ECG in the Athlete

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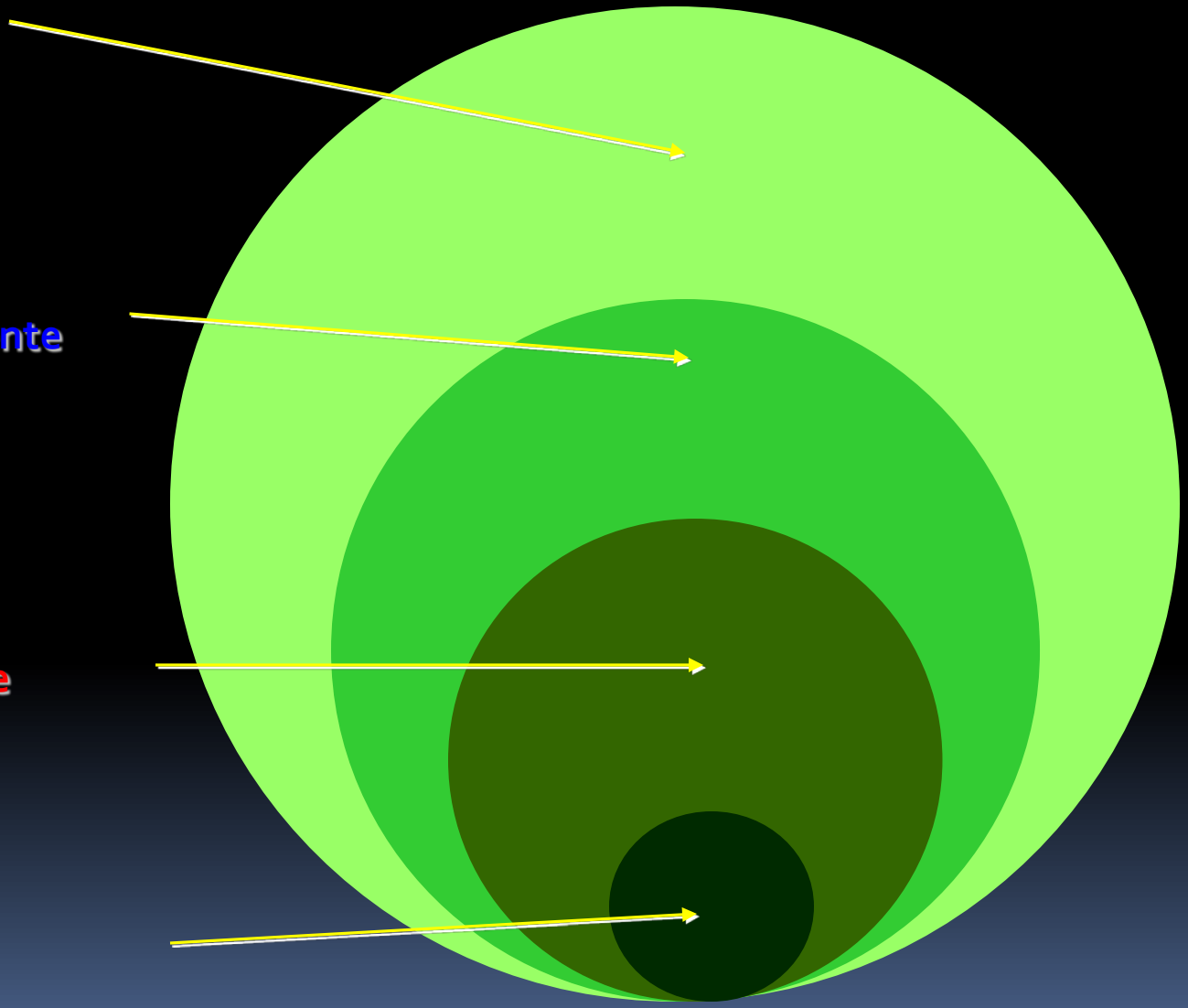
Obiettivo della Legge

60 Milioni
Italiani

11 Milioni
fanno sport occasionalmente

6 Milioni
S'allenano regolarmente e gareggiano

~ 2.000
Atleti di alto livello



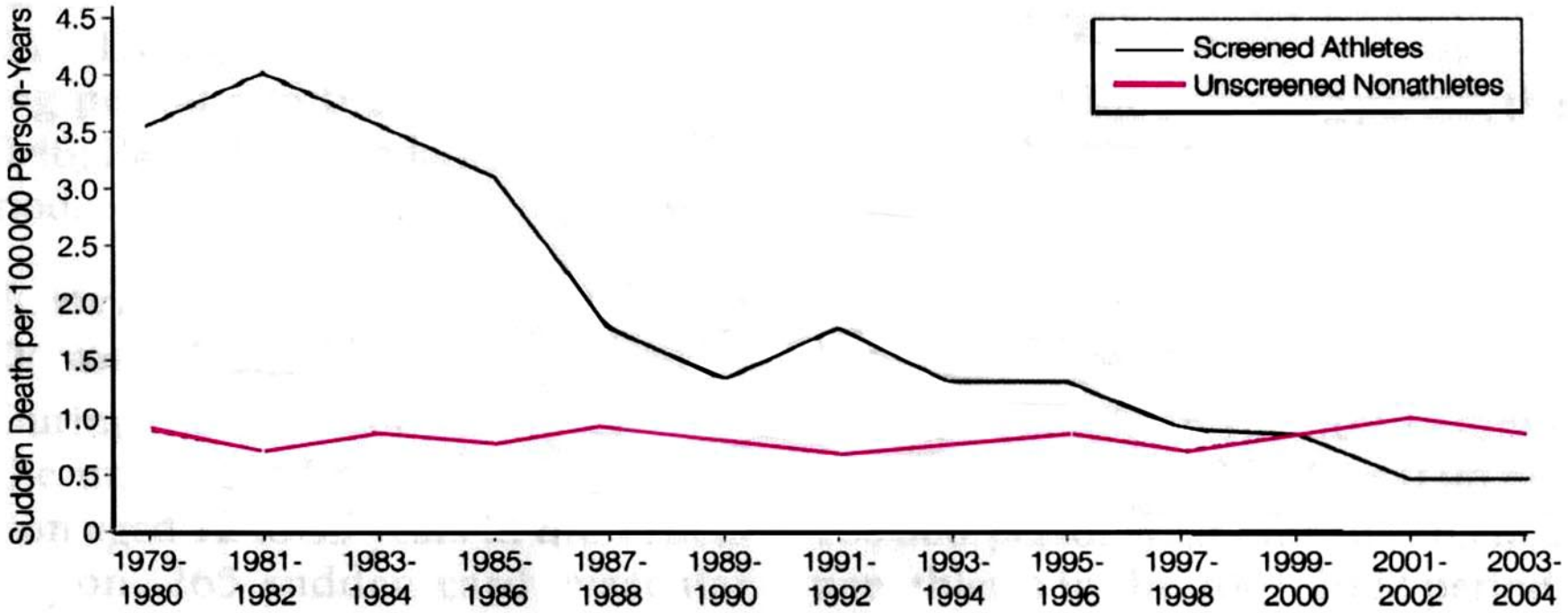
Dati CONI-ISTAT 2011


COMITATO ORGANIZZATIVO CARDIOLOGICO
PER L'IDONEITÀ ALLO SPORT
ANCE - ANMCO - FMSI - SIC - SIC SPORT
Protocolli cardiologici per il giudizio di idoneità allo sport agonistico 2009
Edizione del Ventennale
Casa Editrice Scientifica Internazionale

Trends in Sudden Cardiovascular Death in Young Competitive Athletes After Implementation of a Preparticipation Screening Program

D. Corrado et al.

Figure. Annual Incidence Rates of Sudden Cardiovascular Death in Screened Competitive Athletes and Unscreened Nonathletes Aged 12 to 35 Years in the Veneto Region of Italy (1979-2004)



During the study period, the annual incidence of sudden cardiovascular death decreased by 89% in screened athletes (P for trend $<.001$). In contrast, the incidence rate of sudden cardiovascular death did not demonstrate consistent changes over time in unscreened nonathletes.

How to interprete 12-lead ECG in athlete

- To provide cardiologists and sports medical doctors with a *appropriated and updated* approach to interpretation of ECG in the athlete. They have to be deeply informed about the clinically relevant information which can be obtained from ECG in the athlete.
- To distinguish between *normal physiologic patterns* that should cause no alarm and those that require action and/or additional testing to exclude (or confirm) the *suspect of an underlying cardiovascular conditions* at risk of sudden death during sports.
- For every ECG abnormality, it should be focused on the *ensuing clinical work-up* required for differential diagnosis and clinical assessment.

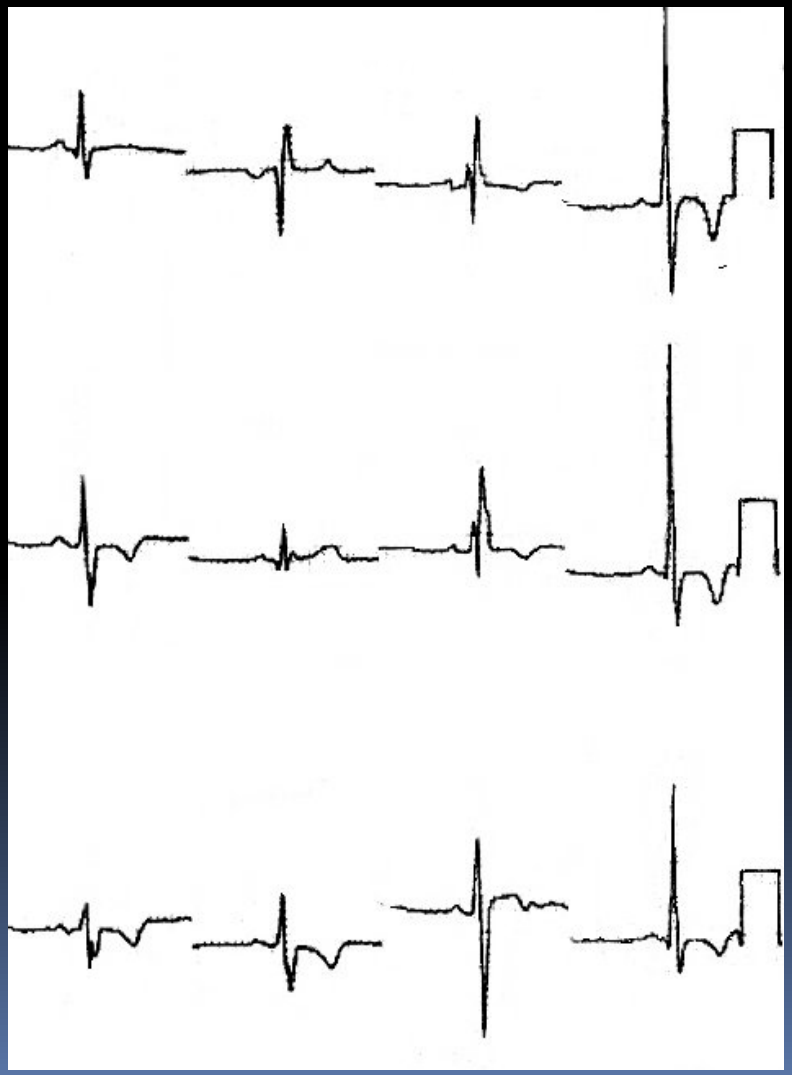
PERSPECTIVE

How to interprete 12-lead ECG in the athlete

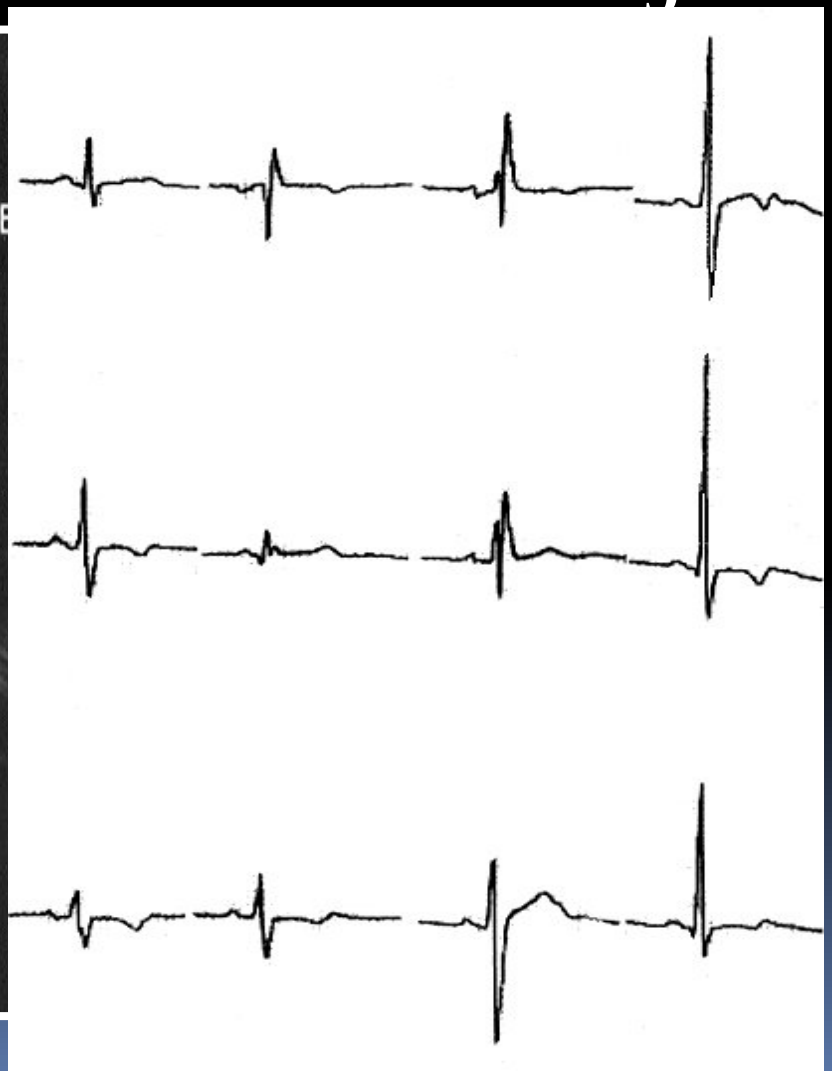
- Appropriate interpretation of athlete's ECG requires the distinction of two main groups of abnormalities based on:
  - prevalence,
  - relation to exercise training and detraining,
  - inherent cardiovascular risk,
  - and need for further clinical investigation to confirm (or exclude) an underlying cardiovascular disease

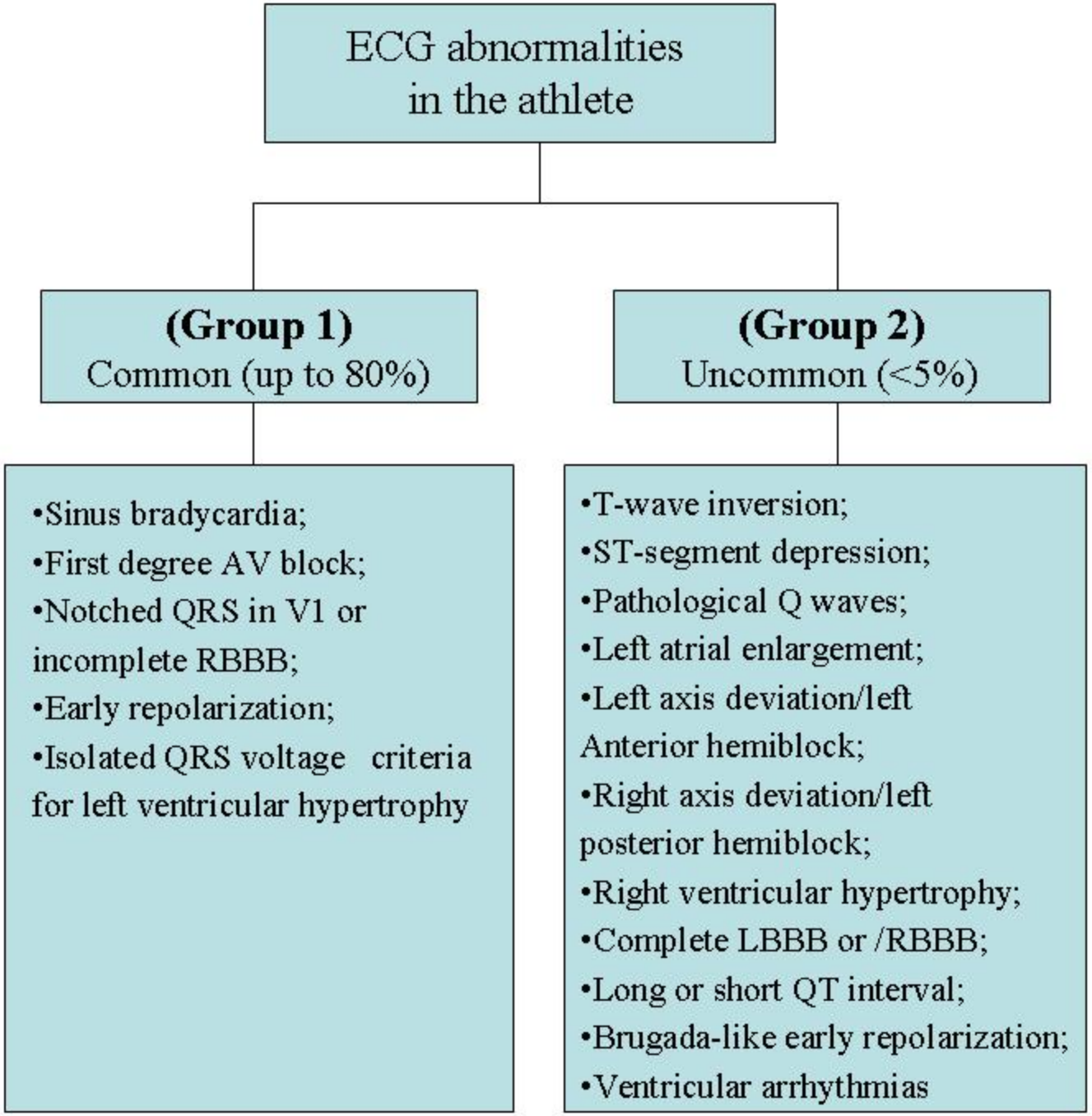
same asymptomatic athlete
(20-year male soccer player)

Peak

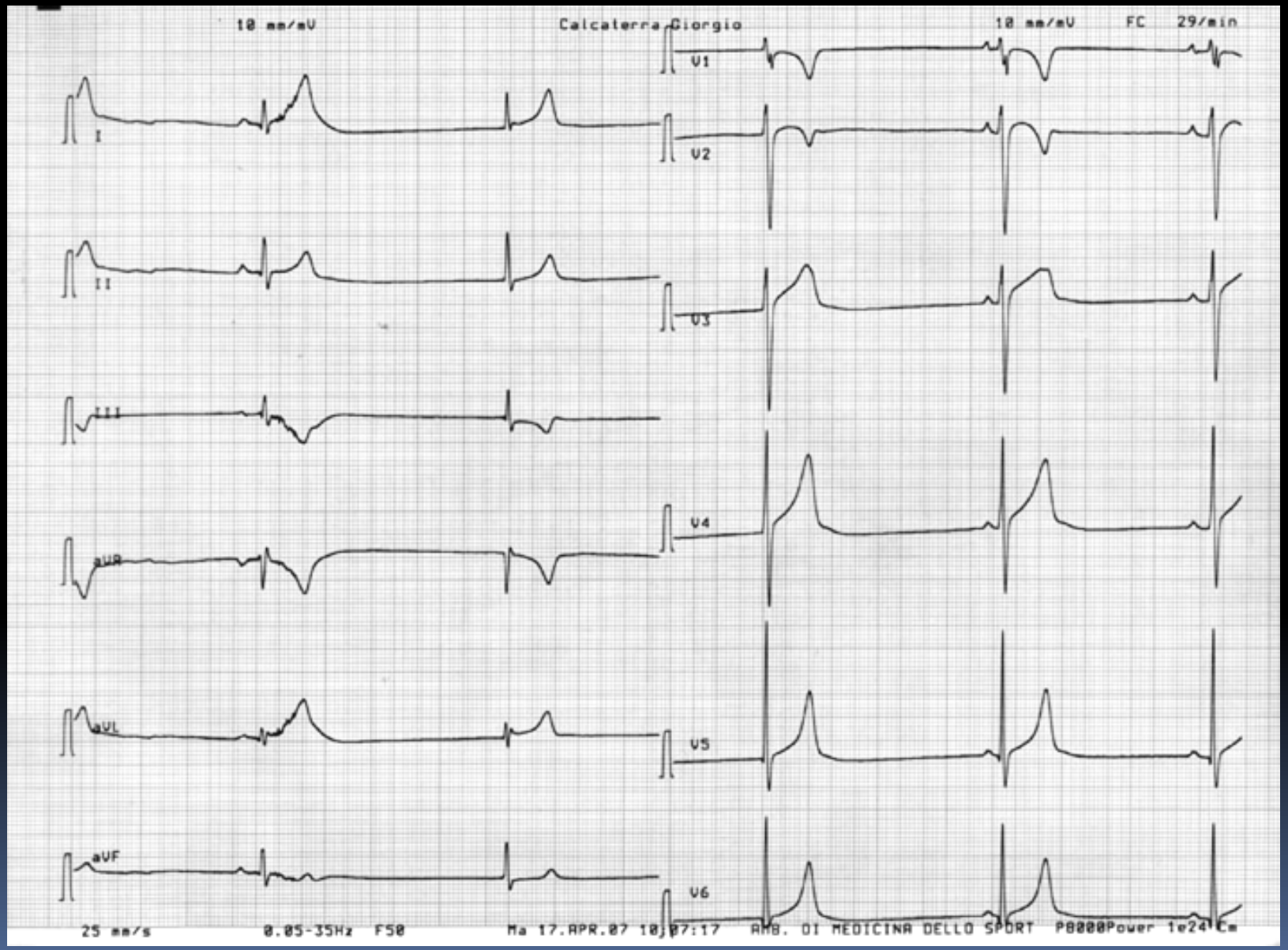


Detraning



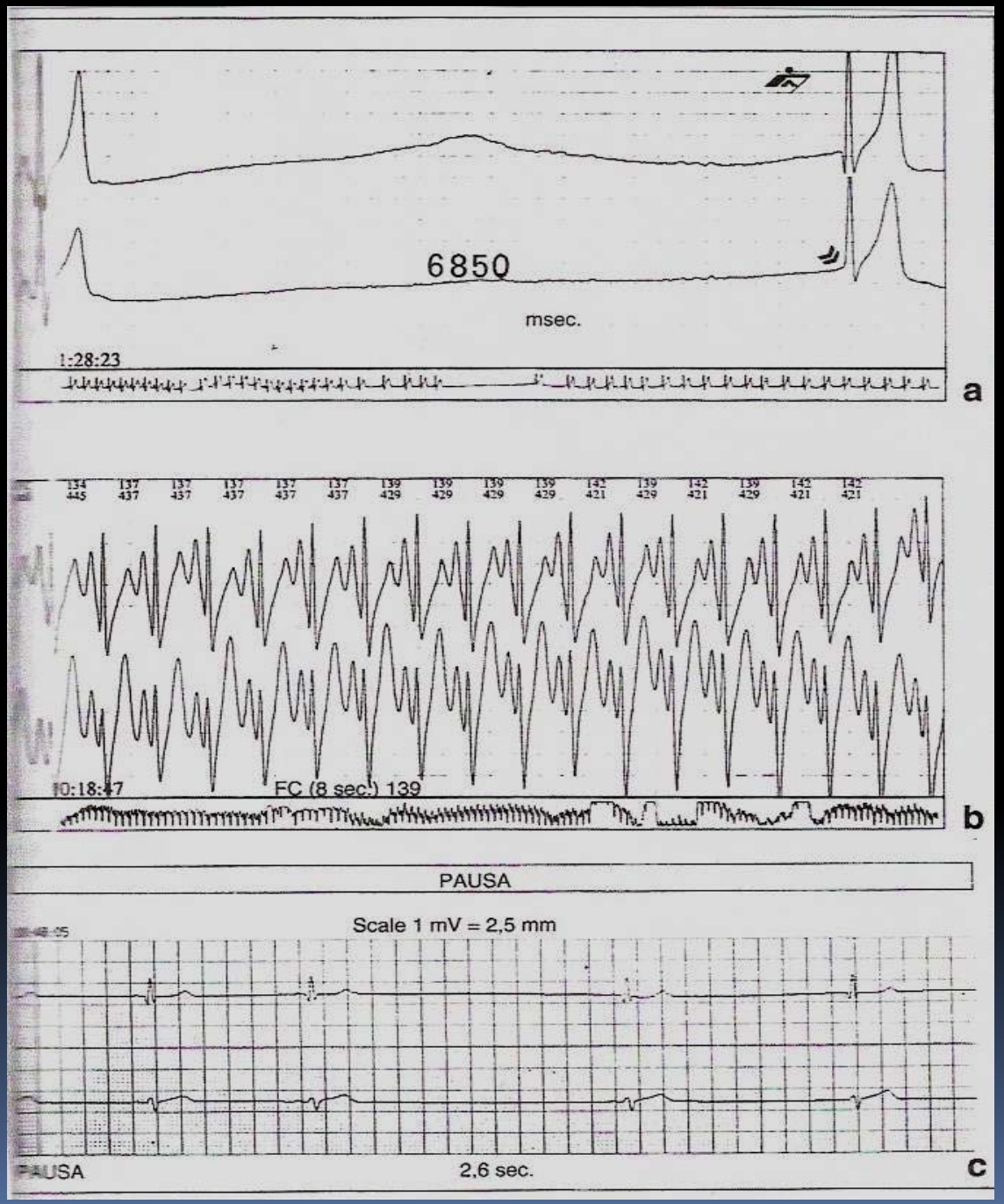

ECG abnormalities
in the athlete
(Group 1)
Common (up to 80%)
(Group 2)
Uncommon (<5%)
•Sinus bradycardia;
•First degree AV block;
•Notched QRS in V1 or
incomplete RBBB;
•Early repolarization;
•Isolated QRS voltage criteria
for left ventricular hypertrophy
•T-wave inversion;
•ST-segment depression;
•Pathological Q waves;
•Left atrial enlargement;
•Left axis deviation/left
Anterior hemiblock;
•Right axis deviation/left
posterior hemiblock;
•Right ventricular hypertrophy;
•Complete LBBB or /RBBB;
•Long or short QT interval;
•Brugada-like early repolarization;
•Ventricular arrhythmias

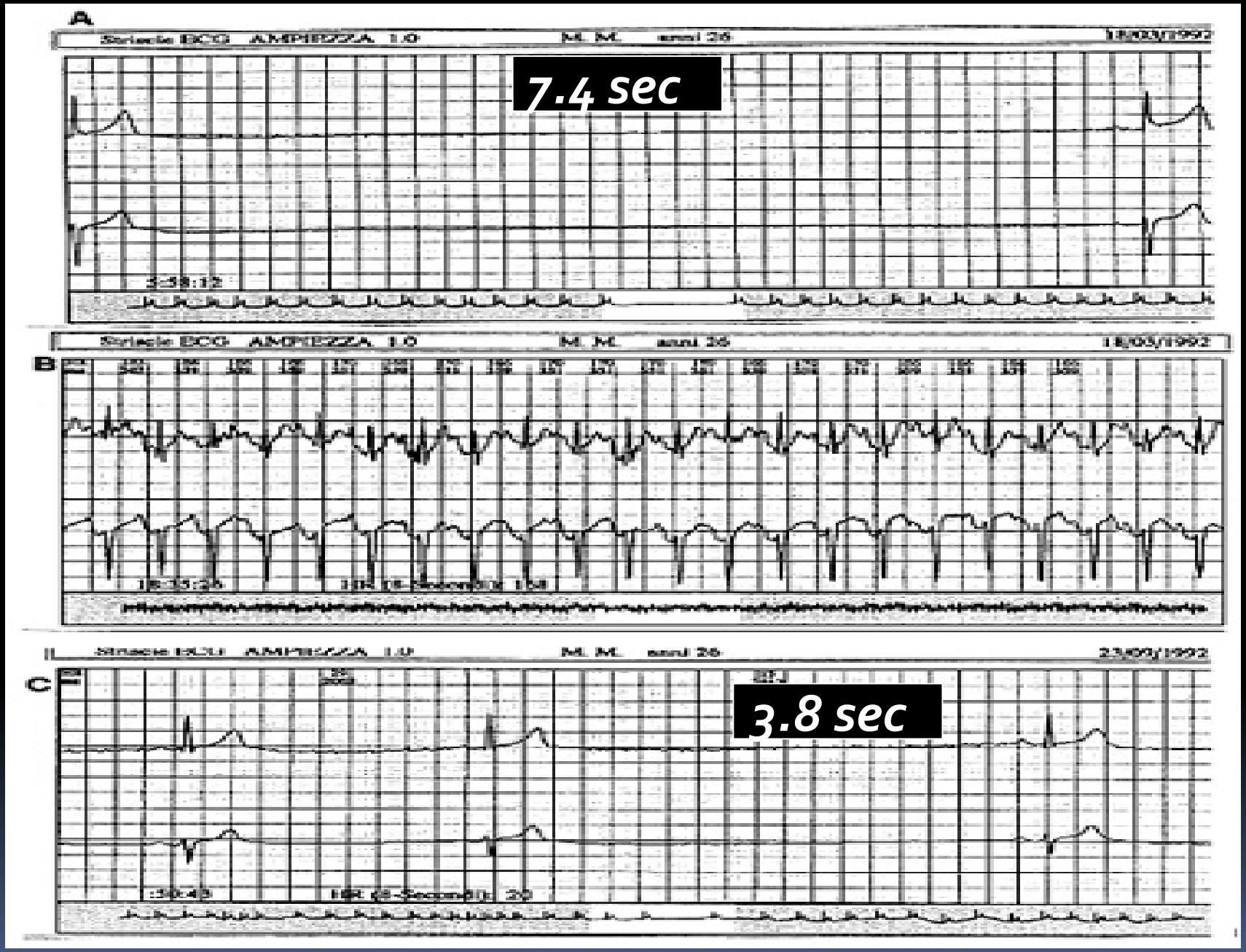
Marathon Runner, 36 yrs, Sinus Bradycardia 29 bpm



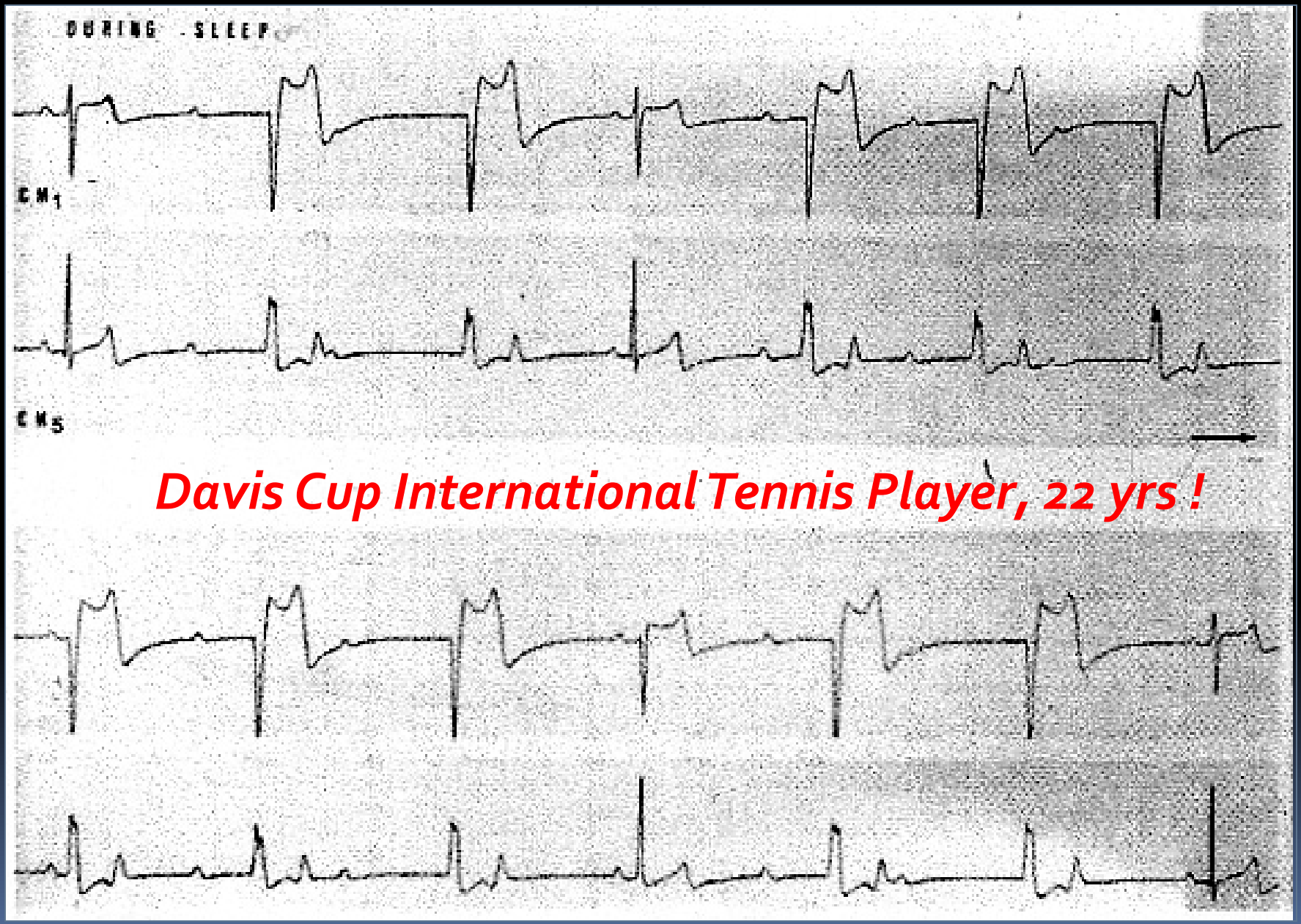
Rower, 28 yrs
Prolonged nocturnal
Sinus pause
asymptomatic

After 3 months of detraining

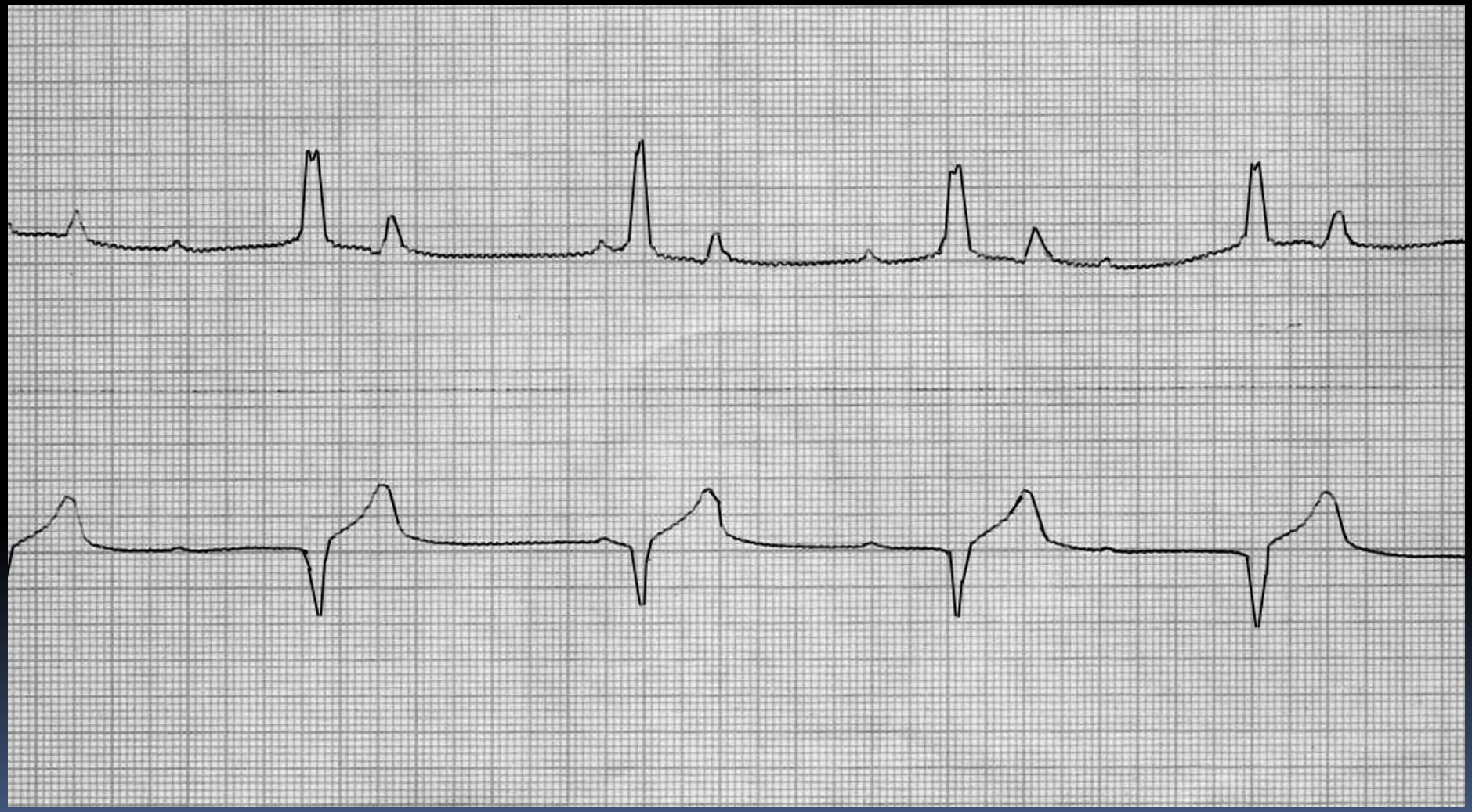


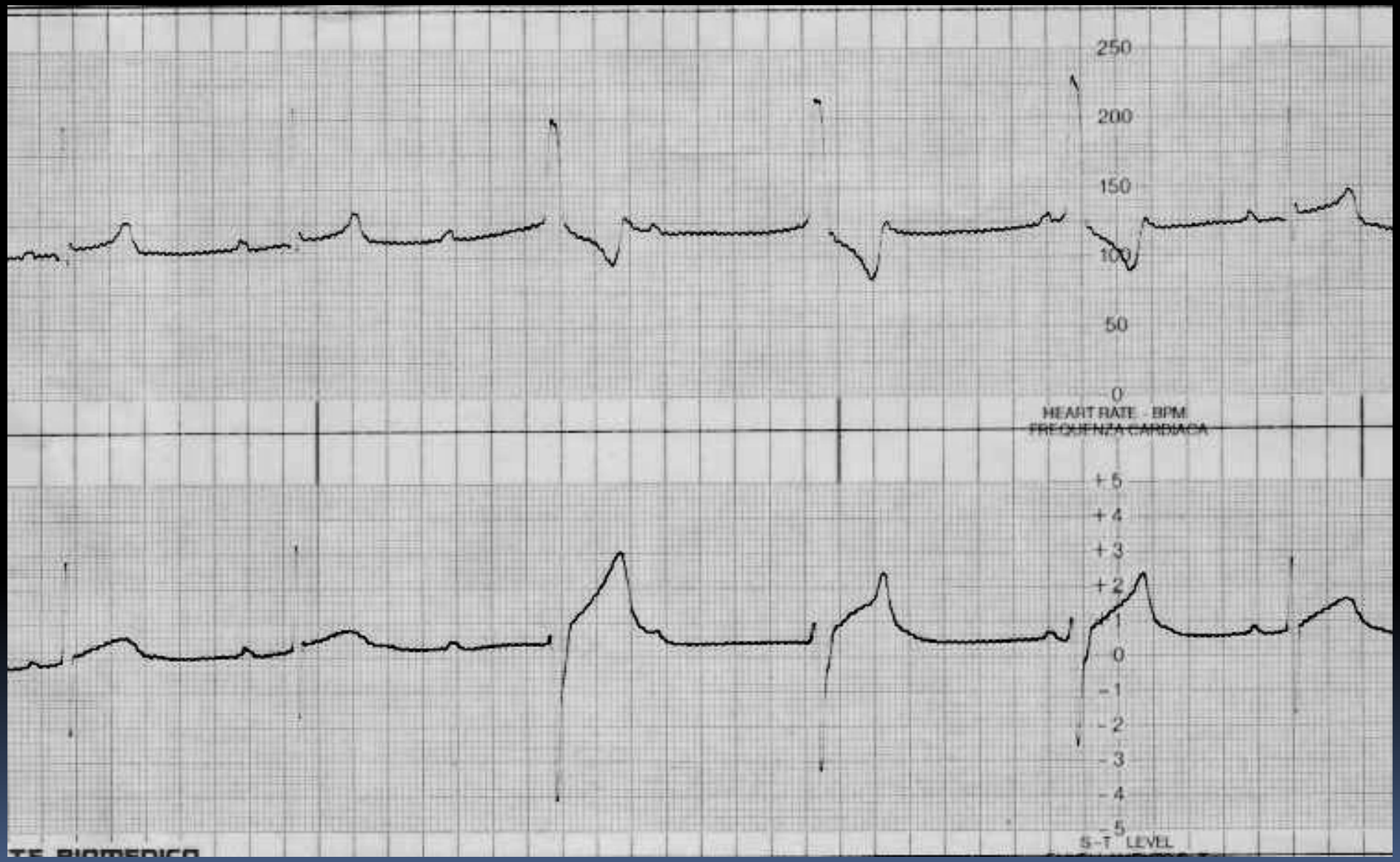


Asymptomatic water-polo player, 27 yrs

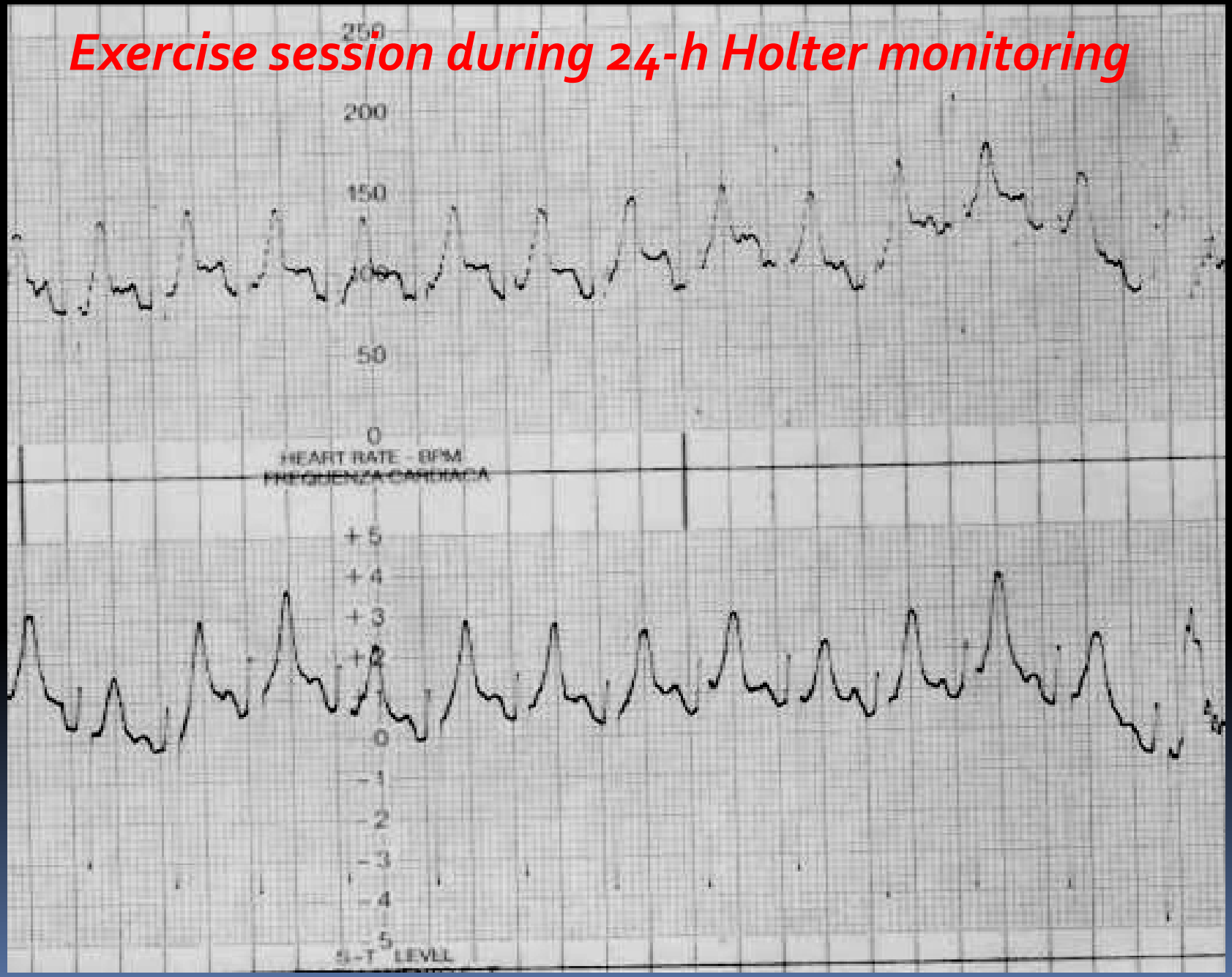


Davis Cup International Tennis Player, 22 yrs !




250
200
150
100
50
0
HEART RATE - BPM
FREQUENZA CARDIACA
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
-5
S-T LEVEL

Exercise session during 24-h Holter monitoring



DELLO SPORT

00197 - Roma, 4/XII/1980
Via dei Campi Sportivi, 46
Tel. 36851

- Prof. SERGIO DALLA VOLTA
Via Belzoni, 16
35100 PADOVA

Prot. 3720/AV/pm

Carissimo Dalla Volta,

da alcuni anni seguiamo un giovane tennista di alto livello, [redacted], il quale presenta a seconda del maggiore o minore grado di allenamento, un BAV di I, II o III grado, del tutto asintomatico.

Gli ultimi controlli sono quelli di cui ti allego i relativi referti. Noi vorremmo, a scopo di avere maggiori ragguagli ed anticipare eventuali obiezioni, avere conferma della nostra interpretazione funzionale attraverso uno studio elettrofisiologico endocavitario ed avrei molto piacere che ciò potesse avvenire presso il tuo Istituto.

Il ragazzo parte adesso per una tournée negli Stati Uniti e tornerà in Italia nei primi di gennaio; può essere a disposizione per eseguire tale indagine dal 15 al 22 gennaio p.v.

Ti sarei grato se potessi fissarmi un appuntamento e dirmi le modalità con le quali ciò potrà essere fatto.

Nell'attesa ti invio i più cordiali saluti e fervidi auguri di buon Natale e felice anno nuovo, unitamente ai tuoi valenti collaboratori.

Antonio Venerando

ISTITUTO DI MEDICINA CLINICA
dell'Università di Padova
Cattedra di Cardiologia
Direttore: Prof. S. Dalla Volta

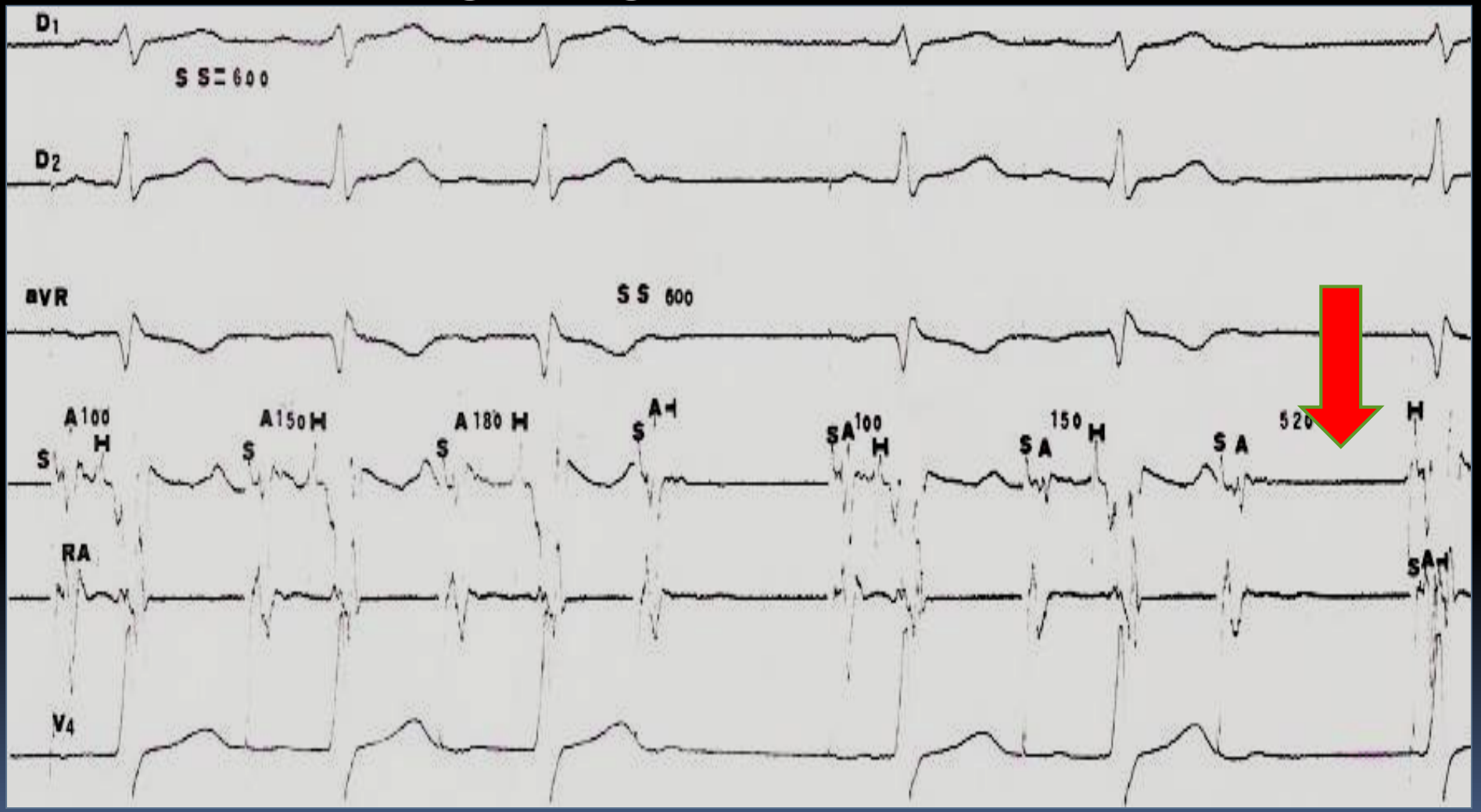
Ch.mo Prof. A. VENERANDO
ISTITUTO DI MEDICINA DELLO SPORT

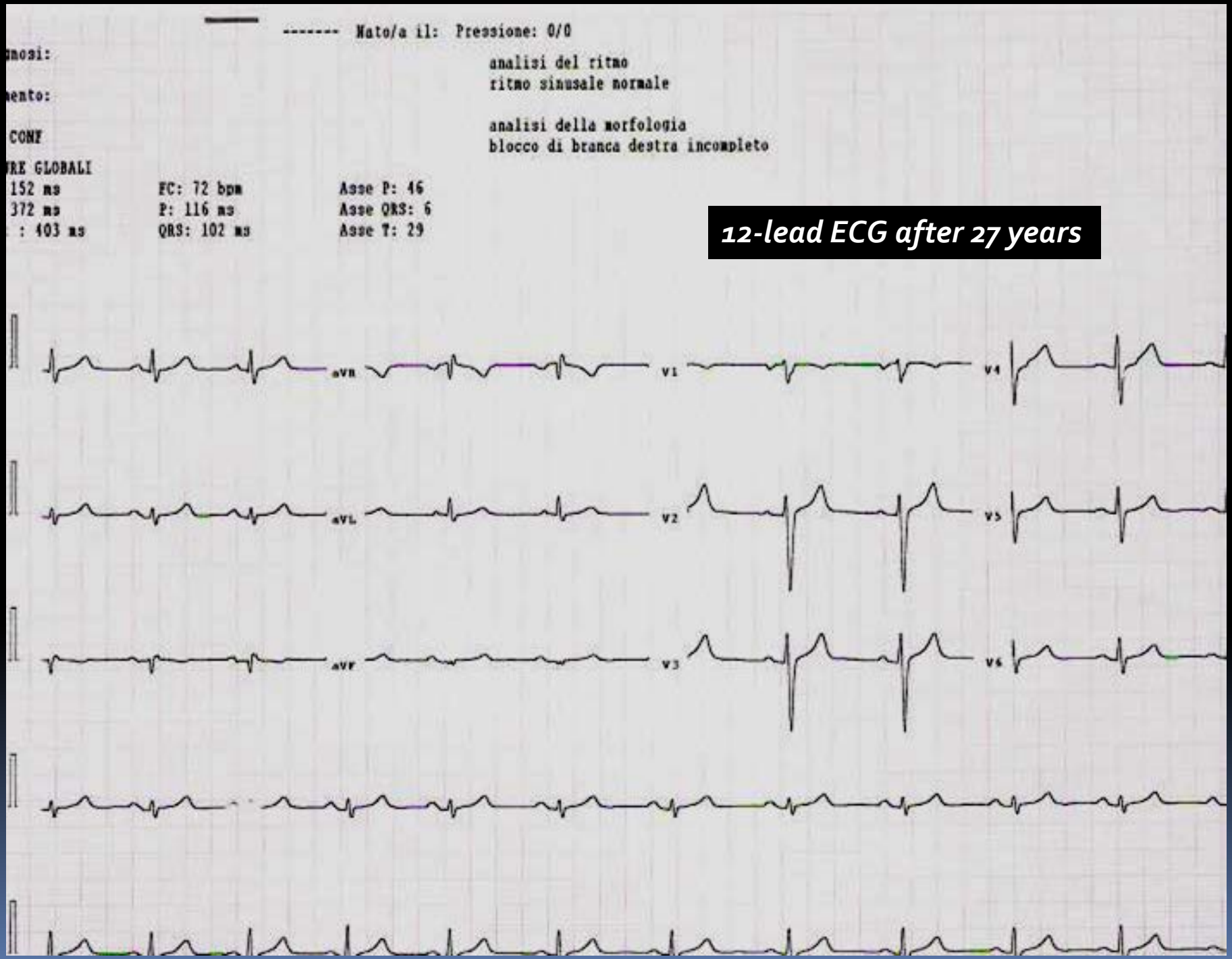
Risposta
di
Dalla Volta

(Studio EFG)

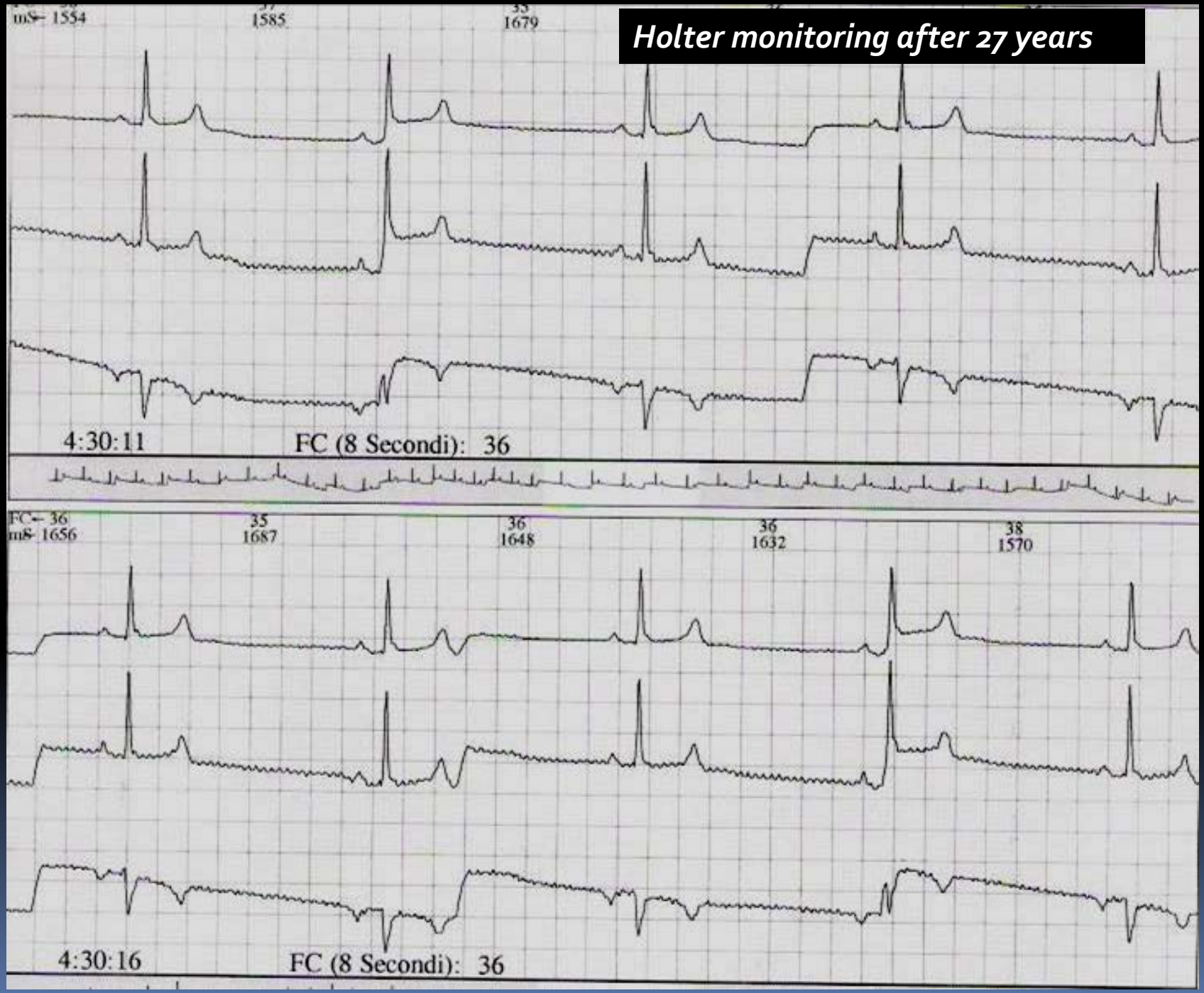
Electrophysiologic study

Supra-hissian high-degree AV block





12-lead ECG after 27 years

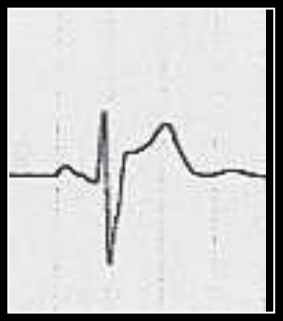

Holter monitoring after 27 years
1554
1585
1679
4:30:11
FC (8 Secondi): 36
FC= 36
1656
35
1687
36
1648
36
1632
38
1570
4:30:16
FC (8 Secondi): 36

EARLY REPOLARIZATION

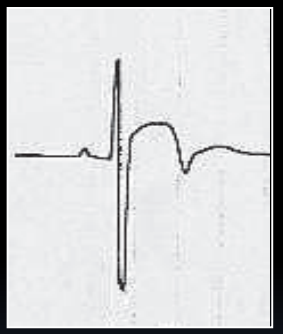
- Early repolarization has traditionally been regarded as an idiopathic and benign ECG phenomenon.
- The prevalence of this ECG pattern ranges between 1 and 2 % and is more commonly observed in young individuals and athletes with a male preponderance. Early repolarization has been noted to be present in 50% to 80% of resting athletes' ECGs, and is the rule rather than the exception in highly trained endurance athletes with sinus bradycardia.
- The most notable ECG feature is ST-segment elevation, that may vary on morphology, location and degree.

EARLY REPOLARIZATION

- The most common pattern (Type 1) is characterized by an elevated J point, often associated with notching or slurring of the terminal QRS complex ("J wave"), an upward concavity of the elevated ST-segment and a positive ("peaked and tall") terminal T-wave



- An other pattern of ER (type 2) consists of an elevated ST-segment which is convex on the top ("domed") and followed by a negative or small/indistinct T-wave; this type is most often observed in black people (African's ECG).



- ER is usually localized in precordial leads, with the greatest ST-segment elevation in mid-to-lateral leads (V3-V4). Maximal ST-segment displacement may also occur more laterally (leads V5, V6, L1 and aVL), inferiorly (L2, L3 and aVF) or anteriorly (leads V2-V3).

The finding of right precordial ST-segment elevation in a healthy young trained athlete, particularly a type 2 pattern with a domed upward ST-segment followed by a negative T-wave, may raise clinical suspicion of a potentially lethal Brugada syndrome and the need for a differential diagnosis.

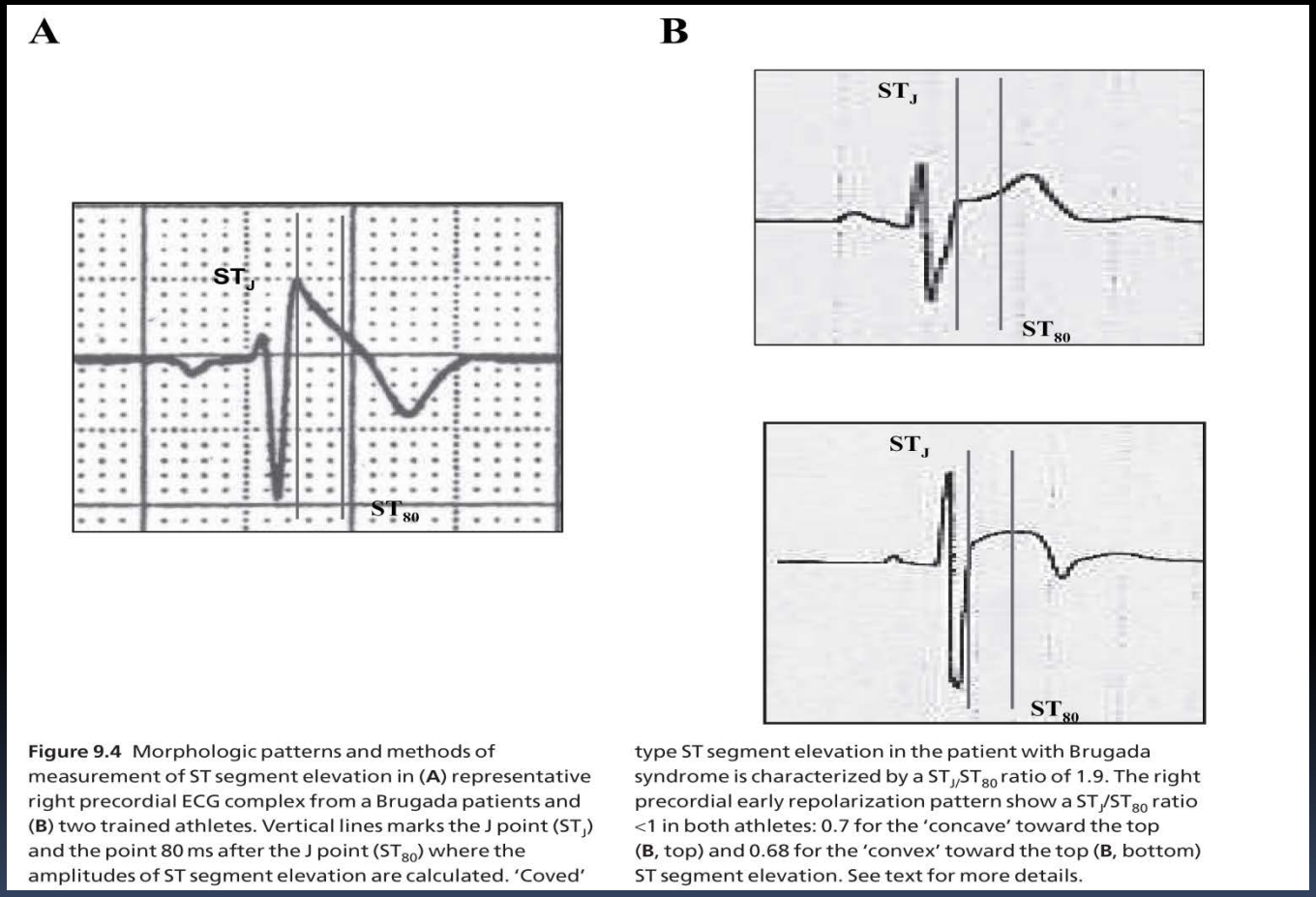
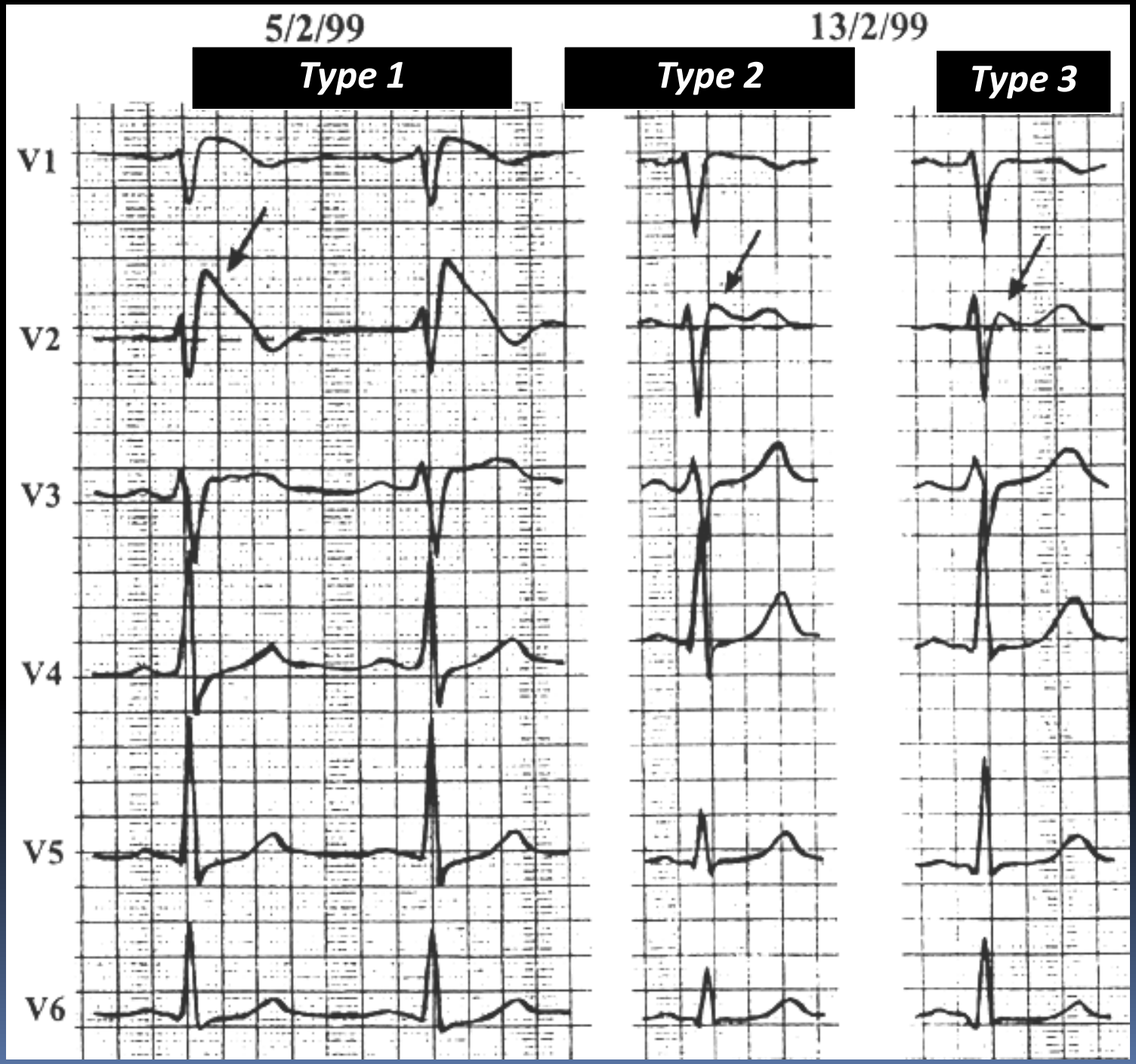


Figure 9.4 Morphologic patterns and methods of measurement of ST segment elevation in (**A**) representative right precordial ECG complex from a Brugada patients and (**B**) two trained athletes. Vertical lines marks the J point (ST_J) and the point 80 ms after the J point (ST_{80}) where the amplitudes of ST segment elevation are calculated. 'Coved' type ST segment elevation in the patient with Brugada syndrome is characterized by a ST_J/ST_{80} ratio of 1.9. The right precordial early repolarization pattern show a ST_J/ST_{80} ratio <1 in both athletes: 0.7 for the 'concave' toward the top (**B**, top) and 0.68 for the 'convex' toward the top (**B**, bottom) ST segment elevation. See text for more details.

The ECG pattern of the early repolarization shows distinctive features allowing accurate distinction from the ECG abnormalities of patients with Brugada syndrome. Such ECG criteria include the J-ST-T waveforms, the amplitude of maximum ST segment displacement at J point (STJ) and after 80 ms (ST80), and STJ/ST80 ratio.

EARLY REPOLARIZATION

- The magnitude of ST-segment elevation is characteristically modulated by autonomic influences, heart rate changes and drugs; this explains the dynamic nature of the ECG abnormalities and a waxing and waning of the ST-T segment over time.
- Slowing of heart rate exaggerates ST-segment elevation, whereas sinus tachycardia occurring during exercise or after isoproterenol reduces and often eliminate ER changes.
- Accordingly, the mechanisms underlying ER in trained athletes are characteristically related to the hypervagotonia which result from athletic training, so that ER is a reversible phenomenon which disappears with deconditioning.


5/2/99
13/2/99
Type 1
Type 2
Type 3
V1
V2
V3
V4
V5
V6

Early rep. in Athletes

- *Up-sloping ST*
- *High positive T waves*
- *QRS high voltages*
- *Normal QRS duration*
- *Increase after β-blockage, bradycardia, etc.*
- *Decrease after β-stimul., tachycardia, exercise, etc.*

Brugada

- *Down-sloping ST*
- *low negative T waves*
- *QRS low voltages*
- *Prolonged QRS*
- *Increase after β-blockage, bradycardia, etc.*
- *Decrease after β-stimul., tachy cardia, exercise, etc.*

Physiologic vs pathologic LVH

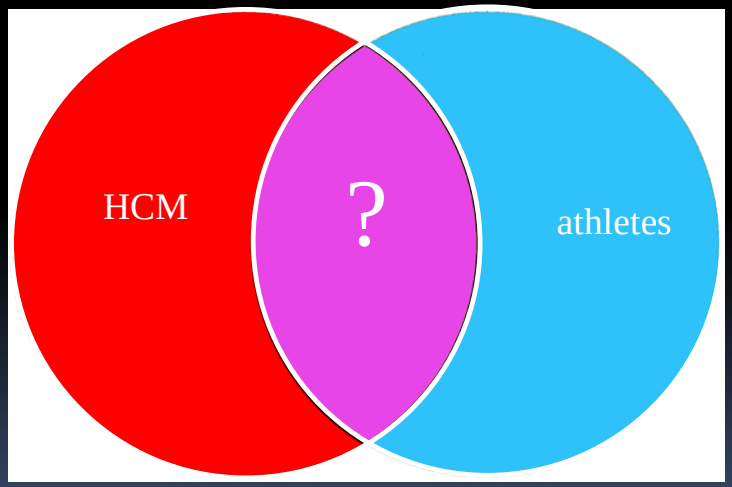
- In order to differentiate physiologic from pathologic LV hypertrophy, it is important to know whether differences exist between:
  - the ECG pattern associated with physiologic remodelling in the context of "athlete's heart" and
  - the ECG abnormalities occurring in structural heart diseases manifesting with an increased LV wall thickened, including hypertrophic cardiomyopathy (HCM), aortic valve diseases, or hypertensive heart disease.

OBJECTIVES

AHA Scientific Sessions 2007

- The purpose of the study is to assess whether ECG abnormalities of pathologic hypertrophy (HCM) overlaps with those of physiologic hypertrophy (athlete's heart).

- The ECG analysis was focused on what proportion of both groups presented with the ECG pattern of isolated voltage criteria for LVH.



HCM
(n. 260)

- Age: 42 years (3 – 82 ys)
- Sex: 184 male (71%)
- DNA analysis: 48 pts (18%)
- Max LV WT: 22 mm ± 6 (range 16 – 46 mm)
- LV EDD: 43 mm ± 10
- Obstruction: 22% (57 pts)

ATHLETES
(n. 1005)

- Age: 23 years (9 - 55 ys)
- Sex: 745 male (74%)
- Race: 1003 Europeans, 2 Africans
- Sport discipline: 38
- Training program: median of 7 years (2-30 ys)
- Max LV WT: 10.7±4
- LV EDD: 54 mm ± 6

STUDY POPULATIONS & DEMOGRAPHICS

RESULTS: ECG PATTERNS IN HCM PTS AND IN ELITE ATHLETES

AHA Scientific Sessions 2007

ECG pattern	Athletes n=1005 (%)	HCM n=260 (%)	p value
Isolated increase of QRS voltages	403 (40)	5 (1.9)	<0.0001
Nonvoltage criteria of LVH	13 (1.3)	155 (59.6)	<0.0001
ST/T repolarization abnormalities	27 (2.7)	209 (80)	<0.0001
Pathologic Q waves	17 (1.7)	103 (39.6)	<0.0001

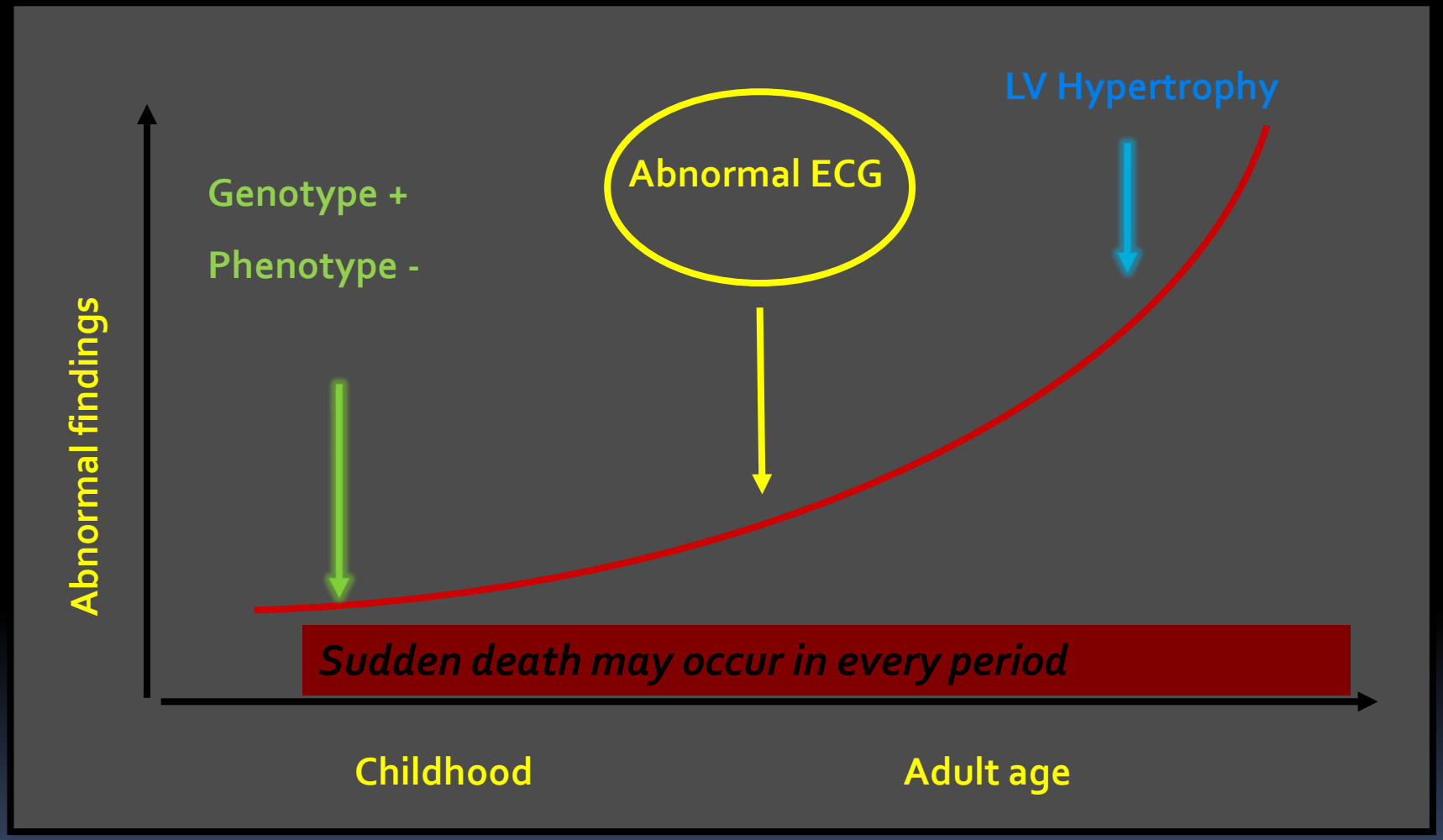
CONCLUSIONS

AHA Scientific Sessions 2007

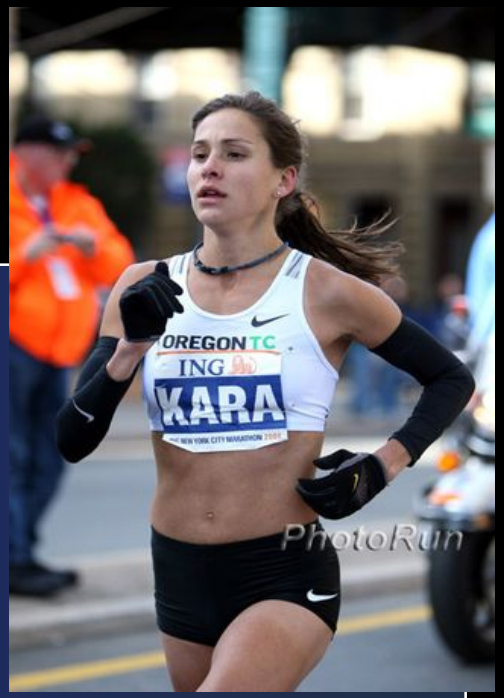
- The vast majority of patients with HCM have an abnormal ECG, with left ventricular hypertrophy associated to repolarization changes and/or pathological Q waves, as well as left atrial enlargement and conduction disturbances.

- Instead, trained athletes usually show an isolated increase of QRS amplitude, right QRS axis deviation, normal atrial and ventricular activation patterns and normal ST-T repolarization.

HCM diagnosis in Young Athletes



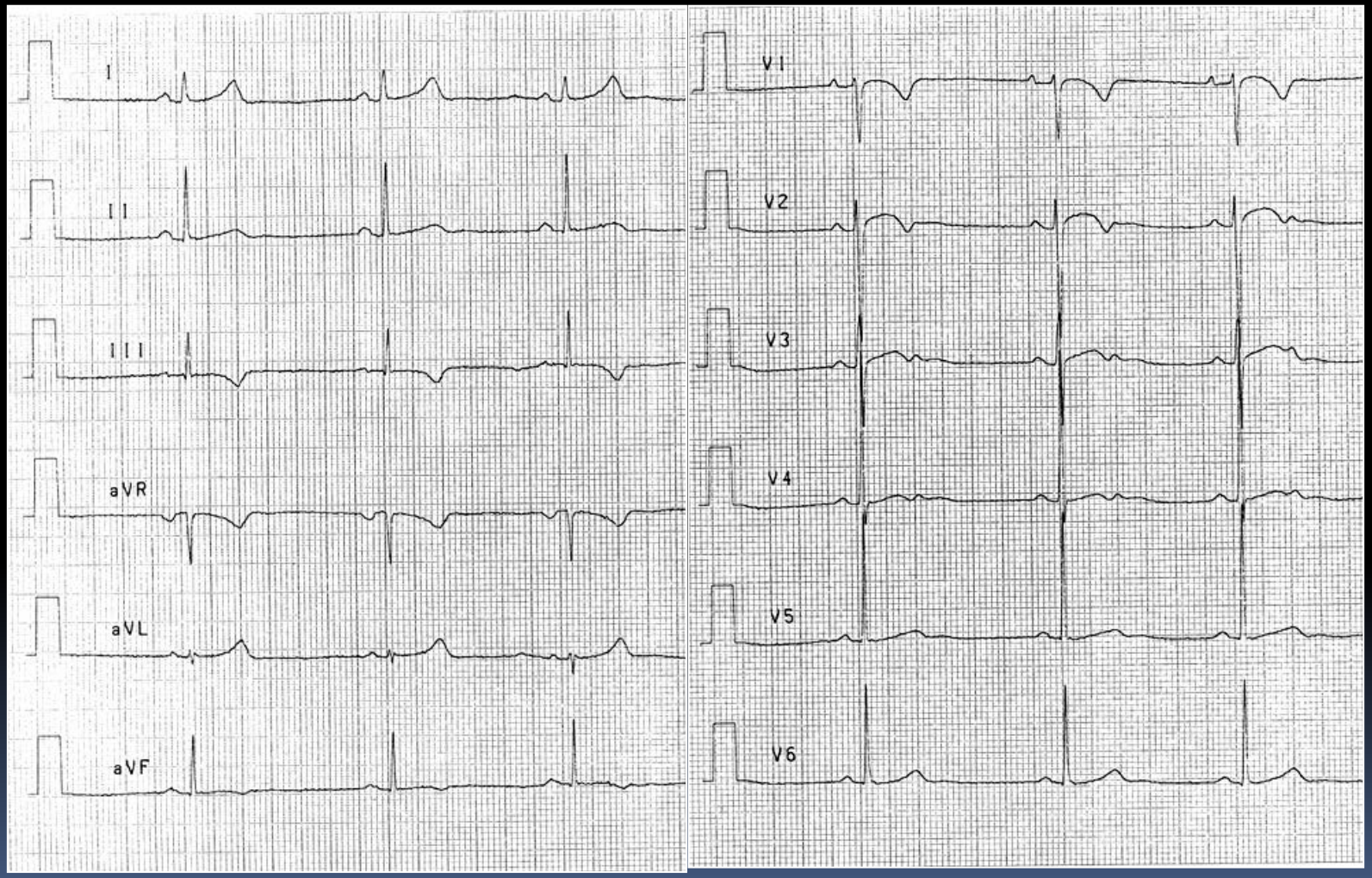
ECG is abnormal before the appearance of hypertrophy



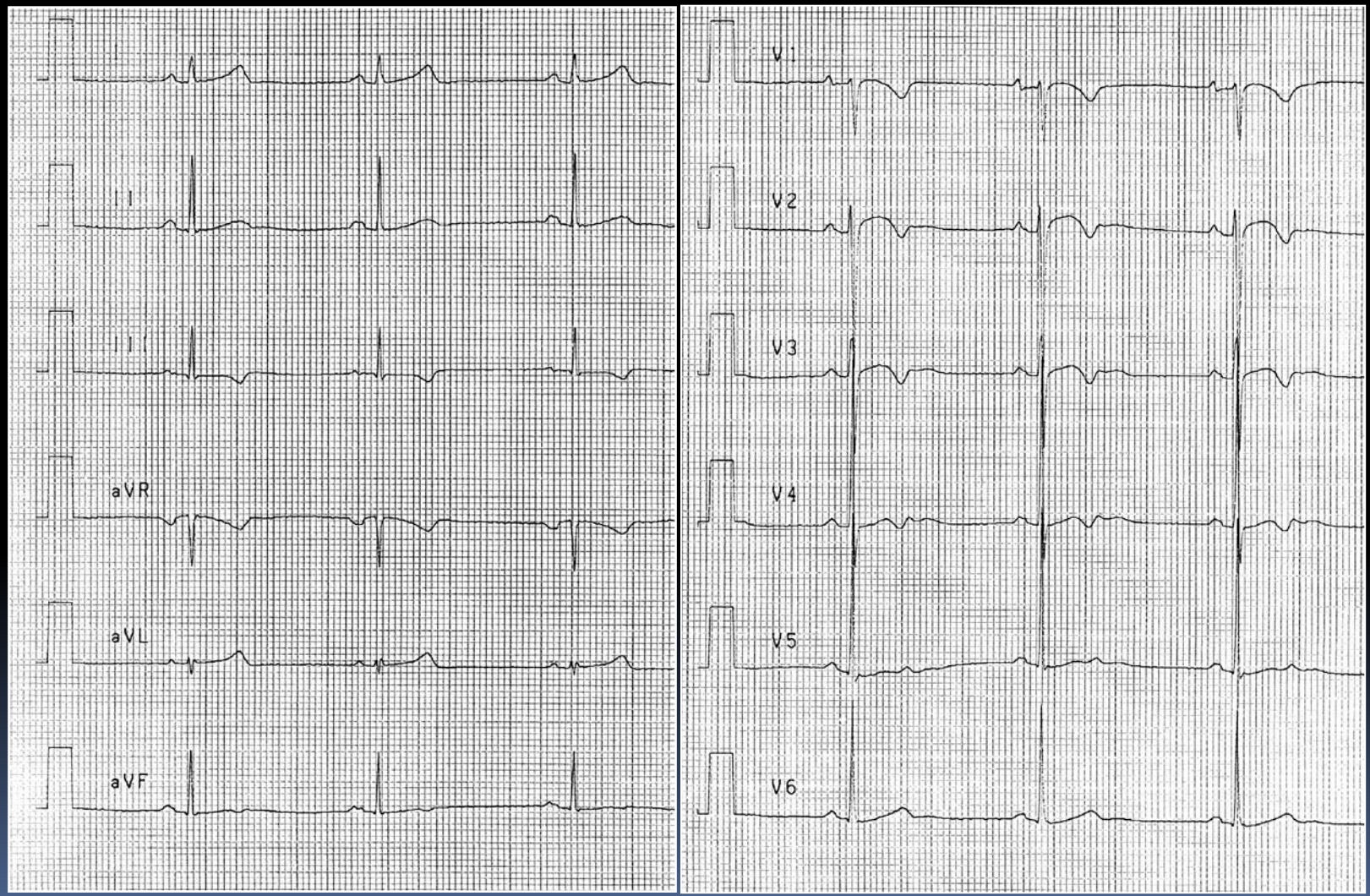
Female 47 yrs, runner

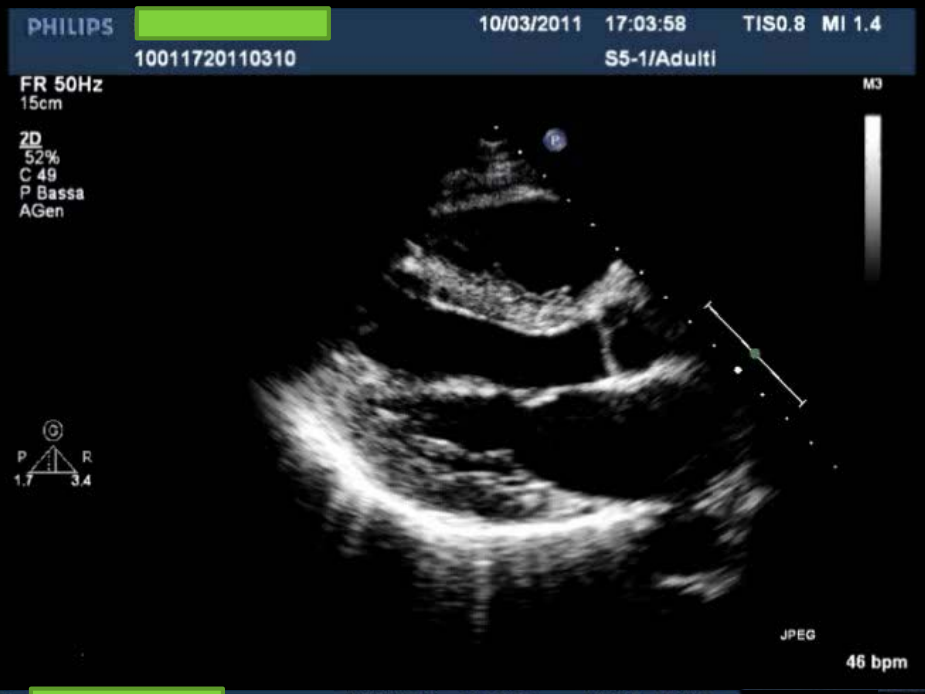
- Height 160 cm; weight 56 Kg;
- Asymptomatic
- Family history negative
- Request for echo because of negative T wave
- PE negative; BP: 115/75mmHg

12-lead ECG in 2008

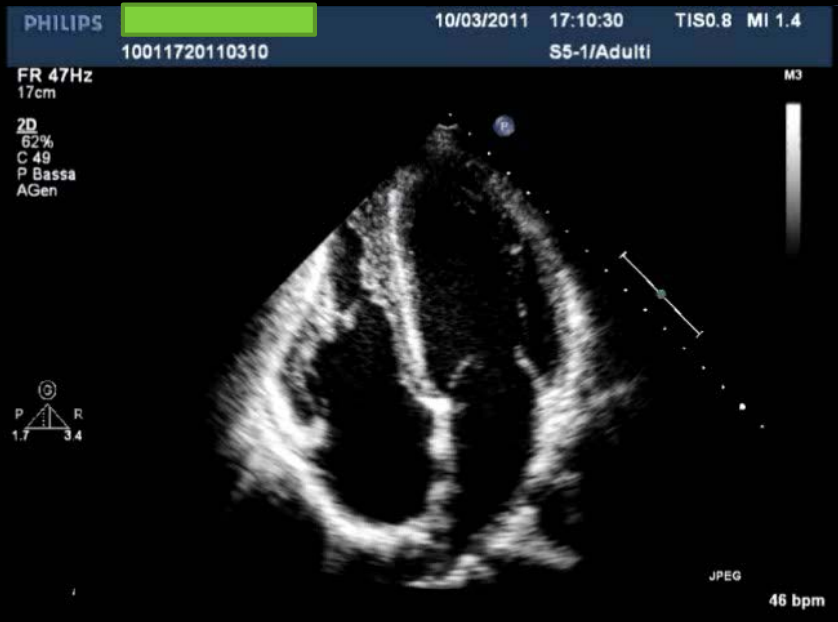


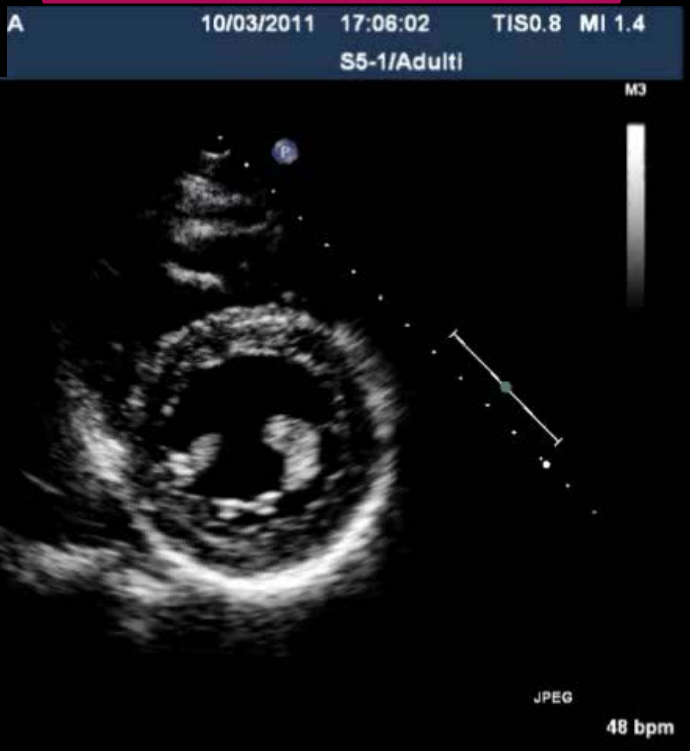
12-lead ECG in 2010





- LV Dd 47 mm
- AVS 12 mm
- Pfw 11 mm
- LA 45 mm
- EF 70%

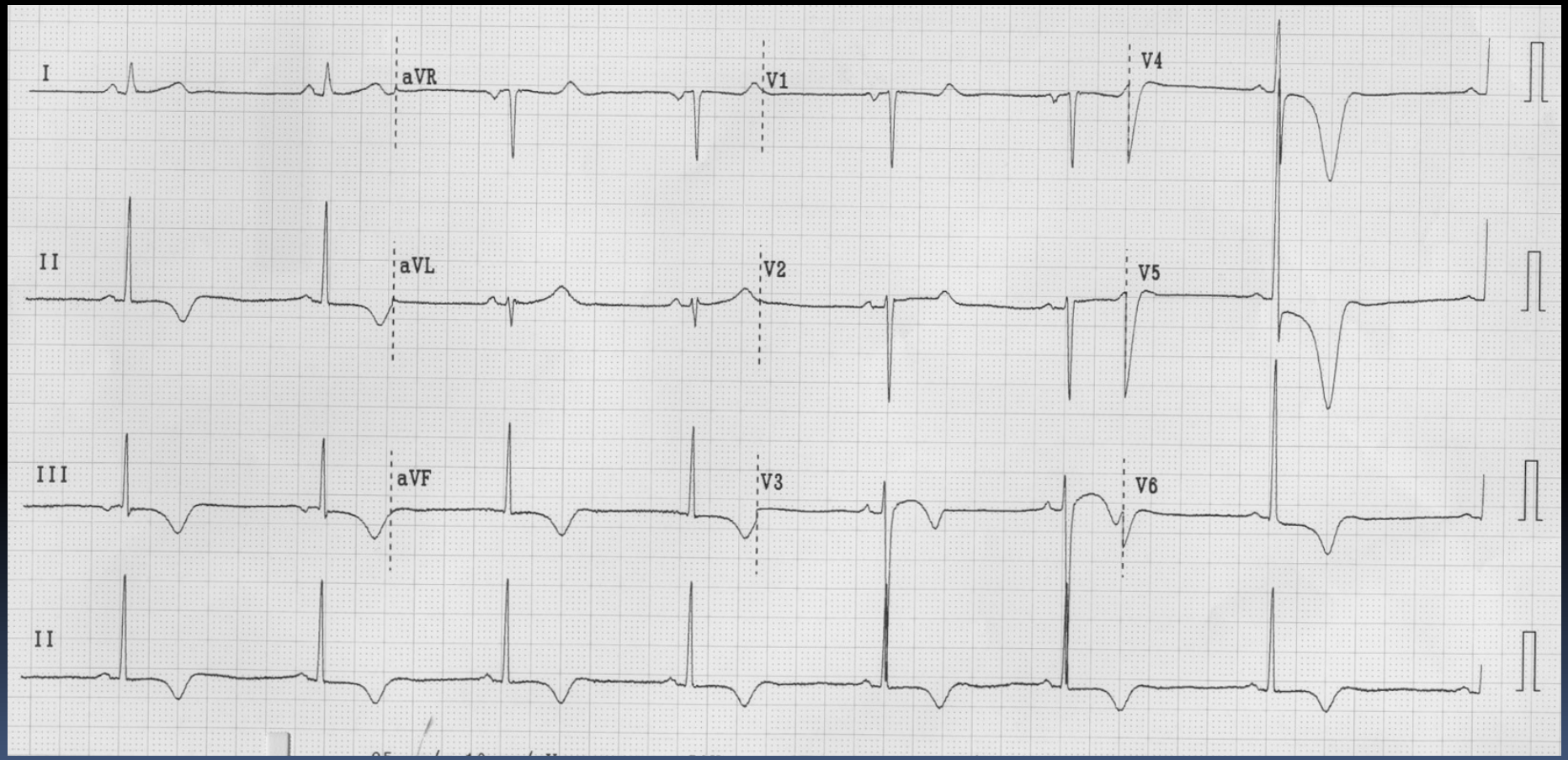


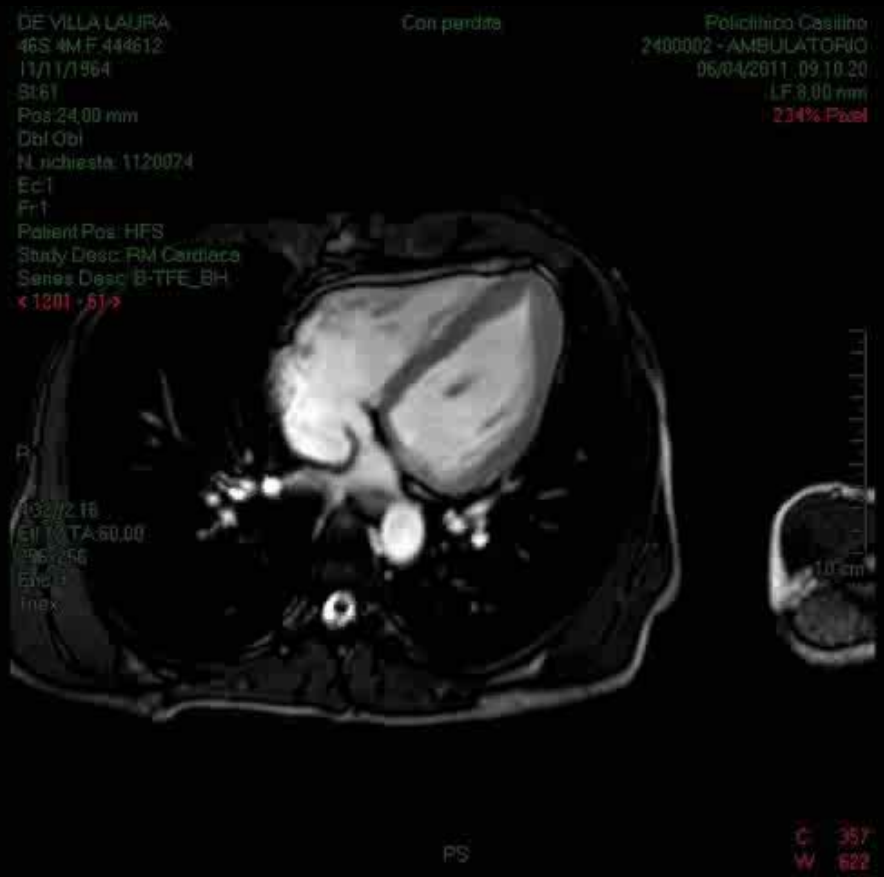


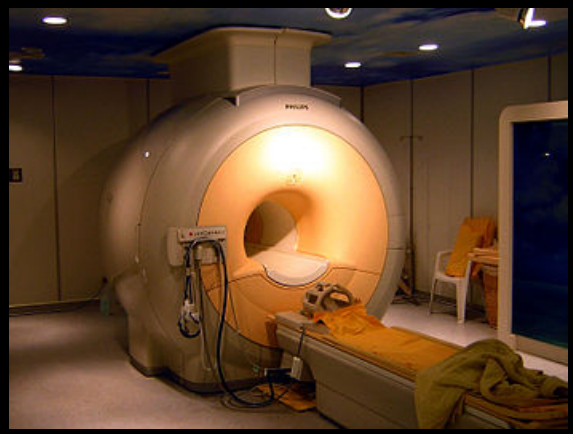
Athlete's heart

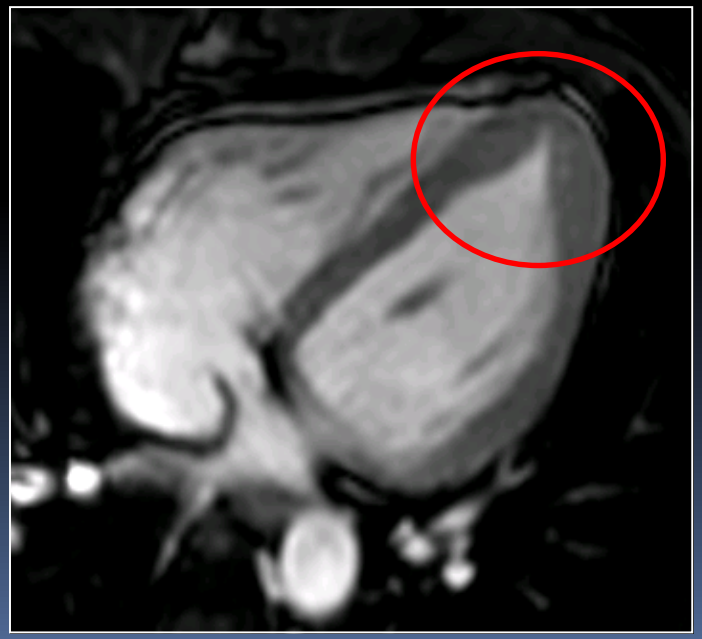
HCM

12-lead ECG in 2011




DE VILLA LAURA
46S 4M F 444612
11/11/1964
St:61
Pos:24,00 mm
Obl Obi
N. richiesta: 1120074
Ec:1
Fr:1
Patient Pos: HFS
Study Desc: RM Cardiaca
Series Desc: B-TFE_BH
< 1201 - 61 >
Con perdita
Policlinico Casilino
2400002 - AMBULATORIO
06/04/2011 09.10.20
LF:8,00 mm
234% Pixel
PS
C 357
W 622





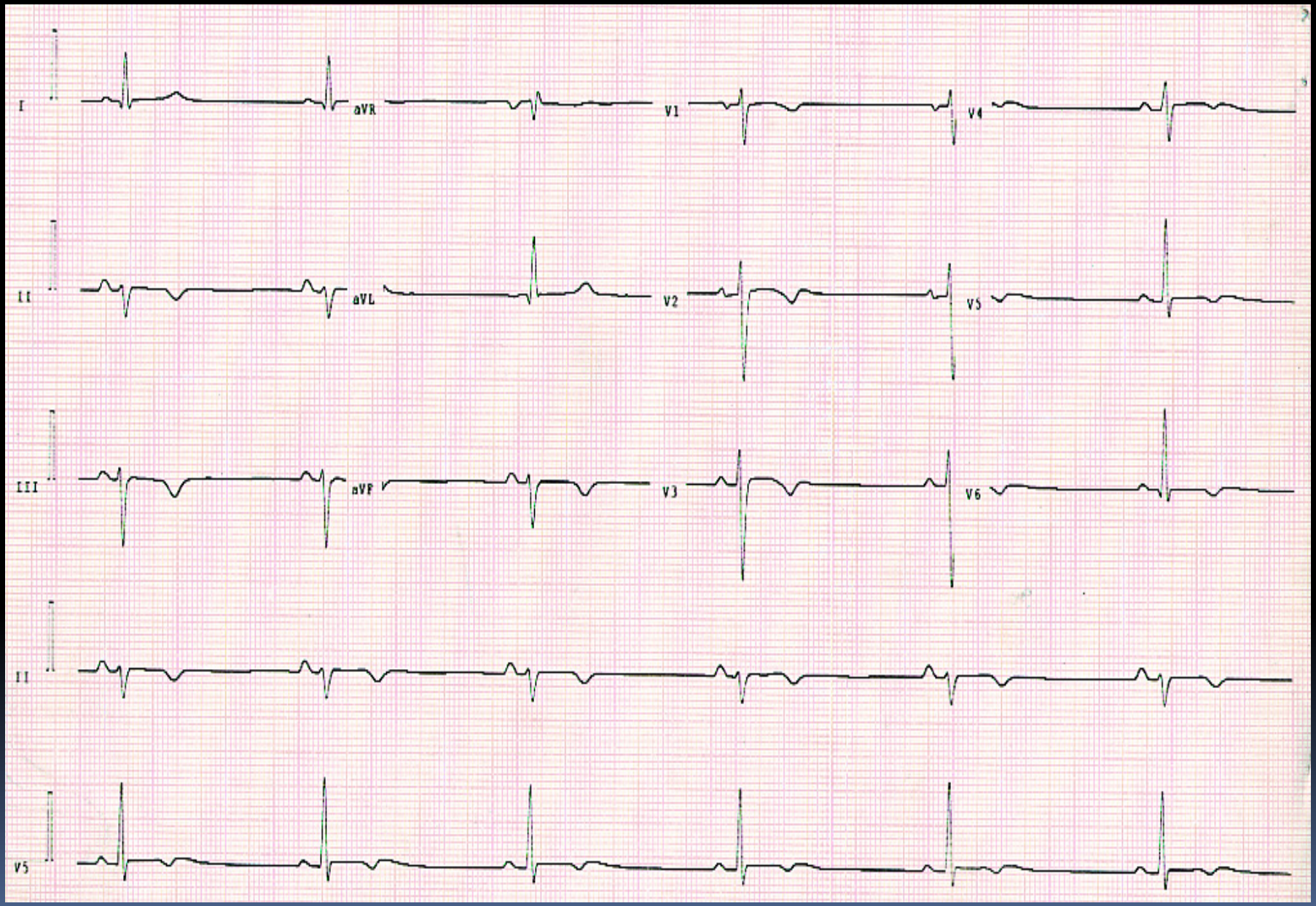
Prevalence of right precordial T-wave inversion at preparticipation ECG screening: a prospective study on 3086 young competitive athletes

- Study population: 3086 consecutive athletes
- Gender: 2138 M, 948 F
- Age: mean 15.4±9 yrs; range 7-35 yrs
- T-wave inversion beyond V1(overall): 127 athl. (4.1%)
  - 70 (2.3%) in leads V1 and V2
  - 57 (1.8%) in leads V1 to V3 or beyond
- T-wave inversion (ath.≥14 years): 1.4%
- T-wave inversion (ath.<14 years): 9,3%

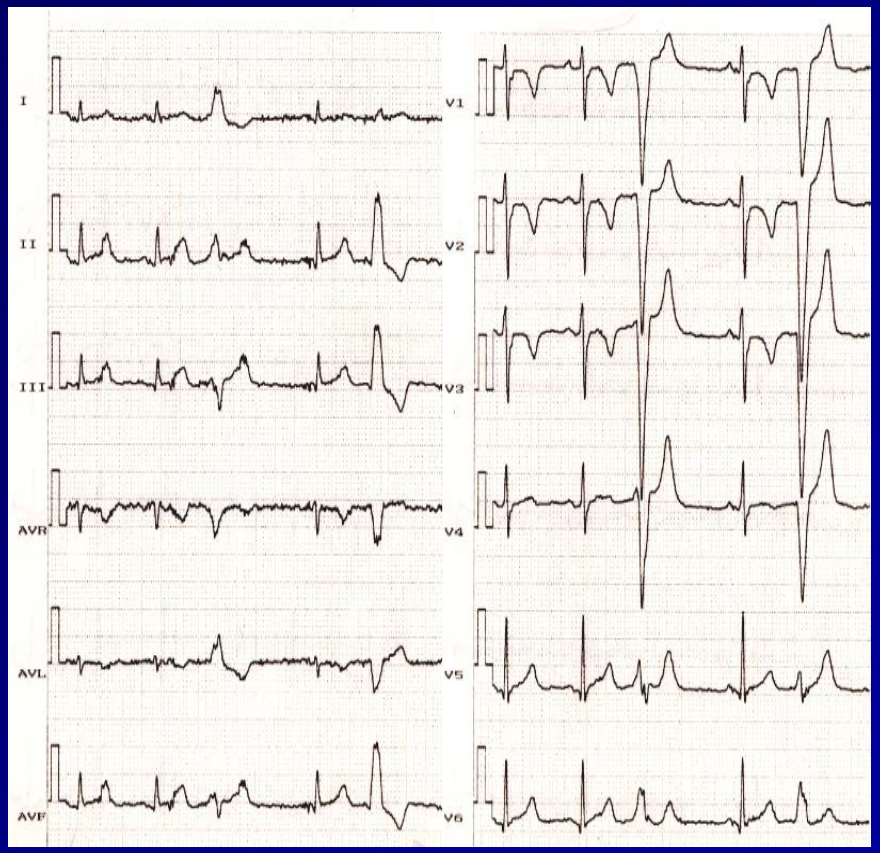
} ($p < 0.001$)

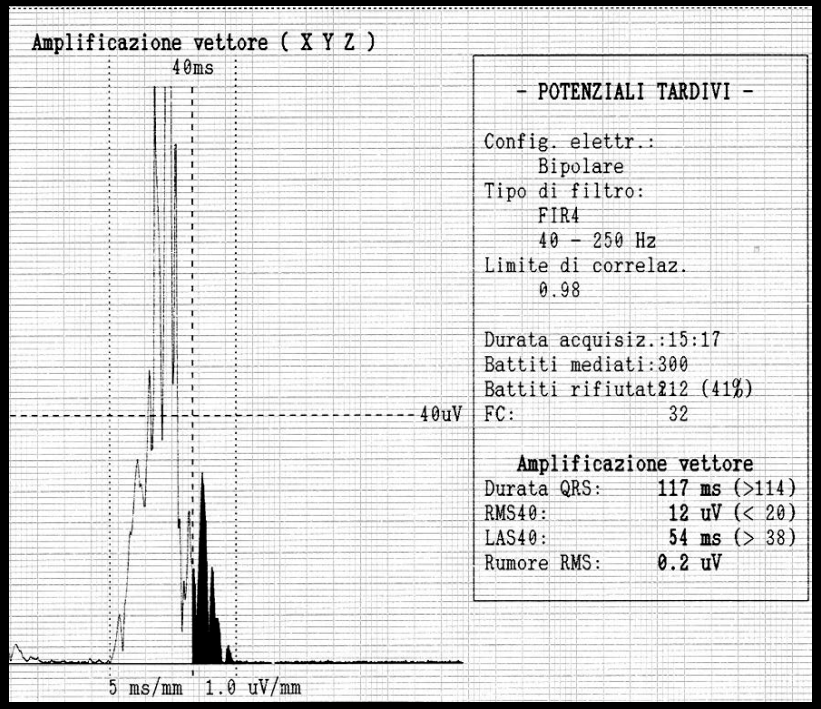
- ARVC/D diagnosis (Echo/cardiac MR): 3 of 127 (2.3%)
- ARVC/D prevalence in this population: 0.1%

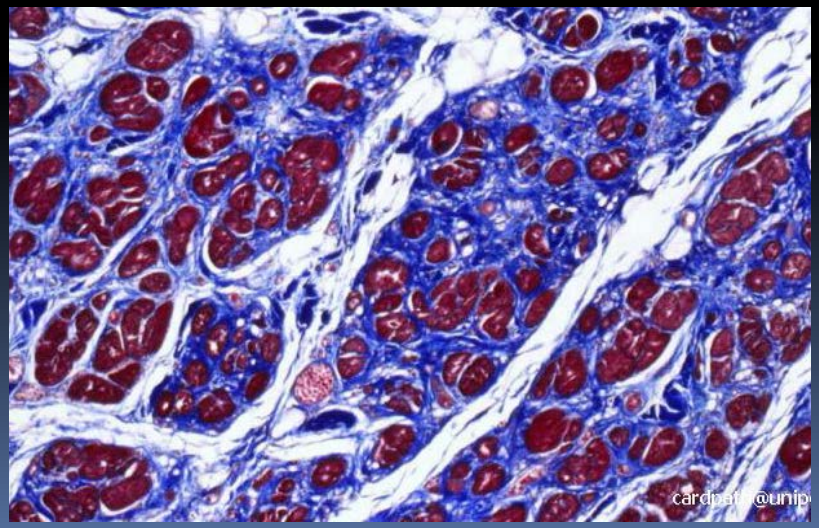
Top-level canoeist, died at 24 yrs for ARVC



Elite rower with ARVC and complex VAs at 24-hour Holter



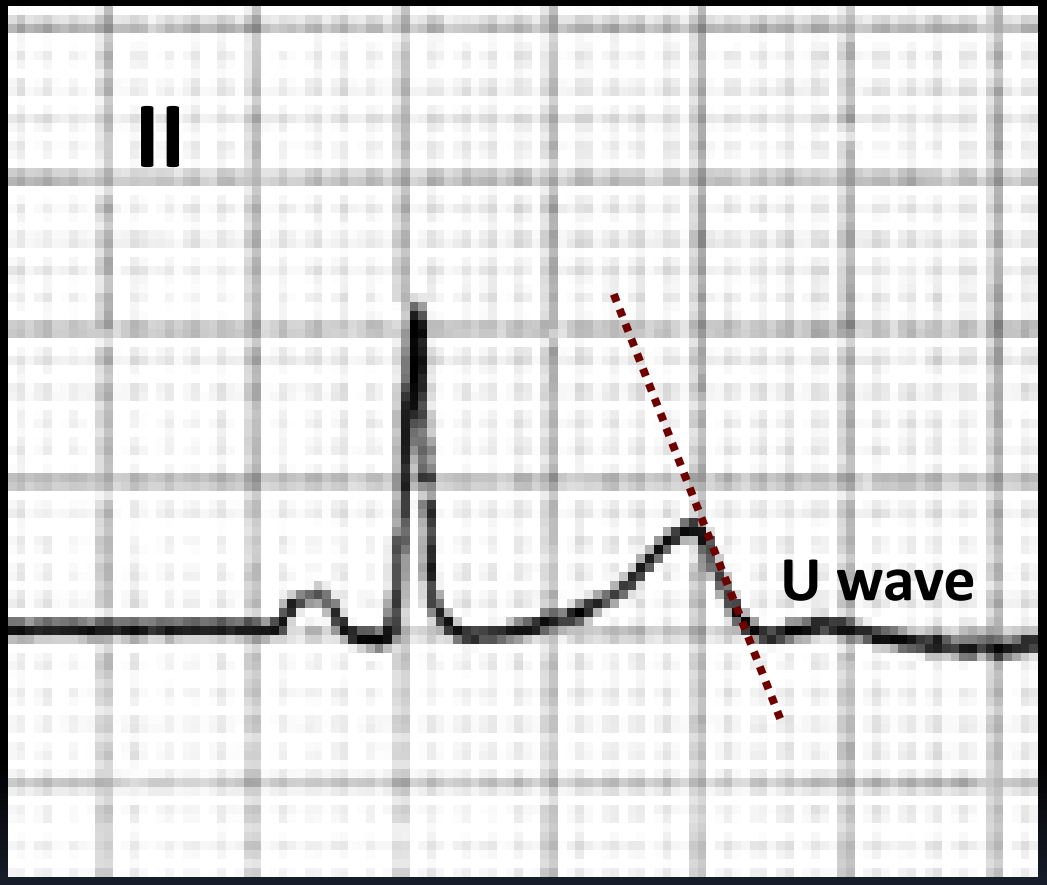


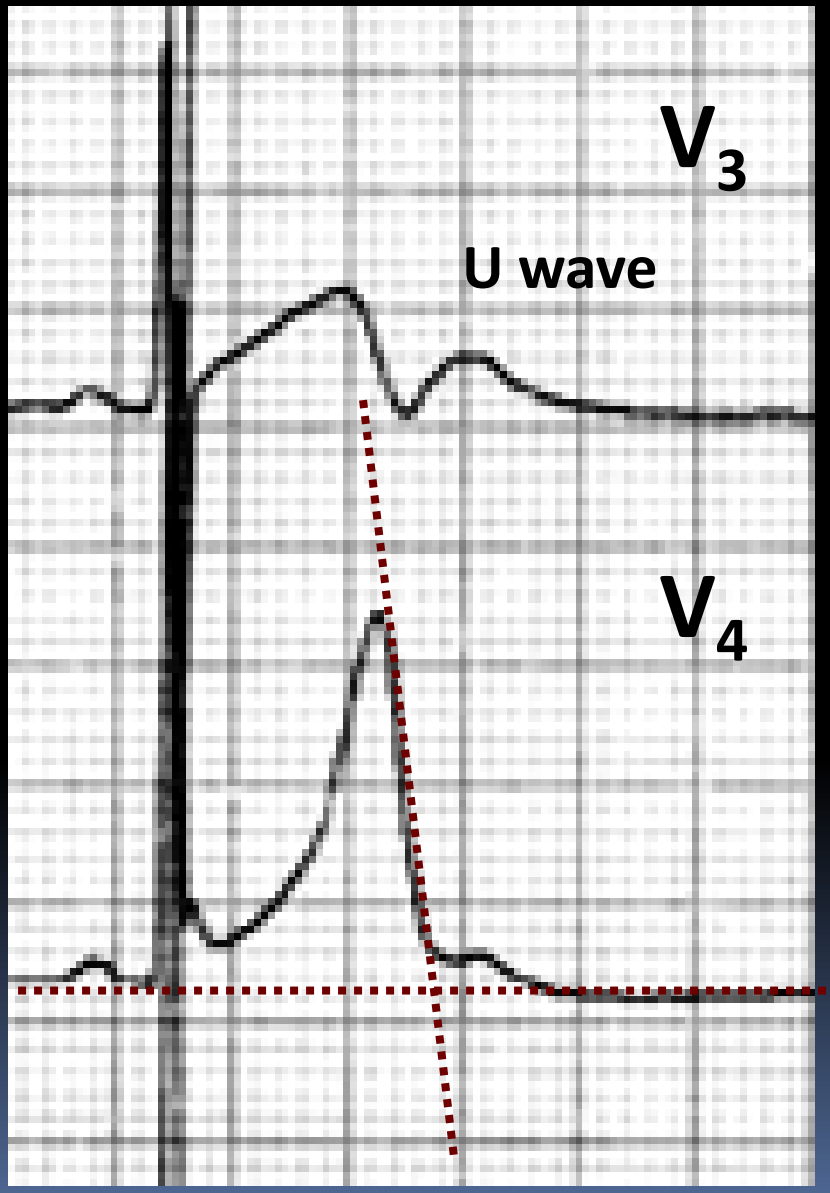


Long QT syndrome: Problems in Athletes

Difficulty to precisely measure QT interval in athletes, because of the frequent presence of bradycardia and U wave

35 yrs, elite marathon runner

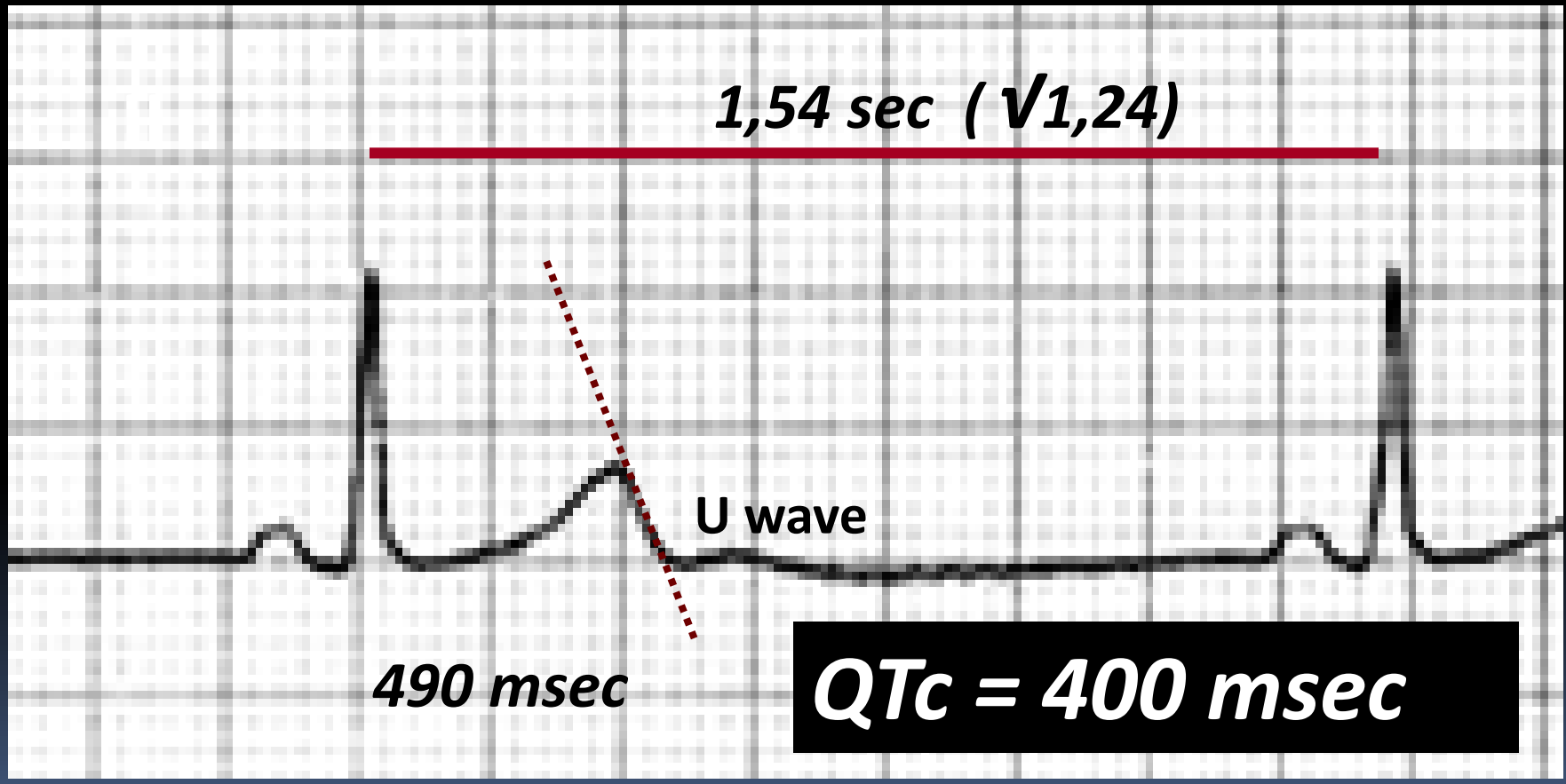




Sinus bradycardia 36 bpm

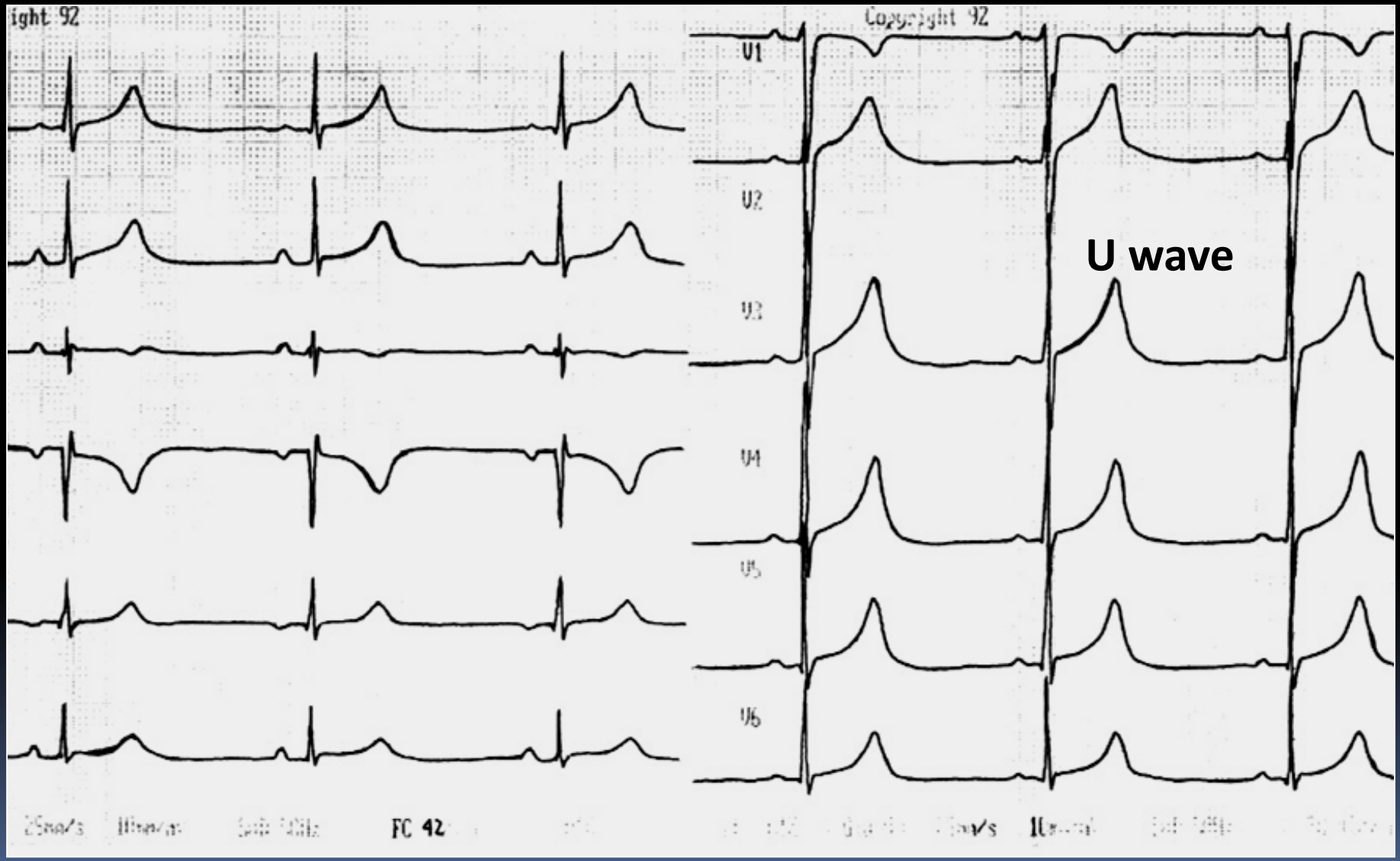
Bazett Formula

QTc (msec) = QT / √R-R (sec)



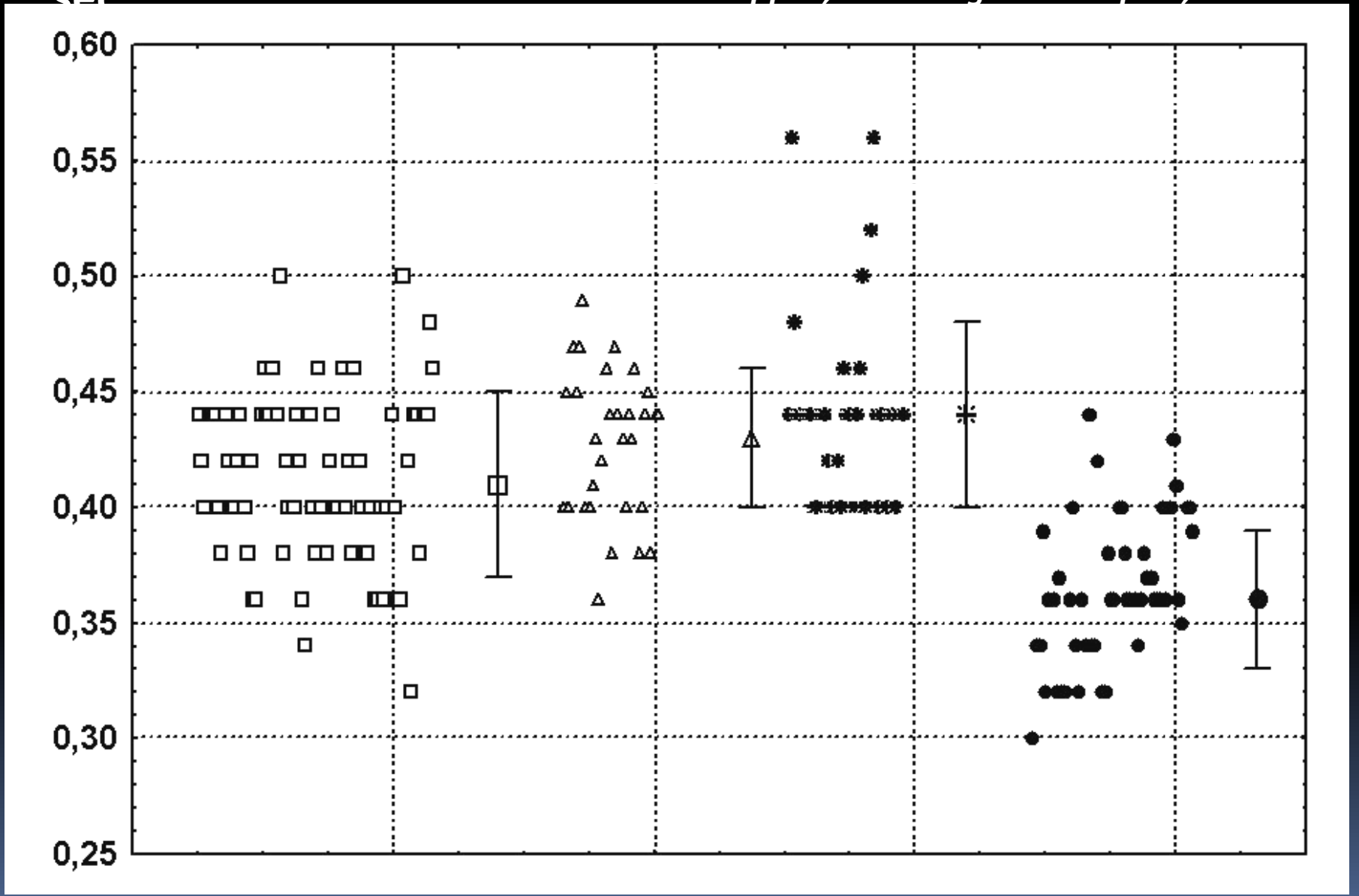
29 yrs., elite cyclist

HR 42 bpm, QT 0,53 sec, QTc 0,435

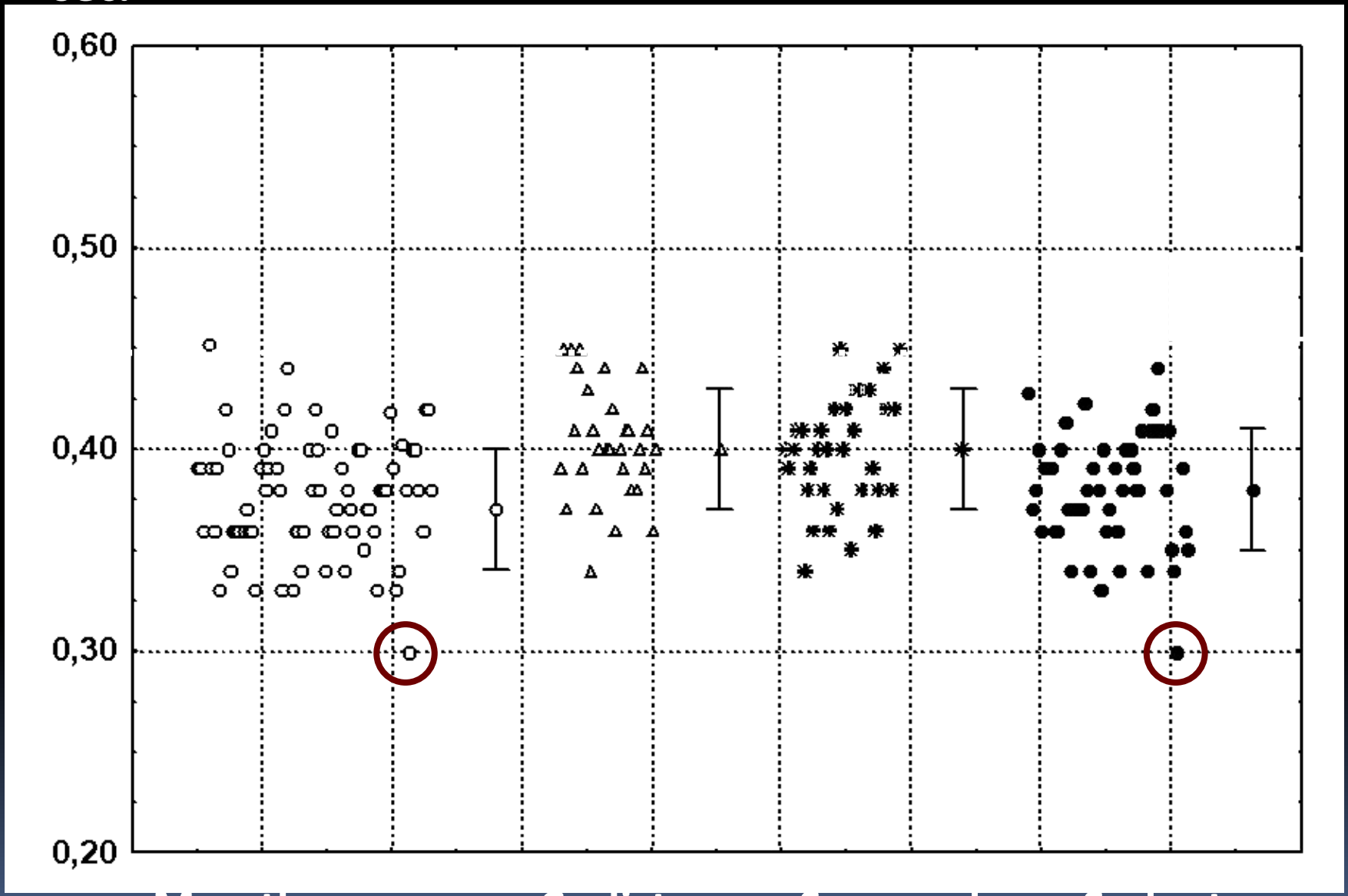


QT interval in athletes and sedentary subjects

Da P. Zeppilli, Cardiologia dello Sport, 2007

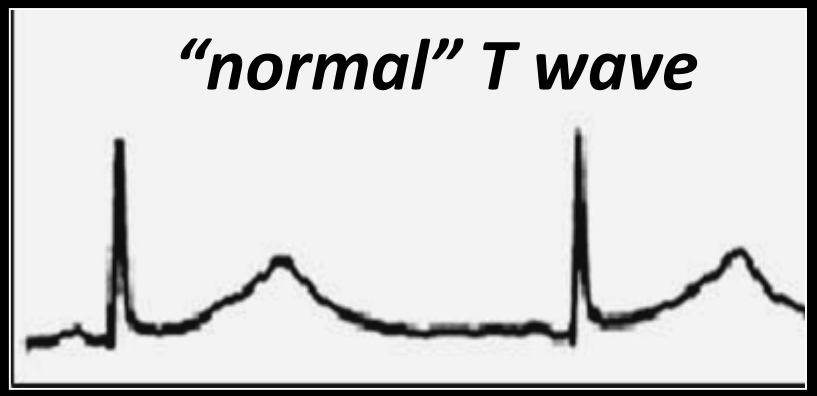


QT c in athletes and sedentary subjects



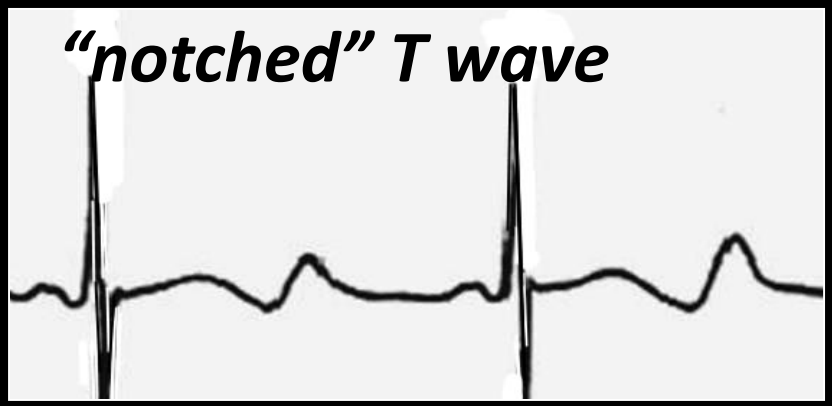
Da P. Zeppilli, Cardiologia dello Sport, 2007

LQT1
(42-55%)



- *KCNQ1 gene*
- *K^+ channel, slow current*
- *Loss of function*
- *Syncope or SD during exercise (swimming)*

LQT2
(35-45%)



- *KCNH2 gene (Herg)*
- *K^+ channel, fast current*
- *Loss of function*
- *Syncope or SD during emotional stress (alarm-clock)*

LQT3
(8-10%)

- *SCN5A gene*
- *Na^+ channel,*
- *Gain of function*
- *SD during sleeping*

Pratical guidelines for suspected long QT in Athletes

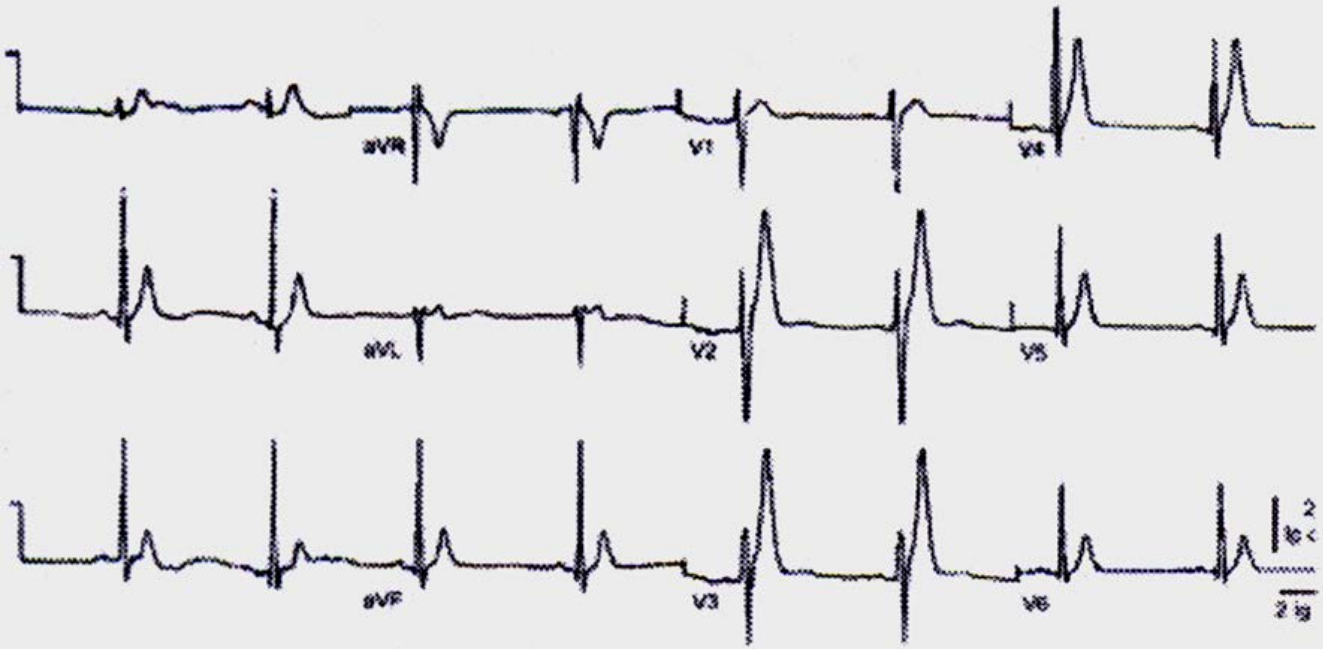
- *To exclude acquired long QT*
  (drugs, ipokalemia, salt-losing tubulopathies, such as Bartter-Gitelman syndrome etc)
- *Family history (syncope, sudden death)*
- *Stress-test ECG, Holter (12 leads):*
  paradox increase of QTc interval with exercise
- *Re-evaluation after detraining*
  verify a reduction of QTc
- *Genetics: is it really helpful?*

Short QT Syndrome

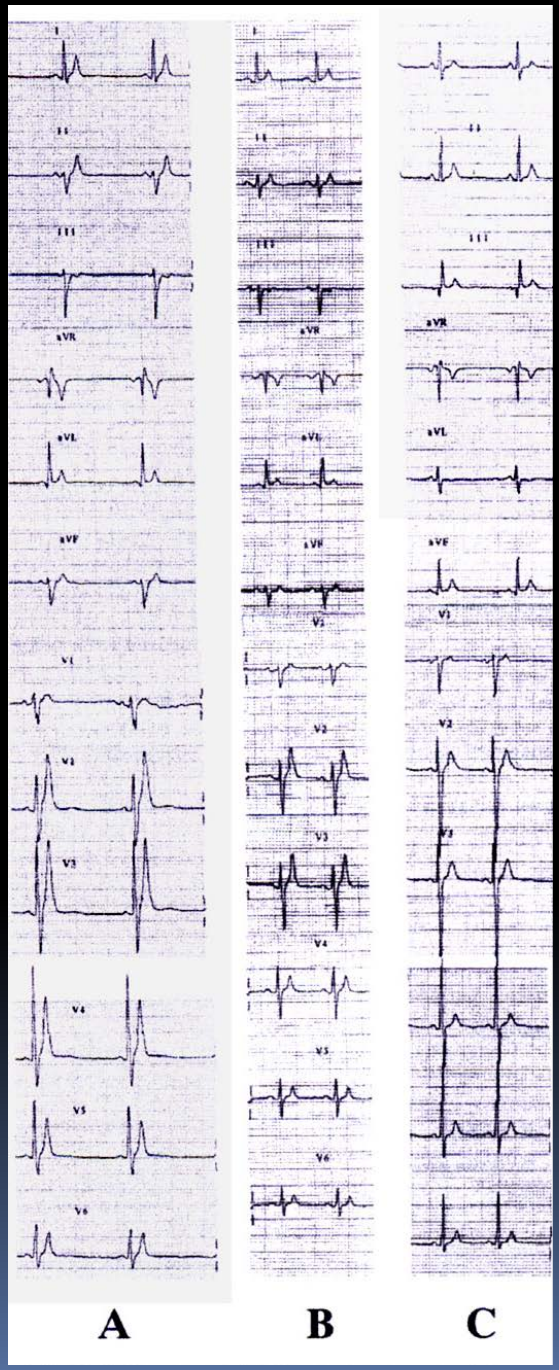
A Familial Cause of Sudden Death

Fiorenzo Gaita, MD; Carla Giustetto, MD; Francesca Bianchi, MD; Christian Wolpert, MD; Rainer Schimpf, MD; Riccardo Riccardi, MD; Stefano Grossi, MD; Elena Richiardi, MD; Martin Borggrefe, MD

Background—A prolonged QT interval is associated with a risk for life-threatening events. However, little is known about prognostic implications of the reverse—a short QT interval. Several members of 2 different families were referred for syncope, palpitations, and resuscitated cardiac arrest in the presence of a positive family history for sudden cardiac death. Autopsy did not reveal any structural heart disease. All patients had a constantly and uniformly short QT interval at ECG.



QTc < 300 msec



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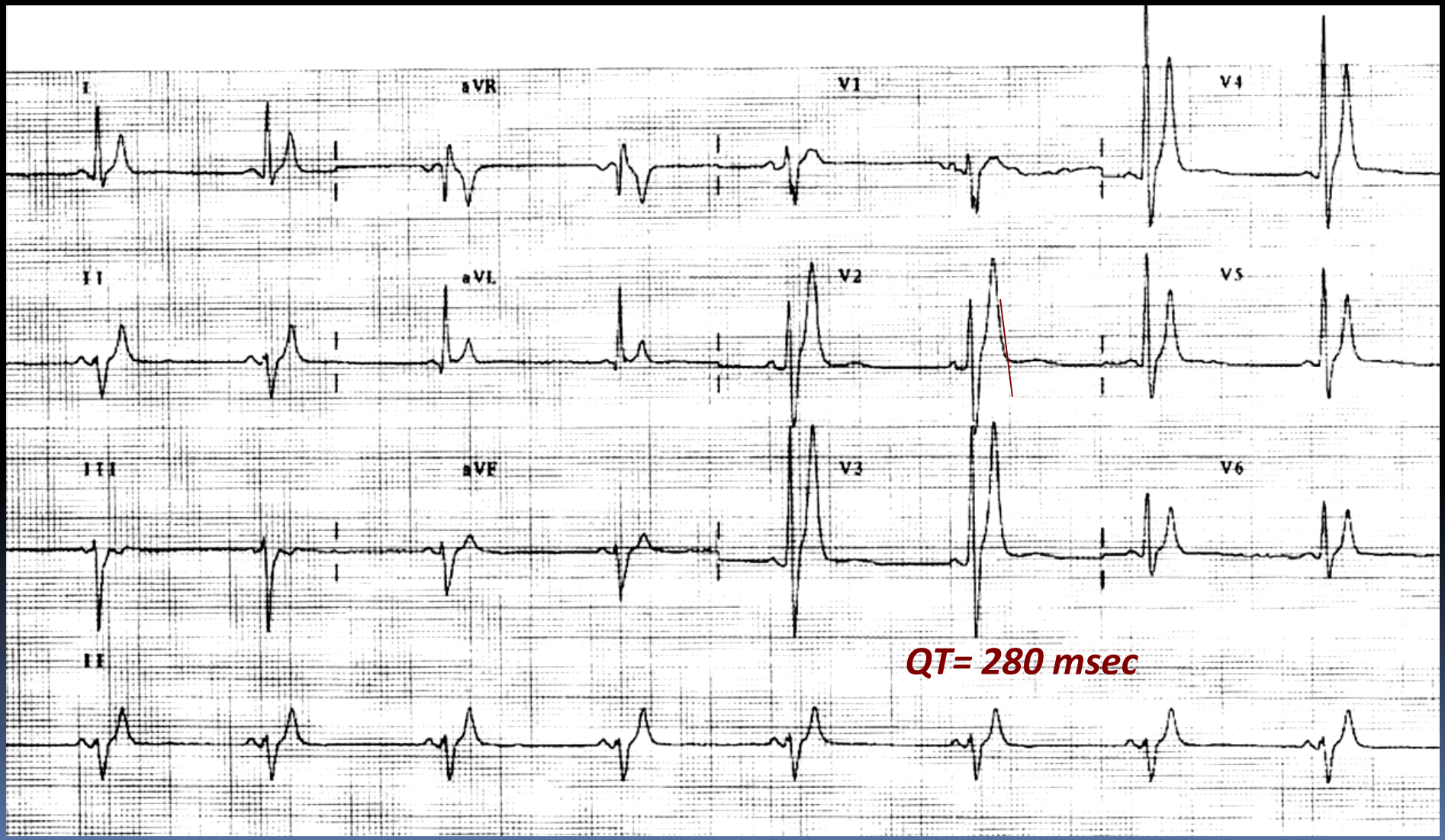
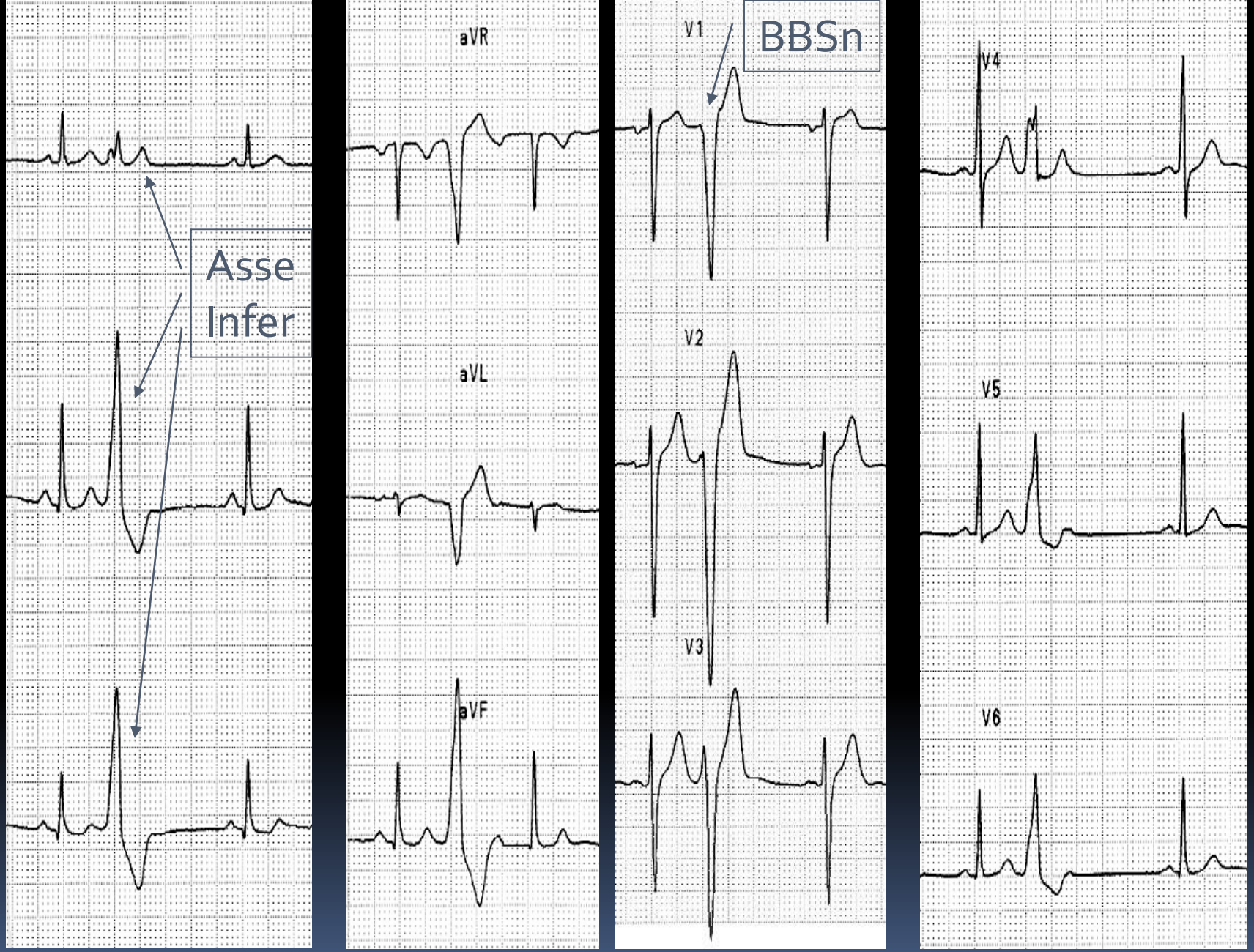
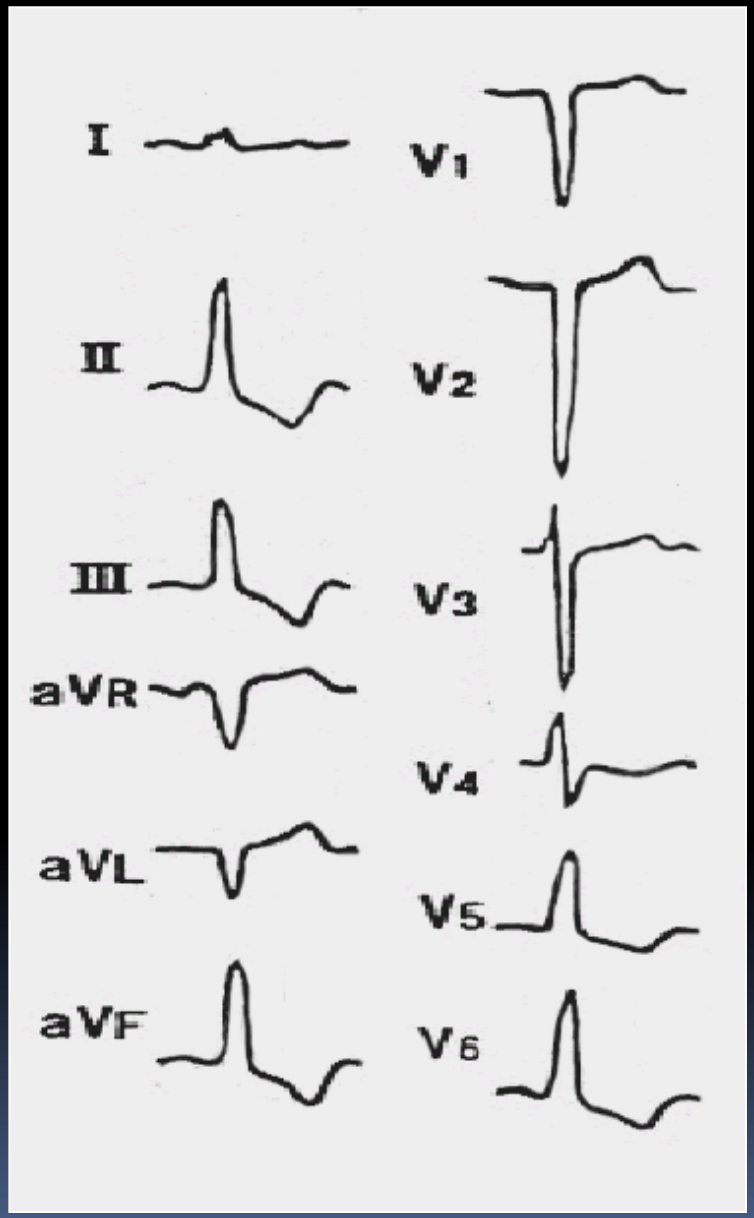


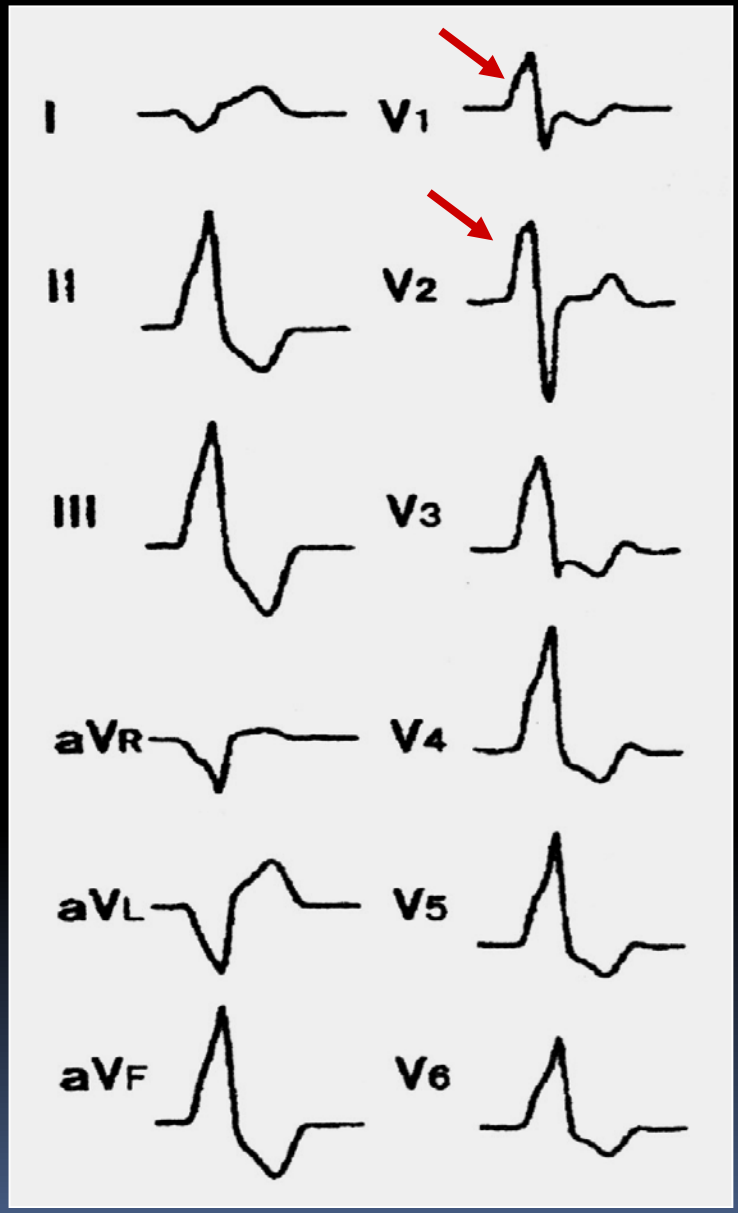


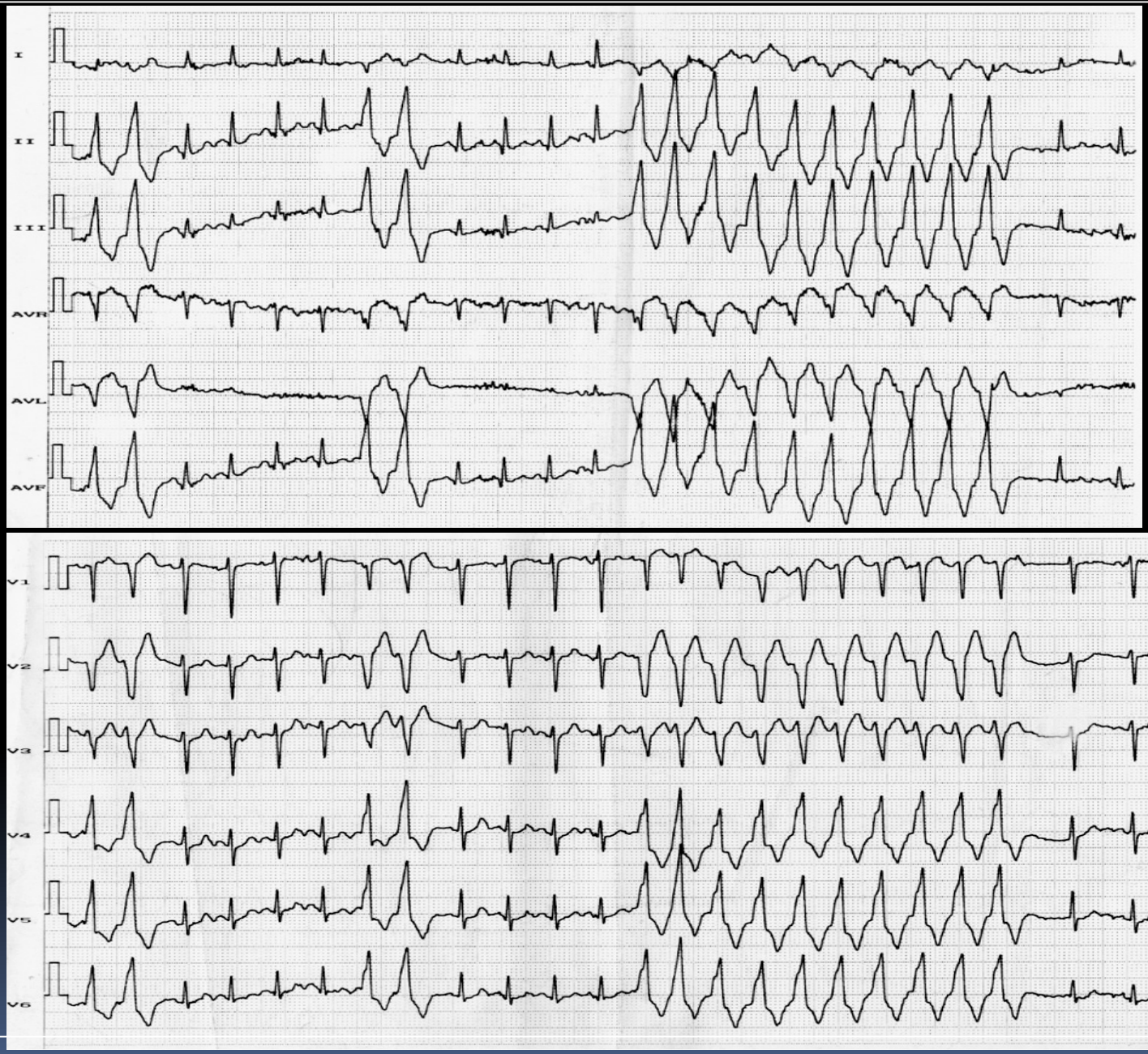
Tipica aritmia ventricolare idiopatica/benigna ad origine dal tratto d'efflusso del ventricolo destro (BBSn + Asse Inferiore)

BPV da efflusso destro



BPV da efflusso sinistro

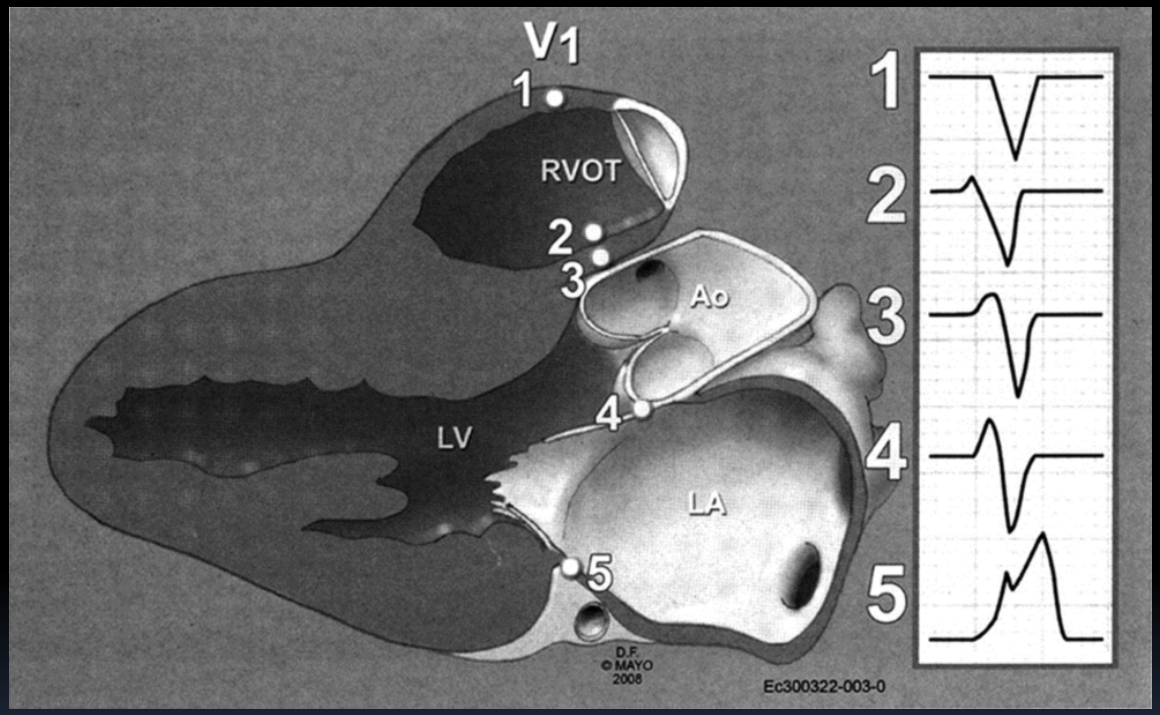



I
II
III
AVR
AVL
AVF
V1
V2
V3
V4
V5
V6

JACC Journals

From: Ventricular Arrhythmias in the Absence of Structural Heart Disease

J Am Coll Cardiol. 2012;59(20):1733-1744. doi:10.1016/j.jacc.2012.01.036



The anatomy of the outflow tract region is such that areas on the right and left sides of the heart can be in close proximity to each other. This can give similar ECG patterns in several leads. However, note that in V1, there is a gradual increase in the amplitude of the r-wave as the site of origin of the ventricular ectopy moves leftward.

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Long-Term Clinical Significance of Frequent and Complex Ventricular Tachyarrhythmias in Trained Athletes

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Rome, Italy, and Minneapolis, Minnesota

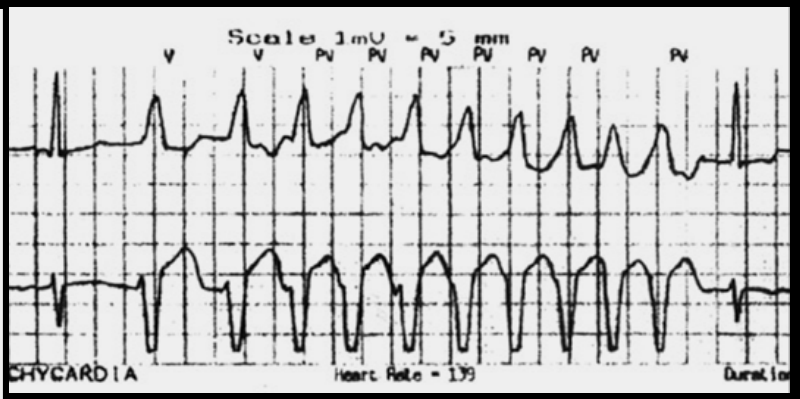
OBJECTIVES The aim of this study was to clarify the clinical relevance of ventricular tachyarrhythmias assessed by 24-h ambulatory electrocardiograms (ECG) in a large, unique, and prospectively evaluated athletic population.

BACKGROUND For athletes with ventricular tachyarrhythmias, the risk of sudden cardiac death associated with participation in competitive sports is unresolved.

METHODS We assessed 355 competitive athletes with ventricular arrhythmias (VAs) on a 24-h ambulatory (Holter) ECG that was obtained because of either palpitations, the presence of ≥3 premature ventricular depolarizations (PVDs) on resting 12-lead ECG, or both.

RESULTS Athletes were segregated into three groups: Group A with ≥2,000 PVDs/24 h (n = 71); Group B with ≥100 <2,000 PVDs/24 h (n = 153); and Group C with only <100 PVDs/24 h (n = 131). Cardiac abnormalities were detected in 26 of the 355 study subjects (7%) and were significantly more common in Group A (21/71, 30%) than in Group B (5/153, 3%) or Group C athletes (0/131, 0% p < 0.001). Only the 71 athletes in Group A were excluded from competition. During follow-up (mean, 8 years), 70 of 71 athletes in Group A and each of the 284 athletes in Groups B and C have survived without cardiovascular events. The remaining Group A athlete died suddenly of arrhythmogenic right ventricular cardiomyopathy while participating in a field hockey game against medical advice.

CONCLUSIONS Frequent and complex ventricular tachyarrhythmias are common in trained athletes and are usually unassociated with underlying cardiovascular abnormalities. Such VAs (when unassociated with cardiovascular abnormalities) do not convey adverse clinical significance, appear to be an expression of "athlete's heart syndrome," and probably do not per se justify a disqualification from competitive sports. (J Am Coll Cardiol 2002;40:446–52) © 2002 by the American College of Cardiology Foundation



Biffi et al.

"... ventricular tachyarrhytmias are common in trained athletes and are usually unassociated with underlying cardiovascular abnormalities ... do not convey adverse clinical significance, appear to be an expression of athlete's heart syndrome".

CONCLUSIONS REMARKS

ECG screening is a lifesaving strategy which meets the criteria for a good screening program:

- still asymptomatic athletes with at-risk cardiovascular diseases are accurately identified by 12-lead ECG;
- an effective management strategy exists based on restriction of life-threatening training/competition and subsequent clinical treatment
- early identification and management of asymptomatic athletes favourably modify the outcome of the underlying diseases leading to substantial reduction of SCD

THANK YOU