. *Pacing Clin Electrophysiol*. 2004;27:224-229.
 15. Benito F, Sanchez C. Radiofrequency catheter ablation of accessory pathways in infants. *Heart*. 1997;78:160-162.
 16. Brugada Terradellas J, Rissech Payret M, Mont Girbau L, et al. Treatment of cardiac arrhythmia with radiofrequency in pediatrics. *An Esp Pediatr*. 1998;48:385-388.
 17. Alonso-García A, Atienza F, Ávila P, et al. Ablación pediátrica con catéter: características y resultados del procedimiento en un centro terciario de referencia. *Rev Esp Cardiol*. 2018;71:794-800.
 18. 16th Official Report of the Spanish Society of Cardiology Working Group on Electrophysiology and Arrhythmias (2016) Fontenla A, García-Fernández J, Ibáñez JL. Spanish Catheter Ablation Registry collaborators. Spanish Catheter Ablation Registry. *Rev Esp Cardiol*. 2017;70:971-982.
 19. Danford DA, Kugler JD, Deal B, et al. The learning curve for radiofrequency ablation of tachyarrhythmias in pediatric patients. Participating members of the Pediatric Electrophysiology Society. *Am J Cardiol*. 1995;75:587-590.