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Contributions of the Instituto Nacional de Cardiología in the diagnosis and treatment of the Wolff-Parkinson-White syndrome

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Abstract

Since the first description of the disease now known as Wolff-Parkinson-White syndrome, much knowledge has been gained through several experimental and clinical studies all over the world. The *Instituto Nacional de Cardiología Ignacio Chávez* in Mexico City has not been the exception. In this report, we describe the clinical, electrocardiographic and electrophysiologic contributions of past and present researchers at the Institute, as well as the experience in the diagnosis and treatment of the W-P-W syndrome at this *Instituto Nacional de Cardiología Ignacio Chávez*.

Contribuciones del Instituto Nacional de Cardiología al diagnóstico y tratamiento del síndrome de Wolff-Parkinson-White

Resumen

Desde la primera descripción de la enfermedad que ahora conocemos como Wolff-Parkinson-White, se ha acumulado una fuente importante de conocimientos a través de múltiples estudios clínicos y experimentales realizados en todo el mundo. El Instituto Nacional de Cardiología Ignacio Chávez no ha sido la excepción, en esta revisión se describen las contribuciones de los investigadores de dicho Instituto, tanto en los aspectos clínicos, electrocardiográficos y electrofisiológicos. Asimismo se presenta la experiencia del Instituto en el diagnóstico y tratamiento de esta entidad.

"No perdamos nada del pasado.
Sólo con el pasado se forma el porvenir."
Anatole France (1844-1924)

Introduction

Since the first description of the disease now known as Wolff-Parkinson-White (W-P-W) syndrome, much knowledge has been gained through several experimental and clinical

studies all over the world. The *Instituto Nacional de Cardiología Ignacio Chávez* in Mexico City has not been the exception. In this report, we describe the clinical, electrocardiographic and electrophysiologic contributions of past and present researchers at the Institute, as well as the experience in the diagnosis and treatment of the W-P-W syndrome at this *Instituto Nacional de Cardiología Ignacio Chávez*. We decided to present a summary of each of these contributions in order to honor the great effort that the authors

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undertook to perform these studies. We expect to offer the reader with a brief review of the historical advance of the knowledge that has been occurring in this passionate field. Contributions are presented in a chronological order, thus this journey begins with the analysis of the ECG findings and ends with the catheter ablation of accessory atrio-ventricular connections using radiofrequency current that is currently an established method for the treatment of patients with W-P-W syndrome.

Contribution to the study of the Wolff-Parkinson-White syndrome by means of endocavitary recordings¹

Sodi-Pallares *et al* studied in 1948 the intracavitary tracings of five subjects with W-P-W syndrome. They studied the intracavitary potential of the right atrium and ventricle. Tracings were registered in the atrium at high, medium and low levels. Different points were studied also in the right ventricular cavity. They used the classification of Rosenbaum, Hecht, Wilson and Johnston. They described not only intracavitary recordings, but also the characteristics of P wave and QRS complex characteristics. They also studied these characteristics in oesophageal leads. At that time, many hypotheses about the genesis of the W-P-W syndrome existed. They intended to explain their findings according to those theories. In that sense, the authors pursued to investigate whether some types of extrasystoles can produce, in the intracavity leads, similar tracings to those just described in the five cases they studied. They reported that it was possible to reproduce experimentally in dog, through the production of extrasystoles in certain regions of the interventricular septum, similar intracavitary potentials, in their general morphology as well as in the delta wave, to those found in human cases with W-P-W syndrome. They also performed electrical stimulation in an attempt to reproduce the W-P-W syndrome. They reported that mechanical stimulation of septal areas near the pulmonary *conus* in dogs, easily gives rise to automatic ectopic rhythms with a frequency similar to the sinus rhythm; in some moments rendering similar tracings to those of the syndrome. At the end, they stated that their results were in accord with two of the numerous hypotheses that existed at that time to explain the syndrome: a) the existence of a high septal ectopic focus (now abandoned); b) the extranodal activation through an anomalous pathway as the one described "very recently" (in 1947) by Segers, Sanabria, Lequime and Denolin in one case of W-P-W studied at autopsy (the validated one).

Effect of procainamide in the Wolff-Parkinson-White syndrome²

Zapata Díaz, Enrique Cabrera and collaborators reported in 1953 the electrocardiographic effect of intravenous procainamide in nine cases of W-P-W syndrome. They were motivated based on a communication presented at the Mexican Society of Cardiology by Dr. Bernal Tirado in 1951. The analysis of the ECG demonstrated that the preexcitation disappeared in all cases after the administration of procainamide. They published very nice ECG's before and

after the antiarrhythmic effect. They pointed out the importance of this effect for the diagnosis of the syndrome.

Wolff-Parkinson-White syndrome in Ebstein's disease³

The first communications on preexcitation syndrome insisted in the original observation of Wolff, Parkinson and White that the syndrome was associated with structurally normal hearts. Later on, its association with congenital heart disease was evident from many cases reported in the literature. However, by 1955 very few cases of W-P-W were reported to be associated with Ebstein's disease. These included one case report from Yater and Shapiro in 1937, and one case from Gotzche and Falholt in 1954. Four cases of W-P-W syndrome type B associated with Ebstein's disease were presented by Sodi-Pallares *et al* in 1955. They included two cases confirmed by autopsy (one of them was the one of Yater and Shapiro previously reported), one case sent for surgical correction of a possible pulmonary stenosis (in which the surgeon proved, by digital exploration through the right atrium, the abnormal insertion of the tricuspid valve), and the fourth case was not confirmed but the clinical picture, ECG, X-ray films and hemodynamics were highly suggestive of Ebstein's disease. They presented very nice ECG's of W-P-W syndrome, including one figure of the effect of procainamide. It is important to note that they stressed the fact that in cases with congenital heart anomalies and with W-P-W syndrome, the possibility of Ebstein's disease must be considered.

Ventricular activation in the Wolff-Parkinson-White syndrome⁴

In 1955, Sodi-Pallares, Abdo Bisteni and Gustavo Medrano decided to study one of the main mechanisms described for the genesis of the W-P-W syndrome, the premature activation of the ventricles. They designed a very clever experiment on dogs: they decided to study the process of ventricular activation in right septal extrasystoles (premature ventricular beats) with QRS morphology similar to that seen in W-P-W syndrome; they even named them as "extrasystoles of the W-P-W type". Based on this model they were able to reproduce, in the dog, ECG's of the W-P-W syndrome. They presented very explicit figures illustrating this fact. They performed a very elegant analysis of the morphology (and the explanation for each morphology) in three different conditions: a) W-P-W syndrome. b) Incomplete left bundle branch block. c) Right septal extrasystoles with morphology of W-P-W syndrome. They accompanied the explanation with a very nice figure. Maybe more relevant is the idea expressed by them, based on these observations, that in the W-P-W syndrome the activation of the right surface and of the free right ventricular wall is in advance, while, on the other hand, the activation of the left septal surface and of the free left ventricular wall occurs in a normal time sequence, suggesting that the stimulus arrived to the left ventricle by the left branch as in normal conditions (as it occurs in right accessory pathways). This concept has proven

to be fundamental to understand ventricular activation through accessory pathways.

Electro and vectorcardiographic studies in a case of Wolff-Parkinson-White syndrome with right bundle branch block due to Ebstein's disease⁵

In 1959, Enrique Cabrera and coworkers studied the ventricular activation from the electric and vectorcardiographic standpoints in a case of W-P-W syndrome associated with a right bundle branch block due to Ebstein's disease. Clinically it was the case of a nine year-old boy with non-cyanotic heart disease and a history of rheumatism, frequent bronchitis and repeated tonsillitis. Catheterization studies were unable to demonstrate shunts or abnormal intracardiac defects. There was a grade II systolic apical murmur and a four beat rhythm at the midprecordial area. Radiologic studies showed enlargement of the right atrium and right ventricle. The ECG showed a W-P-W syndrome of the B type with spontaneous variations (the Ohnell's "concertina" effect described in 1944, now known as "intermittent preexcitation") of such a nature that it changed from the typical morphologies of the syndrome (left bundle branch block image in this case) to those characteristics of complete right bundle branch block (due to the structural disease). There were transitions of apparent normalization but with a short P-R interval (now labeled "unapparent preexcitation"). The authors discussed the electrophysiological meaning of these alterations and suggested the manner of ventricular activation which in their estimation might take place in this case, in the light of the knowledge at that time of the electrophysiology of the heart in bundle branch blocks and in W-P-W syndrome. Clinically relevant, the authors stated that "*The coexisting alternation in the electrocardiogram of right bundle branch block with W-P-W...should lead us to suggest the possibility of Ebstein's disease...*"

A cohort of 70 cases of Wolff-Parkinson-White syndrome⁶

In 1966, Carlos Gausí *et al* reviewed all the cases of W-P-W syndrome seen at the *Instituto Nacional de Cardiología Ignacio Chávez* in Mexico City. They found 70 cases out of 100 000 files, representing the 0.7 per cent of the entire population examined at this Institution at that time. They analyzed clinical and demographic characteristics of the affected individuals with the syndrome including gender, age at diagnosis, presence or absence of heart disease, arrhythmias incidence and reasons for consultation. Many important observations were done, including the fact that the syndrome was seen both in clinically normal hearts and in Ebstein's disease but rarely in other types of congenital heart disease.

Auricular fibrillation and Wolff-Parkinson-White syndrome⁷

Cárdenas and coworkers presented in 1967 six cases of paroxysmal auricular fibrillation associated with the W-P-W syndrome. They found at that time eight cases of atrial

fibrillation out of 123 cases with the diagnosis of W-P-W syndrome. Two cases were in chronic atrial fibrillation and were not part of the analysis. From their study they conclude that these two conditions, although they are in close relation, are not sustained by the same mechanism. Fibrillation would be produced when a retrograde impulse reaches the atria in a vulnerable period. Once the atria are in a state of self-sustained fibrillation, the atrial impulse might reach the ventricles through the anomalous bundle or through the A-V node. The figures are very illustrative and a brilliant description of the diagnostic criteria of atrial fibrillation with W-P-W syndrome was included. An extensive review of the literature up to 1973 was also published by Cárdenas.⁸ The historical, clinical, electrocardiographic, electrophysiological, arrhythmic and therapeutic issues were described and discussed.

A cohort of 235 cases with preexcitation syndrome⁹

In 1973, Antonio Pajarón, José Poveda y Gustavo Medrano analyzed 235 cases of preexcitation syndrome from the *Instituto Nacional de Cardiología Ignacio Chávez*. They performed a similar analysis as the one undertaken previously by Gausí *et al* in 1966. This time they presented the clinical and demographic data based on the presence or absence of structural heart disease. They made four groups: 92 cases without organic heart disease, 39 subjects with congenital heart disease (being the most prevalent Ebstein's disease), 37 patients with rheumatic heart disease and 67 cases with miscellaneous diseases. They found 104 cases of the W-P-W type A and 102 of the type B; they could not determine the "type" in 22 cases ("undetermined type"); they described seven cases as L-G-L variety. It is interesting to note that, of the arrhythmias documented, paroxysmal atrial tachycardia stood out in 72 instances. They also reported atrial fibrillation in 14 cases, atrial flutter in 8 and in 5 instances an association of atrial flutter and fibrillation. Cases, they observed ventricular tachycardia and in one ventricular fibrillation. These three cases of preexcitation syndrome with "malignant" ventricular arrhythmia were analyzed in another communication.¹⁰ In these, the authors described all cases as having had a "disfavorable" or "unfavorable" evolution (meaning a bad outcome), and reported that all of them had heart disease. The therapeutic approaches utilized, as well as the results obtained in these three cases were discussed, as well as the reasons for their bad evolution.

Analysis of atrial fibrillation and/or atrial flutter in preexcitation syndrome¹¹

From the same cohort of 235 cases of preexcitation syndrome, Poveda-Sierra *et al* reviewed the 28 cases (11.91%) that had documented atrial fibrillation and/or atrial flutter. In 12 of them there was atrial fibrillation, atrial flutter in 9, and in the remaining 7 both rhythm disturbances were present. No evident relationship of the arrhythmia with the age of the subject, or with the clinical diagnosis was demonstrated. Based on their observations, they stated that when a tachyarrhythmia is present in an individual with a clinically healthy heart, it seems

justified to look for the existence of a preexcitation syndrome. The administration of digitalis reestablished the sinus rhythm in most of the cases of atrial flutter. On the contrary, it was rarely effective in the cases of atrial fibrillation. Now, we know that digitalis must not be used in this group of patients due to the risk of ventricular fibrillation. Electroversion, which nowadays is the current accepted practice, gave a positive result in all cases of atrial fibrillation and flutter in which it was applied.

Contributions of His bundle electrogram recordings to the study of the atrioventricular conduction in preexcitation syndromes¹²

Fifteen patients with a diagnosis of preexcitation syndromes by clinical electrocardiographic and vectorcardiographic criteria were studied by Cárdenas *et al* in 1976. In all of them, an electrophysiological study of the His electrogram was performed. In the electrogram of the His bundle, ventricular activation preceded or was registered by a very short interval suggestive of a dual conduction system. Atrial stimulations provoked several types of responses demonstrating conduction by fibers with different electrophysiological characteristics and anatomical locations.

Familial occurrence of Wolff-Parkinson-White syndrome¹³

A family of nine members was reported by Mispireta *et al* in 1975, two with W-P-W syndrome: the father had the so-called "type A" and the son a "type B". These two patients were studied from a clinical, electrocardiographic, and vectorcardiographic point of view. They were subjected to hisian electrogram recordings. The atrial-ventricular conduction under basal conditions and during atrial stimulation was analyzed. In both cases, the researchers could be able to demonstrate that atrio-ventricular conduction occurred either through the accessory pathway or the normal conduction system. When the conduction was through the accessory pathway, the presence of preexcitation (recording of the delta wave in the ECG) coincided with the disappearance of the His potential in the intracavitary recording. In contrast, when conduction was through the normal conduction system, the absence of the preexcitation (delta wave) coincided with the presence of the His potential, with normal A-H and H-V intervals. The bibliography of this syndrome was reviewed, showing that there was a strong correlation with sex, as most cases, like the ones herein reported, were males. This gave the authors the impression that W-P-W could be a genetic disorder linked to sex.

Electrophysiology of preexcitation syndromes¹⁴

Fifteen patients with preexcitation syndrome were studied in the *Instituto Nacional de Cardiología Ignacio Chávez* in 1975 by Mispireta *et al*. The diagnosis was established by the classic electrocardiographic criteria. In all the cases, a His bundle electrocardiogram with and without atrial

stimulation was recorded. As in the two cases previously reported by them, they confirmed the presence of a dual atrio-ventricular conduction system based on an early ventricular activation in relation with the His bundle electrograms. Their tracings clearly showed the main differences between the Kent and the Mahaim fibers, both in resting conditions and during atrial stimulation. A very nice scheme of the different types of accessory pathways (Kent, Mahaim) was presented. In two patients, in whom intravenous antazoline were used, the ventricular preexcitation disappeared. The reports by Mispireta *et al* definitively contributed to the study of the electrophysiologic properties of the accessory pathways.

Preexcitation syndrome in monoczygotic twins¹⁵

In this report, Mispireta *et al* studied a family of seven members, two of them were identical twin brothers and had paroxysmal tachycardia. One of them had the W-P-W syndrome type B, and the other had a short PR interval and was classified as a Lown-Ganong-Levine (L-G-L) syndrome. The latter had associated atrial-septal defect, the other twin had no associated cardiovascular lesions. Both had electrocardiogram, vectorcardiogram, as well as His bundle electrograms. In the case with W-P-W, the His bundle electrogram showed the habitual findings in this type of preexcitation: the His bundle potential was preceded by the beginning of delta wave. In the case with short PR interval, the recording of the His bundle electrogram, did not show preexcitation, the tracings in basal conditions as well as during atrial stimulation were normal. The authors speculate that, if both subjects had an accessory pathway, the possibility of a genetic origin of the W-P-W syndrome was high. Many years later, a genetic background for W-P-W syndrome was confirmed by Gollob *et al*, who reported in *New England Journal of Medicine* the identification of a mutation in the gene that encodes the gamma-2 regulatory subunit of AMP-activated protein kinase (PRKAG2) associated with familial ventricular preexcitation.¹⁶

Electrovectorcardiographic manifestations of W-P-W syndrome associated with structural cardiac disease¹⁷

De Micheli *et al* analyzed in 1989 electrovectorcardiographic curves corresponding to W-P-W syndrome associated with structural heart disease on the basis of the sequence of the ventricular depolarization phenomenon as well as of the heart's position and rotation. A more than 30 ms interval between the end of the initial slurring and the vertex of R loop, or of that of R wave in left leads, permitted them to infer the coexistence of left ventricular hypertrophy. Segmental irregularities or distortions of the vectorcardiographic ventricular curves suggest the authors the presence of a limited inactivable zone. Extensive deformations were considered to be more suggestive of a diffuse myocardial damage. Sometimes primary disturbances of ventricular repolarization, probably due to antiarrhythmic medication, were observed.

Wolff-Parkinson-White syndrome with paroxysmal supraventricular tachycardia related to orthodromic A-V reentry¹⁸

Hernández *et al* presented in 1990 one case of W-P-W syndrome with paroxysmal supraventricular tachycardia related to orthodromic atrioventricular reentry using an accessory pathway for retrograde conduction and a rapidly conducting A-V node for anterograde conduction. The pharmacological therapy with digoxine, propranolol, quinidine, disopiramide and propafenone was not effective. An electrophysiologic study showed a reciprocating tachycardia induced by spontaneous ventricular beats. Both the effective refractory period of the A-V node and the anterograde effective refractory period of the accessory pathway were minor or equal to 220 ms difficulting the control of the arrhythmia. Amiodarone was able to suppress the premature ventricular beats, depress conduction and prolong refractoriness in both, the A-V node and accessory pathway to prevent recurrences of atrioventricular reentry. In this patient, a false positive test with ajmaline was documented. The electrophysiologic study showed the association of W-P-W syndrome with an enhanced atrioventricular nodal conduction and allowed the authors to select an appropriate antiarrhythmic agent.

Arrhythmias in Wolff-Parkinson-White syndrome¹⁹

In 1990, Cárdenas described the current knowledge, at that time, of preexcitation syndromes. He reported that circus movement reciprocal atrioventricular tachycardia is seen in 60% of the patients. Most of them are orthodromic. In this group, A-H increases in duration. H-V becomes normal and the delta wave disappears in the electrophysiologic study during the tachycardia. In the antidromic group, A-delta decreases and His potential cannot be recognized. He stated that preexcitation with atrial flutter is a rare but very dangerous situation when atrial impulses are conducted by the anomalous bundle, because of the very high ventricular rate with 250 ms R-R intervals. The same happens in patients with atrial fibrillation, observed in 5% of the patients with W-P-W syndrome; this arrhythmia may provoke multiform (polymorphic) ventricular tachycardia, ventricular fibrillation and sudden death. Sudden death occurs in 0.1% of asymptomatic patients with W-P-W in 1% of those with reciprocal tachycardias and in 5.6% of the patients with atrial fibrillation and R-R intervals of 250 ms or less.

Surgical treatment of the Wolff-Parkinson-White syndrome at the *Instituto Nacional de Cardiología Ignacio Chávez*²⁰

In 1991, Barragán *et al* reported their initial experience in the surgical section of the accessory pathway in thirteen patients: eight patients with W-P-W syndrome and five with concealed conduction (accessory pathway functioning only in direction ventricle to atrium), with recurrent episodes of paroxysmal supraventricular tachycardia with no response to medical treatment. Three of these patients had episodes of auricular fibrillation

with interval RR lower than 250 ms and one patient presented syncope. A total of fifteen accessory pathways were sectioned: seven left lateral, five left posterior, one left posterolateral, one right lateral, and another one right anteroseptal. In the same procedure, two patients had correction of another heart malformation: one with patent ductus arteriosus and another with atrial septal defect. All patients had successful outcome, one of them needed a second surgery for persistent accessory pathway. They had two post-operative complications: one mediastinitis and one patient with ectopic auricular tachycardia.

Electrophysiologic study of Wolff-Parkinson-White syndrome in Ebstein's anomaly²¹

In 1991, Galván *et al* analyzed the electrophysiologic characteristics of 33 patients with Ebstein's anomaly associated to W-P-W syndrome. They clearly stated that the right preexcitation occurred before the activation of the right ventricle mass, overshadowing the manifestations of the right bundle branch block (usual in patients with Ebstein's anomaly without preexcitation). They concluded that the absence of manifestations of right bundle branch block in the presence of Ebstein's anomaly should make us think about the coexistence of the preexcitation. They reported that the association of supraventricular tachycardia in this group is very high (94%), most of them paroxysmal orthodromic tachycardia.

Atrio-ventricular and ventriculo-atrial conduction after surgery of Wolff-Parkinson-White syndrome²²

In 1992, Colín *et al* utilized programmed electrical stimulation to assess the functional characteristics of atrioventricular and ventriculoatrial conduction after surgery for W-P-W syndrome. In 55% of the cases they found accelerated nodal conduction. Programmed electrical stimulation correctly identified 90% of successfully treated patients. They did not find any false positive curve; therefore, they mentioned that this method has a high specificity and concluded that, in post-operative patients with the Wolff-Parkinson-White syndrome: 1. There is a high incidence of accelerated nodal conduction and 2. Programmed electrical stimulation can correctly identify most of the patients who were successfully treated.

Treatment of the Wolff-Parkinson-White syndrome. Comparative study of the surgical procedure vs. radiofrequency catheter ablation²³

In 1993, Iturralde *et al* compared the results of surgery vs. catheter ablation. They studied 70 patients with W-P-W that underwent either surgery or ablation procedure with radiofrequency energy. The surgical procedure was successful in 82%; complications were present in 15% and mortality in 8%. Average hospitalization was 6 to 10 days and the cost from 2 to 10 thousand of new pesos (our former currency). On the other hand, out of 44 patients

that underwent radiofrequency ablation, in 80% the procedure was finally successful with recurrence of 9% and no mortality; the length of stay was one day, and the cost ran from 500 pesos to two-thousand. These results clearly demonstrated the efficacy of the radiofrequency energy ablation in the treatment of W-P-W, being both safe and less expensive than surgery.

Familial frequency of atrio-ventricular accessory pathways²⁴

In 1999, Gutiérrez-Rojas *et al* reported the prevalence of atrioventricular accessory pathways in first degree relatives of patients with proven accessory pathways by electrophysiologic study. In five out of 469 patients (1.06%) they found an accessory pathway in one or more members of their family. The identification of family members with preexcitation syndrome suggested the authors a hereditary predisposition.

The location of the preexcitation zone in the Wolff-Parkinson-White syndrome by means of surface thoracic circle electrocardiogram²⁵

In this study, thoracic circle lead electrocardiograms were recorded during sinus rhythm in 50 patients with W-P-W syndrome. The following were analyzed: delta wave polarity, QRS axis in the frontal plane, ventricular preexcitation, the pattern of precordial R wave transition and QRS morphology in the unipolar leads; concordance between electrocardiographic patterns and the site of the accessory pathway was determined also during electrophysiological study. Electrocardiograms from patients with left lateral sites showed negative delta waves in leads LI or aVL, V7 to V9, positive delta waves in V3R to V9R, a normal QRS axis and early precordial R wave transition (20 of 23 patients). Left posterior sites manifested negative delta waves in L3, aVF, V7 to V9 in L3, aVF, V7R to V9R and a prominent R wave in V1 (4 of 5 patients). Left posteroparaseptal sites had the same pattern plus negative delta waves in L2, a superior QRS axis, and RS or Rs morphology in V1 (3 of 3 patients). Right posteroparaseptal sites had negative delta waves in L2, L3, aVF, V3R to V9R, positive delta waves in V7 to V9, a superior QRS axis and R > S in V1 (10 of 11 patients). Right free wall locations manifested negative delta waves in L3, aVR, V3R to V9R, positive delta waves in V7 to V9, a normal QRS axis and R wave transition in V3 to V5 with QS morphology since V3R to V9R (6 of 7 patients). One patient with right anterior septal site had negative delta waves in V3R to V9R, a normal QRS axis and R wave transition in V3 to V5. The authors concluded that the thoracic circle electrocardiogram identified correctly the preexcitation locations in 44 of 50 patients (88%) and it was very useful for the differential diagnosis between right or left accessory pathway, particularly in the posterior septal region.

A new ECG algorithm for the localization of accessory pathways using only the polarity of the QRS complex²⁶

A new algorithm was proposed for localization of accessory atrioventricular pathways by use of a 12-lead

electrocardiogram (ECG) by Iturralde and coworkers. The polarity of the QRS complex in leads III, V1 and V2 from 102 patients with W-P-W syndrome with manifested preexcitation who underwent successful radiofrequency catheter ablation was analyzed. Accessory pathways on the right side of the heart were localized to three regions around the tricuspid annulus, and left-sided pathways were localized to two regions around the mitral valve annulus. In 42 of 46 patients (91%) with left posterolateral accessory pathways, a common characteristic of the ECG was a positive QRS complex in leads III and V1 (sensitivity 91%, specificity 95%). Of 19 patients with left inferior paraseptal or inferior accessory pathways, 16 (84%) had a negative QRS complex in lead III and a positive QRS complex in lead V1 (sensitivity 84%, specificity 98%). All six patients with right anterosuperior paraseptal accessory pathways had a positive QRS complex in lead III but a negative QRS complex in lead V1 (sensitivity 100%, specificity 97%). The 25 patients with right inferior paraseptal or inferior accessory pathways had a negative or isodiphasic QRS complex in leads III and V1, but the QRS complex was positive in lead V2 in 21 of these patients (sensitivity 84%, specificity 100%). Finally, five of the six patients (83%) with right anterior accessory pathways had a negative QRS complex in leads III, V1, and V2 (sensitivity 83%, specificity 96%). With this algorithm, the localization of accessory pathways was thus identified in 90 of the 102 patients (88%).

Successful radiofrequency ablation of an accessory pathway during pregnancy²⁷

The preexcitation syndrome is a rare entity during pregnancy. Domínguez *et al* presented a 20-week pregnant patient with W-P-W syndrome and recurrent episodes of unstable tachycardia, refractory to medical treatment that required electrical cardioversion several times. They reported a successful radiofrequency ablation of a right posteroseptal accessory pathway using only 70 seconds of total fluoroscopy time and without complications. They consider catheter ablation as an alternative and safer treatment in those cases in which the tachyarrhythmias compromise the hemodynamic state during pregnancy.

Radiofrequency catheter ablation for the treatment of supraventricular tachycardias in children and adolescents²⁸

We report our experience in radiofrequency catheter ablation between April 1992 and December 1998, in which we treated 287 patients less than 18 years of age (mean 14.3 ± 3.1 years) with supraventricular tachycardia. Accessory pathways were the arrhythmic substrate in 252 of the patients (87.8%), the patients having a total of 265 accessory pathways. Atrioventricular nodal re-entry was the cause of tachycardia in 26 patients (9.0%), while atrial flutter was detected in the remaining 9 patients (3.1%). We were able successfully to eliminate the accessory pathway in 236 patients (89%), but 25 patients had recurrent arrhythmias. Ablation proved successful in all cases of atrioventricular node re-entry tachycardia, the

slow pathway being ablated in 25 patients, and the fast pathway in only one case. Recurrence of the arrhythmia occurred in three patients (11.5%). We performed a second ablation which proved to be successful at that time. The ablation was successful in all cases of atrial flutter, with one recurrence (11.1%). Overall, therefore, ablation was immediately successful in 271 patients (94.4%), with a recurrence of the arrhythmia in 29 cases (10.7%). The incidence of serious complications was 2.09%. There was one late death due to infective endocarditis, 3 patients suffered complete heart block, one had mild mitral regurgitation, and one patient developed a hematoma in the groin. We conclude that radiofrequency catheter ablation can now be considered a standard option for the management of paroxysmal supraventricular tachycardia in children and young adults.

Sudden death in intermittent Wolff-Parkinson-White syndrome²⁹

Sudden death is a rare condition in asymptomatic patients with asymptomatic intermittent W-P-W; for this reason it was believed that these patients should not undergo radiofrequency ablation. In 2001, Medeiros *et al* reported an asymptomatic 44 year-old man who developed ventricular fibrillation with a preexcited RR interval less than 200 ms during atrial fibrillation, as a first manifestation of W-P-W syndrome. The Holter monitoring showed intermittent preexcitation at low heart rate (70 bpm). During the electrophysiological study a successfully radiofrequency catheter ablation of a right posteroseptal accessory pathway was performed. They concluded that intermittent preexcitation may not be used to identify patients who are at risk of sudden death. Radiofrequency catheter ablation should be recommended in those patients with a very high success rate, and a low incidence of serious complications.

Radiofrequency ablation of multiple accessory pathways³⁰

The aim of the study was to review the clinical and electrophysiological characteristics and results of radiofrequency catheter ablation in patients with multiple accessory pathways to compare them with those of patients with single accessory pathways. Electrophysiological study and radiofrequency catheter ablation were performed in 1010 consecutive cases with Wolff-Parkinson-White syndrome. Presence of multiple accessory pathways was documented in 31 patients (3.1%); 30 had two, and 1 had three accessory pathways. Of the 63 accessory pathways, 42 were manifest and 21 concealed. Nine patients had Ebstein's anomaly associated with atrioventricular bypass tracts. The most common combination was right posteroseptal with right free wall bypass tracts (15 patients with 30 accessory pathways). Fifty-one of the sixty-three accessory pathways (81%) were ablated successfully without complications. The duration of the procedure was 100 ± 58 minutes and the fluoroscopic time 40 ± 17 minutes. A follow up of 5 ± 3 years after ablation, demonstrated recurrences of six accessory pathways (9.5%). Authors concluded that

patients with multiple accessory pathways can be treated by radiofrequency ablation in only one session with a high success rate although slightly less than that in patients with a single accessory pathway (81% vs. 93%, $p < 0.01$)

Electrocardiographic characteristics of patients with Ebstein's anomaly before and after ablation of an accessory atrioventricular pathway³¹

The abnormal development of the tricuspid valve in patients with Ebstein's anomaly results in several activation abnormalities including delayed intra-atrial conduction, right bundle branch block, and ventricular preexcitation. The aim of the present study was to define the ECG characteristics before and after ablation of an accessory A-V pathway (AP) in patients with Ebstein's anomaly. A series of 226 patients with Ebstein's anomaly was studied. We selected sixty three for our study. Thirty-three patients with recurrent tachycardia underwent electrophysiologic study and catheter ablation of an AP. The remaining 30 patients without tachycardia served as the control group. The ECG during sinus rhythm was analyzed in all patients. All 33 patients who underwent electrophysiologic study had one right sided AP. Only 21 of 33 patients (62%) had a typical ECG pattern of preexcitation. In addition, none of the patients had an ECG pattern of RBBB during sinus rhythm. In contrast, 28 of 30 (93%) patients in the control group had RBBB ($p < 0.001$). Radiofrequency ablation was successfully performed in all patients resulting in appearance of RBBB in 31 of 33 (94%) patients. The absence of RBBB in patients with Ebstein's anomaly and recurrent tachycardia had 98% sensitivity and 92% specificity for the diagnosis of an AP. The positive predictive value was 91% (0.77- 0.97; CI 95%) and the negative predictive value was 98% (0.85-0.99; CI 95%).

One third of patients with Ebstein's anomaly and symptomatic tachyarrhythmias have minimal or absent ECG features of ventricular preexcitation. They found that, in these patients, the absence of RBBB pattern is a strong predictor of an AP.

On the electrical manifestations of some heart diseases associated with ventricular preexcitation³²

In 2006, de Micheli *et al* described the electrical manifestations of some heart diseases associated with ventricular preexcitation. They stated that electro-vectorcardiographic curves, corresponding to some heart diseases, must be analyzed in the light of the ventricular depolarization sequence, as well as on the heart's position and rotation. A more than 30 ms interval between the end of the initial slurring (delta) and the vertex of the R wave in the left unipolar leads or the main axis of the vectorcardiographic ventricular curves, allows us to infer the coexistence of left ventricular hypertrophy. On the other hand, segmental irregularities or distortions of the electric curves suggest the presence of a limited myocardial zone unable to be activated. Extensive or multiple deformations of these curves are more suggestive of a diffuse myocardial

damage. Finally, they stated that sometimes signs of preexcitation due to a pharmacological action can also appear.

Wolff-Parkinson-White syndrome in Ebstein's anomaly³³

In 2007, Iturralde presented a review of W-P-W syndrome in Ebstein's anomaly. The abnormal development of the tricuspid valve that occurs in these patients is described along with the mechanisms underlying conduction and rhythm disturbances including delayed intraatrial conduction, right bundle branch block, and ventricular preexcitation. He defined the ECG characteristics before and after ablation of an accessory atrio-ventricular pathway in patients with Ebstein's anomaly as previously reported. The series of patients studied at the *Instituto Nacional de Cardiología Ignacio Chávez* was updated. From 224 subjects, 64 (28%) had a documented tachycardia. Thirty-three patients with recurrent tachycardia were found to have a single right-sided accessory pathway that was successfully ablated. Only 21 of 33 patients (62%) had a typical ECG pattern of preexcitation. In addition, none of the patients had an ECG pattern of RBBB during sinus rhythm. Radiofrequency catheter ablation resulted in appearance of RBBB in 94% patients. The absence of RBBB in patients with Ebstein's anomaly and recurrent tachycardia had a 98% sensitivity and 92% specificity for the diagnosis of an accessory pathway. One third of patients with Ebstein's anomaly and symptomatic tachyarrhythmias have minimal or absent ECG features of ventricular preexcitation. In these patients, the absence of RBBB pattern is a strong predictor of an accessory pathway. This review offers the contributions of the researches of the *Instituto Nacional de Cardiología Ignacio Chávez* in Mexico in the diagnosis and treatment of the W-P-W syndrome. We made a great effort to include all of them and we would like to express our regrets if anyone is missing.

Conclusion

Preexcitation syndromes have fascinated physicians for decades. Most of the interest is focused on the W-P-W, which has been anatomically and pathophysiologically characterized in great detail. The electrophysiologist must have mastered cognitive information built on a 40-year foundation of invasive clinical cardiac electrophysiology that itself was fashioned from 65 years of electrocardiography. The ability to eliminate a preexcitation syndrome with a catheter in the heart has revolutionized the practice of clinical cardiac electrophysiology. Catheter ablation of the W-P-W provides the only truly curative procedure in cardiology.

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