CASE REPORT
ADOLESCENT WITH SUDDEN DEATH

This ECG for a 15 year old male who was referred to the hospital after he experienced out of hospital sudden death. Here is his first ECG [ECG 1] in the hospital and the second ECG [ECG 2] during follow up in the hospital before the ICD implantation.

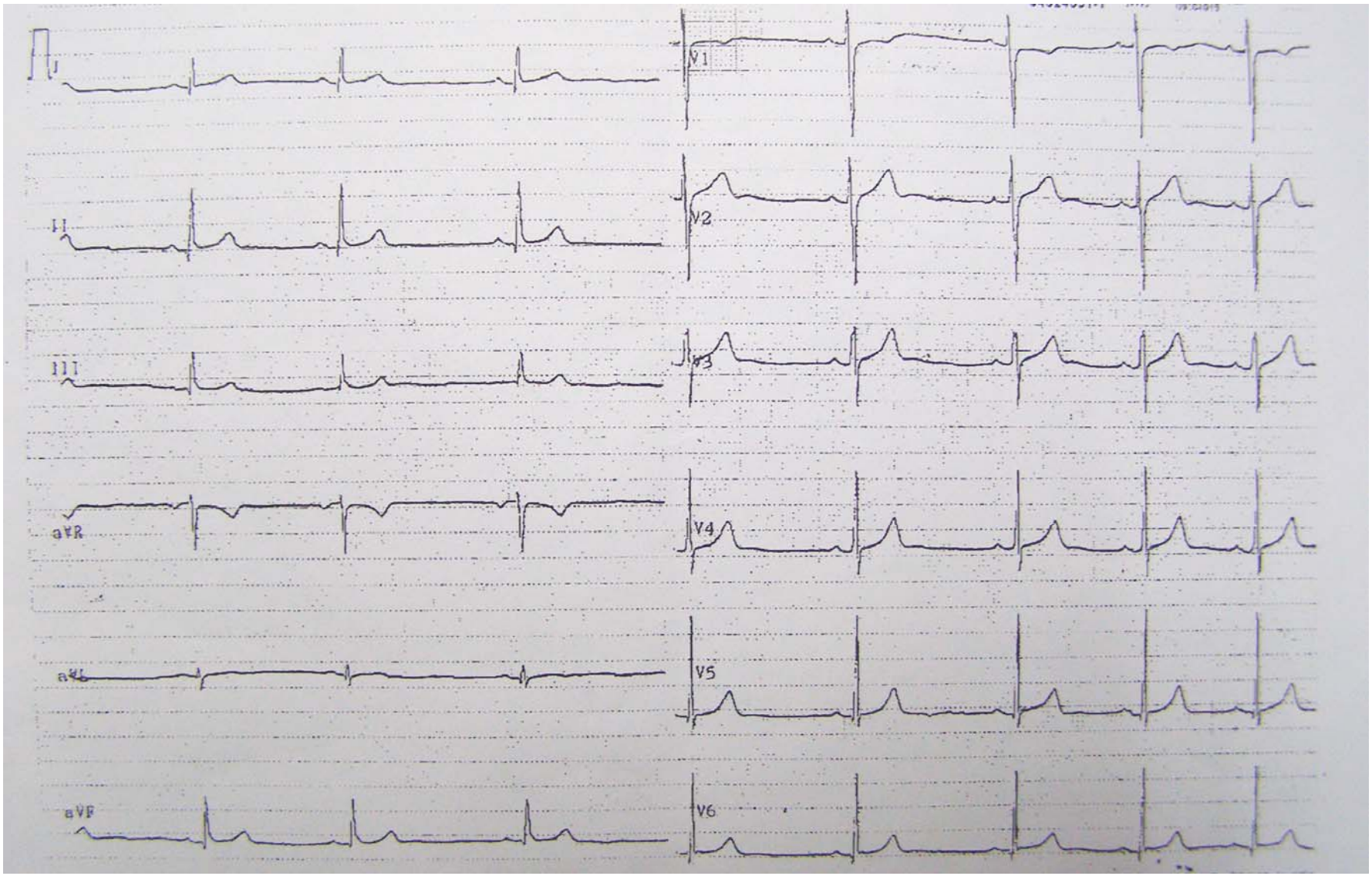
He is appropriate to his age regarding his built. He has a negative family history of SCD or CAD, the family's ECGs are normal. He has normal echocardiography, MRI, exercise test, and normal routine lab data.

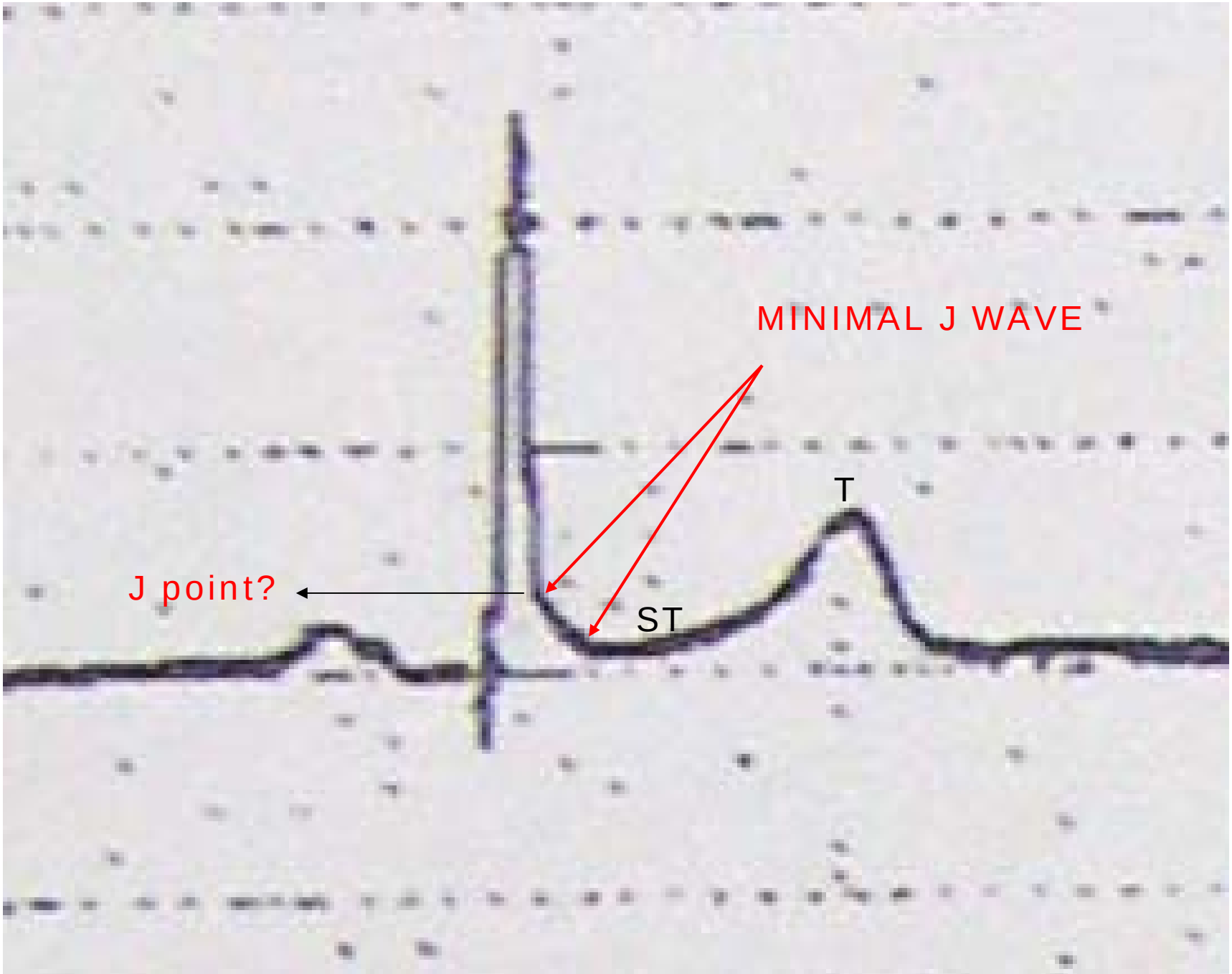
The patient underwent detailed evaluation, including provocation tests like ajmaline and epinephrine tests. Both were negative.
We noticed his minimal J wave after QRS complexes.

Suggestions?
Andrés Ricardo Pérez Riera

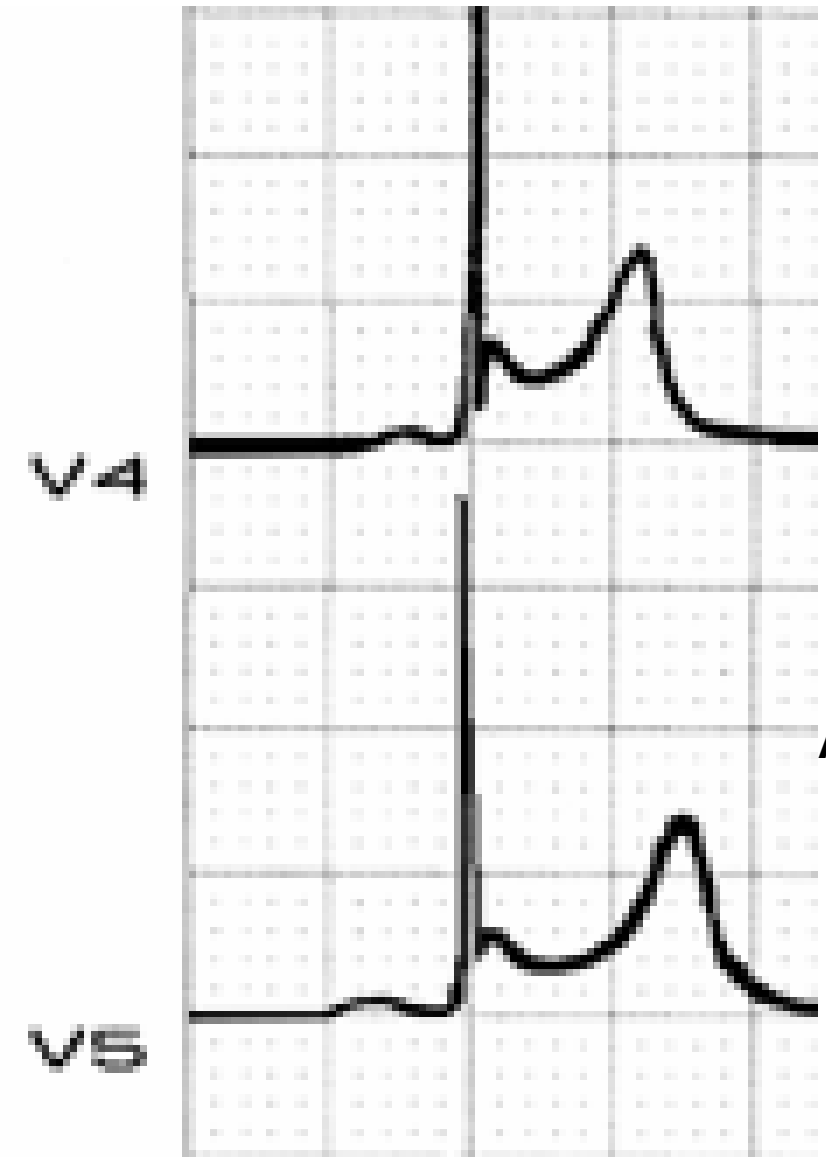
ECG 1

Name: Gender: Male Age: 15 yo. Ethnic Group: Caucasian
Weight: ?? Kg Height: ?? m Biotype: Normoline Date: Aug. 6 2009

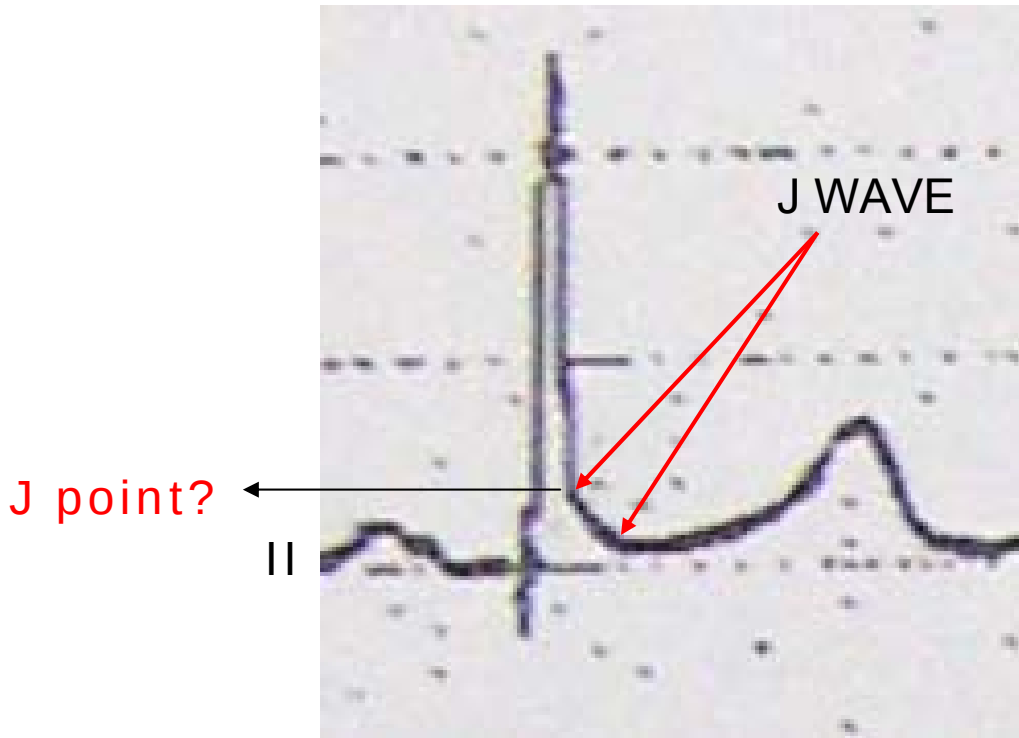



MINIMAL J WAVE
T
J point?
ST
II

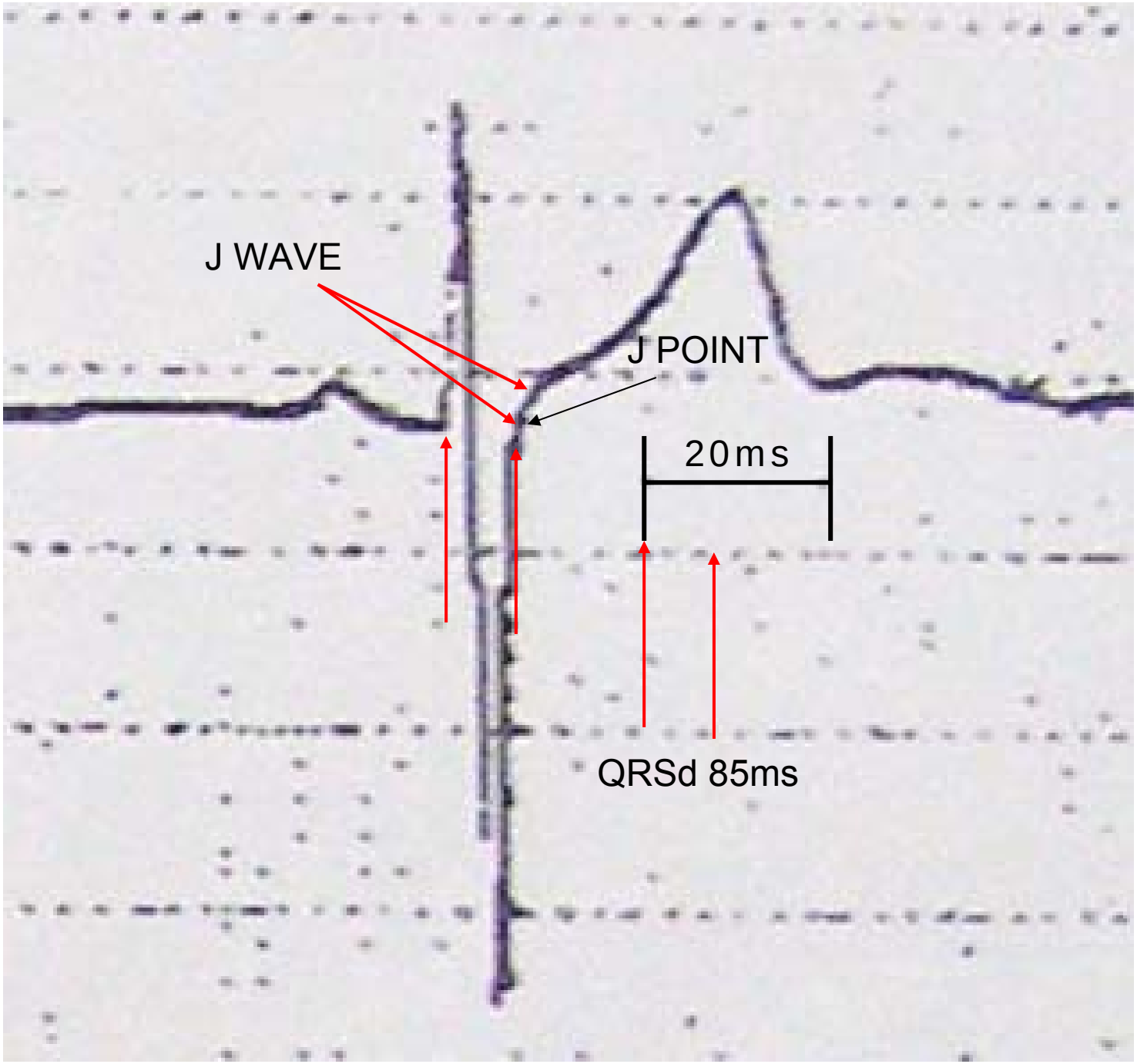
A. TYPICAL EARLY REPOLARIZATION PATTERN IN ELITE AFRO-DESCENDENT YOUNG ATHLETE MAN



B OUR CASE



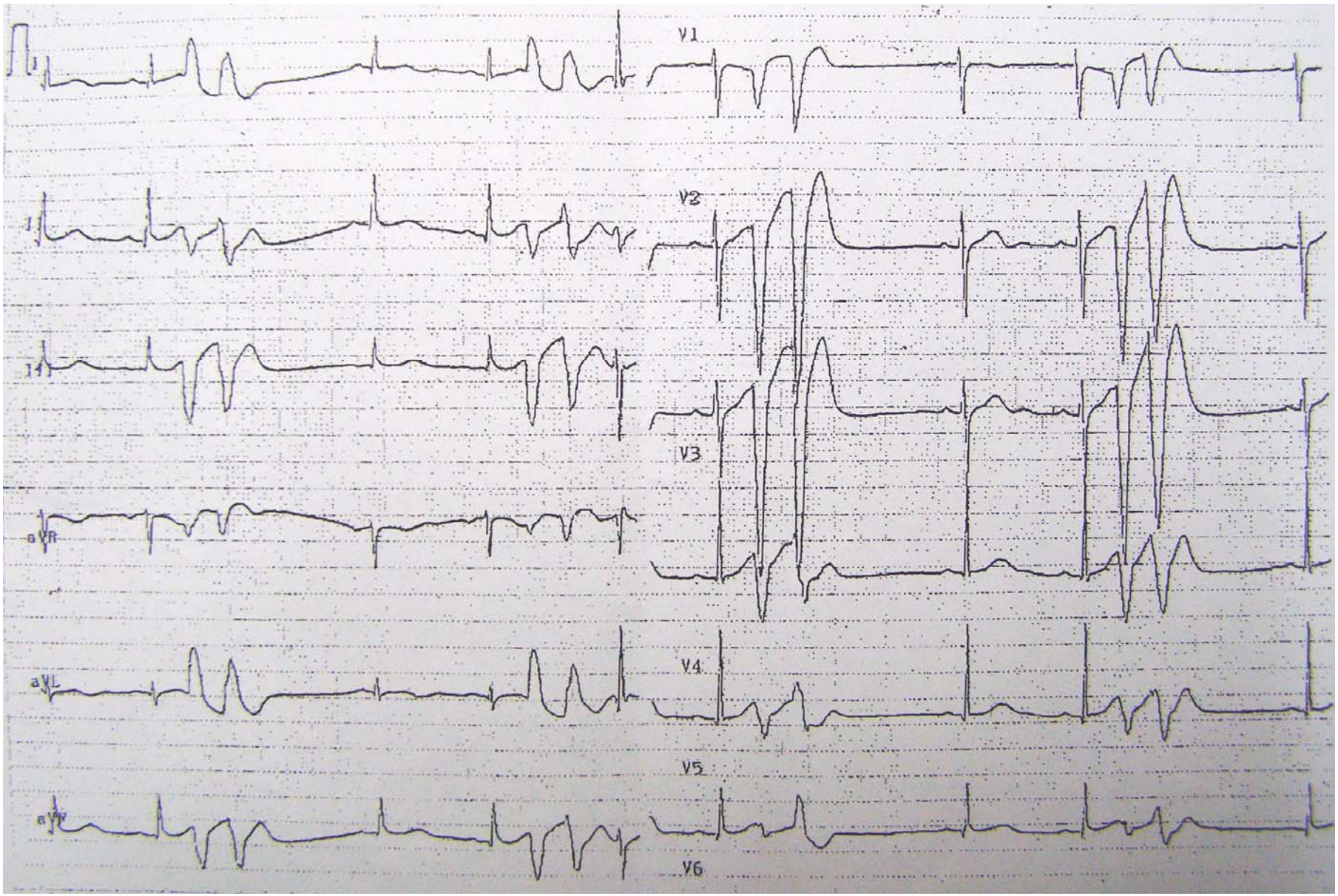
A. Sinus bradycardia (heart rate: 50 bpm), minimally elevated J point, upward concavity of the initial portion of the upsloping ST segment, and notching or slurring of the terminal QRS complex (J point). ST elevation > 4mm in the precordial in the mid-to-left precordial leads.


J WAVE
J POINT
20ms
QRSd 85ms

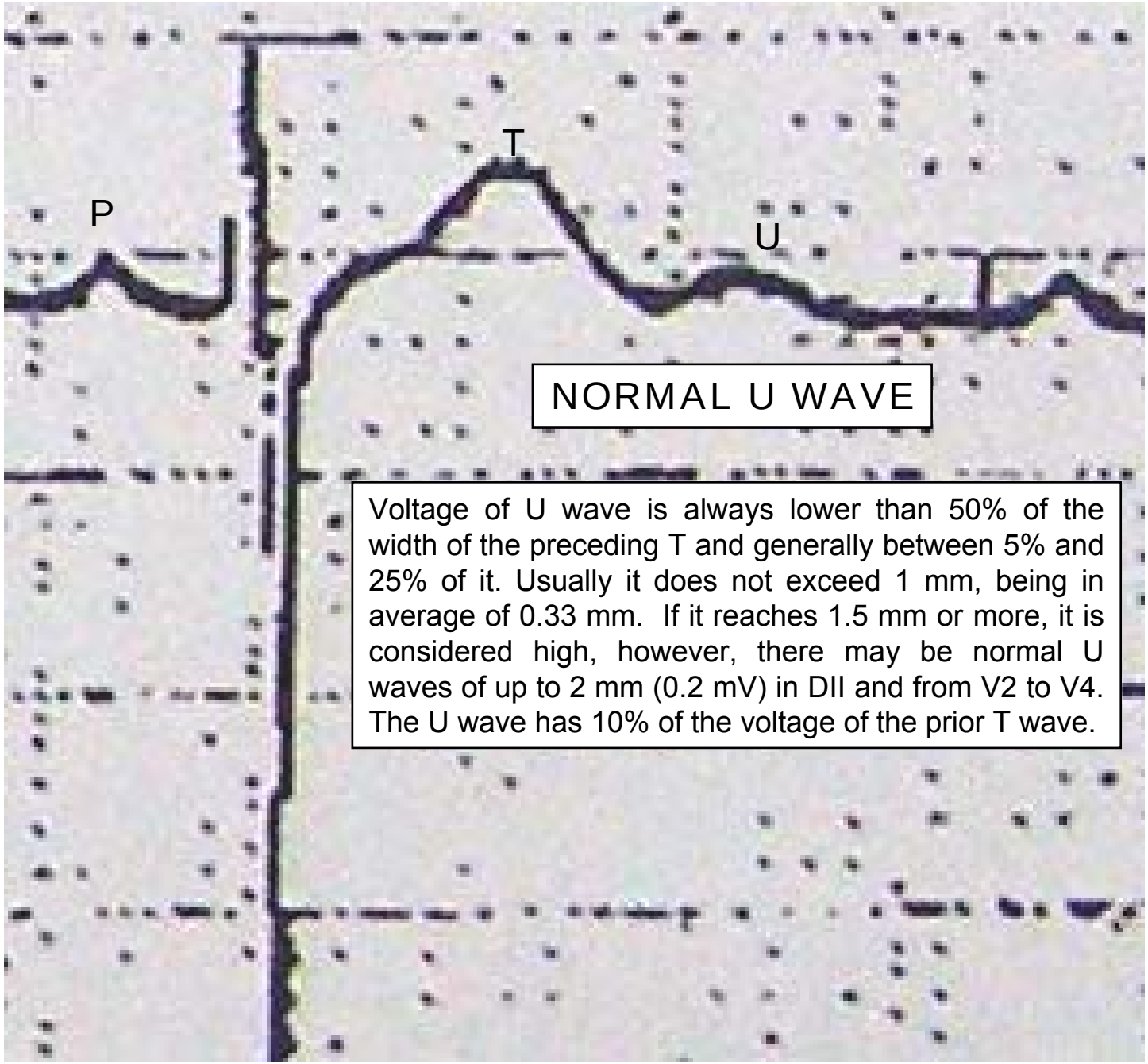
ECG 2

Name: Gender: Male Age: 15 yo. Ethnic Group: Caucasian

Weight: ?? Kg Height: ?? m Biotype: Normoline Date: Aug. 6 2009



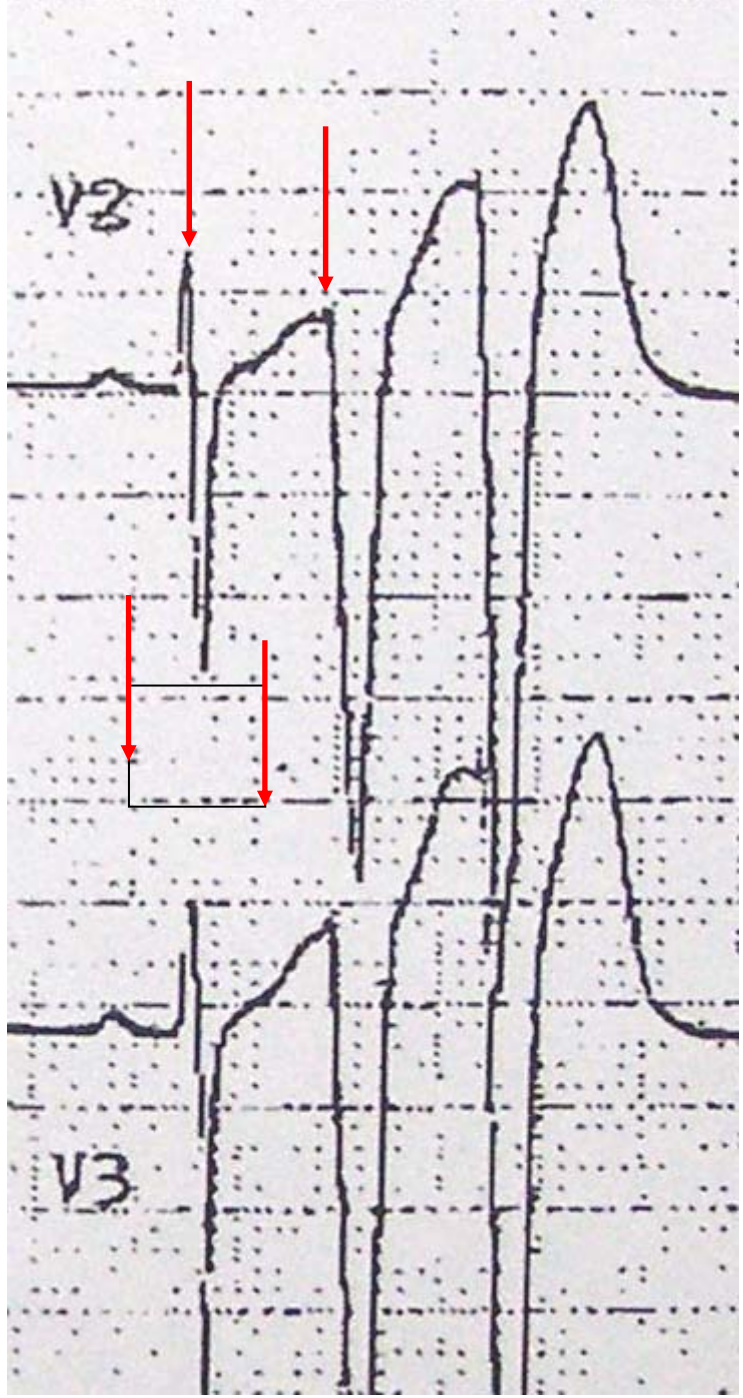
Second ECG


P
T
U
V3
NORMAL U WAVE
Voltage of U wave is always lower than 50% of the width of the preceding T and generally between 5% and 25% of it. Usually it does not exceed 1 mm, being in average of 0.33 mm. If it reaches 1.5 mm or more, it is considered high, however, there may be normal U waves of up to 2 mm (0.2 mV) in DII and from V2 to V4. The U wave has 10% of the voltage of the prior T wave.

PVCs WITH EXTREME SHORT COUPLED INTERVAL = 245ms

R-ON-T PHENOMENOM

Definition: In electrocardiographic tracing, it is the superimposition of an ectopic beat on the T wave of a preceding beat, or simply, R waves interrupting T waves.



First answer

Dr Borys Surawicz bsurawic@yahoo.com

Dear Andres: I do not see anything abnormal in QRS, but there is a very disturbing R on T phenomenon which suggests marked dispersion of ventricular repolarization leading to re-entrant VT, Some kind of short QT variant?
Borys

Second answer

Professor E. Schulze-Bahr

Department Genetics of Heart Diseases
Hospital of the University of Münster - D- 48129 Münster - Germany

Andres,
If you have DNA, we would be happy to get a sample. It may that we have a molecular explanation (recent, first/single finding).

Very best,
ERIC

Answer to Eric Question:

Unfortunately, his family refused to give blood samples for his genetic testing. They are religious people and refused such things.

Thank you for your time and kind interest.

Andrés

Third answer Dr Ihor Gussak

Hi Andrés,

I do not see anything overwhelmingly "conclusive" to suspect any primary electrical diseases from these 2 ECG tracings, except "scary" (R on T) coupled PVCs followed by a moderate accentuation (compare with the first ECG) of the U waves. Evidently, this is not a case of "narrow and tall QRS".

I hope that this young fellow is doing OK.

Cheers,

Ihor

Fourth Answer Dr. Adrian Baranchuk

Your case and the 3 cases from the editorial are slightly different:

The editorial cases presented with repetitive syncope and one post-exercise presyncope. Yours presented with aborted SD.

The editorial cases have no Epinephrine test (?CPVT) and no documented arrhythmia. Yours have a spontaneous couplet suggesting a right ventricle (inferobasal) origin. Both PVCs are very premature, with R on T phenomenon.

The editorial cases have a negative EP study while yours have no EP study.

What was the rhythm during the SD episode, how was he resuscitated?

Despite a negative epinephrine test, I would like to perform an EP study in your patient and to pace the ventricle with and without Isoproterenol?

Chagas serology for undetermined phase?

We have so much to learn, thanks for the opportunity to discuss this case with you and our colleagues.

OUR HYPOTHESIS:

We think in two possibilities:

1) Idiopathic ventricular fibrillation (IVF) with minimal degree of early repolarization pattern (ERP). IVF with J waves in inferior, lateral or inferior lateral leads or both
2) Short-coupled variant of torsade de pointes, verapamil responsive or " Leenhardt type"

Genuine idiopathic ventricular fibrillation: It patients have a high recurrence rate of potentially fatal ventricular arrhythmias, excluding patients with the Brugada syndrome or other known causes. ICD prevents SCD but inappropriate shocks remained a major issue in this young and active population. It is necessary exclude systematically . Brugada syndrome, by the absence of the typical electrocardiogram (ST elevation in the right precordial leads) at rest and/or after pharmacological tests (ajmaline, flecainide, or procainamide Our case). In the EPS, 39% of patients are inducible, but inducibility fail to predict subsequent arrhythmic events[1].

A higher incidence of recurrent VF was observed in patients with J wave and ERP on the ECG compared with those without such abnormalities[2].

1) Champagne J, et al. Recurrent cardiac events in patients with idiopathic ventricular fibrillation, excluding patients with the Brugada syndrome. BMC Med. 2005 Jan 1;3(1):1

2) Noda T, et al. Idiopathic ventricular fibrillation associated with J wave and early repolarization: a really benign electrocardiographic sign? Future Cardiol. 2009 May;5(3):227-9.

ATYPICAL BRUGADA SYNDROME OR IVF WITH J WAVES IN INFERIOR, LATERAL OR INFERIOR LATERAL LEADS OR BOTH IN THE RIGHT PRECORDIAL AND THE HIGH LATERAL LEADS.

Until today two mutations in genes SCN5A and KCNJ8 have been identified:

1) On SCN5A gene (1).

2) On KCNJ8 gene (2;3): Missense variant in exon 3 (NC-000012) of the KCNJ8 gene, a subunit of the K (ATP) channel2; 3. Genomic DNA sequencing of K(ATP) channel genes showed missense variant in exon 3 (NC_000012) of the KCNJ8 gene, a subunit of the K(ATP) channel, conferring predisposition to dramatic repolarization changes and ventricular vulnerability.

From a multicenter cohort of 122 patients (90 male, age 37 +/- 12 years) with IVF and early repolarization pattern (ERP) in the inferolateral leads, Haïssaguerre et al selected all patients with more than 3 episodes of VF (multiple) including those with electrical storms (≥3 VF in 24 h). Multiple recurrences of VF occurred in 27% of patients with ERP and likely life threatening. Isoproterenol in acute cases and quinidine in chronic cases are effective antiarrhythmic drugs. The last one is necessarily associated to cardioverter-defibrillator.

The so-called atypical BrS is characterized by ECG abnormalities of the J wave, and ST-segment elevation appeared in the inferior and/or lateral leads. The ERP in inferolateral leads is not an uncommon finding in BrS **(4)**. There is a high incidence of the ERP confined in inferolateral leads, in patients with IVF. The ECGs have an elevation of the QRS-ST junction of at least 0.1 mV from baseline in the inferior or lateral lead, manifested as QRS slurring or notching. Among patients with a history of IVF, there is an increased prevalence of ERP.

Recently, Bonakdar et al described a patient with the BrS and frequent episodes of the traumatic syncope. This patient presented with alternating ST-segment elevation in the right precordial and the high lateral leads (5).

1) Potet F, et al. Novel brugada SCN5A mutation leading to ST segment elevation in the inferior or the right precordial leads. J Cardiovasc Electrophysiol. 2003 Feb; 14: 200-203.

2) Haissaguerre M, et al. Sudden cardiac arrest associated with early repolarization. N Engl J Med. 2008 May 8; 358:2016-2023.

3) Haïssaguerre M, et al. Characteristics of recurrent ventricular fibrillation associated with inferolateral early repolarization role of drug therapy. J Am Coll Cardiol. 2009 Feb 17; 53: 612-619.

4) Letsas KP, et al. Prevalence of early repolarization pattern in inferolateral leads in patients with Brugada syndrome Heart Rhythm. 2008 Dec; 5:1685-1689.

5) Bonakdar H, et al. Brugada Syndrome Manifested by the Typical Electrocardiographic Pattern both in the Right Precordial and the High Lateral Leads. Indian Pacing Electrophysiol J. 2008 Apr 1; 8: 137-140.

SHORT-COUPLED VARIANT OF TORSADES DE POINTES AND NORMAL QT INTERVAL AND DIFFERENTIAL DIAGNOSIS WITH BRUGADA SYNDROME

The main characteristics of the so-called short-coupled variant of torsades de pointes (TdP) and normal QT interval and the differential aspects with Brugada syndrome (BrS).

Both entities occur in patients without apparent structural heart disease, possibly with positive family background, predominantly affect people in their productive time of life, have a high tendency to appearance of syncope and/or sudden cardiac death as a consequence of bursts of polymorphic ventricular tachycardia (PVT) that degenerate into ventricular fibrillation (VF), not related to strain and in which an extremely short coupling of initial extra-systole, frequent episodes of electrical storm, normal(or near normal) QT/QTc interval on ECG and heterogeneity of ventricular refractoriness in some area of ventricular wall thickness are observed.

Additionally, both could be related to hypokalemia[1];[2]. Even presenting so many coincidences, there are elements that enable a differentiation between both entities, such as the genetic aspects known only in BrS, race incidence and different predominant gender, ECG characteristics (although in both prominent J waves have been described)[3], morphological aspects of tachyarrhythmic events, and the presence of supraventricular arrhythmias, triggers, preferential moments of tachyarrhythmic events and different response to therapeutic measures. Analysis of the etiology and mechanism of the tachycardia is of paramount importance for initiation of specific therapies. Although mechanical cardiac function may seem normal, such patients might have certain discrete anatomic abnormalities, unidentifiable with current investigation tools[4].

1) Nimmannit S, Malasit P, Chaovakul V, et al: Pathogenesis of sudden unexplained nocturnal death (lai tai) and endemic distal renal tubular acidosis. *Lancet* 1991; 338:930-932

2) Kusano KF, Hata Y, Yumoto A, Emori T, Sato T, Ohe T. Torsade de pointes with a normal QT interval associated with hypokalemia: a case report. Jpn Circ J. 2001; 65:757-760

3) Durand-Dubief A, Burri H, Chevalier P, Touboul P. Short-coupled variant of torsades de pointes with intractable ventricular fibrillation: lifesaving effect of cardiopulmonary bypass. J Cardiovasc Electrophysiol. 2003; 14:329

4) Wever EF, Robles de Medina EO. Sudden death in patients without structural heart disease. J Am Coll Cardiol. 2004; 43:1137-1144.

The short-coupled variant of torsades de pointes and normal QT interval is a polymorphic, polymorphous or multiform[1] PVT with typical morphology of TdP: the QRS morphology shows alternating polarity in a modulating pattern, so that the complexes appear to be twisting around the baseline, observed in patients without organic heart disease, adverse drug effects, or electrolyte disturbances, which occurs spontaneously and initiated by short-coupled premature ventricular complex (240 ms in average) in patients with normal QT interval[2].

The classical or typical TdP on the other hand is characterized not only by its particular ECG pattern, but also by its context of congenital or acquired long QT syndrome and with long coupling interval (telediastolic) of the initial premature beat. In short-coupled variant of TdP exists an unusual particularity: an extremely short coupling interval of the first beat or of the isolated premature beats. These patients have clinical and electrocardiographic abnormalities that are sufficiently coherent for them to constitute a new pathological entity, which Leenhardt et al., suggest calling "torsades de pointes with a short coupling interval"[3,4] (Leenhardt disease).

The entity is observed in young, healthy children and young adults (average: 34.6 years) and most probably covers several underlying electrophysiological abnormalities[5].

Some ECG recordings showed isolated ventricular extrasystoles with short coupling intervals. The PVT is characterized by changing QRS morphology, sometimes accompanied by slight changes in the rate. It is a particularly malignant form of PVT that is thought to be intermediate between ordinary PVT, and ventricular fibrillation (VF).

1) Guaragna RF, et al. Multiform ventricular tachycardias and Torsades de Pointe G Ital Cardiol. 1983; 13:260-268

2) Cheng TO. Short-coupled variant of torsades des pointes with normal QT interval and risk of sudden death. Am J Cardiol. 1996; 77:1028-1029

3) Leenhardt A, et al. Torsades de pointes with short coupling interval Arch Mal Coeur Vaiss. 1993; 86:777-782

4) Leenhardt A, et al. Short-coupled variant of torsade de pointes. A new electrocardiographic entity in the spectrum of idiopathic ventricular tachyarrhythmias. Circulation. 1994; 89:206-215.

5) Coumel P. Polymorphous ventricular tachyarrhythmias in the absence of structural heart disease. Pacing Clin Electrophysiol. 1997; 20: 2065-2067

There are references in literature of electrical storm[1] (ES) and intractable VF lifesaving with cardiopulmonary bypass or deep sedation followed by a combination therapy using verapamil and mexiletine. In this case, the ECG pattern consisting of a prominent J wave in leads V3-V6 that disappears with the use of those drugs. The ES was evoked with autonomic receptor stimulation and a blockade test. The patient's frequent VF attacks were triggered by short-coupled premature ventricular contractions with RBBB morphology and left-axis deviation.

There are references of hypokalemia as etiology (K=3.4 mmol/L). Monophasic action potential duration at 90% repolarization (MAPD90) in the right ventricular apex was very short (175 ms). The MAPD90 returned to normal after loading potassium (230 ms) and after oral amiodarone therapy (240 ms), and PVT no longer occurred. With continued oral amiodarone and spironolactone therapy, the patient has been free of syncope attack over a follow-up period of 5 years. A familial history of TdP and SCD was described[2].

Heterogeneity of ventricular refractoriness was observed together with shortness of the effective refractory period measured at the right ventricular inflow site where the paced QRS morphology was the same as that of the initial beat of TdP. Verapamil could suppress frequent ventricular premature complexes with a short coupling interval, which lead to TDP.

PVT can be induced by triple ventricular extrastimuli.

A pure potassium channel blocker was successful in inhibiting PVT inducibility by prolongation of refractoriness. These results suggested that triggered ventricular premature complexes might be representing the initiating mechanism, whereas the shortness of local refractory period and heterogeneity of ventricular refractoriness may play a role in the development and the maintenance of TdP[3].

1) Takeuchi T, et al. A case of a short-coupled variant of torsades de Pointes with electrical storm. Pacing Clin Electrophysiol. 2003; 26:632-636

2) Strasberg B, et al. Familial inducible torsade de pointes with normal QT interval. Eur Heart J. 1983; 4:383-390

3) Shiga T, et al. Electrophysiological characteristic of a patient exhibiting the short-coupled variant of torsade de pointes. J Electrocardiol. 2001; 34:271-275

This kind of VT had a high incidence of SCD, so it was very important for physicians to identify and treat it promptly with long-term verapamil[1]. Although verapamil is frequently recommended, mortality rates remain high[2].

The entity is a malignant disease that shares several characteristics with IVF.

In the next slide we show now the possible etiology of truly PVT and TdP.

ETIOLOGY OF POLYMORPHIC VENTRICULAR TACHYCARDIA (TRULY PVT AND TdP)

A) WITH STRUCTURAL HEART DISEASE

1) CHRONIC CORONARY HEART DISEASE;
2) PRINZMETAL VARIANT;
3) ACUTE MYOCARDIAL INFARCTION;
4) SEVERE HEART FAILURE.

B) WITHOUT STRUCTURAL HEART DISEASE

1) Congenital long QT syndrome: TdP associated with long QT interval related to bradyarrhythmia. The most prevalent inclusion bradyarrhythmia is > or = second-degree AV block, preceding pauses or electrolytes abnormalities. Predictors for these are previous amiodarone or diuretic intake, presentation as syncope, low serum potassium level, and longer QTc at admission[3];
2) Congenital short QT syndrome;
3) Genuine idiopathic ventricular fibrillation with normal basal electrocardiogram;
4) Brugada syndrome;
5) Some Sudden Unexpected Nocturnal Death Syndrome (SUNDS) or SUDS;
6) Idiopathic ventricular tachycardia;
7) PVT of ventricular pre-excitation* (atrial fibrillation with a rapid ventricular response);
8) PVT verapamil sensitive or TdP with short coupling interval in a patient without organic heart disease and normal QT interval (Leenhardt disease);
9) Catecholaminergic Polymorphic Ventricular Tachycardia (CPVT); catecholamine-sensitive polymorphic ventricular tachycardia or Familial Polymorphic Ventricular Tachycardia (FPVT).

*** Presence of multiple accessory pathways, posteroseptal accessory pathways, and a pre-excited R-R interval of less than 220 ms during atrial fibrillation are associated with a higher risk for VF.**

1) Ruan Y, et al. Short-coupled variant of torsade de pointes. J Tongji Med Univ. 2001; 21:30-31
2) Soffer J, et al. Polymorphous ventricular tachycardia associated with normal and long Q-T intervals. Am J Cardiol. 1982; 49: 2021-2029
3)Diaz-Castro O, et al. Predictors of in-hospital ventricular fibrillation or torsades de pointes in patients with acute symptomatic bradycardia. J Electrocardiol. 2004; 37:55-60