Differential Diagnosis With Idiopathic Monomorphic Right Ventricular Tachycardia arising from Right Ventricular Outflow Tract (IMVT-RVOT) – 2007

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The principal conditions that need to be differentiated from ARVC/D, is Idiopathic Monomorphic Ventricular Tachycardia arising from Right Ventricular Outflow Tract (IMVT-RVOT)

ARVC/D is a genetically determined and progressive heart muscle disease or sporadic associated with arrhythmia, and SCD. The entity with time may lead to more diffuse RV involvement and LV abnormalities and culminate in CHF.

The IMVT-VT can be exactly the same, but there is no structural abnormality of the heart, unlike the situation in ARVC/D where commonly there is dilation of the ventricle.

IMVT-RVOT is more common than ARVC/D; and both observed in young, otherwise healthy people.

Both entities ARVC/D and IMVT-RVOT being significantly different in prognosis and treatment, follow-up monitoring is essential sometime to establish the definitive diagnosis (Kuhn A, Kottkamp H, Thiele H, Idiopathic right ventricular tachycardia or arrhythmogenic right ventricular tachycardia? Dtsch Med Wochenschr. 2000;125:692-677.).

(I) FAMILY HISTORY OF ARRHYTHMIA OR SCD

IMVT-RVOT: Has not family history antecedents.

ARVC/D: Family history is present in 30% to 50% of cases. In the setting of positive family history, even minor ECG abnormalities are diagnostic. Several gene defects were mapped, thus providing evidence for genetic heterogeneity (Basso C, Thiene G, Nava A, D et al. Arrhythmogenic right ventricular cardiomyopathy: a survey of the investigations at the University of Padua.Clin Cardiol. 1997; 20:333-336.).

(II) AGE OF CLINICAL MANIFESTATION

IMVT-RVOT: Most patients are initially diagnosed between the ages of 30 and 50 years. In Lermans series there ranged between 6 and 77 years (Lerman BB, Kenneth M, Stein SM, et al. Ventricular Tachycardia in Patients With Structural Normal Heart. In Zipes DP & Jalife J Cardiac Electrophysiology From Cell to Bedside 3rd. 2000; Chapter 70 pp: 640-656)

ARVC/D: Manifest between the 15 and 30 years old. Adolescence and early adulthood (Nava A, Bauce B, Basso C, et al. Clinical profile and long-term follow-up of 37 families with arrhythmogenic right ventricular cardiomyopathy. J Am Coll Cardiol. 2000; 36:2226-2233.).

The illness is cause of SCD in < 35 years old. At least 80% of cases being diagnosed before the age of 40.

(III) SEX PREDOMINANCE

IMVT-RVOT: Adenosine-sensitive RVOT segregates equally between both sexes. (Lerman BB, Kenneth M, Stein SM, et al. Ventricular Tachycardia in Patients With Structural Normal Heart. In Zipes DP & Jalife J Cardiac Electrophysiology From Cell to Bedside 3rd. 2000; Chapter 70 pp: 640-656.).

ARVC/D: Male predominance 3:1 or iqual.

(IV) PATTERN OF INHERITANCE

IMVT- RVOT: Non-familial arrhythmic condition.

ARVC/D: Sporadic (65%) or familial (35%) autosomal-dominant, (Wlodarska EK, Konka M, Kepski R, et al. Familial form of arrhythmogenic right ventricular cardiomyopathy. Kardiol Pol. 2004; 60:1-14.) although an autosomal-recessive pattern has also been reported which affects the long arm of chromosome 17 (17q21) associated to non-epidermolytic palmoplantar keratoderma with woolly hair. ("Naxos disease"). (Protonotarios N, Tsatsopoulou A, Anastasakis A, et al. Genotype-phenotype assessment in autosomal recessive arrhythmogenic right ventricular cardiomyopathy (Naxos disease) caused by a deletion in plakoglobin. J Am Coll Cardiol. 2001; 38:1477-1484).

(V) PREVALENCE

IMVT- RVOT: More frequently that ARVC/D.

ARVC/D: It is estimated as 1/5000 (Czarnowska E, Wlodarska EK, Zaleska T. Arrhythmogenic right ventricular cardiomyopathy (dysplasia): etiology, clinical presentation, diagnosis and treatment Kardiol Pol. 2003; 58:58-63.)

The prevalence is estimated at 0.4% depending on geographic circumstances. (Hagenah G, Andreas S, Konstantinides S. Accidental left ventricular placement of a defibrillator probe due to a patent foramen ovale in arrhythmogenic right ventricular dysplasia. Acta Cardiol. 2004; 59:449-451.).

(VI) ENDEMIC AREAS OF THE WORLD

IMVT-RVOT: No preference in some endemic areas.

ARVC/D: It is estimated as 1/5000. (Czarnowska E, Wlodarska EK, Zaleska T. Arrhythmogenic right ventricular cardiomyopathy (dysplasia): etiology, clinical presentation, diagnosis and treatment Kardiol Pol. 2003; 58:58-63.).

The prevalence is estimated at 0.4% depending on geographic circumstances. (Juang JM, Huang SK. Brugada Syndrome - An Under-Recognized Electrical Disease in Patients with Sudden Cardiac Death. Cardiology. 2004; 101: 157-169.).

Endemic in Veneto region (Italy), Nova Scotia and Naxus Greek island (recesive form).

(VII) ANNUAL RATE OF SUDDEN CARDIAC DEATH (SCD)
IMVT RVOT: Rare. Excellent prognosis.

ARVC/D: The incidence of SCD is approximately 2.5% a year.

(VIII) SYMPTOMS
IMVT-RVOT: In 80% palpitations; 50% dizziness; 10% syncope during VT, In 80% class I and II symptoms;

In 20% class III: Pre-syncope or Syncope.

Triggered by stress or exercises, gestation, extreme consumption of alcohol, coffee or tobacco.

ARVC/D: Palpitations are the most common complaint (Maia IG, Sa R, Bassan R, et al. Arrhythmogenic right ventricular dysplasia Arq Bras Cardiol. 1991; 57:97-102.). Syncope, dizziness or SCD, frequently triggered by stress or exercise.

(IX) P WAVE AND SINUS FUNCTION
IMVT- RVOT: Normal.

ARVC/D: There is a description of giant P wave associated with a QRS of a very low amplitude in a patient with ARVC/D. (Martini B, Nava A, Buja GF, et al. Giant P wave in a patient with right ventricular cardiomyopathy. Clin Cardiol. 1990;1 3:143-145.).

ARVC/D is associated with a significantly higher incidence of inducible supraventricular tachyarrhythmias than in a control population. Supraventricular tachycardias may precede ventricular tachycardias. This association argues for a diffuse myocardial disorder in ARVC/D. (Brembilla-Perrot B, Jacquemin L, et al. Increased atrial vulnerability in arrhythmogenic right ventricular disease.Am Heart J. 1998;135:748-754.).

Standard ECG with right atrial enlargement and an increased mean precordial QRS dispersion of 47.1+/-18.9 ms is observed in cases of right heart failure.

Biatrial enlargement and a reduced precordial QRS dispersion of 33.0+/-23.1 ms are observed in cases of biventricular heart failure. (Peters S, Peters H, Thierfelder L. Heart failure in arrhythmogenic right ventricular dysplasia-cardiomyopathy. Int J Cardiol. 1999; 71:251-256.).

There is a report a case of ARVC/D in a 60-year-old man who developed sick sinus syndrome during evolution (sinus node recovery time of 6113 mseg). The authors explain atrial arrhythmias by gradual replacement of right atrium myocytes by adipose tissue. (Balderramo DC, Caeiro AA. Arrhythmogenic right ventricular dysplasia and sick sinus syndrome Medicina (B Aires). 2004; 64: 439-441.).

(X) PR INTERVAL OF ECG
IMVT-RVOT: Normal.

ARVC/D: Prolongation of the PR interval is possible. (Wisten A, Andersson S, Forsberg H, et al. Sudden cardiac death in the young in Sweden: electrocardiogram in relation to forensic diagnosis. J Intern Med. 2004; 255:213-220.).

(XI) IRBBB OR CRBBB PATTERN
IMVTRVOT: Present in 10% of cases. (Buxton AE, Waxman HL, Marchlinski FE, et al. Right ventricular tachycardia: clinical and electrophysiologic characteristics. Circulation. 1983; 68:917-927.)

ARVC/D: the QRS complex may show incomplete RBBB in approximately 18% of the cases and the complete form (CRBBB) in 15%. With the objective to provide data on the prevalence of disturbances of rhythm in the general population Niwa et al (Niwa K, Warita N, Sunami Y, et al.Prevalence of arrhythmias and conduction disturbances in large population-based samples of children. Cardiol Young. 2004; 14:68-74.) analyzed prevalence of disturbances of rhythm in a population of 152,322, comprised of 71,855 elementary school students, 36,692 males and 35,163 females, aged from 5 to 6 years, and 80,467 students of junior high school, 41,842 males and 38,625 females, aged from 12 to 13 years. IRBBB and CRBBB were higher in males than females, at 0.983% and 0.083% in males versus 0.410% and 0.161% in females ($p < 0.0001$).

The mechanism of the right conduction defects is not disease of the bundle branch itself but a distal block probably situated in the RV wall. This hypothesis is supported by the histological appearances of the dysplastic zones. (Fontaine G, Frank R, Guiraudon G, et al. Significance of intraventricular conduction disorders observed in arrhythmogenic right ventricular dysplasia. Arch Mal Coeur Vaiss. 1984; 77:872-879.).

Among those without RBBB, a prolonged S-wave upstroke in V1 through V3 > or = 55 ms was the most prevalent ECG feature (95%) and correlated with disease severity and induction of VT on electrophysiological study. This feature also best distinguished ARVD/C (diffuse and localized) from RVOT.(Nasir K, Bomma C, Tandri H, et al. Electrocardiographic features of arrhythmogenic right ventricular dysplasia/cardiomyopathy according to disease severity: a need to broaden diagnostic criteria.Circulation. 2004; 110:1527-1534.).

Patients with the ECG pattern of RBBB and right precordial ST-segment elevation may experience SCD in the setting of either ARVC/D or a functional electrical disorder such as BrS (Corrado D, Basso C, Buja G, et al. Right bundle branch block, right precordial st-segment elevation, and sudden death in young people. Circulation. 2001; 103:710-717.).

(XII) T-WAVE POLARITY
IMVT-RVOT: Always T wave upright from V2- V5.
ARVC/D: Negative T waves of V1 to V2 or V3 are very characteristic when present in children over 12 years old in the absence of RBBB. (Metzger JT, deChillou C, Cheriax E, et al.: Value of the 12-lead electrocardiogram in arrhytmogenic right ventricular dysplasia, and absence of correlation with echocardiographic finding. Am J Cardiol 1993; 72: 964.).

T-wave inversions in V1 through V3 were observed in 85% of ARVC/D patients in the absence of RBBB compared with none in RVOT and normal controls, respectively. (Nasir K, Bomma C, Tandri

H, et al. Electrocardiographic features of arrhythmogenic right ventricular dysplasia/cardiomyopathy according to disease severity: a need to broaden diagnostic criteria.Circulation. 2004; 110:1527-1534.).

Often presents as T-wave inversion in the anterior leads of the electrocardiogram. (Toh KW, Nadesan K, Sie MY, et al. Postoperative death in a patient with unrecognized arrhythmogenic right ventricular dysplasia syndrome. Anesth Analg. 2004;99:350-352.)

Nava et al suggests that the extension of T loop negativity in horizontal plane loop of VCG and T wave on precordial leads of ECG are probably caused by dislocation of the LV backwards secondary to RV dilatation, asynchronous RV repolarization or intraparietal RV conduction defects. In 24 cases T wave was negative only on V1 in 37%; from V1 to V2 in 25%; from V1 to V3 in 8%; from V1 to V4 in 4% and from V1 to V5 in 8%. (Nava A, Canciani B, Buja G, et al. Electrovectorcardiographic Study of Negative T Waves on Percordial Leads in Arrhtyhmogenic Right Ventricular Dysplasia: Relationship With Right Ventricular Volumes J of Electrocardiol 1998: 21: 239-245.).

(XIII) PARIETAL BLOCK

IMVT-RVOT: Absent. QRSD <110 ms in V1, V2 or V3.

ARVC/D: The QRS complex could be normal, with a slightly increased duration in precordial leads from V1 to V3 (> 110 ms) and with lower duration from V3 to V6. For this reason, a protocol for ECG recording when there is a suspicion of ARVC/D, has been proposed:

1. The tracing must have a double velocity and amplitude of (50 mm/s and 20 mm/s) with the aim of comparing QRS duration for all precordial leads. It is better to observe the possible presence of the epsilon wave.

2. In the limbs leads, the right -arm electrode should be placed on the xiphoid appendage, the electrode of left arm on the manubrium of the sternum, and the one of the left leg on the rib on V4 or V5 with the aim of observing the epsilon wave better.

The QRSD ratio of V1 + V2 + V3 / QRSD V4 + V5 + V6 > than 1.2 is found in 97% of the ARVC/D cases.

The specificity of this criterion has not been completely established yet in patients without this entity, as well as the sensitivity; QRSD > 110 ms in V1, V2 or V3 84% sensitivity and high specificity.

The diagnosis of ARVC/D could be determined by ECG with 84% sensitivity and 100% specificity if QRSD in leads V1, V2 or V3 was longer than 110 ms, T wave was negative in V2 or if T wave was negative in V1, but in this latter case only provided IRBBB was present.

ARVC/D can be excluded if the ECG is found to be normal 6 years or later after a first ventricular tachycardia attack.

The QRSD is correlated with the amount of fibrous tissue in patients with VT of RV origin.

Which includes depolarization (QRS) and ventricular repolarization (ST/T = JT interval).

Thus, when there is branch block (as in the some cases of BS), the measurement of ventricular repolarization through QTc may be incorrect. In these cases, the measurement of the JT interval (JT = QT - QRSD) is more accurate than the QT interval, because it excludes the depolarization that is found prolonged, because the biventricular chamber activates sequentially and not concomitantly as normally. This is the reason why it is essential to know accurately the exact point where depolarization ends and repolarization begins.

(XIV) EPSILON WAVE

These are low amplitude and short duration waves located near the end of the QRS complex and the beginning of the ST segment (in the J point); visible from V1 to V3 and rarely in the leads of the frontal plane.

IMVT-RVOT: Absent. Do not exist.

ARVC/D: Is not pathognomonic but característic of the entity. Present in 30% of cases. The R' wave may be mistaken or an epsilon wave. They correspond to late potentials that can be translated into RV delayed activation.

Epsilon wave was present in 56.3% of patients with M-VT and LBBB, in 4.8% of patients with P-VT and in none of the patients with M-VT and RBBB. (Makarov LM, Gorlitskaia OV, Kuryleva TA, et al. Prevalence of electrocardiographical signs of right ventricular arrhythmogenic dysplasia Kardiologiia. 2004; 44:23-28.).

Epsilon wave is considered mayor criteria of the diagnosis of ARCVC/D. This condition is characterized by the presence of delayed potentials, which appear after the end of ventricular depolarization as recorded by epicardial mapping. This post-excitation phenomenon may also be demonstrated either by an intracavitary electrode or sometimes on an amplified ECG.

(XV) NEGATIVE T-WAVE FROM V1 TO V2 OR V3
IMVT-RVOT: Absent.

ARVC/D: Typical if present in > 12 year old without RBBB. The most relevant ECG features are inverted T wave from V1 to V3 leads and widened QRS complex (> 120 ms) in V1 lead (Topalov V, Kovacevic DV, Kovacevic D, et al. Arrhythmogenic right ventricular dysplasia Med Pregl.2000; 53: 355-362.).

(XVI) FRONTAL PLANE QRS AXIS OF VT
IMVT-RVOT: Positive in inferior leads III and AVF, negative in lead AVL. LBBB morphology inferior axis.

In 10% it may originate in the LV, in the region of the postero-inferior division of left bundle with RBBB morphology and extreme deviation of SÂQRS to the left.

Another morphology that suggests the focus of origin in the LV, is LBBB associated to early transition in the V2 lead.

Dominant R in V1 and inferior SÂQRS points the focus of superior origin in the LV.

Rarely, it could have an epicardial origin, characterized by positive concordance in precordial leads and negative complexes in DI and aVL.

TV has been described in literature, as presenting both LBBB and RBBB morphologies, each one with identical SÂQRS, which suggests that the focus originates in the interventricular septum with a dual exit to the left and to the right (Dixit S, Gerstenfeld EP, Callans DJ, et al. Electrocardiographic patterns of superior right ventricular outflow tract tachycardias: distinguishing septal and free-wall sites of origin. J Cardiovasc Electrophysiol. 2003; 14:1-7.).

According to the QRS configuration during episode of IM-VT four groups were distinguished by Mont et al (Mont L, Seixas T, Brugada P, et al. The electrocardiographic, clinical, and electrophysiologic spectrum of idiopathic monomorphic ventricular. Am Heart J. 1992; 124:746-753.).

1) Group I: RBBB morphology and SÂQRS superior on frontal plane: It group had dizziness during VT less frequently, but they needed cardioversion to terminate their arrhythmias more often. They experienced tachycardia during exercise less often, and tachycardia was not initiated during exercise testing. They had fewer PVCs according to the Holter recording. During the electrophysiologic study, VT was induced and terminated by pacing more often in this group. Reentry seems to be the most likely arrhythmia mechanism in this group.

2) Group II: RBBB morphology and intermediate SÂQRS on frontal plane;

3) Group III: LBBB morphology and left axis deviation;

4) Group IV: LBBB morphology wit right axis deviation or intermediate;

ARVC/D: Can be inferior or Superior. LBBB morphology with inferior axis if originates from RVOT and LBBB morphology with superior axis if originate form RVIT or apex.

(XVII) ARRHYTHMIAS

IMVT-RVOT: PVBs, non-sustained VT or sustained VT at rest or with exercise. The most common form of idiopathic VT is repetitive M-VT (RMVT), which typically occurs at rest and is characterized by frequent ventricular ectopy and salvos of NS-VT with intervening sinus rhythm. Although the arrhythmia occurs at rest, the constellation of findings in idiopathic VT that is characterized by RMVT is consistent with the mechanism of cAMP-mediated triggered activity. Therefore, the spectrum of VT resulting from this mechanism includes not only paroxysmal exercise-induced VT but also RMVT (Lerman BB, Stein K, Engelstein ED, et al. Mechanism of repetitive monomorphic ventricular tachycardia. Circulation. 1995; 92:421-429.). Several distinctive ECG characteristics and detailed ECG analysis can differentiate free wall RVOT from septum-VT/ PVCs:

1) R wave amplitudes in the inferior leads were significantly smaller in free wall;

2) RVOT or PVCs than in septum VT/PVC;

3) An RR' pattern in the inferior leads was observed significantly more often in free wall RVOT/PVC than in septum -VT/PVC;

4) QS-wave amplitude in each of leads V1 to V3 was significantly deeper in free wall -RVOT/PVC

than in septum -VT/PVC (Tada H, Ito S, Naito S, et al. Prevalence and electrocardiographic characteristics of idiopathic ventricular arrhythmia originating in the free wall of the right ventricular outflow tract. Circ J. 2004; 68:909-914.).

ARVC/D: MVT with LBBB morphology with exercise.

Sustained VT occurs spontaneously or during exercise. The PVCs and the VT have LBBB contour, suggesting RV site of origin.

ARVC/D could be a common cause of VT in children with an apparently normal heart (Dungan WT, Garson A Jr, Gillette PC. Arrhythmogenic right ventricular dysplasia: a cause of ventricular tachycardia in children with apparently normal hearts. Am Heart J. 1981; 102:745-750.).

The effort plays an important role in the induction of VT in patients with localized RV impairment. In conclusion a wide spectrum of VT is present in the ARVC/D. Probably there are varied RV "arrhythmogenic" zones and electrophysiological mechanisms (Nava A, Canciani B, Scognamiglio R, et al. Tachycardia and ventricular fibrillation in the arrhythmogenic right ventricle (arrhythmogenic dysplasia of the right ventricle). Clinical and electrocardiographic spectrum G Ital Cardiol. 1986; 16:741-749.).

(XVIII) VENTRICULAR ARRHYTHMIAS MECHANISM
IMVT-RVOT:

1) Trigged activity (Adenosine-Sensitive): 70% of cases. cAMP-mediated triggered activity.
2) Delayed triggered activity, dependent on post-depolarization in phase 4, associated to increase of cyclic AMP and mediated by catecholamines: adrenergic-dependent.

3) Intrafascicular Reentry (Verapamil sensitive); 10% of cases.

4) Enhanced Automaticy (Propranolol-sensitive);

5) Reentry
6) Undifferentiated (Lerman BB, Stein KM, Markowitz SM.: Idiopathic right ventricular outflow tract tachycardia: A clinical approach. Pacing Clin Electrophysiol. 1996 19:2120-2137.).

Dynamic changes in the T-U wave were observed in patients with idiopathic M-VT originating from the RVOT. Further investigations are required to elucidate the precise role of the U wave in arrhythmogenesis in these patients (Nakagawa M, Ooie T, Hara M, et al. Dynamics of T-U wave in patients with idiopathic ventricular tachycardia originating from the right ventricular outflow tract. Pacing Clin Electrophysiol. 2004; 27:148-155.).

ARVC/D: Four mechanism are related in literature:

1) VT around an anatomical obstacle: the fibrofatty substitution of the RV myocardium constitutes the substrate for reentrant circuits, leading to the onset of ventricular arrhythmias (Bauce B, Basso C, Nava A. Signal-averaged electrocardiographic parameter progression as a marker of increased electrical instability in two cases with an overt form of arrhythmogenic right ventricular cardiomyopathy.Pacing Clin Electrophysiol. 2002; 25:362-364.). VT in ARVC/D has been previously explored using entrainment mapping techniques but little is know about VT mechanisms and the characteristics of their circuits using an electroanatomical mapping system. Peritricuspid ventricular reentry is a frequent mechanism of VT in patients with ARVC/D which can be identified

by detailed 3D electroanatomical mapping. This novel form of mapping is valuable in identifying VT mechanisms and in guiding RF ablation in patients with ARVD.(Miljoen H, State S, de Chillou C, et al. Electroanatomic mapping characteristics of ventricular tachycardia in patients with arrhythmogenic right ventricular cardiomyopathy/dysplasia. Europace. 2005; 7:516-524.);

2) VT as a result of increased automaticity during exercise;

1) Vortex-like reentrant VT, which may explain SCD during sleep;

2) Combination of the previous ones.

In ARVD/C the tachycardia cycle length of clinical VT, PVS-induced VT and follow-up VT correlate well implicating that a PVS-guided approach does not provide additional information. Spontaneous arrhythmia in combination with clinical presentation allows identification of patients in need for an ICD.(Pezawas T, Stix G, Kastner J, Schneider B, Wolzt M, Schmidinger H.Ventricular tachycardia in arrhythmogenic right ventricular dysplasia/cardiomyopathy: Clinical presentation, risk stratification and results of long-term follow-up. Int J Cardiol. 2006; 107:360-368.);

(XIX) ATRIAL ARRHYTHMIAS
IMVT-RVOT: Absent.

ARVC/D: Late and secondary.

(XX) VECTORCARDIOGRAM
IMVT-RVOT: No mentioned.

ARVC/D: There is evidence of peripheral blocks of the RBBB in ARV/CD) as Fontaine showed: the IRBBB or CRBBB topography occurs in the divisional portion of the right branch, i.e. in the free wall of the RV after the trunk of the branch splits in the base of the papillary muscle of the tricuspid valve, and its mechanism seems to respond to dysplastic involvement of the free wall, whether in the RVOT, the RVIT, or in the apical region (dysphasia triangle) where the dysplastic area is found (Fontaine G, Frank R, Guiraudon G, et al. Significance of intraventricular conduction disorders observed in arrhythmogenic right ventricular dysplasia. Arch Mal Coeur Vaiss. 1984; 77:872-879.).

Nava et al. Showed modifications on HP T loop of VCG. The authors observed three morphologic characteristics:

1) CCW rotation with a mean axis range of + 150 to -100;

2) A figure-eight pattern with mean range of +100 to - 400;

3) CW rotation with mean axis range of - 400 to -1100 (Nava A, Canciani B, Buja G, et al. Electrovectorcardiographic Study of Negative T Waves on Percordial Leads in Arrhtyhmogenic Right Ventricular Dysplasia: Relationship With Right Ventricular Volumes J of Electrocardiol 1998: 21: 239-245.).

(XXI) SIGNAL AVERAGED ECG
IMVT-RVOT: Always normal.

ARVC/D: Usually abnormal. Filtering in the range of 20 to 250 Hz is more sensitive for identification of asymptomatic cases than the usual band pass of 40 to 250 Hz.

From 138 patients studied the signal averaged ECG was abnormal in 57% of the patients.

The sensitivity was 57%, specificity 95% and positive predictive value 92%.

The signal averaged ECG was abnormal in 94.4% of patients with the extensive form of the disease, in 77.7% of patients with the moderate form and in 31.8% of patients with the minor form, demonstrating good correlation with the extent of the disease.

There is a closer correlation between the signal averaged ECG and extent of disease than with the presence of ventricular arrhythmias. The signal averaged ECG is not helpful in diagnosing minor forms of the disease, but since it is a non-invasive method, it may be useful in evaluating progression of the disease (Oselladore L, Nava A, Buja G, et al. Signal-averaged electrocardiography in familial form of arrhythmogenic right ventricular cardiomyopathy.Am J Cardiol. 1995; 75:1038-1041.) (Nava A, Folino AF, Bauce B, et al. Signal-averaged electrocardiogram in patients with arrhythmogenic right ventricular cardiomyopathy and ventricular arrhythmias. Eur Heart J. 2000; 21:58-65.).

(XXII) MICROVOLT T-WAVE ALTERNANS (TWA)

It is a new risk marker for ventricular arrhythmias.

IMVT-RVOT: Negative for T-wave alternans in > 90% of cases.

ARVC/D: Positive for TWA in 87% of cases (Kinoshita O, Tomita T, Hanaoka T, et al. T-wave alternans in patients with right ventricular tachycardia. Cardiology. 2003; 100:86-92.). So, TWA could be an appropriate test to detect arrhythmic risk in patients with ARVC/D.

(XXIII) EXERCISE STRESS TESTING

IMVT-RVOT: In 50% of cases adrenergic-dependent effort induced VT and Provocable by exercise or effort induced VT. Tree variants are Exercise induced: The variant Adenosine-Sensitive (Triggered Activity); The variant Propanolol-Sensitive and the Undifferentiated.

The variant Adenosine-Sensitive (Triggered Activity) is exercise-induced with repetitive M-VT.

The variant Propanolol-Sensitive is Exercise induced with incessant.

ARVC/D: Should be performed with particular attention paid to evaluating ST segment changes in RV precordial leads.

Occurrence of extrasystoles during increasing exercise followed by a prolonged observation during the recovery phase. A crescendo of PVCs.

(XXIV) AMBULATORY ELECTROCARDIOGRAPHY OR LONG-TERM ELECTROCARDIOGRAPHIC RECORDING

(HOLTER MONITORING AND LOOPER)

IMVT-RVOT: Detection of frequent or in bursts monomorphic PVCs that occur predominantly during the day.

Record M-VT with LBBB pattern with inferior SÂQRS: between + 300 and + 1200 indicative of RVOT origin.

ARVC/D: Proper evaluation requires a 12-lead Holter system;

Record MVT with typical LBBB pattern.

(XXV) ECHOCARDIOGRAM

IMVT-RVOT: Normal in 90% of cases. Rarely, slight enlargement of RV.

ARVC/D: Increased RV size and/or wall motion abnormalities. Dilatation of the RVOT and hypocontractility It is difficult in patients with minimal RV abnormalities. Aneurysm of the basal RV free wall below tricuspid valve is related (Maia IG, Sa R, Bassan R, et al. Arrhythmogenic right ventricular dysplasia Arq Bras Cardiol. 1991; 57:97-102.).

(XXVI) RV VENTRICULOGRAM

IMVT-RVOT: Usually Normal

ARVC/D: Usually abnormal. It is difficult to evaluate in patients with minimal RV abnormalities.

(XXVII) CARDIAC MAGNETIC RESONANCE IMAGING OR NUCLEAR MAGNETIC RESONANCE (CMRI, MRI OR NMR)

IMVT-RVOT: Usually normal, but data in literature is conflicting. Carlson et al (Farwell DJ, Freemantle N, Sulke AN. Use of implantable loop recorders in the diagnosis and management of syncope. Eur Heart J. 2004; 25:1257-1263.) refer: focal wall thinning focally diminished systolic wall thickening, and abnormal systolic wall motion.

Focal fatty infiltration was referred.

RV abnormalities were revealed in 32 (60%) of the 53 patients: fixed thinning in 27 (84%), fatty replacement in eight (25%), and reduced wall thickening or motion in 31 (97%). RV abnormalities were found in 35 (76%) of 46 patients with idiopathic RVOT tachycardia. Mild RV abnormalities are likely sources for arrhythmias, even in the absence of ARVC/D (Carlson MD, White RD, Trohman RG, et al. Right ventricular outflow tract ventricular tachycardia: detection of previously unrecognized anatomic abnormalities using cine magnetic resonance imaging.J Am Coll Cardiol. 1994; 24:720-727.) (White RD, Trohman RG, Flamm SD, et al. Right ventricular arrhythmia in the absence of arrhythmogenic dysplasia: MR imaging of myocardial abnormalities. Radiology. 1998;207:743-751.).

.Menghetti et al (Menghetti L, Basso C, Nava A, et al. Spin-echo nuclear magnetic resonance for tissue characterisation in arrhythmogenic right ventricular cardiomyopathy.Heart. 1996;76:467-

470.) studied fifteen patients that had a clinical diagnosis of ARVC/D with spin-echo T1-weighted NMR and multislice scan. Ten of the 15 patients with ARVC had an abnormal NMR result (67% sensitivity), with areas that had signal intensity close to that of pericardial or subcutaneous fat. In the remaining five cases the NMR signal was inadequate.

ARVC/D: Increased signal intensity of RV free wall; wall motion abnormalities with CINE MRI has emerged as clinical tools for evaluation of myocardial pathology. The device providing morphologic and functional information, has the ability to demonstrate intramyocardial fat, which is the pathological hallmark in ARVC/D (Menghetti L, Basso C, Nava A, et al. Spin-echo nuclear magnetic resonance for tissue characterisation in arrhythmogenic right ventricular cardiomyopathy. Heart. 1996;76:467-470.) (Tandri H, Bomma C, Calkins H, et al. Magnetic resonance and computed tomography imaging of arrhythmogenic right ventricular dysplasia. J Magn Reson Imaging. 2004; 19:848-858.) (Desai MY, Lima JA, Bluemke DA. Cardiovascular magnetic resonance imaging: current applications and future directions. Methods Enzymol. 2004; 386:122-148.).

MRI allows the clearest visualization of the heart, in particular because the RV is involved, which is usually more difficult to explore with the other imaging modalities. Furthermore, MRI offers the specific advantage of visualizing adipose infiltration as a bright signal of the RV myocardium. MRI provides the most important anatomic, functional, and morphologic criteria for diagnosis of ARVC/D within one single study. As a result, MRI appears to be the optimal imaging technique for detecting and following patients with clinical suspicion of ARVC/D (Castillo E, Tandri H, Rodriguez ER, et al. DA. Arrhythmogenic Right Ventricular Dysplasia: Ex Vivo and in Vivo Fat Detection with Black-Blood MR Imaging. Radiology. 2004; 232:38-48.).

(XXVIII) ELECTRON-BEAM COMPUTED TOMOGRAPHY

(ELECTRON-BEAM CT) OR ULTRAFAST COMPUTERIZED TOMOGRAPHY)

IMVT-RVOT: Normal.

ARVC/D: Characteristic electron-beam CT findings are frequently observed only in patients with ARVC/D. Electron-beam CT is useful for evaluating for LV involvement and can estimate mapping electrophysiology study.

The frequencies of abundant epicardial adipose tissue, low-attenuation trabeculations, scalloping of the RV free wall, and intramyocardial fat deposits were 86%, 71%, 79%, and 50%, respectively, in the ARVC/D group, whereas these findings were not observed in control groups (van der Wall EE, Kayser HW, Bootsma MM, et al. Arrhythmogenic right ventricular dysplasia: MRI findings. Herz. 2000; 25:356-364.).

(XXIX) RESPONSE TO PROGRAMMED

ELECTRICAL STIMULATION (PES) (INDUCTION)

IMVT-RVOT: Inducibility of VT by PES with ventricular extra stimuli: 3%;

Presence of more than one ECG morphology during tachycardia: 0%;

Fragmented diastolic potentials during ventricular arrhythmia: 0%.

ARVC/D: Inducibility of VT by PES with ventricular extrastimuli: 93%,

Presence of more than one ECG morphology during tachycardia: 73%,

Fragmented diastolic potentials during ventricular arrhythmia: 93% (Takagi M, Aihara N, Kuribayashi S, et. al. Abnormal response to sodium channel blockers in patients with Brugada syndrome: augmented localized wall motion abnormalities in the right ventricular outflow tract region detected by electron beam computed tomography. Heart 2003; 89:169-74.).

(XXX) ENTRAI ENTRAINMENT

Technique that consists in applying extra-stimuli in series during S-VT, using cycles for at least 20 ms less than the VT cycle, accelerating the tachycardia to stimulated rate.

IMVT-RVOT: Negative. Insensitive / not present.

ARVC/D: Positive. Sensitive / present.

(XXXI) RESPONSE TO CATECHOLAMINES AGENTS ISOPROTERENOL, ISOPRENALINE OR DOBUTAMINE

IMVT-RVOT: Facilitates in cAMP-Triggered Activity

(Adenosine-Sensitive) and Propanolol-Sensitive (Automatic).

Facilitates/no effect in reentry in Verapamil-Sensitive, in undifferentiated, atriofascicular and Bundle Brach reentry variants.

ARVC/D: Catecholamines Facilitation. The induction of the VT generally is dependent of the infusion of isoproterenol. Catecholamines increase the ST segment elevation.

(XXXII) RESPONSE TO AJMALINE HYDROCHLORIDE TESTING

(CLASS 1A AGENT)

IMVT-RVOT: No tested.

Observation:

Class IA agents such as procainamide e Quinidine are used for the treatment and are effective in approximately 25% to 50% of patients.

ARVC/D: Could be positive: coved ST segment elevation of at least 2 mm in at least two right precordial leads (Shimizu W, Kamakura S. Catecholamines in children with congenital long QT syndrome and Brugada syndrome. J Electrocardiol 2001; 34: 173-175.).

(XXXIII) RESPONSE TO CLASS II ANTIARRHYTHMIC AGENTS: BETA-ADRENOCEPTOR BLOCKERS: PROPRANOLOL AND OTHERS

IMVT-RVOT:

Adenosine-Sensitive: Present/ sensitive;

Verapamil-Sensitive: Present/ sensitive or not present/insensitive;

Propanolol-Sensitive:

Terminates/transient suppression;

Undifferentiated: not present/insensitive;

ARVC/D: Beta-blocking agents by themselves do not offer a fail-safe protection in adult with ARVC/D (Brugada R, Brugada J, Antzelevitch C, et al, Brugada Sodium channel blockers identify risk for sudden death in patients with ST-segment elevation and right bundle branch block but structurally normal hearts. Circulation. 2000; 101:510-515.).

They decrease the elevation of the J point and ST segment. Sympathetic over activity is reported to cause SCD.

They are of choice in the cases of clearly effort-induced arrhythmias.

Carvedilol is not only useful for controlling arrhythmia but also for improving LV function in some patients with ARVC/D. Carvedilol may be a first-line drug for some patients with ARVC/D (Hiroi Y, Fujiu K, Komatsu S, et al. Carvedilol therapy improved left ventricular function in a patient with arrhythmogenic right ventricular cardiomyopathy. Jpn Heart J. 2004; 45:169-177.).

(XXXIV) EFFECT OF FEVER OR HIGER TEMPERATURE

IMVT-RVOT: No influenced.

ARVC/D: No influenced.

(XXXV) PLASMA LEVELS OF BRAIN NATRIURETIC PEPTIDE (BNP)

IMVT-RVOT: Plasma levels of BNP are not increased.

Mean value: 8.3+/-5. 5 pg/mL

ARVC/D: Plasma levels of BNP are increased in ARVC/D patients.

Mean value: 61.4+/-59.6 pg/mL (Matsuo K, Nishikimi T, Yutani C, et al. Diagnostic value of plasma levels of brain natriuretic peptide in arrhythmogenic right ventricular dysplasia. Circulation. 1998; 98:2433-2440.).

(XXXVi) ENDOMYOCARDIAL BIOPSY (EMB)

IMVT-RVOT: Usually negative: without structural heart disease.

Recent studies with EMB contradict this concept, having shown abnormalities in more than 65% of cases, which increases to more than 80% when the material is product of an autopsy. Thus, the following were described (Markowitz SM, Litvak BL, Ramirez de Arellano EA, et al. Adenosine-sensitive ventricular tachycardia: right ventricular abnormalities delineated by magnetic resonance imaging. Circulation. 1997; 96:1192-200.):

Indicatives of structural heart disease:

1) Hamartoma of Purkinje fibers was described (Garson A Jr, Smith RT Jr, Moak JP, et al. Incessant ventricular tachycardia in infants: myocardial hamartomas and surgical cure. J Am Coll Cardiol. 1987; 10:619-626.) ;

2) Mild form of ARVC/D;

3) Microangiopathy associated to subendocardial fibrosis;

4) Sub-clinical myocarditis;

5) Focal cardiomyopathy;

6) Atherosclerotic ischemic cardiomyopathy;

7) Non-atherosclerotic ischemic cardiomyopathy;

8) Hypertrophic cardiomyopathy;

9) Mitral valve prolapse.

ARVC/D: It has the potential for in vivo demonstration of typical fibrofatty replacement of the RV myocardium. However, sensitivity of this test is low because, for reasons of safety, samples are usually taken from the septum, a region uncommonly involved by the disease.

Fibrofatty replacement of the myocardium, the hallmark pathologic feature, may be a response to injury caused by myocyte detachment.

Apoptosis is present in EMB of patients with ARVC/D, especially in the early symptomatic phase of disease (Valente M, Calabrese F, Thiene et al. In vivo evidence of apoptosis in arrhythmogenic right ventricular cardiomyopathy. Am J Pathol. 1998; 152:479-484.).

In all patients, it is necessary preformed the EMB in the apex, RVOT, inferior wall of the RVIT and in the septal-apical region of the LV.

A Myocarditis involving the RV can mimic a ARVC/D. EMB appears the most reliable diagnostic technique, with significant prognostic and therapeutic implications (Chimenti C, Pieroni M, Maseri A, Histologic findings in patients with clinical and instrumental diagnosis of sporadic arrhythmogenic right ventricular dysplasia. J Am Coll Cardiol. 2004; 43: 2305-2313.). Thirty patients with LBBB morphology VT and echocardiographic, angiographic, and MRI findings diagnostic of ARVC/D were studied. All patients, besides diagnostic, noninvasive, and invasive cardiac studies, underwent EMB in the apex, anterior free wall, inferior wall of the RV and in the septal-apical region of the LV. RESULTS: Diagnostic histologic features of ARVC/D were found 30% patients and a myocarditis, according to the Dallas criteria, in the remaining 70% patients.

Morphometric evaluation of RV samples showed significant differences in fatty tissue and myocyte percent area between ARVC/D and myocarditis. Conversely, no difference was found between the two groups in arrhythmic patterns and structural and functional echocardiographic, angiographic, and MRI RV alterations.
MRI showed hyperintense signals in 67% of ARVC/D and in 62% of myocarditis group. During follow-up (mean, 23 +/- 14 months), all patients with myocarditis remained stable on antiarrhythmic therapy while five patients with ARVC/D required implantation of an ICD.

From January 1985 through December 1990, 534 patients underwent EMB at Johns Hopkins Hospital for suspected myocarditis. One hundred thirty-eight (26%) biopsy specimens were diagnosed histologically by two cardiac pathologists as either active (n = 85, 16%) or borderline (n = 53, 10%) myocarditis. Of the 138 patients, 60 were excluded based on either specific concurrent clinical conditions or noncongestive heart failure presentations. Immunohistochemical staining for common leukocyte antigen infiltrating cells performed on the remaining 78 specimens confirmed the presence of focal or multifocal inflammatory infiltrates in 58, of which 49 had histologic evidence of active myocarditis. All 49 patients presented with CHF and LV EF of < 40%.

Compared with patients with either idiopathic dilated cardiomyopathy (n = 207) or ischemic cardiomyopathy (n = 44), these patients with myocarditis had a less striking male predominance (58 vs 69 and 83%, respectively) (p = 0.02) and were younger (43 +/- 16 vs 50 +/- 17 and 55 +/- 13 years, respectively, p = 0.005). Racial distributions were similar. (Herskowitz A, Campbell S, Deckers J, et al. Demographic features and prevalence of idiopathic myocarditis in patients undergoing endomyocardial biopsy. Am J Cardiol. 1993; 71:982-986.).

In 10-year of experience with EMB in myocarditis associated to idiopathic CHF with specific reference to frequency of myocarditis, treatment policy, relative benefits, and follow-up, Arbustini et al. (Arbustini E, Gavazzi A, Dal Bello B, et al. Ten-year experience with endomyocardial biopsy in myocarditis presenting with congestive heart failure: frequency, pathologic characteristics, treatment and follow-up.G Ital Cardiol. 1997;27:209-223.) shows that the frequency of myocarditis diagnosed according to Dallas criteria is high in patients with clinical diagnosis of myocarditis, while it is extremely low in dilated cardiomyopathy patients.

Of the 601 patients, 38 were clinically suspected of having myocarditis on the bases of a very recent onset of CHF and/or of arrhythmias and/or of conduction disturbances, and of a close-to-recent history of flu-like febrile illness.

Corresponding EMBs showed myocarditis in 16 of the 38 cases (42.1%). A further 10 EMBs, from patients with a recent onset of CHF without prior infection episodes, showed myocarditis.

(XXXVII) RESPONSE TO THERAPY
IMVT-RVOT: Therapy only mandatory if presyncope or syncope present.

Beta-blockers are effective in 35% of cases;

Calcium channels blockers: are effective in 30% of cases;

Association Class IA and IC is effective in 35% of cases;

Class III drugs are effective in 50% of cases.

Acute termination: Vagal maneuver; adenosine, intravenous verapamil and lidocaine.

ARVC/D:

1) Empirical drug therapy:

Sotalol; amiodarone +/- ; beta blockers, carvedilol (alpha and beta blocker).

2) Anticoagulant therapy.

In patients in whom ARVC/C has progressed to severe RV or biventricular systolic dysfunction with risk of thromboembolic complications (Corrado D, Basso C, Nava A, et al. Arrhythmogenic right ventricular cardiomyopathy: current diagnostic and management strategies.Cardiol Rev. 2001;9:259-265.).

3) Radiofrequency catheter ablation: See bellow in specific next topic.

4) Implantable Cardioverter-Defibrillators (ICDs)

Indication:

a) Patients with documented cardiac arrest or unequivocal syncopal episode that cannot be induced in PES;

b) Patients who have non-coronary ST segment elevation in the right precordial leads. They may have inducible PVT/VF at rest or sleep;

c) SCD in a close family member;

d) Patients that do not want to take antiarrhythmic drugs for the rest of theirs lives;

e) Patients in who drugs are producing unacceptable side effects;

f) Patients who do not respond to drug therapy by PES or because of clinical recurrence (Roguin A, Bomma CS, Nasir K, et al. Implantable Cardioverter-Defibrillators in patients with arrhythmogenic right ventricular Dysplasia/Cardiomyopathy. J Am Coll Cardiol. 2004 19; 43:1843-1852.).

Greater awareness of ARVC/D among physicians and judicious use of ICDs may help to prevent unnecessary deaths (Sen-Chowdhry S, Lowe MD, Sporton SC, et al. Arrhythmogenic right ventricular cardiomyopathy: Clinical presentation, diagnosis, and management. Am J Med. 2004; 117:685-695.).

5) Heart transplantation or Orthotopic Heart Transplantation (OHT)

Indicated in patients who develop severe intractable ventricular failure.

(XXXVIII) RADIOFREQUENCY CATHETER ABLATION (RFCA)

IMVT-RVOT: Usually is an effective, curative and safe therapy. RFCA is the treatment of choice in drug-refractory VT in structurally normal heart.

A new RBBB develops in 2% of cases.

Procedural success: noninducibility of VT after RFCA (van der Burg AE, de Groot NM, van Erven L, et al. Long-term follow-up after radiofrequency catheter ablation of ventricular tachycardia: a successful approach? J Cardiovasc Electrophysiol 2002; 13:417-23.) (Maciag A, Sterlinski M, Pytkowski M, et al. Successful radiofrequency catheter ablation of the symptomatic ventricular tachycardia in structurally normal heart. Case report. Pol Arch Med Wewn. 2003; 110:1453-1457.) .

Recently, Ito et al (Ito S, Tada H, Naito S, et al. Development and validation of an ECG algorithm for identifying the optimal ablation site for idiopathic ventricular outflow tract tachycardia. J Cardiovasc Electrophysiol. 2003;14:1280-1286.) describe a new ECG algorithm having a high sensitivity(88%) and specificity(96%) to identify the optimal ablation site for idiopathic ventricular outflow tachycardia or PVCs. The catheter sites were verified by multi-plane fluoroscopy.

The author divided the RVOT in six subdivisions:

1) RV septum;

2) RV free wall;

3) RV near the His-bundle region;

4) LV endocardium;

5) Left sinus of Valsalva (LSV);

6) LV epicardium remote from the LSV.

A PVCs originating from the LV epicardium remote from the LSV was defined as a PVCs in which the earliest ventricular activation was recorded at the LSV and RFCA from the LSV failed.

Noncontact mapping is a safe and effective alternative method to guide ablation of hemodynamically unstable or nonsustained ventricular arrhythmia originating from RVOT (Fung JW, Chan HC, Chan JY, et al. Ablation of nonsustained or hemodynamically unstable ventricular arrhythmia originating from the right ventricular outflow tract guided by noncontact mapping. Pacing Clin Electrophysiol. 2003;26:1699-1705.).

ARVC/D: Seldom curative; it may modify substrate to permit AA drugs to be effective.

Arrhythmias of different morphology tend to recur.

In general the procedure does not have success for the gradual nature of the illness and the multiple morphologies of VT.

Defining the abnormal electrophysiological anatomical VT substrates mapping for guiding ablation of ARVD-VTs using a non-contact mapping system linear ablation across a critical isthmus or between the early activation and the exit point can effectively cure these arrhythmias (Zou J, Cao K, Yang B, et al. Dynamic Substrate Mapping and Ablation of Ventricular Tachycardias in Right Ventricular Dysplasia. J Interv Card Electrophysiol. 2004; 11:37-45.). Useful for electrical storm.

(XXXIX) NATURAL HISTORY, PROGNOSIS, LONG-TERM FOLLOW-UP

IMVT-RVOT: Usually good. SCD is rare in this patient population. Frequent episodes may result in cardiomyopaty and render the decision of RFCA of the focus more imperative.

In children the prognosis is favorable, however, appropriate treatment and follow-up were required in children with S-VT, symptomatic VT or VT with a high rate (Suner S, Simon HK, Feit LR, et al. Child with idiopathic ventricular tachycardia of prolonged duration. Ann Emerg Med. 1995; 25:706-709.).

Although the prognosis of these patients remains excellent, they should continue to have periodic cardiac follow-up to rule out latent progressive heart disease such as ARVC/D or cardiomyopathy or other forms of cardiomyopathies (Chiu C, Sequeira IB. Diagnosis and treatment of idiopathic ventricular tachycardia. AACN Clin Issues. 2004; 15:449-461.).

Usually benign. 5% to 20% spontaneous VT remission.

ARVC/D: Early RV dysplasia is characterized by a "concealed phase" in which electrocardiographic and imaging abnormalities are often absent, but patients may nonetheless be at risk for arrhythmic events. In this phase, it can be confused with idiopathic Ventricular Fibrillation (Nava A, Thiene G, Canciani B et al. Clinical profile of concealed form fo arrhythmogenic right ventricular cardiomyopathy presenting with apparently idiopathic ventricular arrhythmias. Int J Cardiol 1992; 35:195-206.) or with BS.SCD or later in the disease evolution; progressive impairment of ventricular contractility may result in right or biventricular heart failure.

SCD or CHF.

Progressive.

All patients who died had a history of VT. Multivariate analysis showed that after adjustment for sex, history of syncope, chest pain, inaugural VT, recurrence of VT, and QRS dispersion, clinical signs of RV failure and left ventricular dysfunction both remained independently associated with cardiovascular mortality. The combined presence of one of these risks factors and VT identifies high-risk subjects for cardiovascular mortality, whereas patients without VT displayed the best prognosis (Hulot JS, Jouven X, Empana JP, et al. Natural history and risk stratification of arrhythmogenic right ventricular dysplasia / cardiomyopathy. Circulation. 2004; 110:1879-1884.).

The noninvasive risk profile, which emerges from retrospective analysis of clinical and pathologic series, is characterized by history of syncope, physical exercise, spontaneous VT or VF, RV dysfunction, lLV involvement, right precordial negative T wave, RBBB, QT-QRS dispersion, right precordial ST-segment elevation and late potentials. At present only QRS dispersion, history of syncope and right and/or LV abnormalities at radionuclide angiography proved to be independent noninvasive predictors of SCD. (Turrini P, Corrado D, Basso C, et al. Noninvasive risk stratification in arrhythmogenic right ventricular cardiomyopathy. Ann Noninvasive Electrocardiol. 2003; 8:161-169.).

The significant correlation between SDNN and ventricular arrhythmias confirmed the influences of autonomic activity in the modulation of the electrical instability in ARVC/C patients. However, SDNN was not predictive of spontaneous episodes of S-VT (Folino AF, Buja G, Bauce B, et al. Heart rate variability in arrhythmogenic right ventricular cardiomyopathy correlation with clinical and prognostic features. Pacing Clin Electrophysiol. 2002; 25:1285-1292.).

In the athletes group < 35 years, coronary artery disease and acute myocarditis are the predominant

causes of SCD, but also hypertrophic cardiomyopathy (HCM) and ARVC/D (Sack S. Sports Death-a Problem Related to Internal Medicine? Herz. 2004; 29:414-419.).

QRS dispersion (>/=40 ms) was the strongest independent predictor of SCD in ARVC/D. Syncope, QT dispersion >65 ms, and negative T wave beyond V(1) refined arrhythmic risk stratification in these patients (Turrini P, Corrado D, Basso C, et al. Dispersion of ventricular depolarization-repolarization: a noninvasive marker for risk stratification in arrhythmogenic right ventricular cardiomyopathy. Circulation. 2001; 103:3075-3080.).