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From ECG to Ablation: A Modern Review of Wolff-Parkinson-White Syndrome

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Abstract

Introduction and purpose

Wolff-Parkinson-White (WPW) syndrome is a clinical manifestation of pre-excitation syndrome, characterized by the congenital presence of an additional conduction pathway in the form of a muscle fibre - Kent's bundle between the atria and ventricles, resulting in paroxysmal supraventricular tachycardia and increasing the risk of sudden cardiac death when atrial fibrillation occurs.

The aim of this study is to show a structured knowledge of the pathophysiology and epidemiology, clinical manifestations, diagnosis, risk assessment and management of Wolff-Parkinson-White syndrome based on a review of the literature, Pubmed and Google Scholar databases.

Description of state of knowledge

Based on current data, the prevalence of electrographic features of pre-excitation is estimated at 0.15-0.25% in the general population. The presence of an additional conduction pathway between the ventricles, predominantly conducting impulses like healthy His and Purkinje fibres, results in a characteristic ECG pattern, allowing the diagnosis of pre-excitation syndrome. Each excitation from sinoatrial node is conducted not only by the physiological pathway, but also by an accessory pathway, the clinical consequences of which will be the occurrence of supraventricular tachycardias such as an orthodromic and antidromic atrioventricular reentrant tachycardia (AVRT), atrial fibrillation or even the ventricular fibrillation, which can be the first symptom of the syndrome. The diagnosis is aided by electrophysiology studies (EPS) to confirm the presence of an accessory pathway, with usually simultaneous invasive treatment - percutaneous ablation, which is also a causal therapy with an efficacy of approximately 92%. Pharmacological treatment of patients with WPW is based on group IA and IC antiarrhythmic drugs, but these act only for symptoms, they are ineffective in eliminating the underlying cause of disease.

Conclusions

The development of cardiology and electrophysiology, as well as the possibility of applying ablation in patients with Wolff-Parkinson-White syndrome, has made this condition curable. Despite the generally low risk of sudden cardiac death (SCD), it is important to properly assess the factors that may contribute to ventricular fibrillation.

Key words: Wolff-Parkinson-White syndrome, sudden cardiac arrest, sudden cardiac death, accessory pathway, AVRT, radiofrequency ablation, pre-excitation

1. Introduction

Wolff-Parkinson-White (WPW) syndrome is rare, but important condition that affects the electrical system of the human heart, leading to episodes of arrhythmias. It occurs when an extra electrical pathway, known as an accessory pathway (AP), forms in early stage of embryological differentiation between the heart's upper and lower chambers. This abnormal pathway can cause arrhythmias, leading to symptoms like palpitations, dizziness, and even fainting. While WPW syndrome can be diagnosed in individuals of all ages, as a congenital abnormality, it is often identified in young, otherwise healthy individuals. Though it is generally manageable with treatment, if left untreated, it can increase the risk of more severe complications, including sudden cardiac arrest. In this article, we will explore the causes, symptoms, diagnosis, and treatment options for Wolff-Parkinson-White syndrome, shedding light on this intriguing cardiac disorder and how it can be effectively managed.

2. Definitions and epidemiology

WPW syndrome is a main type of pre-excitation syndrome, a congenital abnormality characterized by the presence of at least one muscular bundle that allows electrical activation of part of the ventricle outside the normal conduction system, bypassing it [1,5]. This muscular bundle is a so-called Kent's bundle. The terms "WPW pattern" and "WPW syndrome" are commonly used to describe patients with ventricular pre-excitation, but they do not denote equivalent concepts. The "WPW pattern" refers to the ECG findings that show ventricular pre-excitation (shortening of PR interval and the presence of delta wave), while "WPW syndrome" refers to the combination of these ECG findings along with symptoms that suggest arrhythmia related to the pre-excitation, such as palpitations, occasional dizziness, near-fainting, syncope, or even cardiac arrest [7]. The prevalence of WPW pattern is 0,15% - 0,25%, moreover, it is estimated that one-third of these individuals will experience arrhythmias over a 10-year period of follow-up [8,9,10,11]. It is indispensable to acknowledge the potential for an increased incidence of APs, attributable to the existence of latent accessory pathways. This term refers to an AP that is undetectable or only minimally visible, primarily due to its location or because of fast conduction through the atrioventricular node (AVN). Concealed AP refers to an AP that conducts only retrograde [6].

Wolff–Parkinson–White syndrome is diagnosed 1,5 - 2 times more frequently in men than in women, though this gender disparity is not seen in children [1,3]. Brugada et al. [6] highlight

that multiple pathways are found in fewer than 12% of adult patients with pre-excitation, whereas in less than 9% of the pediatric population [12]. Additionally, multiple APs occur in patients with structural heart disease, around 50% in patients with Ebstein's anomaly [13].

In the majority of cases, WPW syndrome is observed in structurally normal hearts, but there is an association with some congenital heart disease such us Ebstein's anomaly, mitral valve prolapse syndrome, hypertrophic cardiomyopathy (HCM), aortic stenosis or transposition of the great arteries [14]. Uncommon inherited forms of pre-excitation, which are linked to left ventricular hypertrophy and multisystem disorders, have also been reported. These include mutations in the PRKAG2 gene (encoding the gamma 2 subunit of AMP-activated protein kinase), as well as conditions like Danon disease and Fabry disease, among others [6].

3. Patophysiology

The accessory atrioventricular (AV) conduction pathway arises during fibrous ring development as a congenital anomaly. From a histological perspective, the cells of the APs are typical working myocardium, with connexin43 gap-junction distribution common for such cells [1,15], which, unlike AVN, usually transmit fast, with no-delay [7], likewise Purkinje fibers. Approximately 8% of the accessory pathways present decremental conduction. Those bypass tracts frequently occur in the posteroseptal region and conduct only retrograde [1].

While most APs conduct impulses in both the anterograde and retrograde directions, some transmit signals in only one direction. Pathways that conduct exclusively in the anterograde direction are rare (≤10%), while those that only conduct retrogradely (concealed APs) are more common (≤50%) [6]. The last-mentioned manifests only with AVRT and on resting ECG pre-excitation pattern cannot be detected, hence, their true occurrence is unidentified [29].

The majority of APs are located on the left side, regardless of demographic factors. About 60% are situated along the mitral valve and are called left free wall APs. Around 25% are located at the septal side of the mitral or tricuspid annulus, while approximately 15% are found along the right free wall [6]. However, Jamal SZ. et al. described a significant association between the gender of the patient and the localization of accessory pathway. Left anterior (LA) and left lateral (LL) were found in 48% of the males, followed by right postertoseptal (RPS) at 20.4%. Whereas, RPS was found in 33.9% of the females, followed by LL and LA pathways in 32.2%. The least common pathway amongst both genders is the

mid-septum pathway, while males are generally predominant in patients with this particular pathway [16].

4. Clinical symptoms

Patients with a WPW pattern who have not experienced any arrhythmias will typically be asymptomatic, meaning their medical history and physical examination will generally appear normal. The pattern may have been identified on a previous ECG, and the patient might be aware of their condition. However, some accessory pathway conduction can be transient or hidden, which could result in previous ECGs being normal or intermittently normal [17].

The clinical presentation of WPW syndrome is typically non-specific, highly variable, depending on AP location and conduction properties and, crucially, is often associated with arrhythmic episodes [3]. Patients with a WPW syndrom, who develop a tachyarrhythmia, commonly experience symptoms related to the arrhythmia, such as palpitations, chest pain, shortness of breath, dizziness, lightheadedness, presyncope, and most worrisome: syncope, collapse, and in even sudden cardiac death [17], which may be the first symptom of WPW syndrom.

The main tachyarrhythmias found in populations with Wolff-Parkinson-White syndrome are atrioventricular re-entrant tachycardia (AVRT), categorized into orthodromic and antidromic conduction, and atrial fibrillation (AF). Others, such as atrial tachycardia, atrial flutter or atrioventricular nodal reciprocating tachycardia (AVNRT) are infrequent, where AP do not play an important role in the mechanism of re-entry [6].

Orthodromic AVRT stands for 90-95% of re-entrant tachycardia among patients with AP, which involves a circuit that first conducts in the anterograde direction through the AV node and His-Purkinje system, followed by conduction through the ventricle. This is followed by retrograde conduction through the accessory pathway (AP), completing the circuit by returning through the atrium to the AV node [5]. Orthodromic AVRT is typically a rapid tachycardia, with heart rates usually ranging from 150 to, in rare cases, over 220 beats per minute. Throughout the circuit, ECG displays narrow QRS (specifically, when patient presents pre-existed or rate-related bundle branch block), RP interval constant and, usually but not invariably, up to one-half of the tachycardia cycle length ST segment depression [5,6].

On the other hand, antidromic AVRT appears in 3-8% of patients [18,19,20]. In contrary to orthodromic AVRT, this tachyarrhythmia transmits anterograde from the atrium through the AP, to the ventricle, which results in wide QRS. The retrograde limb are Purkinje cells and His bundle or another AP, conducting back to the AVN. In 30-60% of patients with

spontaneous antidromic AVRT, multiple accessory pathways (either manifest or concealed), which may or may not function as the retrograde limb during the AVRT, can be identified [6]. Paroxysmal AF occurs in up to 38-50% of patients with WPW. While atrial fibrillation can occasionally originate on its own, it is more commonly caused by elevated atrial pressure resulting from decreased ventricular filling time, which is triggered by oAVRT. Manifest APs with rapid anterograde conduction and a short refractory period may lead to life-threatening ventricular fibrillation (VF) and SCD [3,6,21].

5. Diagnostics

The resting ECG in terms of WPW pattern have main typical features: shortening of PR interval (≤120ms), prolonged QRS duration (>120ms) and the slurred upstroke (or downstroke) of QRS complex (a delta wave). The lack of this pattern does not exclude the possibility of an accessory pathway, as some pathways can conduct impulses only under specific conditions or in a retrograde direction [17]. Pre-excitation on the surface ECG can be temporary and may even resolve permanently in up to 35% of cases over time. Additionally, the extent of pre-excitation can vary depending on the location of the AP and the conduction properties of the AVN. [1,6]. The ECG in WPW syndrome can be deceptive and may result in the incorrect diagnosis of various other ECG-clinical conditions [22-24]. When the interpretation of ECG causes difficulties, the examination can be repeated after administration intravenous 6 mg of adenosine, which will block the AVN node and the AP will be revealed [1].

The direction of the delta wave and the shape of QRS have become the basis of assessment of localization of AP [1]. Various algorithms, including those by Pambrum, Arruda, Chiang, St George or Milstein have been employed to predict the location of the accessory pathway, utilizing different electrocardiographic criteria derived from delta wave analysis. Some can be applied for either children and adults, whereas others exclusively for a specific age group. One of the most recent studies, from El Hamriti M. et al,, developed an algorithm, EASY-WPW, which applied to the overall study population outperformed Pambrun or Arruda systems in accuracy [3, 25].

6. Risk assessment

The non-decremental nature of conduction is a key factor in the potential for sudden death in individuals with WPW syndrome. Due to the possibility of an absent delay in conduction between the atria and ventricles, atrial fibrillation—where atrial rates can reach up to >350

beats per minute—may result in rapid ventricular depolarization. This can lead to dangerously high ventricular rates, which have the potential to progress into ventricular fibrillation (VF) [7]. Moreover, despite being quite rare and unusual, sudden death may be the first manifestation of pre-excitation syndrome, particularly in the children and young adults population [26].

The risk of cardiac arrest in asymptomatic patients with WPW is very low, and the risk of death is even lower, with the rate of cardiac arrest ranging from 0.85 to 1.5 per 1000 patient years [7], though it can not be unacknowledged.

High-risk features that should be estimated on clinical evaluation are: young age (approximately first two decades of life) of detecting WPW pattern, male sex, familial WPW syndrome (PRKAG2 gene mutation), history of symptomatic tachycardia, history of atrial fibrillation, concomitant congenital heart disease, especially Ebstein's anomaly. It needs to be emphasized that the functional properties of the accessory pathways might change in the setting of adrenergic stress as encountered in sporting or other activities during daily life, so risk factors such as a profession of high public responsibility should be taken into consideration [5,27].

All patients with WPW syndrome should undergo risk stratification due to the potential risk of sudden death. This can be achieved through both invasive and non-invasive methods. The aim is to evaluate the anterograde refractory period of the accessory pathway, which serves as a surrogate marker for the conduction rate over the pathway during atrial fibrillation [3,28].

Non-invasive tests involve 12-lead ECG, 24h ECG Holter monitoring and exercise testing or interpretation of ECG after the administration of procainamide, propafenone, or disopyramide [1,3]. The abrupt loss of delta wave and normalization of PR interval during above mentioned methods has been identified as markers of low risk. However, the varying sensitivity of accessory pathways changes in adrenergic stimulation and makes the clinical utility of non-invasive tests questionable [6].

Electrophysiological study (EPS) is an invasive diagnostic procedure used to assess accessory pathways. It allows to verify the presence of accessory pathways, their number, location, conduction properties, descending and retrograde refractoriness, to induce tachyarrhythmias and is commonly an introduction to the catheter ablation [1].

The key measures evaluated during EPS at baseline and amid catecholamine infusion are the shortest pre-excited RR interval in atrial fibrillation (SPERRI), the accessory pathway effective refractory period (APERP), and the shortest pre-excited paced cycle length during atrial pacing (SPPCL). Above mentioned parameters aim to determine the anterograde

conduction over the APs and therefore, the risk of VF. It is also crucial to assess inducibility (and, ideally, hemodynamic tolerance) of sustained arrhythmias such as orthodromic atrioventricular reentrant tachycardia (oAVRT), atrioventricular reentrant tachycardia (aVRT), and atrial fibrillation (AF), as these are common triggers for VF or sudden cardiac arrest (SCA) [3].

SPERRI ≤250ms at baseline and AP ERP <240 ms are considered to be high-risk electrophysiological factors of SCD [30, 31, 32]. The rationale of performing an EP study in pre-excitation are symptoms to risk-stratify for life-threatening arrhythmias events and asymptomatic population of competitive athletes or with high risk occupations and findings suggesting an increased chance of sudden arrhythmic events on non-invasive testing [27].

7. Treatment

The management of patients with WPW syndrome differs depending on the presence of symptoms. Acute therapy of tachyarrhythmias should be concentrated on ceasing the recurrent conduction over the AV node and APs. In AVRT, vagal maneuvers, including Valsalva and carotid sinus massage, should be a first-choice procedure to intermit the supraventricular tachycardia since they can be done quickly. However, in hemodynamically unstable patients or when drug therapy is ineffective, synchronized electric cardioversion should be performed. Adenosine should be administered carefully when treating AVRT, due to the risk of triggering fast atrial fibrillation, which could be conducted over the anterograde AP to the rapid ventricular rate and further to the VF. Pharmacological therapy includes drugs acting on the AVN, such as beta-blockers, diltiazem or verapamil or on the AP - antiarrhythmic drugs - ibutilide, procainamide, propafenone, or flecainide, which are preferred in antidromic AVRT. Additionally, in the case of treatment-resistant antidromic AVRT, amiodarone may be considered [6].

In pre-excited atrial fibrillation (AF), electric cardioversion is a primary approach, especially in hemodynamically unstable patients. Administration of ibutilide, propafenone, procainamide or flecainide could also be effective in restoring the sinus rhythm. However, it is important to emphasize that IC (flecainide, propafenone) drug agents are not without risk, as they may impact the AV node. Intravenous digoxin, intravenous amiodarone, intravenous or oral beta blockers, diltiazem, and verapamil are potentially harmful for treatment in patients with pre-excited AF [3, 6, 27, 34].

Catheter ablation in WPW syndrome turned out as a breakthrough in its management, providing a high success rate of >94%, with a recurrence rate of 6.2% and a complication rate

of 1% [35], emerging as the preferred method that is potentially accessible to all WPW patients. The method is stated to be first-line therapy for patients with symptomatic and recurrent AVRT or pre-excited AF. Borregaard et al. evaluated that the patients with radiofrequency ablation(RFA)-treated WPW syndrome have a post-procedure mortality comparable with the background population, also emphasized that RFA do not seem to decrease the incidence of AF after the procedure [2]. Ablation of APs in septal or midseptal areas or near coronary sinus are related with lower succession rate, respectively 50%, 73%, 50% [35, 36]. Serious complications, such as third-degree atrioventricular block (0,17 - 2,7%) or cardiac tamponade (0,13 - 1,1%) were associated with ablation of AP localized in the intraventricular septum [38]. Marazzato J et al. achieved a lower frequency of AV block while using cryoenrgy during ablation [39], however, the recurrence of previously blocked pathways has been found to be considerably greater when cryoenergy is applied [40].

The most challenging for cardiologists is the management of individuals with only the WPW pattern. For patients with asymptomatic and infrequent episodes, treatment decisions should weigh the overall risks and benefits of the invasive nature of ablation against the long-term commitment to pharmacological therapy. Recent guidelines suggest that invasive screening using an EPS is now advised for individuals in high-risk occupations or competitive athletes, and it should also be considered for other patients. The catheter ablation in asymptomatic patients is recommended when during EPS high-risk factor for SCD such as SPERRI ≤250ms, AP ERP ≤250ms, multiples APs and inducibility of AVRT are identified. In this population, it is important to discuss the risks and benefits of the procedure, especially of heart block associated with ablation of septal APs [6]. Telishevska M. et al. reached a 91% success rate during ablation in 182 asymptomatic patients with WPW pattern, both children and adults, without major complications [41]. In children under 12 years old, the likelihood of a fatal event appears to be low, so a more cautious approach is typically recommended [42], however the findings of Pappone C. et al. registry from 2004 should reassure physicians and parents alike that in asymptomatic children with the Wolff–Parkinson–White syndrome who are at high risk for arrhythmias, ablation is an appropriate option [43].

Symptomatic patients with WPW syndrome, for whom ablation is not indicated or who have not consented to invasive treatment, may use antiarrhythmic drugs from group Ic to inhibit orthodromic AVRT, unless ischemic or structural heart disease has been excluded. If no pre-excitation is observed on resting ECG, the addition of a beta-blocker, verapamil, or digoxin should be considered [6]. It is important to note that persistent AVRT involving an accessory pathway can lead to tachyarrhythmic cardiomyopathy and heart failure [1].

8. Conclusion

Wolff-Parkinson-White syndrome, while a relatively rare condition, presents significant challenges in both diagnosis and management due to its potential for life-threatening arrhythmias, such as atrioventricular reentrant tachycardia (AVRT) and atrial fibrillation (AF), which can lead to sudden cardiac death. Advances in electrophysiology and the development of catheter ablation have provided a curative treatment option, significantly improving patient outcomes. Early identification through electrocardiographic (ECG) findings and electrophysiological studies is crucial for risk stratification and timely intervention. Although the risk of sudden cardiac death in asymptomatic individuals is low, those with high-risk features such as young age, symptomatic arrhythmias, or concomitant structural heart disease, should be closely monitored and appropriately treated. Radiofrequency ablation has emerged as the first-line therapy for symptomatic patients, offering a high success rate and low complication rate. As the understanding of WPW syndrome continues to evolve, personalized treatment plans, including careful consideration of ablation for asymptomatic patients with high-risk features, are key to optimizing patient care. Ultimately, proper risk assessment, timely intervention, and personalized management strategies can significantly reduce the risk of serious complications associated with this syndrome, improving both quality of life and long-term outcomes for affected individuals.

Authors contributions

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All authors declare that they have no conflicts of interest.

References

1. Szczeklik A., Interna Szczeklika., wyd. Medycyna Praktyczna, Kraków 2023.
2. Borregaard R, Lukac P, Gerdes C, Møller D, Mortensen PT, Pedersen L, Nielsen JC, Jensen HK. Radiofrequency ablation of accessory pathways in patients with the Wolff-Parkinson-White syndrome: the long-term mortality and risk of atrial fibrillation. Europace. 2015 Jan;17(1):117-22. doi: 10.1093/europace/euu176. Epub 2014 Jul 10. PMID: 25013013
3. Vătășescu RG, Paja CS, Șuș I, Cainap S, Moisa ȘM, Cinteză EE. Wolf-Parkinson-White Syndrome: Diagnosis, Risk Assessment, and Therapy-An Update. Diagnostics (Basel).

2024 Jan 30;14(3):296. doi: 10.3390/diagnostics14030296. PMID: 38337810; PMCID: PMC10855590.

4. Bengali R, Wellens HJ, Jiang Y. Perioperative management of the Wolff-Parkinson-White syndrome. J Cardiothorac Vasc Anesth. 2014 Oct;28(5):1375-86. doi: 10.1053/j.jvca.2014.02.003. Epub 2014 Jul 11. PMID: 25027102.
5. Bhatia A, Sra J, Akhtar M. Preexcitation Syndromes. Curr Probl Cardiol. 2016 Mar;41(3):99-137. doi: 10.1016/j.cpcardiol.2015.11.002. Epub 2015 Nov 10. PMID: 26897561.
6. Brugada J., Katritsis D.G., Arbelo E., Arribas F., Bax J.J., Blomström-Lundqvist C., Calkins H., Corrado D., Deftereos S.G., Diller G.-P., et al. 2019 ESC Guidelines for the management of patients with supraventricular tachycardia, The Task Force for the management of patients with supraventricular tachycardia of the European Society of Cardiology (ESC) Eur. Heart. J. 2019;41:655–720. doi: 10.1093/eurheartj/ehz467.
7. Kim SS, Knight BP. Long term risk of Wolff-Parkinson-White pattern and syndrome. Trends Cardiovasc Med. 2017 May;27(4):260-268. doi: 10.1016/j.tcm.2016.12.001. Epub 2016 Dec 5. PMID: 28108086.
8. Munger TM, Packer DL, Hammill SC, Feldman BJ, Bailey KR, Ballard DJ, Holmes DR Jr, Gersh BJ. A population study of the natural history of Wolff-Parkinson-White syndrome in Olmsted County, Minnesota, 1953-1989. Circulation. 1993 Mar;87(3):866-73. doi: 10.1161/01.cir.87.3.866. PMID: 8443907.
9. SMITH RF. THE WOLFF-PARKINSON-WHITE SYNDROME AS AN AVIATION RISK. Circulation. 1964 May;29:672-9. PMID: 14153940.
10. CHUNG KY, WALSH TJ, MASSIE E. WOLFF-PARKINSON-WHITE SYNDROME. Am Heart J. 1965 Jan;69:116-33. doi: 10.1016/0002-8703(65)90224-3. PMID: 14253091.
11. Krahn AD, Manfreda J, Tate RB, Mathewson FA, Cuddy TE. The natural history of electrocardiographic preexcitation in men. The Manitoba Follow-up Study. Ann Intern Med. 1992 Mar 15;116(6):456-60. doi: 10.7326/0003-4819-116-6-456. PMID: 1739235.
12. Weng KP, Wolff GS, Young ML. Multiple accessory pathways in pediatric patients with Wolff-Parkinson-White syndrome. Am J Cardiol. 2003 May 15;91(10):1178-83. doi: 10.1016/s0002-9149(03)00263-7. PMID: 12745099.
13. Cappato R, Schlüter M, Weiss C, Antz M, Koschyk DH, Hofmann T, Kuck KH. Radiofrequency current catheter ablation of accessory atrioventricular pathways in Ebstein's anomaly. Circulation. 1996 Aug 1;94(3):376-83. doi: 10.1161/01.cir.94.3.376. PMID: 8759079.

14. Cain N, Irving C, Webber S, Beerman L, Arora G. Natural history of Wolff-Parkinson-White syndrome diagnosed in childhood. Am J Cardiol. 2013 Oct 1;112(7):961-5. doi: 10.1016/j.amjcard.2013.05.035. Epub 2013 Jul 2. PMID: 23827401.

15. Peters NS, Rowland E, Bennett JG, Green CR, Anderson RH, Severs NJ. The Wolff-Parkinson-White syndrome: the cellular substrate for conduction in the accessory atrioventricular pathway. Eur Heart J. 1994 Jul;15(7):981-7. doi: 10.1093/oxfordjournals.eurheartj.a060619. PMID: 7925521.

16. Jamal SZ, Zaidi KA, Sheikh SA, Ahmed A, Irfan G, Qadir F. Localization Of Accessory Pathways In Wolff Parkinson White Syndrome Using R/S Ratios On Surface Ecgs. J Ayub Med Coll Abbottabad. 2019 Apr-Jun;31(2):146-150. PMID: 31094105.

17. Chhabra L, Goyal A, Benham MD. Wolff-Parkinson-White Syndrome. 2023 Aug 7. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. PMID: 32119324.

18. Packer DL, Gallagher JJ, Prystowsky EN. Physiological substrate for antidromic reciprocating tachycardia. Prerequisite characteristics of the accessory pathway and atrioventricular conduction system. Circulation. 1992 Feb;85(2):574-88. doi: 10.1161/01.cir.85.2.574. PMID: 1735153.

19. Brembilla-Perrot B, Pauriah M, Sellal JM, Zinzius PY, Schwartz J, de Chillou C, Cismaru G, Beurrier D, Voilliot D, Selton O, Louis P, Andronache M, Nosu R, de la Chaise AT. Incidence and prognostic significance of spontaneous and inducible antidromic tachycardia. Europace. 2013 Jun;15(6):871-6. doi: 10.1093/europace/eus354. Epub 2012 Nov 12. PMID: 23148120.

20. Ceresnak SR, Tanel RE, Pass RH, Liberman L, Collins KK, Van Hare GF, Gates GJ, Dubin AM. Clinical and electrophysiologic characteristics of antidromic tachycardia in children with Wolff-Parkinson-White syndrome. Pacing Clin Electrophysiol. 2012 Apr;35(4):480-8. doi: 10.1111/j.1540-8159.2011.03317.x. Epub 2012 Feb 10. PMID: 22324823.

21. Deneke T, Mügge A. Atrial fibrillation and Wolff-Parkinson-White syndrome: mechanisms revisited? J Cardiovasc Electrophysiol. 2012 Mar;23(3):287-9. doi: 10.1111/j.1540-8167.2011.02236.x. Epub 2011 Dec 15. PMID: 22171958.

22. Ruskin JN, Akhtar M, Damato AN, Ticzon AR, Lau SH, Caracta AR. Abnormal Q waves in Wolff-Parkinson-White syndrome. Incidence and clinical significance. JAMA. 1976 Jun 21;235(25):2727-30. PMID: 946885.

23. Chung EK. Electrocardiography. Practical Applications With Vectorial Principles. Hagerstown, MD: Harper and Row; 1974.

24. SEARS GA, MANNING GW. The Wolff-Parkinson-White pattern in routine electrocardiography. Can Med Assoc J. 1962 Dec 8;87(23):1213-7. PMID: 13987543; PMCID: PMC1920815.

25. El Hamriti M, Braun M, Molatta S, Imnadze G, Khalaph M, Lucas P, Nolting JK, Isgandarova K, Sciacca V, Fink T, Bergau L, Sohns C, Kiuchi K, Nishimori M, Heeger CH, Borlich M, Shin DI, Busch S, Guckel D, Sommer P. EASY-WPW: a novel ECG-algorithm for easy and reliable localization of manifest accessory pathways in children and adults. Europace. 2023 Feb 16;25(2):600-609. doi: 10.1093/europace/euac216. PMID: 36504238; PMCID: PMC9935024.

26. Yıldırım I, Özer S, Karagöz T, Şahin M, Özkutlu S, Alehan D, Çeliker A. Clinical and electrophysiological evaluation of pediatric Wolff-Parkinson-White patients. Anatol J Cardiol. 2015 Jun;15(6):485-90. doi: 10.5152/akd.2014.5462. Epub 2014 Jun 23. PMID: 26006136; PMCID: PMC5779142.

27. Page RL, Joglar JA, Caldwell MA, Calkins H, Conti JB, Deal BJ, Estes NA 3rd, Field ME, Goldberger ZD, Hammill SC, Indik JH, Lindsay BD, Olshansky B, Russo AM, Shen WK, Tracy CM, Al-Khatib SM; Evidence Review Committee Chair‡. 2015 ACC/AHA/HRS Guideline for the Management of Adult Patients With Supraventricular Tachycardia: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Circulation. 2016 Apr 5;133(14):e471-505. doi: 10.1161/CIR.0000000000000310. Epub 2015 Sep 23. Erratum in: Circulation. 2016 Sep 13;134(11):e232-3. doi: 10.1161/CIR.0000000000000447. PMID: 26399662.

28. Sethi KK, Dhall A, Chadha DS, Garg S, Malani SK, Mathew OP. WPW and preexcitation syndromes. J Assoc Physicians India. 2007 Apr;55 Suppl:10-5. PMID: 18368860.

29. Katritsis DG, Josephson ME. Differential diagnosis of regular, narrow-QRS tachycardias. Heart Rhythm. 2015 Jul;12(7):1667-76. doi: 10.1016/j.hrthm.2015.03.046. Epub 2015 Mar 28. Erratum in: Heart Rhythm. 2016 Feb;13(2):629. PMID: 25828600.

30. Pappone C, Vicedomini G, Manguso F, Saviano M, Baldi M, Pappone A, Ciaccio C, Giannelli L, Ionescu B, Petretta A, Vitale R, Cuko A, Calovic Z, Fundaliotis A, Moscatiello M, Tavazzi L, Santinelli V. Wolff-Parkinson-White syndrome in the era of catheter ablation: insights from a registry study of 2169 patients. Circulation. 2014 Sep

2;130(10):811-9. doi: 10.1161/CIRCULATIONAHA.114.011154. Epub 2014 Jul 22. PMID: 25052405.

31. Pappone C, Vicedomini G, Manguso F, Baldi M, Pappone A, Petretta A, Vitale R, Saviano M, Ciaccio C, Giannelli L, Calovic Z, Tavazzi L, Santinelli V. Risk of malignant arrhythmias in initially symptomatic patients with Wolff-Parkinson-White syndrome: results of a prospective long-term electrophysiological follow-up study. Circulation. 2012 Feb 7;125(5):661-8. doi: 10.1161/CIRCULATIONAHA.111.065722. Epub 2012 Jan 3. PMID: 22215859.

32. Klein GJ, Bashore TM, Sellers TD, Pritchett EL, Smith WM, Gallagher JJ. Ventricular fibrillation in the Wolff-Parkinson-White syndrome. N Engl J Med. 1979 Nov 15;301(20):1080-5. doi: 10.1056/NEJM197911153012003. PMID: 492252.

33. Pappone C, Santinelli V, Rosanio S, Vicedomini G, Nardi S, Pappone A, Tortoriello V, Manguso F, Mazzone P, Gulletta S, Oreto G, Alfieri O. Usefulness of invasive electrophysiologic testing to stratify the risk of arrhythmic events in asymptomatic patients with Wolff-Parkinson-White pattern: results from a large prospective long-term follow-up study. J Am Coll Cardiol. 2003 Jan 15;41(2):239-44. doi: 10.1016/s0735-1097(02)02706-7. PMID: 12535816.

34. Schiavone M, Filtz A, Gasperetti A, Zhang X, Forleo GB, Santangeli P, Biase LD. Pre-Excited Atrial Fibrillation in Wolff-Parkinson-White (WPW) Syndrome: A Case Report and a Review of the Literature. Rev Cardiovasc Med. 2024 Mar 29;25(4):125. doi: 10.31083/j.rcm2504125. PMID: 39076547; PMCID: PMC11263991.

35. Ibrahim Ali Sherdia AF, Abdelaal SA, Hasan MT, Elsayed E, Mare'y M, Nawar AA, Abdelsalam A, Abdelgader MZ, Adam A, Abozaid M. The success rate of radiofrequency catheter ablation in Wolff-Parkinson-White-Syndrome patients: A systematic review and meta-analysis. Indian Heart J. 2023 Mar-Apr;75(2):98-107. doi: 10.1016/j.ihj.2023.02.001. Epub 2023 Feb 8. PMID: 36758831; PMCID: PMC10123428.

36. Cain ME, Luke RA, Lindsay BD. Diagnosis and localization of accessory pathways. Pacing Clin Electrophysiol. 1992 May;15(5):801-24. doi: 10.1111/j.1540-8159.1992.tb06847.x. PMID: 1382283.

37. Krause U, Paul T, Bella PD, Gulletta S, Gebauer RA, Paech C, Kubus P, Janousek J, Ferrari P, De Filippo P. Pediatric catheter ablation at the beginning of the 21st century: results from the European Multicenter Pediatric Catheter Ablation Registry 'EUROPA'. Europace. 2021 Mar 8;23(3):431-440. doi: 10.1093/europace/euaa325. PMID: 33227133.

38. Jackman WM, Wang XZ, Friday KJ, Roman CA, Moulton KP, Beckman KJ, McClelland JH, Twidale N, Hazlitt HA, Prior MI, et al. Catheter ablation of accessory atrioventricular pathways (Wolff-Parkinson-White syndrome) by radiofrequency current. N Engl J Med. 1991 Jun 6;324(23):1605-11. doi: 10.1056/NEJM199106063242301. PMID: 2030716.

39. Marazzato J, Fonte G, Marazzi R, Doni LA, Mitacchione G, Vilotta M, De Ponti R. Efficacy and safety of cryoablation of para-Hisian and mid-septal accessory pathways using a specific protocol: single-center experience in consecutive patients. J Interv Card Electrophysiol. 2019 Jun;55(1):47-54. doi: 10.1007/s10840-018-0498-9. Epub 2019 Jan 3. PMID: 30603856.

40. Bravo L, Atienza F, Eidelman G, Ávila P, Pelliza M, Castellanos E, Loughlin G, Datino T, Torrecilla EG, Almendral J, Sánchez PL, Arenal Á, Martínez-Alzamora N, Fernández-Avilés F. Safety and efficacy of cryoablation vs. radiofrequency ablation of septal accessory pathways: systematic review of the literature and meta-analyses. Europace. 2018 Aug 1;20(8):1334-1342. doi: 10.1093/europace/eux269. PMID: 29036312.

41. Telishevska M, Hebe J, Paul T, Nürnberg JH, Krause U, Gebauer R, Gass M, Balmer C, Berger F, Molatta S, Emmel M, Lawrenz W, Kriebel T, Hessling G. Catheter ablation in ASymptomatic PEDiatric patients with ventricular preexcitation: results from the multicenter "CASPED" study. Clin Res Cardiol. 2019 Jun;108(6):683-690. doi: 10.1007/s00392-018-1397-x. Epub 2018 Dec 5. PMID: 30519781.

42. Pelliccia A, Sharma S, Gati S, Bäck M, Börjesson M, Caselli S, Collet JP, Corrado D, Drezner JA, Halle M, Hansen D, Heidbuchel H, Myers J, Niebauer J, Papadakis M, Piepoli MF, Prescott E, Roos-Hesselink JW, Graham Stuart A, Taylor RS, Thompson PD, Tiberi M, Vanhees L, Wilhelm M; ESC Scientific Document Group. 2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease. Eur Heart J. 2021 Jan 1;42(1):17-96. doi: 10.1093/eurheartj/ehaa605. Erratum in: Eur Heart J. 2021 Feb 1;42(5):548-549. doi: 10.1093/eurheartj/ehaa835. PMID: 32860412.

43. Pappone C, Manguso F, Santinelli R, Vicedomini G, Sala S, Paglino G, Mazzone P, Lang CC, Gulletta S, Augello G, Santinelli O, Santinelli V. Radiofrequency ablation in children with asymptomatic Wolff-Parkinson-White syndrome. N Engl J Med. 2004 Sep 16;351(12):1197-205. doi: 10.1056/NEJMoa040625. PMID: 15371577.