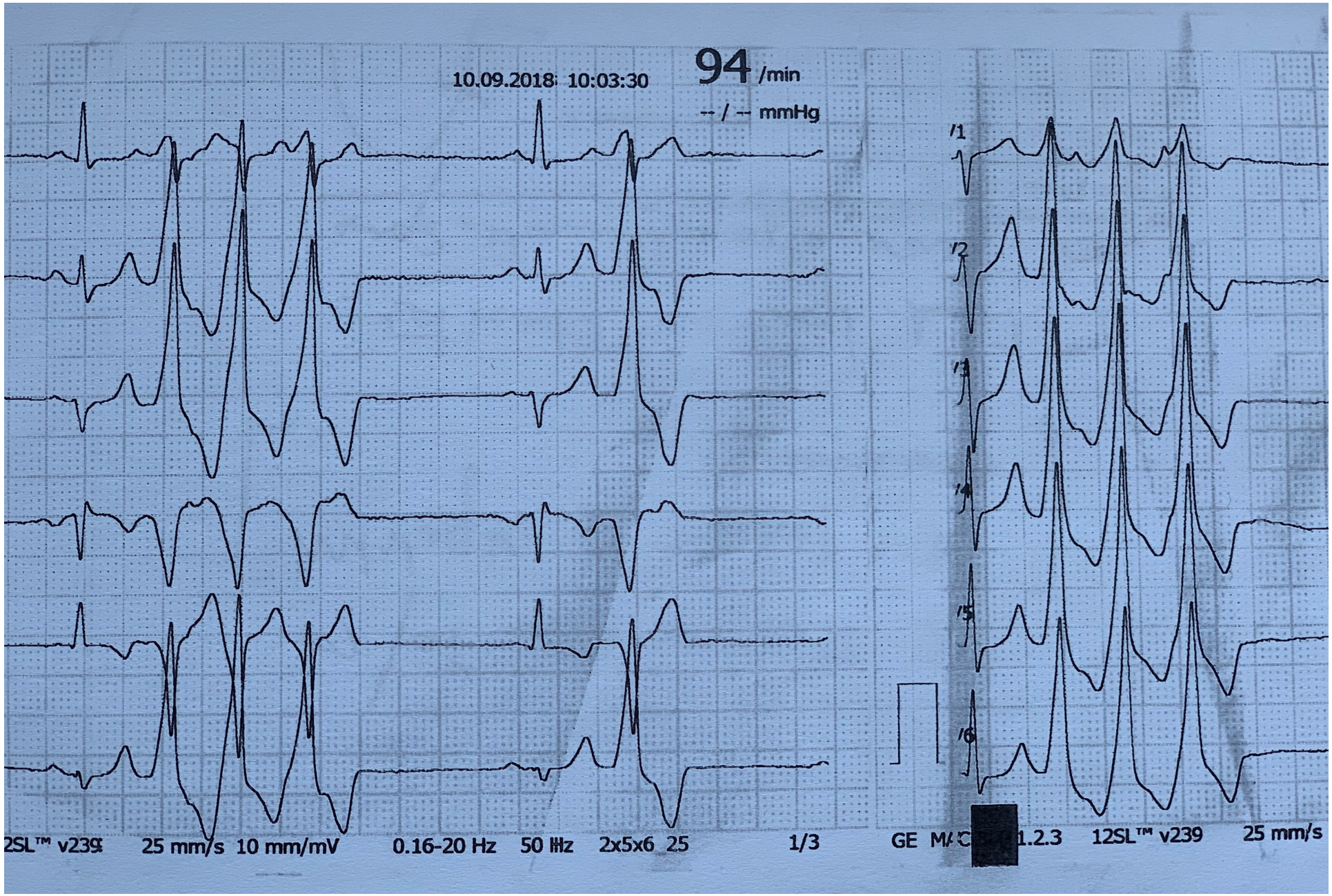
Extrasistolia ventricolare: le buone, le brutte e le cattive

Leonardo Calò

Università degli Studi di Roma «Foro Italico»
Cardiologia - Policlinico Casilino Roma

Case 7

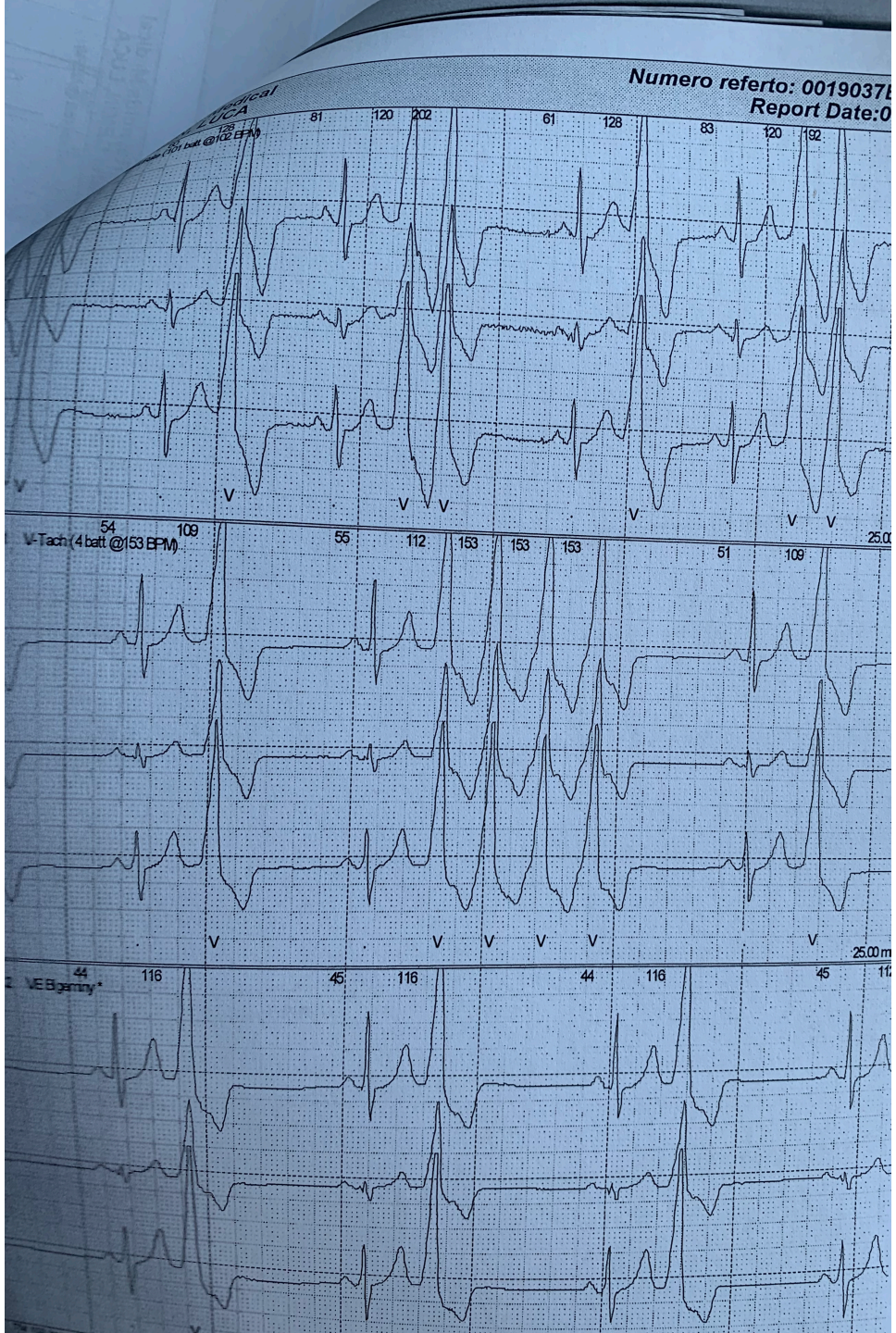

10.09.2018 10:03:30
94 /min
-- / -- mmHg
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
12SL™ v239
25 mm/s 10 mm/mV
0.16-20 Hz 50 Hz 2x5x6 25
1/3
GE M/C
1.2.3
12SL™ v239
25 mm/s

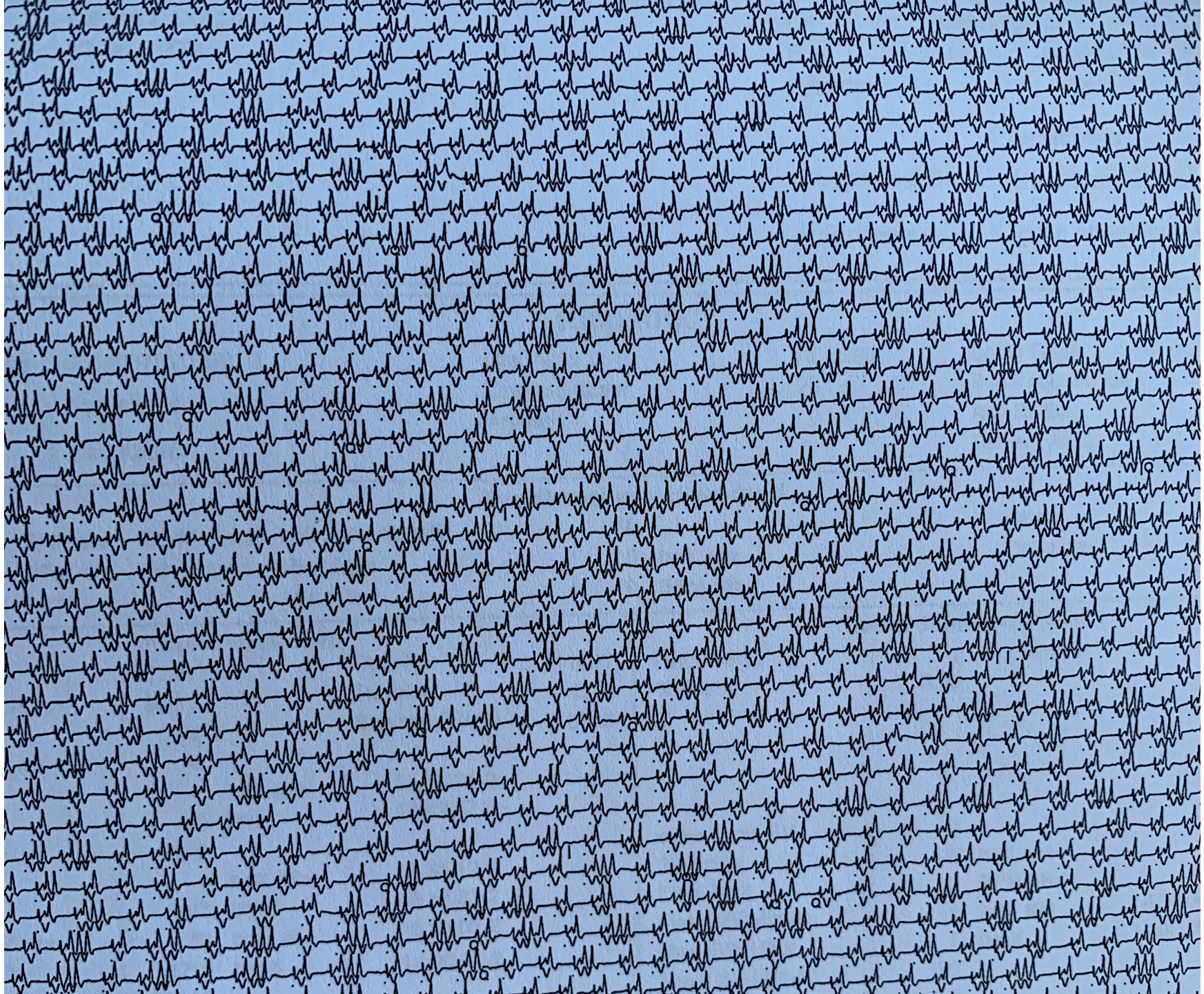
Eventi Ventricolari

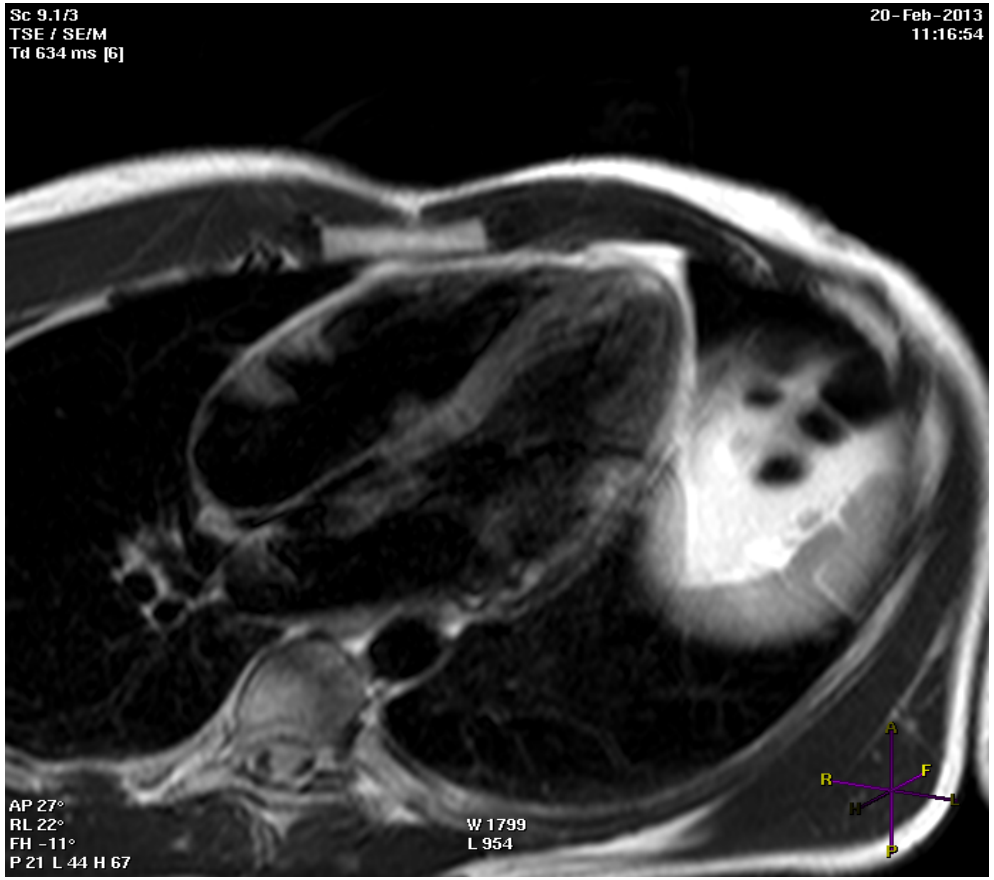
:	67724		Coppie	:	11002
:	58,31		Triplette	:	4370
:	243		Bigeminy Runs	:	5518
:	4				
:	4	batt. alle	15.29.25-2		
:	86	BPM	13.49.37-2		
:	4422				
:	4	batt. alle	18.35.12-1		
:	207	BPM	08.38.33-2		
:	63	batt. alle	15.23.00-2		
:	3210	beatt.	14.00.00-2		
:	2944,5				
:	583,1				

Eventi Sopreventricolari

Battiti Totali	:	1	Coppie	:	0	
% Beats	:	0,00				
salve Tachi SV	:	0				
Piu lunga	:	0	batt. alle			
Freq. Max	:	0	BPM alle			
Max SVE/Minute	:	1	batt. alle	14.56.00-2		
Max SVE/Hour	:	1	beatt.	14.00.00-2	-	
Mean SVE/Hour	:	0,0				
SVE/1000	:	0,0				


Numero referto: 0019037
Report Date:0
81 120 202
61 128
83 120 192
V-Tach (4 batt @153 BPM)
54 109
55 112 153 153 153
51 109
44 116
45 116
44 116
45





MRI absence of heart disease

EPS no inducibility of arrhythmias
No low voltage areas during electroanatomical mapping

II. Curable and Mild Monomorphic Ventricular Extrasystoles with Paroxysms of Tachycardia

This type is entirely different from the first and, since Gallavardin's original descriptions, its particular features, its benign course, and its curability have become well established. It is characterized by an almost permanent extrasystolic irregularity interspersed with paroxysms of tachycardia of brief duration; in severe forms these paroxysms tend to become longer and longer until they coalesce into prolonged attacks which are interrupted by sinus beats only at long intervals. This trouble specially affects young subjects with healthy hearts and, as a rule, it is very resistant to therapy, including quinidine.

The paroxysms are strictly monomorphic from an electrical point of view; the frequent isolated extrasystoles have the same contour as the beats that constitute the paroxysms. It is a rare functional disorder which may cause vertigo with alternating pallor and flushing of the face such as is seen in Stokes-Adams syndrome; more rarely faintness occurs at the onset, and still more rarely, episodes of transient heart failure occur when the attacks are unusually prolonged (Gallavardin). Yet the essentially benign character of these paroxysms is proved by their persistence over long periods, for example two of our cases were followed over periods of 35 and 24 years: in both the disorder proved perfectly benign and in both it was completely cured in spite of its initial severity.

Case 1. A woman was regularly observed from 33 to 64 years of age (1920–51) with ventricular extrasystoles and paroxysms of tachycardia: these were intense for the first 20 years, but gradually improved and almost completely disappeared during the last 15 or 20 years.

This case was originally published by Louis Gallavardin; further information was supplied by Froment (1932) and by Léon Gallavardin (1946). The patient was re-examined in 1951 when she was perfectly well and completely free from her trouble.

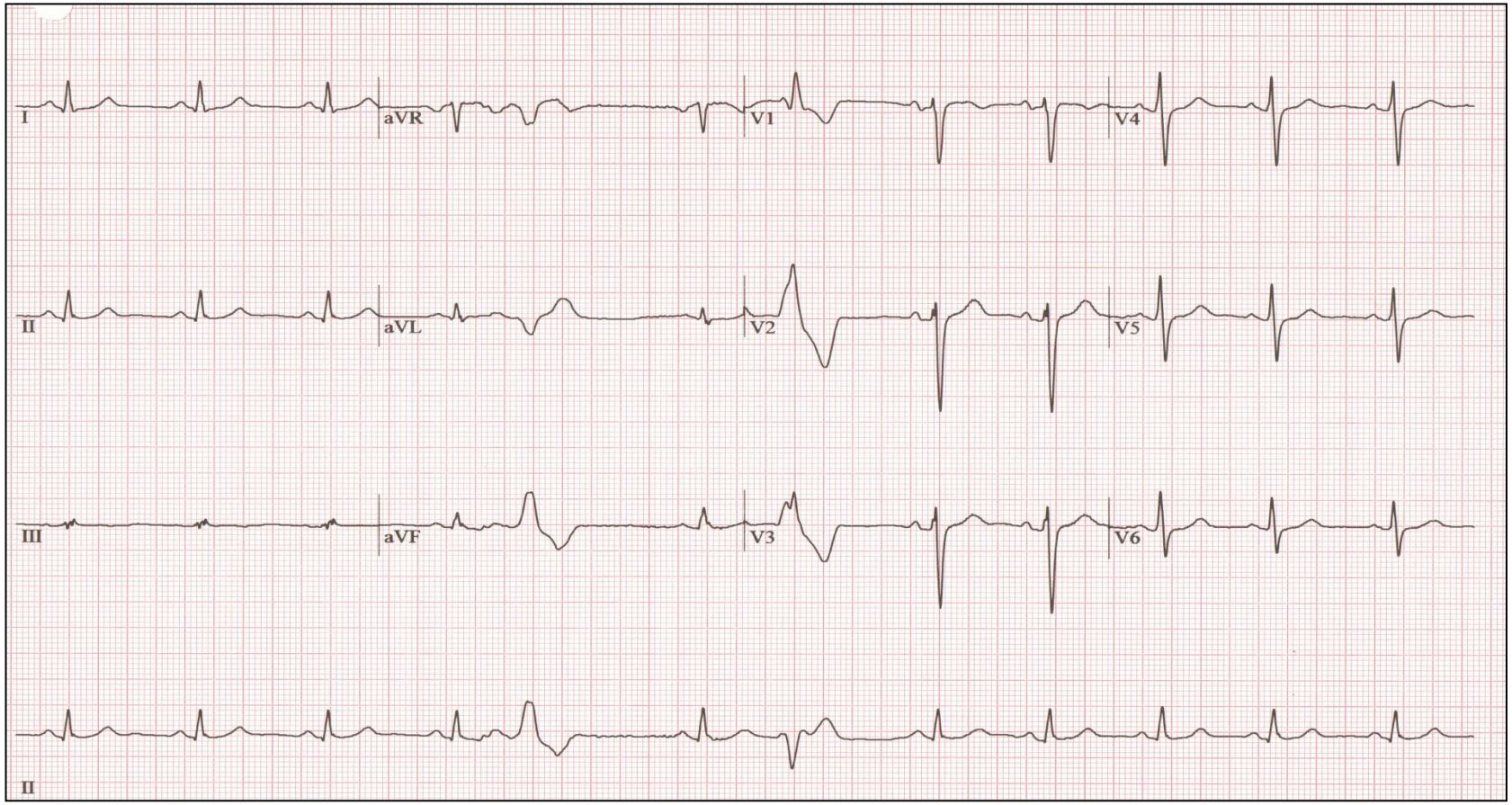
From 1915 to 1932 the rhythm disorder was very persistent with innumerable ventricular extrasystoles. During bad periods there were prolonged paroxysms of tachycardia lasting 5 to 30 days, with asystolic manifestations; they were of such intensity that the severe ascites wrongly led to a diagnosis of tuberculous peritonitis, and in our absence the patient was submitted to operation.

After 1932 the trouble diminished, the paroxysms became shorter and shorter, not exceeding ten seconds, and much less frequent. Since that time she has been working hard as a midwife in a hospital and in 1946 she only presented infrequent extrasystoles with occasional paroxysms. At present she is in excellent health and leads an active life for a 64-year-old woman.

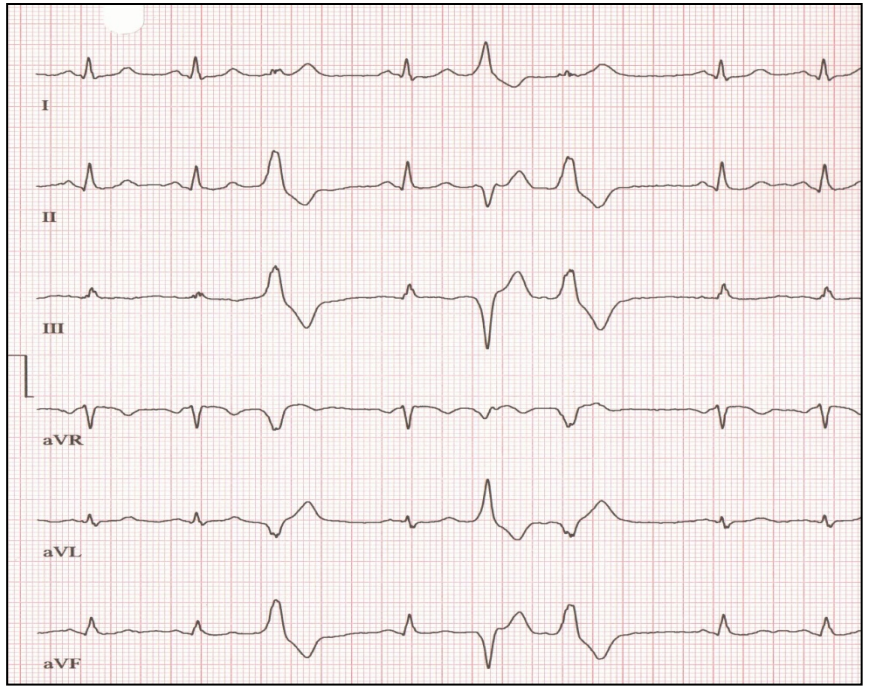
The cardiovascular examination between attacks showed nothing abnormal; in 1946 her blood pressure was 130/80 mm., the size of the heart was normal, and so was the electrocardiogram except for infrequent ventricular extrasystoles similar to the more numerous ones presented before. In 1951, there was no longer any disturbance of rhythm or any sign of heart failure.

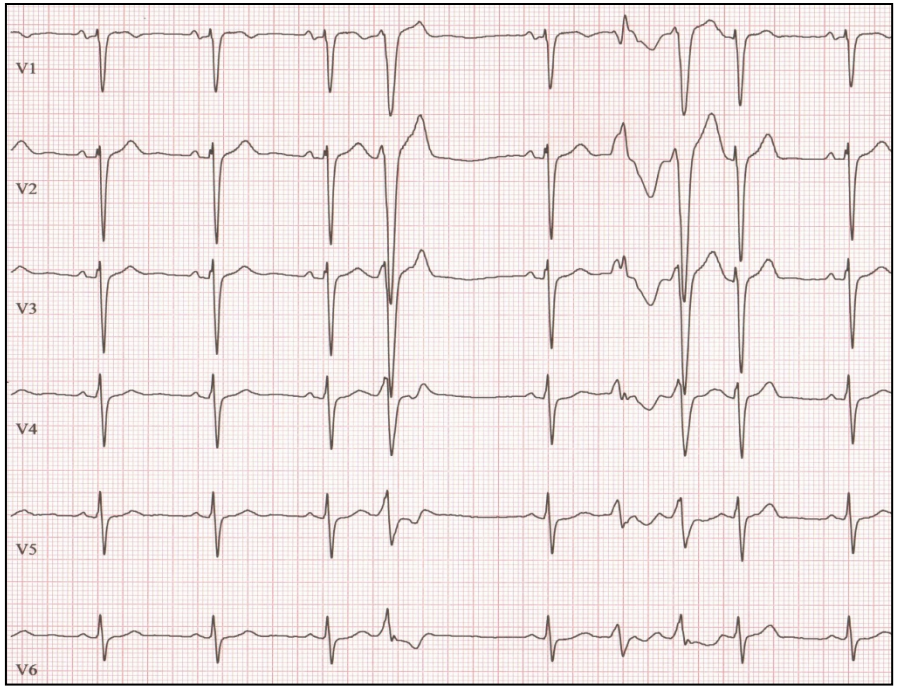
Case 9

Athlete 45 y.o. male caucasian with 15000 polymorphic PVC, isolated, 228 couplets, 15 NSVT 4 beats

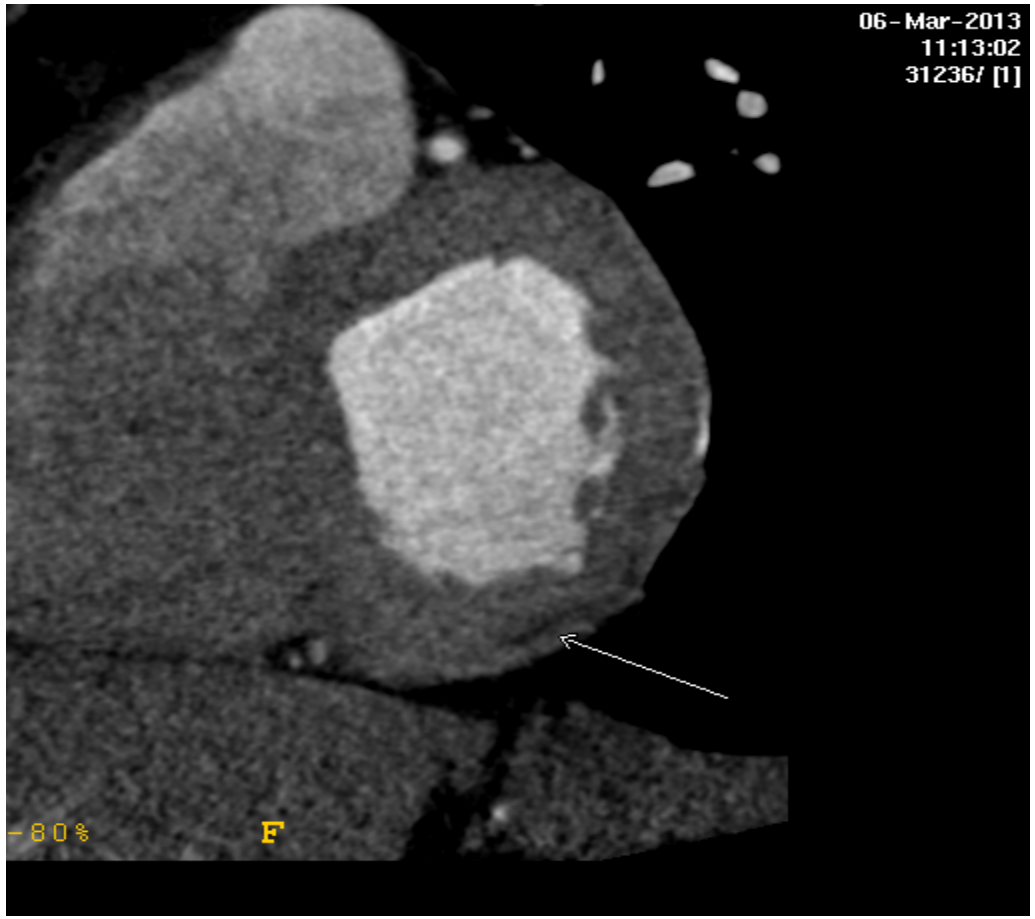


Athlete 45 y.o. male caucasian with 15000 polymorphic PVC, isolated, 228 couplets, 15 NSVT 4 beats





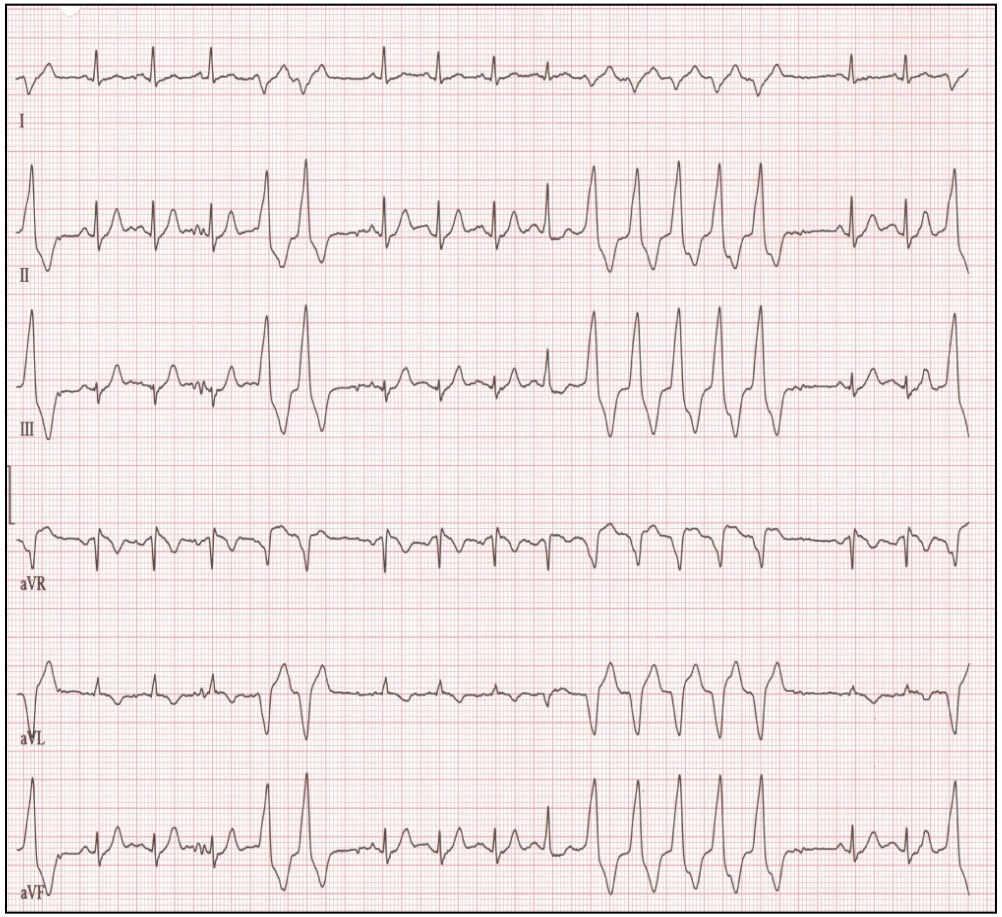
Athlete 45 y.o. male caucasian with 15000 polymorphic PVC, isolated, 228 couplets, 15 NSVT 4 beats

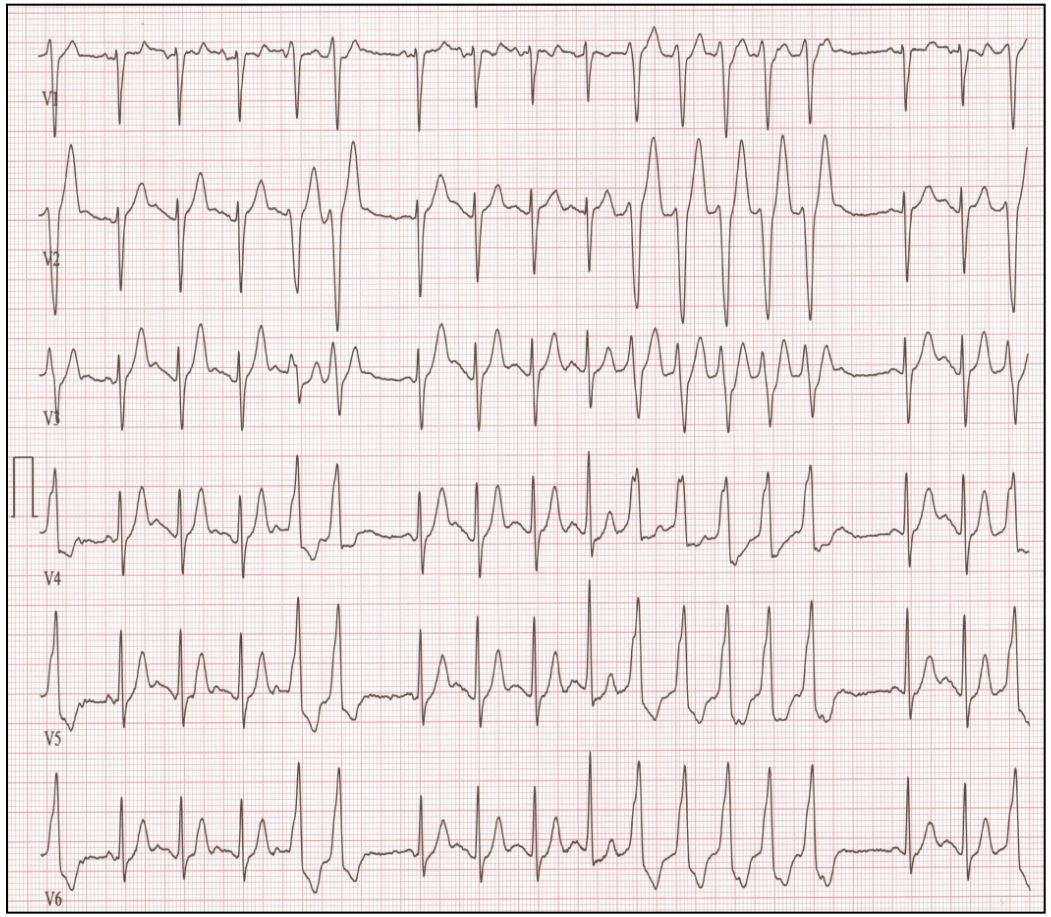


MRI late enhancement inferior basal wall

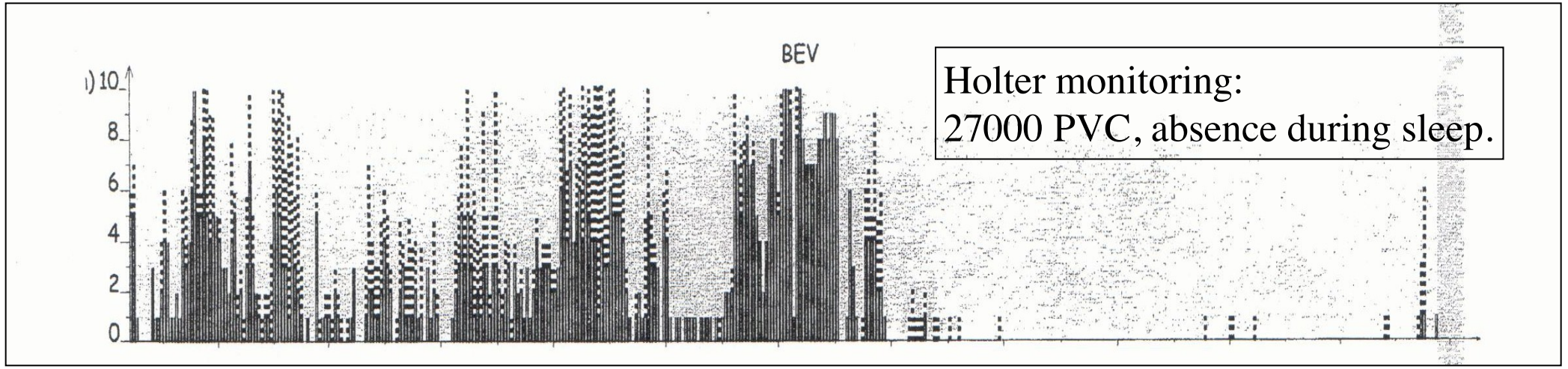
Case 2

Athlete 34 y.o. male caucasian with repetitive monomorphic NSVT
No family history of heart disease
Symptomatic for palpitations, no syncope



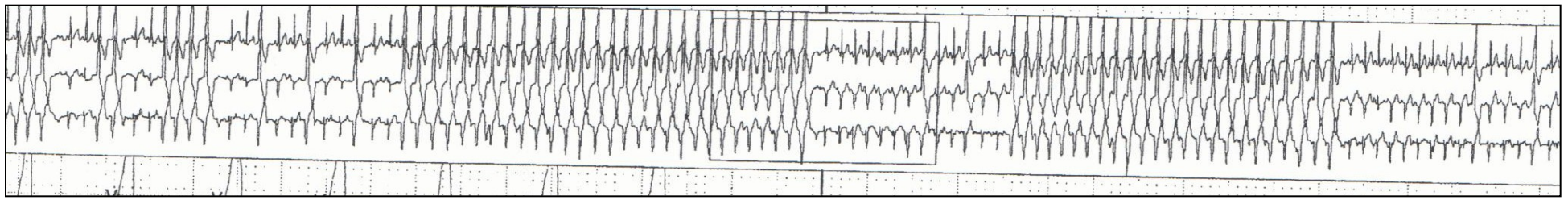


Athlete 34 y.o. male caucasian with repetitive monomorphic NSVT (GALLAVARDIN)
MRI: absence of cardiomyopathy

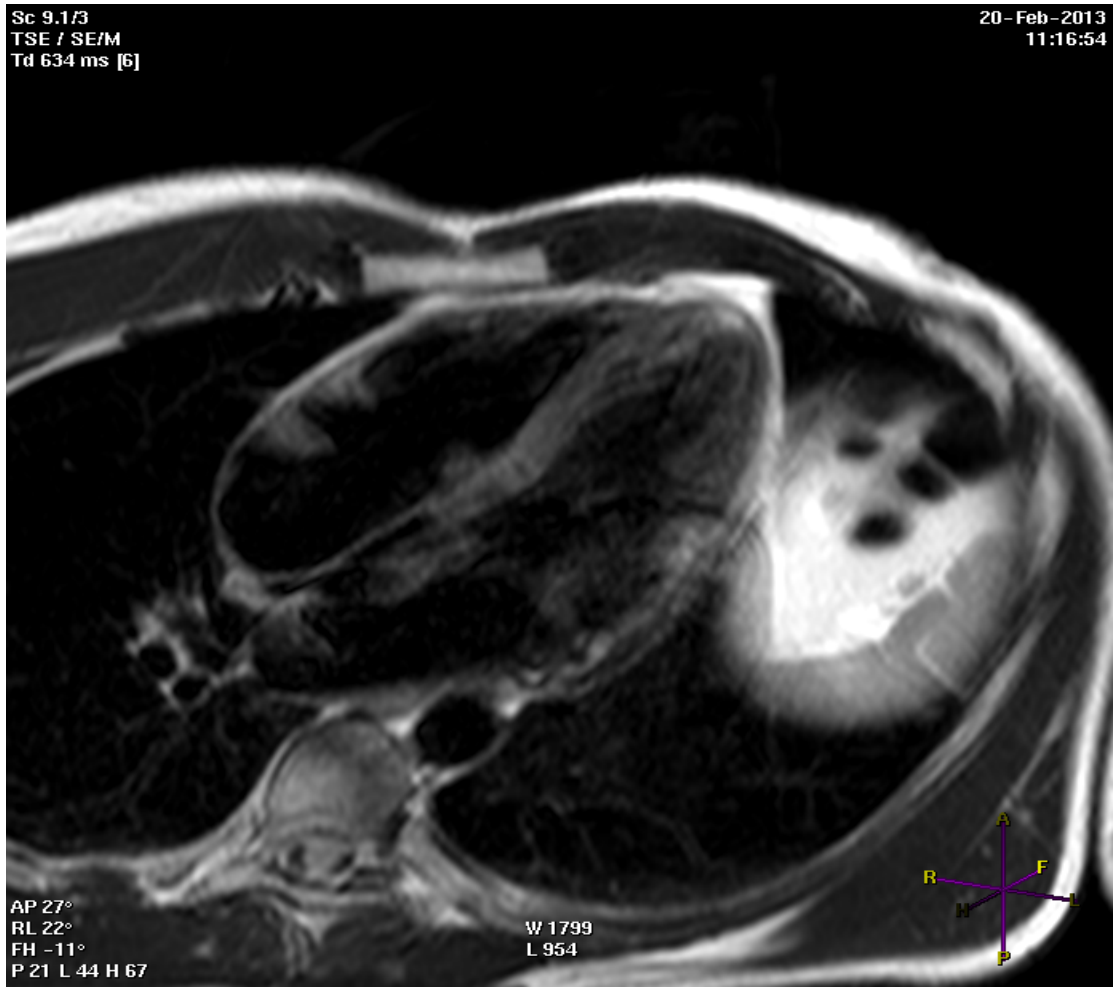


Holter monitoring:
27000 PVC, absence during sleep.

NSVT during Holter monitoring.



Electrophysiological study:
mapping of right ventricular outflow tract (RVOT),
inducibility of arrhythmias, RF ablation



MRI absence of heart disease

EPS no inducibility of arrhythmias
No low voltage areas during electroanatomical mapping

Case 8

- 32 yo male soccer player
- Symptomatic for palpitation during effort
- Negative medical/familiar history
- Normal ECG and echocardiogram findings

ECG Holter monitoring

Report Finale

Totale QRS: **103861** Durata Registrazione: **24 ore, 0 min** Dati analizzati: **24 ore, 0 min**

Report Freq. Card.:

F.C. Min.: **39** **alle 05:50:47**
F.C. Max.: **199** **alle 17:43:42**
F.C. Media: **73**

Episodi di tachicardia/bradicardia:

Tachicardia più lunga: **0:22:30, 168 BPM Med** alle 17:38:40
Tachicardia più veloce: **0:22:30, 168 BPM Med** alle 17:38:40
Bradicardia più lunga:
Bradicardia più lenta:

Battiti Sopraventricolari:

Singoli: **0**
Coppie: **0**
Runs: **0**

Totale: **0**

Battiti Ventricolari:

Singoli: **3861**
Coppie: **67**
Runs: **13**
Run più veloce: **277 BPM alle 23:11:17**
Run più lunga: **8 alle 23:07:50**
Totale: **4058**

Variabilità RR:

%RR>50: **21%**
rms-SD: **87 ms**
Magid SD: **102 ms**
Kleiger SD: **211 ms**

Variazione ST:

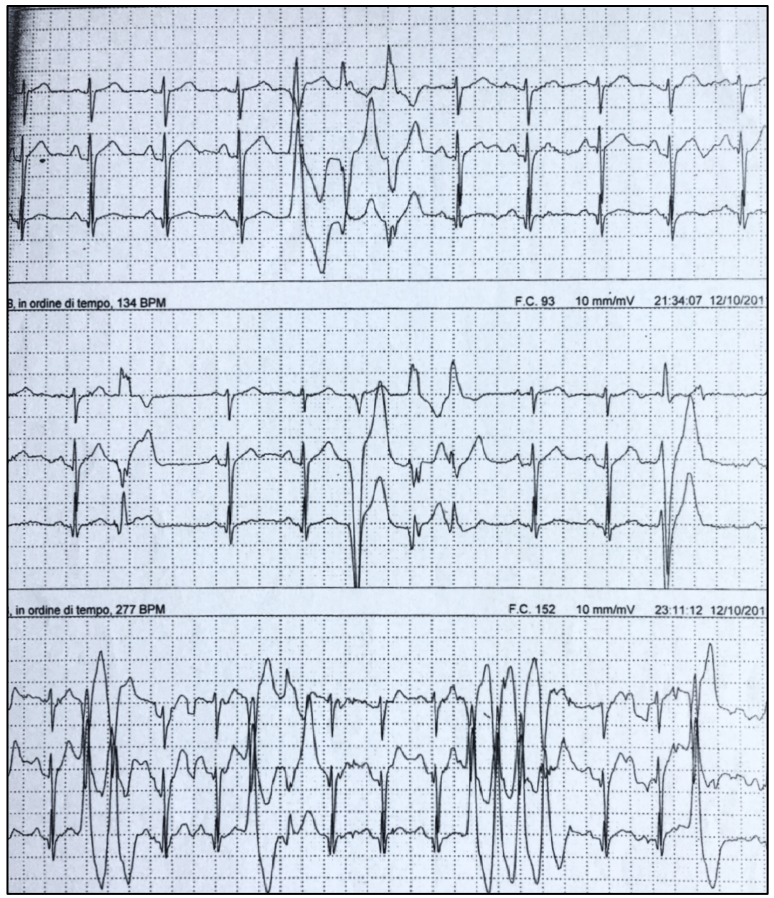
	II/Ore:	V/Ore:
Max Sottosliv. (µV):	/	-75 / 18:37:00
Max Sopraliv. (µV):	1025 / 17:42:00	250 / 17:42:00

Pause:

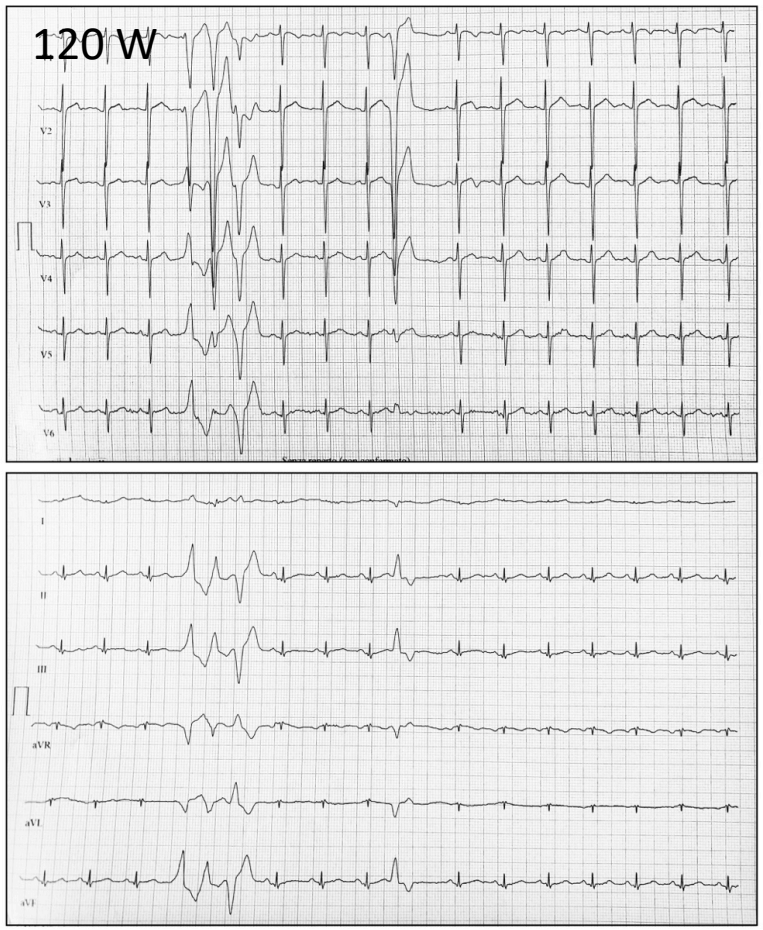
RR più lungo: **1,88 sec** **alle 06:43:34** # RRs > 2,0 sec: **0**

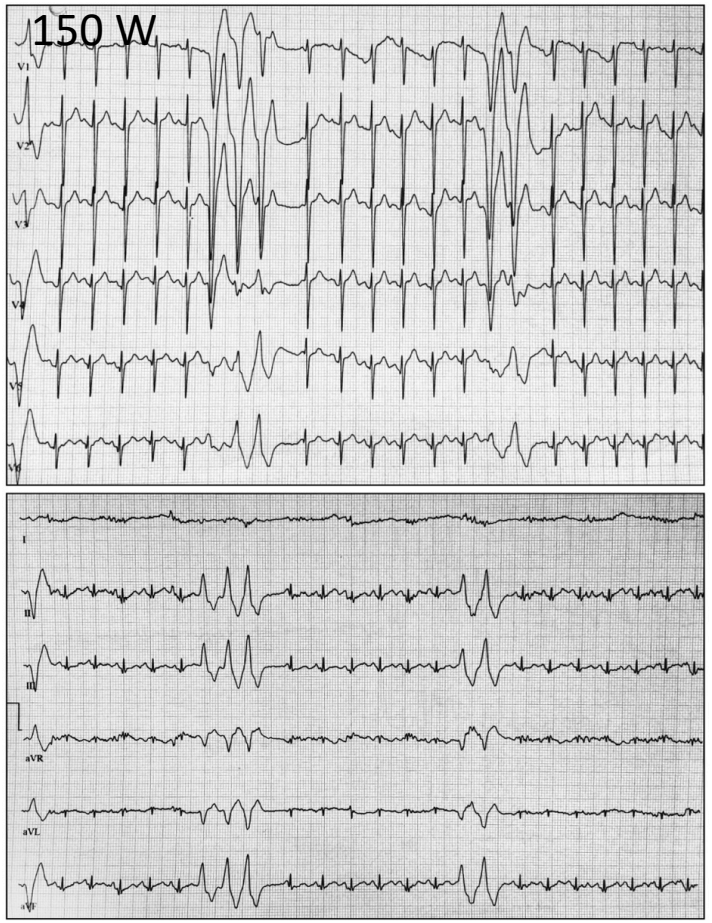
Commento:

Ritmo sinusale con frequenza media di 73 b/m.
Numerose extrasistoli ventricolari isolate.
Durante sforzo fisico comparsa di coppie , triplette e brevi salve di TV.
Assenza di anomalie del tratto ST-T

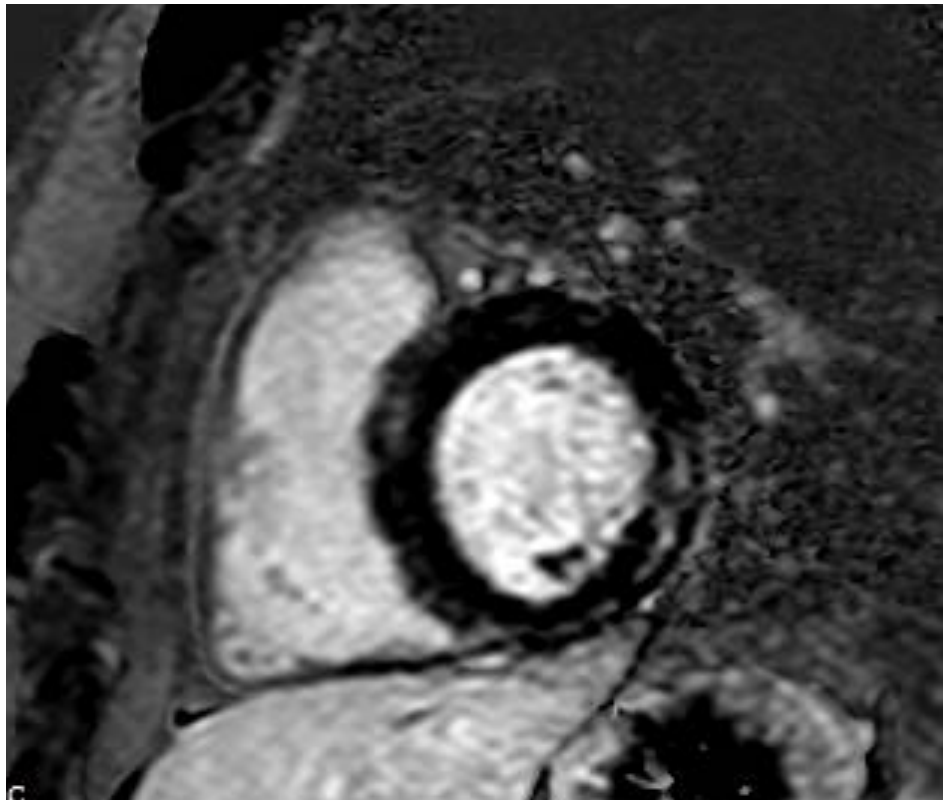


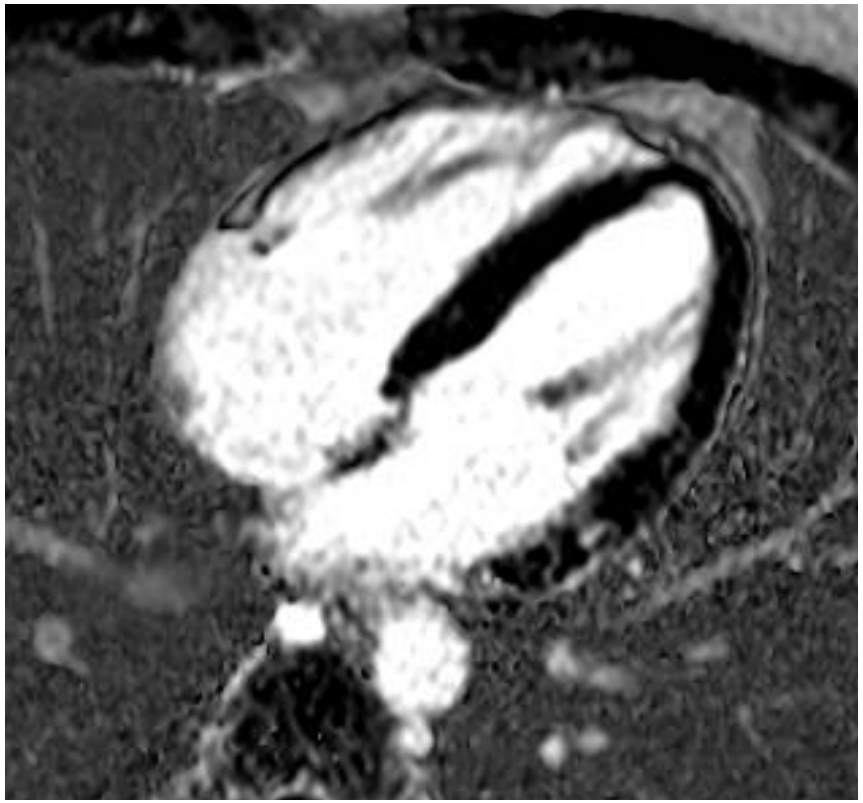
Exercise test





Cardiac Magnetic Resonance

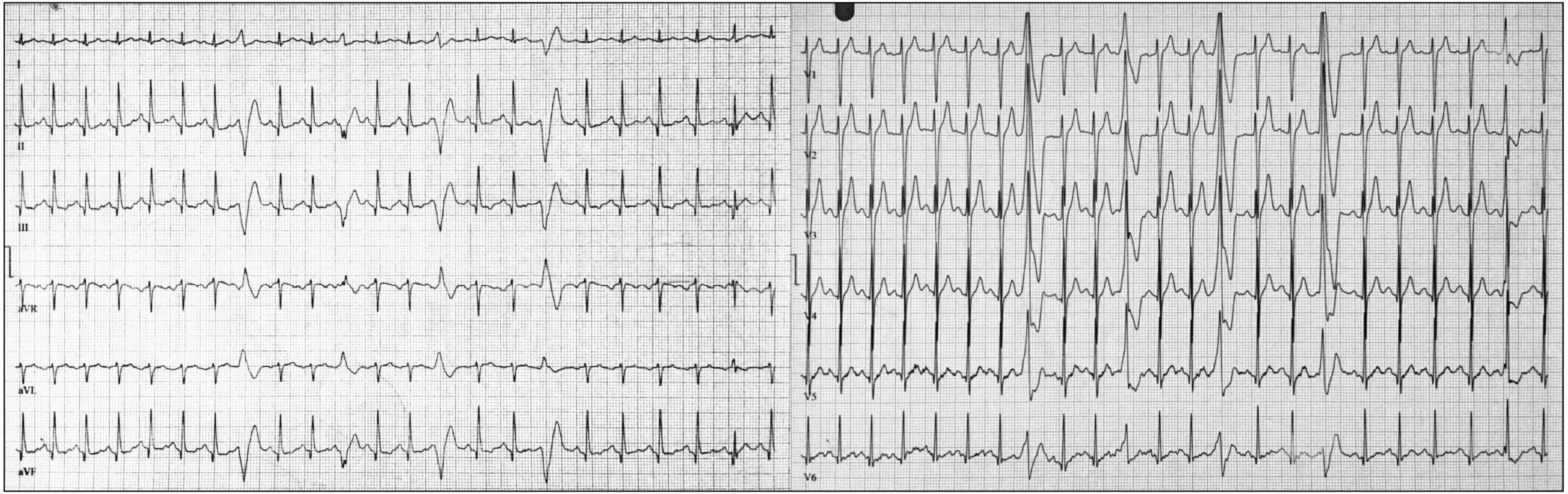




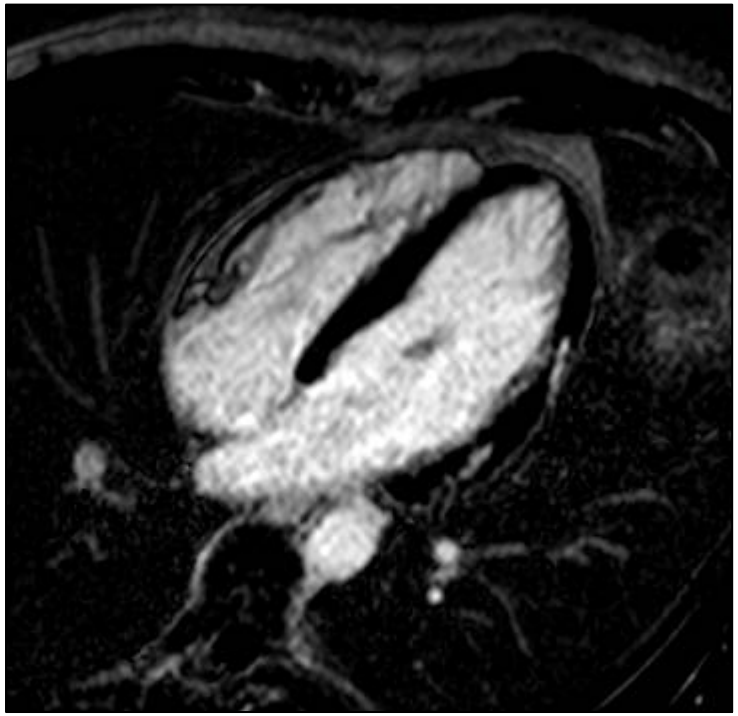
Case 5

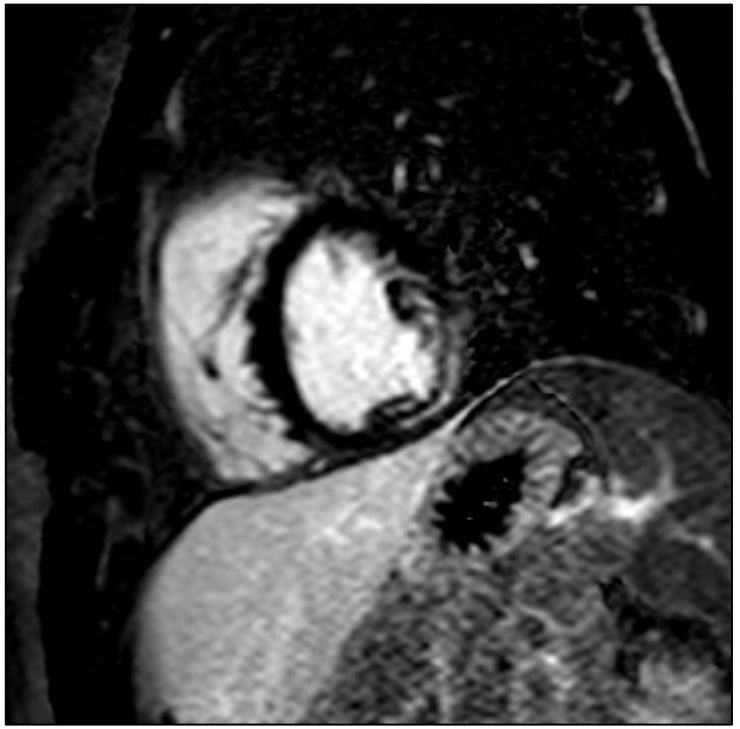
- 27 yo male;
- History of paroxysmal atrial fibrillation (1 episode)
- Symptomless
- Normal echocardiogram findings
- ECG Holter monitoring: 119 PVBs

Exercise test



Cardiac Magnetic Resonance





Journal of the American Heart Association

ORIGINAL RESEARCH

Predictors of Left Ventricular Scar Using Cardiac Magnetic Resonance in Athletes With Apparently Idiopathic Ventricular Arrhythmias

Cinzia Crescenzi, MD*; Alessandro Zorzi, MD, PhD*; Teresina Vessella, MD; Annamaria Martino, MD, PhD; Germana Panattoni, MD, PhD; Alberto Cipriani, MD; Manuel De Lazzari, MD, PhD; Martina Perazzolo Marra, MD, PhD; Armando Fusco, MD; Luigi Sciarra, MD; Fabio Sperandii, MD; Emanuele Guerra, MD; Eliana Tranchita, MD; Chiara Fossati, MD; Fabio Pigozzi, MD, PhD; Patrizio Sarto, MD; Leonardo Calò, MD, FESC†; Domenico Corrado, MD, PhD†

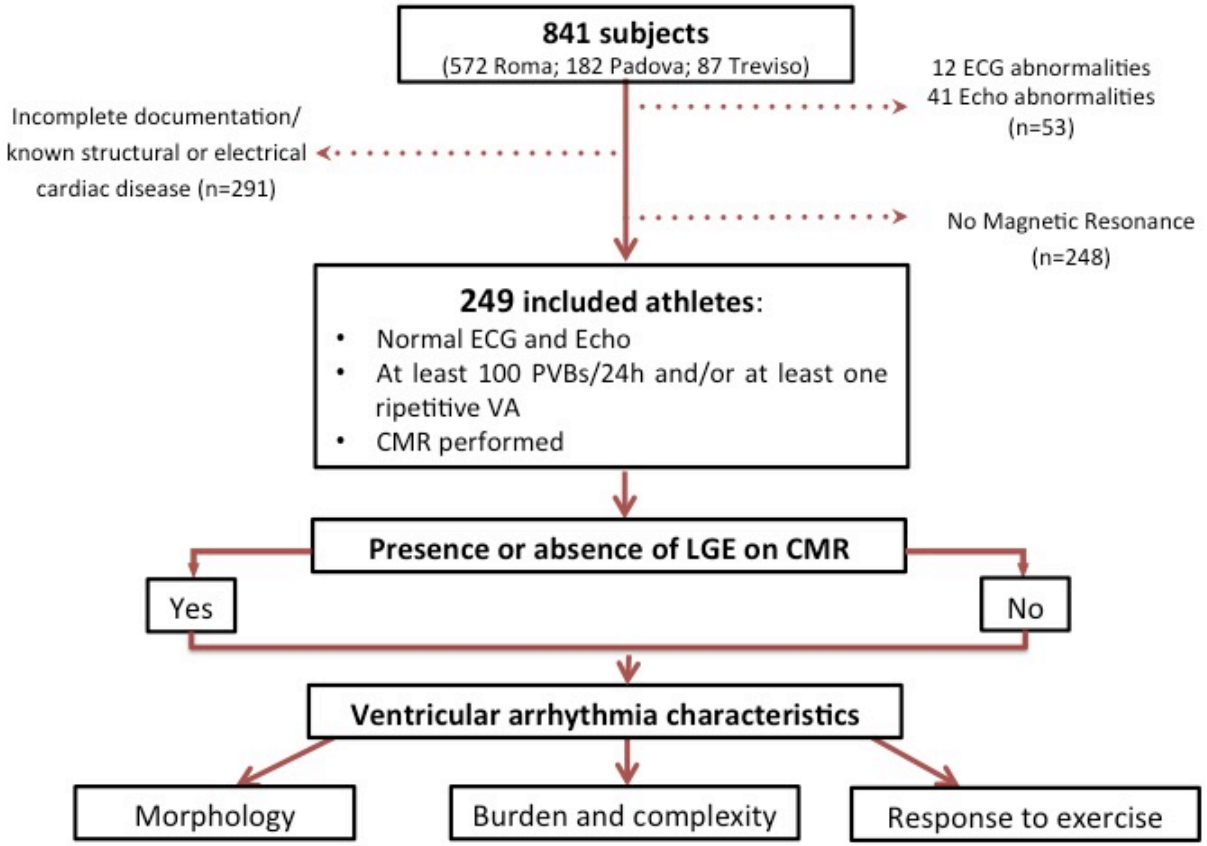
BACKGROUND: In athletes with ventricular arrhythmias (VA) and otherwise unremarkable clinical findings, cardiac magnetic resonance (CMR) may reveal concealed pathological substrates. The aim of this multicenter study was to evaluate which VA characteristics predicted CMR abnormalities.

METHODS AND RESULTS: We enrolled 251 consecutive competitive athletes (74% males, median age 25 [17-39] years) who underwent CMR for evaluation of VA. We included athletes with >100 premature ventricular beats/24 h or ≥1 repetitive VA (couplets, triplets, or nonsustained ventricular tachycardia) on 12-lead 24-hour ambulatory ECG monitoring and negative family history, ECG, and echocardiogram. Features of VA that were evaluated included number, morphology, repetitivity, and response to exercise testing. Left-ventricular late gadolinium-enhancement was documented by CMR in 28 (11%) athletes, mostly (n=25) with a subepicardial/midmyocardial stria pattern. On 24-hour ECG monitoring, premature ventricular beats with multiple morphologies or with right-bundle-branch-block and intermediate/superior axis configuration were documented in 25 (89%) athletes with versus 58 (26%) without late gadolinium-enhancement ($P<0.001$). More than 3300 premature ventricular beats were recorded in 4 (14%) athletes with versus 117 (53%) without positive CMR ($P<0.001$). At exercise testing, nonsustained ventricular tachycardia occurred at peak of exercise in 8 (29%) athletes with late gadolinium-enhancement (polymorphic in 6/8, 75%) versus 17 athletes (8%) without late gadolinium-enhancement ($P=0.002$), ($P<0.0001$). At multivariable analysis, all 3 parameters independently correlated with CMR abnormalities.

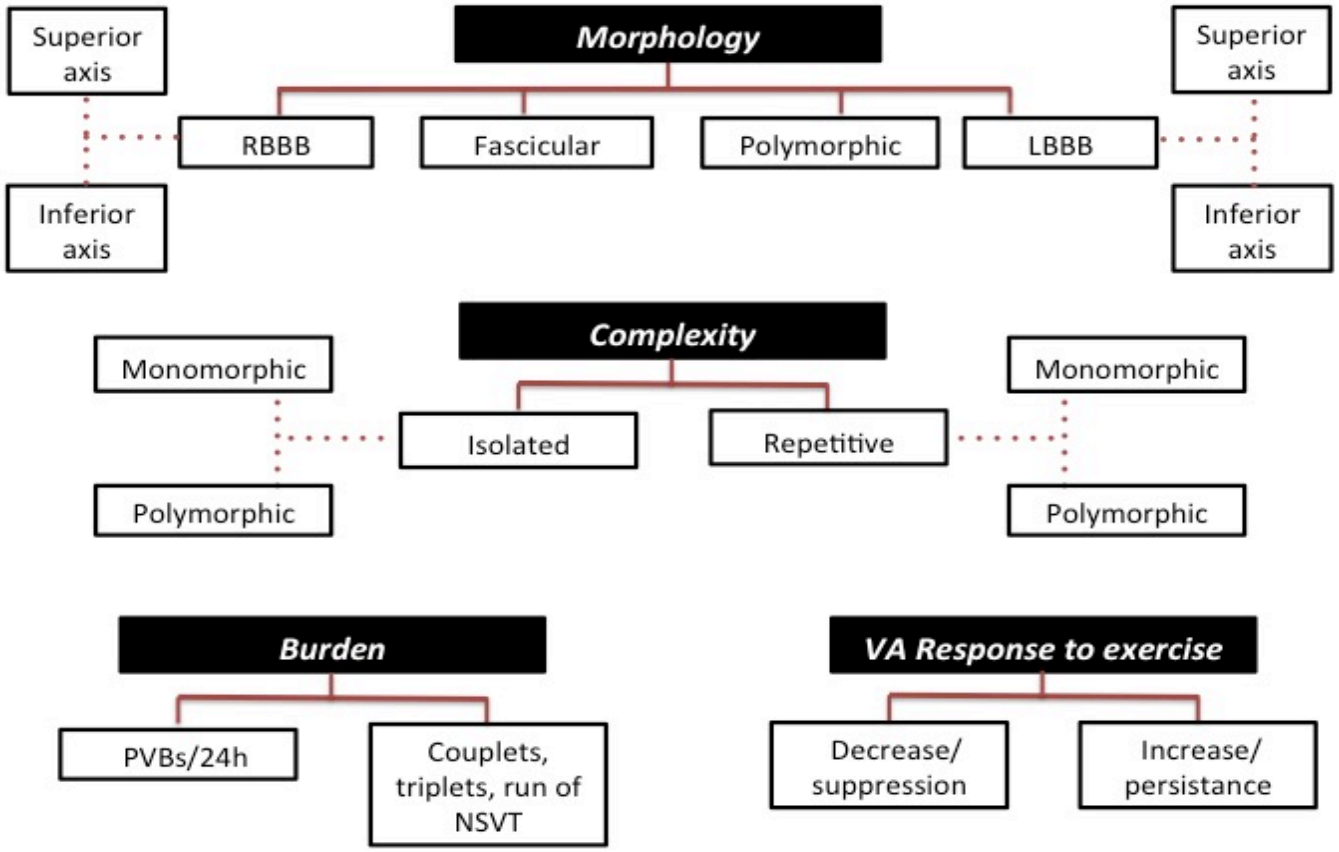
CONCLUSIONS: In athletes with apparently idiopathic VA, simple characteristics such as number and morphology of premature ventricular beats on 12-lead 24-hour ambulatory ECG monitoring and response to exercise testing predicted the presence of concealed myocardial abnormalities on CMR. These findings may help cost-effective CMR prescription.

J Am Heart Assoc. 2021;10:e018206. DOI: 10.1161/JAHA.120.018206

Methods (1)


841 subjects
(572 Roma; 182 Padova; 87 Treviso)
12 ECG abnormalities
41 Echo abnormalities
(n=53)
Incomplete documentation/
known structural or electrical
cardiac disease (n=291)
No Magnetic Resonance
(n=248)
249 included athletes:
Normal ECG and Echo
At least 100 PVBs/24h and/or at least one ripetitive VA
CMR performed
Presence or absence of LGE on CMR
Yes
No
Ventricular arrhythmia characteristics
Morphology
Burden and complexity
Response to exercise

Methods (1)


Morphology
Superior axis
Inferior axis
RBBB
Fascicular
Polymorphic
LBBB
Superior axis
Inferior axis
Complexity
Monomorphic
Polymorphic
Isolated
Repetitive
Monomorphic
Polymorphic
Burden
PVBs/24h
Couplets, triplets, run of NSVT
VA Response to exercise
Decrease/ suppression
Increase/ persistance

Morphology

Variable	Tot n = 249	LGE + n =28	LGE - n = 221	P value
Ventricular arrhythmia morphology				
Monomorphic, n (%)	199 (79.9)	9 (32.1)	190 (86.0)	<0.0001
- RBBB with superior axis, n (%)	37 (14.9)	5 (17.9)	32 (14.5)	0.7
- RBBB with inferior axis, n (%)	28 (11.2)	2 (7.1)	26 (11.8)	0.5
- LBBB with superior axis, n (%)	38 (15.3)	2 (7.1)	36 (16.3)	0.3
- LBBB with inferior axis, n (%)	87 (34.9)	0	87 (39.4)	<0.0001
- Fascicolar, n (%)	9 (3.6)	0	9 (4.1)	0.3
Polymorphic, n (%)	50 (20.1)	19 (67.9)	31 (14.0)	<0.0001

Burden and complexity

Variabile	Tot n = 249	LGE + n =28	LGE - n = 221	P value
Ventricular arrhythmia complexity				
Repetitive, n (%)	178 (71.5)	27 (96.4)	151 (68.3)	0.002
- monomorphic, n (%)	132 (53.0)	9 (32.1)	123 (55.7)	0.02
- polymorphic, n (%)	46 (18.5)	18 (64.3)	28 (12.7)	<0.0001
Isolated, n (%)	71 (28.5)	1 (3.6)	70 (31.7)	0.001
-monomorphic, n (%)	67 (26.9)	0	67 (30.3)	0.0001
-polymorphic, n (%)	4 (1.6)	1 (3.6)	3 (1.4)	0.4
Burden				
PVBs, n	2625 (299-10583)	662 (69-4083)	3858 (372-12140)	<0.0001
n=number of patient;				

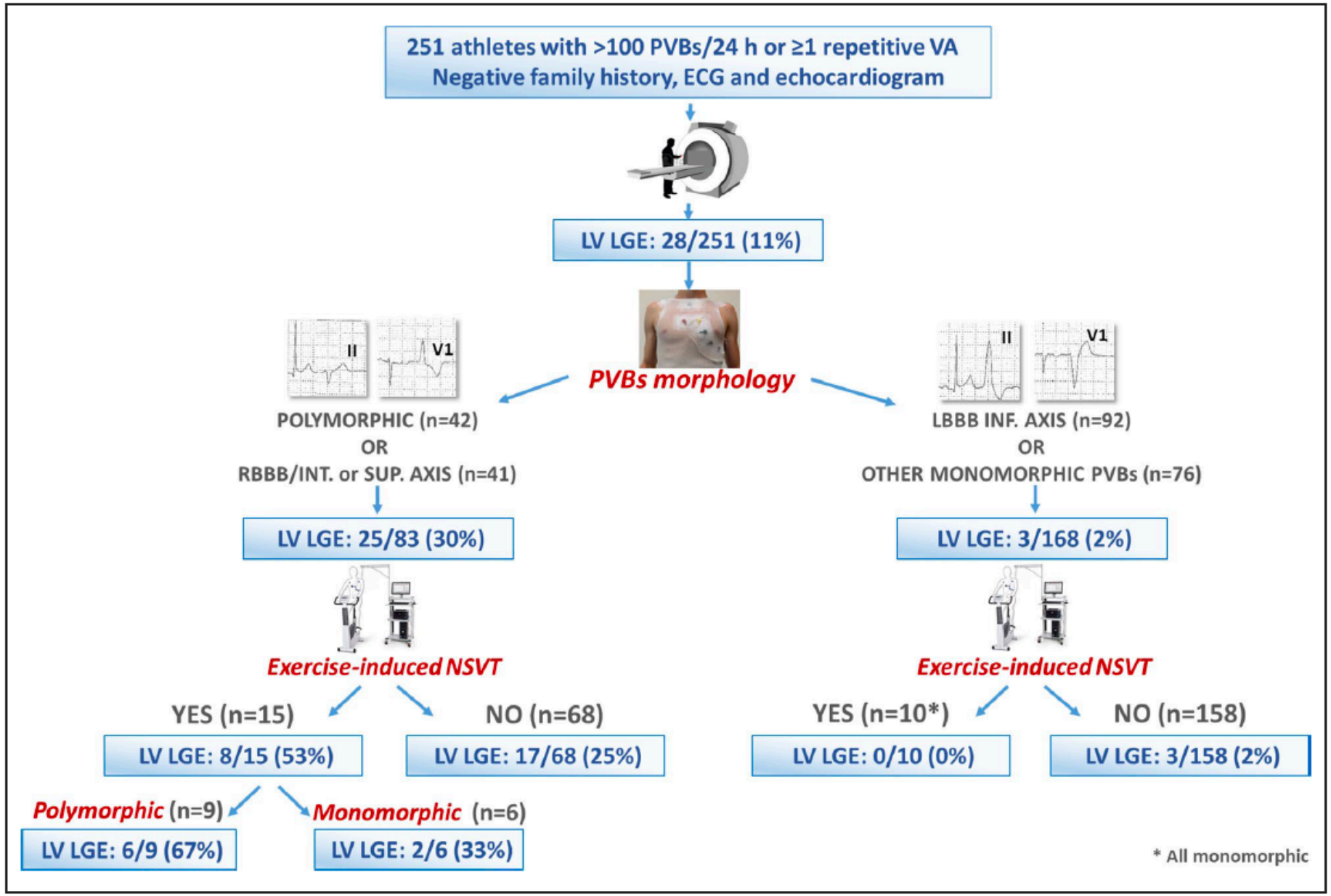
Response to exercise

Variable	Overall n = 249	LGE + n =28	LGE - n = 221	P value
Response to exercise testing				
Decrease/Suppression, n (%)	187 (75.1)	13 (46.4)	174 (78.7)	0.0002
Increase/Persistence, n (%)	62 (24.9)	15 (53.6)	47 (21.3)	0.0002
- isolated, n (%)	22 (8.8)	3 (10.7)	19 (8.6)	0.7
- repetitive, n (%)	40 (16.1)	12 (42.9)	28 (12.7)	<0.0001
- repetitive and polymorphic, n (%)	15 (6.0)	8 (28.6)	7 (3.2)	<0.0001

- Ventricular arrhythmias ***decreased and/or suppressed*** by exercise are more common in athletes ***without LGE;***
- ***Exercise-induced*** ventricular arrhythmias are more common in athletes ***with LGE;***
- Athletes ***with LGE*** show more frequently ***repetitive and polymorphic ventricular arrhythmias exercise-induced***.

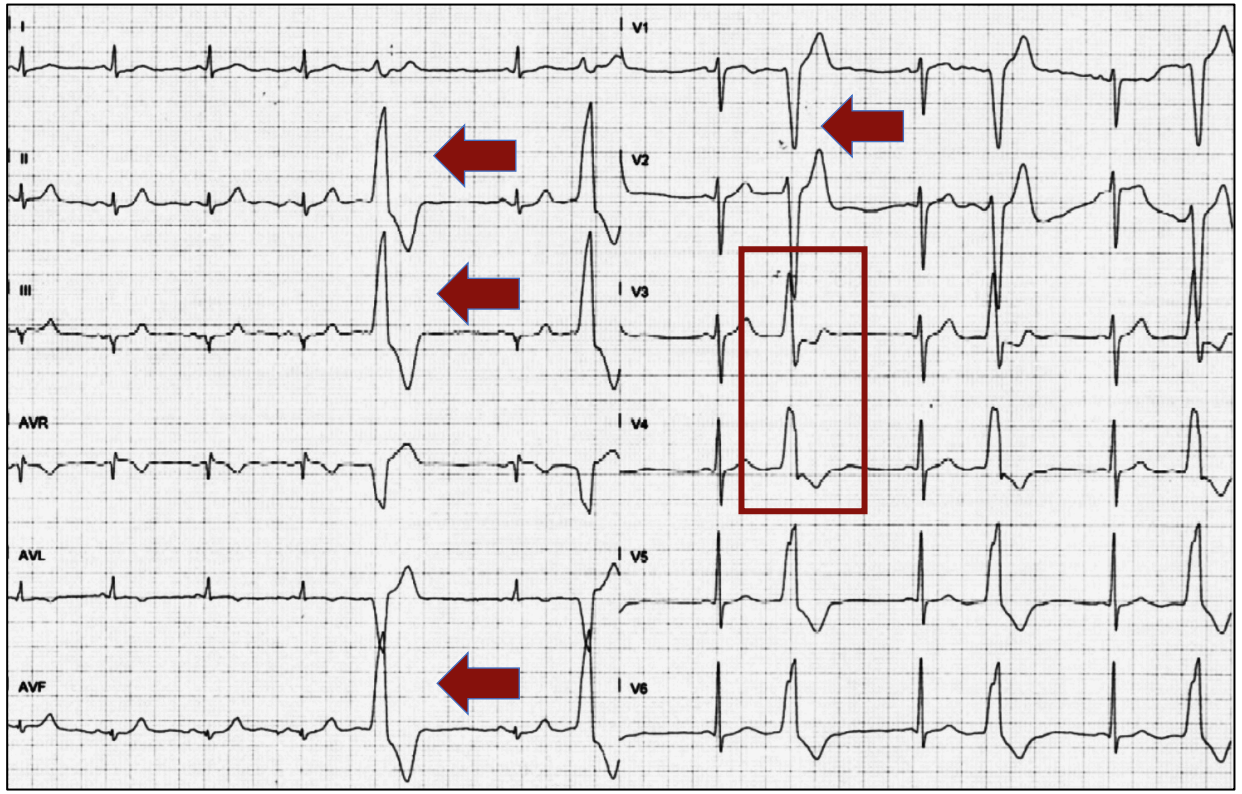
Univariable and multivariable analysis

Univariable and multivariable analysis for prediction of LGE		
Variable	**Univariable analysis OR (95% CI)**	**Multivariable analysis OR (95% CI)**
Morphology		
Polymorphic, n (%)	12.3 (5.3-31.1), p < 0.0001	8.1 (3.1-20.5), **p < 0.0001**
Burden and complexity		
PVBs/24 die < 2000, n (%)	4.8 (1.9-12.4), p = 0.001	4.4 (1.5-12.5), **p = 0.005**
Repetitive VA	12.5 (1.6-93.9), p=0.014	6.1 (0.7-50.4), p=0.091
Response to exercise testing		
Repetitive, exercise-induced VA, n (%)	5.1 (2.2-12.0), p<0.0001	2.7 (1.0-7.4), **p=0.047**
Repetitive, exercise induced monomorphic VA, n (%)	1.5 (0.5-5.0), p =0.431	
Repetitive, exercise induced polymorphic VA, n (%)	12.2 (4.0-37.2), p < 0.0001	


251 athletes with >100 PVBs/24 h or ≥1 repetitive VA
Negative family history, ECG and echocardiogram
LV LGE: 28/251 (11%)
II
V1
PVBs morphology
II
V1
POLYMORPHIC (n=42)
OR
RBBB/INT. or SUP. AXIS (n=41)
LBBB INF. AXIS (n=92)
OR
OTHER MONOMORPHIC PVBs (n=76)
LV LGE: 25/83 (30%)
LV LGE: 3/168 (2%)
Exercise-induced NSVT
Exercise-induced NSVT
YES (n=15)
NO (n=68)
YES (n=10*)
NO (n=158)
LV LGE: 8/15 (53%)
LV LGE: 17/68 (25%)
LV LGE: 0/10 (0%)
LV LGE: 3/158 (2%)
Polymorphic (n=9)
Monomorphic (n=6)
LV LGE: 6/9 (67%)
LV LGE: 2/6 (33%)
* All monomorphic

Evaluation of morphology /site of origin of ventricular arrhythmias

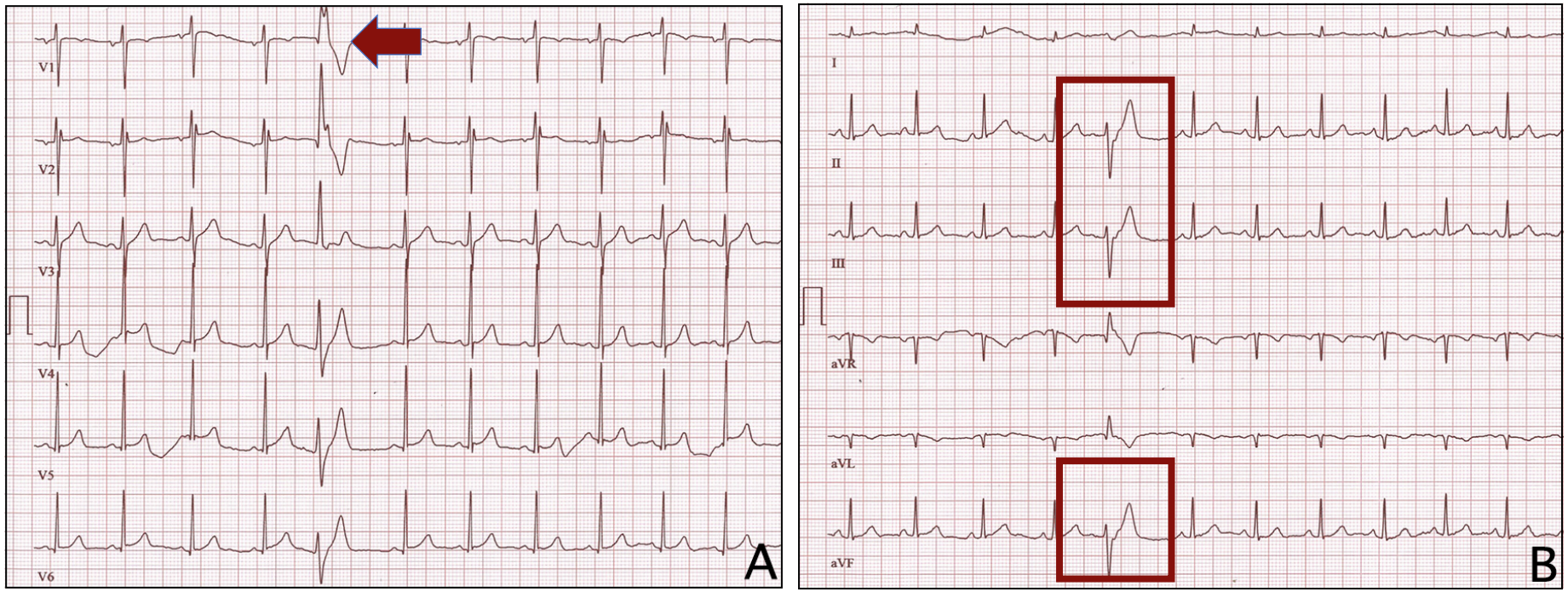
Background



The most common form of idiopathic PVBs shows an ECG pattern of the ***left bundle branch*** block (LBBB) with inferior QRS axis (also referred to as an '***infundibular***' pattern).

Results

PVBs with RBBB and superior axis morphology

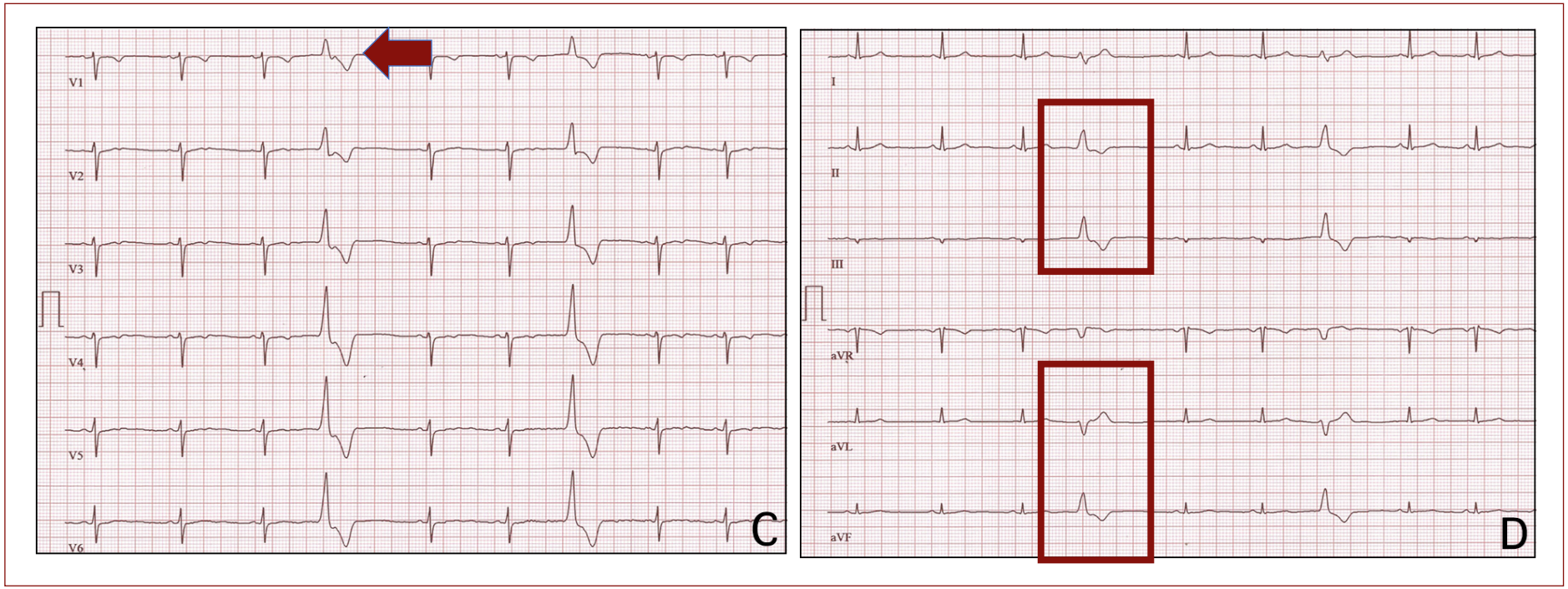


n = 38

53.5 %

Results

PVBs with RBBB and inferior axis morphology



n = 33

46.5 %

An electrocardiographic scoring system for distinguishing right ventricular outflow tract arrhythmias in patients with arrhythmogenic right ventricular cardiomyopathy from idiopathic ventricular tachycardia

Kurt S. Hoffmayer, MD,[*] Prashant D. Bhave, MD,[†] Gregory M. Marcus, MD, MAS, FHRS,[*] Cynthia A. James, PhD,[‡] Crystal Tichnell, MGC,[‡] Nagesh Chopra, MD,[§] Laura Moxey, BSc, CCRA, CCRP,[‖] Andrew D. Krahn, MD, FHRS,[‖] Sanjay Dixit, MD, FHRS,[¶] William Stevenson, MD, FHRS,[§] Hugh Calkins, MD, FHRS,[‡] Nitish Badhwar, MBBS,[*] Edward P. Gerstenfeld, MD, FHRS,[*] Melvin M. Scheinman, MD, FHRS[*]

*From the *Division of Cardiology, University of California, San Francisco, California, [†]Division of Cardiology, Northwestern University, Chicago, Illinois, [‡]Division of Cardiology, Johns Hopkins University, Baltimore, Maryland, [§]Division of Cardiology, Brigham and Women's Hospital, Boston, Massachusetts, [‖]University of Western Ontario, Ontario, Canada and [¶]Division of Cardiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania.*

BACKGROUND Ventricular arrhythmias in patients with arrhythmogenic right ventricular dysplasia/cardiomyopathy (ARVD/C) and idiopathic ventricular tachycardia (VT) can share a left bundle branch block/inferior axis morphology. We previously reported electrocardiogram characteristics during outflow tract ventricular arrhythmias that helped distinguish VT related to ARVD/C from idiopathic VT.

OBJECTIVE To prospectively validate these criteria.

METHODS We created a risk score by using a derivation cohort. Two experienced electrophysiologists blinded to the diagnosis prospectively scored patients with VT/premature ventricular contractions (PVCs) with left bundle branch block/inferior axis pattern in a validation cohort of 37 ARVD/C tracings and 49 idiopathic VT tracings. All patients with ARVD/C had their diagnosis confirmed based on the revised task force criteria. Patients with idiopathic VT were selected based on structurally normal hearts with documented right ventricular outflow tract VT successfully treated with ablation. The scoring system provides 3 points for sinus rhythm anterior T-wave inversions in leads V_1–V_3 and during ventricular arrhythmia: 2 points for QRS duration in lead I $\geq$120 ms, 2 points for QRS notching, and 1 point for precordial transition at lead V_5 or later.

RESULTS A score of 5 or greater was able to correctly distinguish ARVD/C from idiopathic VT 93% of the time, with a sensitivity of 84%, specificity of 100%, positive predictive value of 100%, and negative predictive value of 91%.

CONCLUSIONS We describe a simple scoring algorithm that uses 12-lead electrocardiogram characteristics to effectively distinguish right ventricular outflow tract arrhythmias originating from patients with ARVD/C versus patients with idiopathic VT.

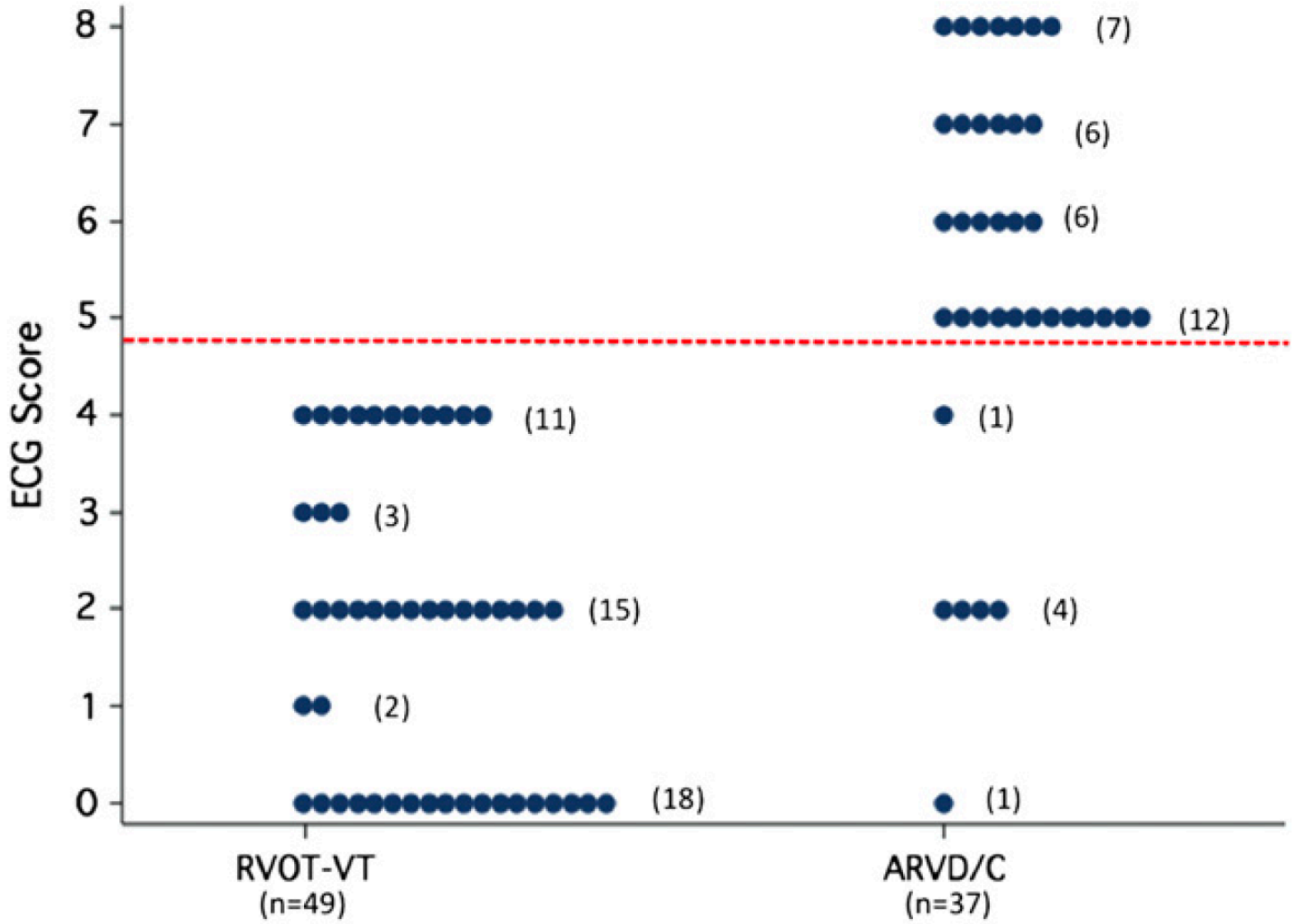
KEYWORDS ARVD/C; RVOT-VT; Idiopathic VT; Electrocardiogram; Risk score

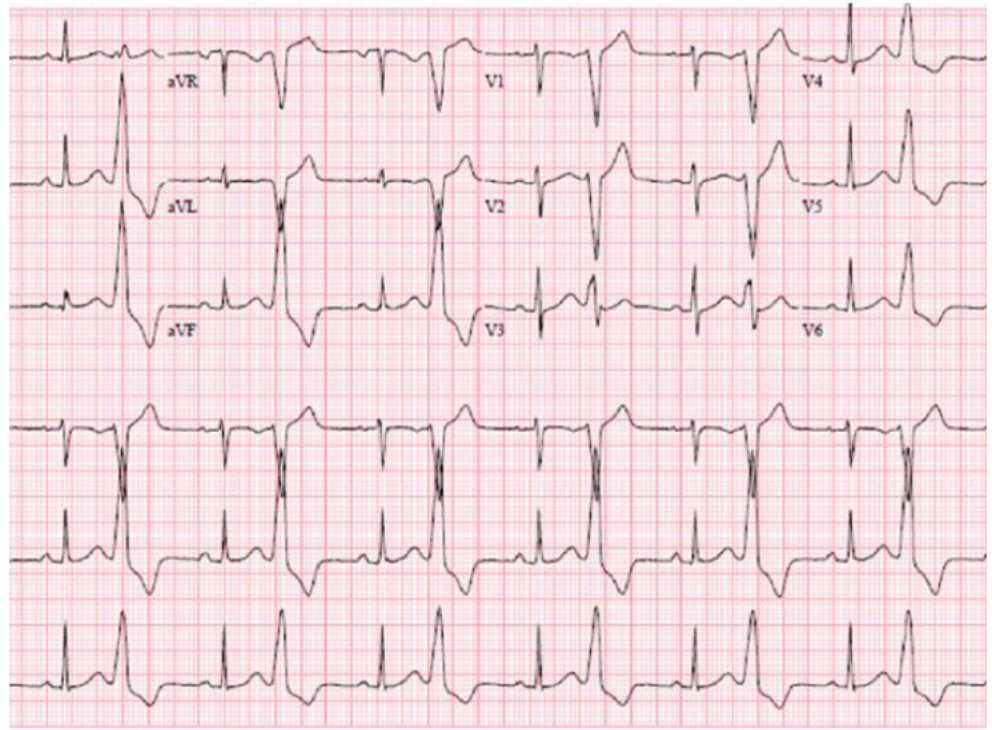
ABBREVIATIONS **ARVD/C** = Arrhythmogenic right ventricular dysplasia/cardiomyopathy; **CI** = confidence interval; **ECG** = electrocardiogram; **LBBB** = left bundle branch block; **PVC** = premature ventricular contraction; **ROC** = receiver operator characteristic; **RV** = right ventricular; **RVOT** = right ventricular outflow tract; **VT** = ventricular tachycardia

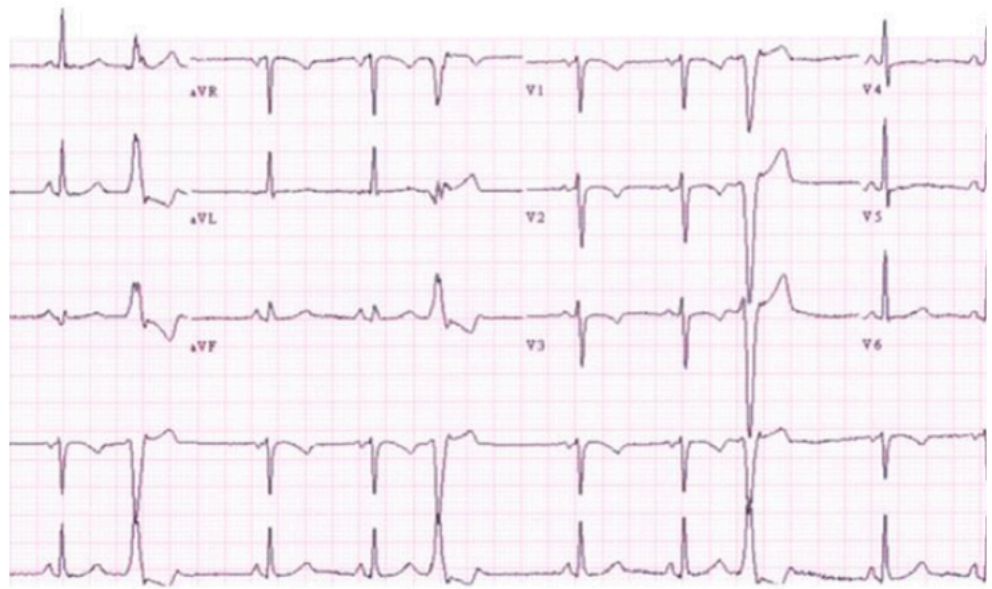
(Heart Rhythm 2013;10:477–482) © 2013 Heart Rhythm Society. All rights reserved.

Table 1 Electrocardiographic ARVD/C risk score

ECG characteristic	Points
Anterior T-wave inversions (V_1–V_3) in sinus rhythm	3
VT/PVC	
Lead I QRS duration $\geq$120 ms	2
QRS notching (multiple leads)	2
V_5 transition or later	1
Maximum total	8


ECG Score
8
7
6
5
4
3
2
1
0
(7)
(6)
(6)
(12)
(11)
(1)
(3)
(15)
(4)
(2)
(18)
(1)
RVOT-VT
(n=49)
ARVD/C
(n=37)


aVR
V1
V4
aVL
V2
V5
aVF
V3
V6


aVR
V1
V4
aVL
V2
V5
aVF
V3
V6

Europace
doi:10.1093/europace/euw018

CLINICAL RESEARCH

Electrocardiographic differentiation of idiopathic right ventricular outflow tract ectopy from early arrhythmogenic right ventricular cardiomyopathy

Jan Novak[1,2,3†], Alessandro Zorzi[1,4†], Silvia Castelletti[1,2], Antonis Pantasis[1,2], Ilaria Rigato[4], Domenico Corrado[4], William Mckenna[1,2], and Pier D. Lambiase[1,2*]

[1]Institute of Cardiovascular Science, University College of London, London, UK; [2]Barts Heart Centre, St Barthomolew's Hospital, West Smithfield, London EC1A 7BE, UK; [3]Department of Cardiology, Solothurner Spitaeler AG, Solothurn, Switzerland; and [4]Department of Cardiac, Thoracic, and Vascular Sciences, University of Padova, Padova, Italy

Received 8 November 2015; accepted after revision 15 January 2016

Aims The differentiation between idiopathic right ventricular outflow tract (RVOT) arrhythmias and early arrhythmogenic right ventricular cardiomyopathy (ARVC) can be challenging. We aimed to assess whether QRS morphological features and coupling interval of ventricular ectopic beats (VEBs) can improve differentiation between the two conditions.

Methods and results Twenty desmosomal-gene mutation carriers (13 females, mean age 43 years) with no or mild ARVC phenotypic expression and 33 age- and sex-matched subjects with idiopathic RVOT arrhythmias were studied. All patients exhibited isolated monomorphic VEBs with left bundle branch block/inferior axis morphology. The predictive value of ectopic QRS morphology and coupling interval was evaluated. Five ectopic QRS features were significantly more common in desmosomal-gene mutation carriers than in idiopathic RVOT-ventricular arrhythmia patients: maximal QRS duration >160 ms (60 vs. 27%, $P = 0.02$), intrinsicoid deflection time >80 ms (65 vs. 24%, $P = 0.01$), initial QRS slurring (40 vs. 12%, $P = 0.04$), QS pattern in lead V1 (90 vs. 36%, $P < 0.001$), and QRS axis $>90^{\circ}$ in limb leads (60 vs. 24%, $P = 0.01$). In the multivariate analysis, intrinsicoid deflection time >80 ms [odds ratio (OR) $= 9.9$], QS pattern in lead V1 (OR $= 28$), and QRS axis $>90^{\circ}$ (OR $= 5.7$) remained independent predictors of early ARVC. The coupling interval did not differ between the two groups.

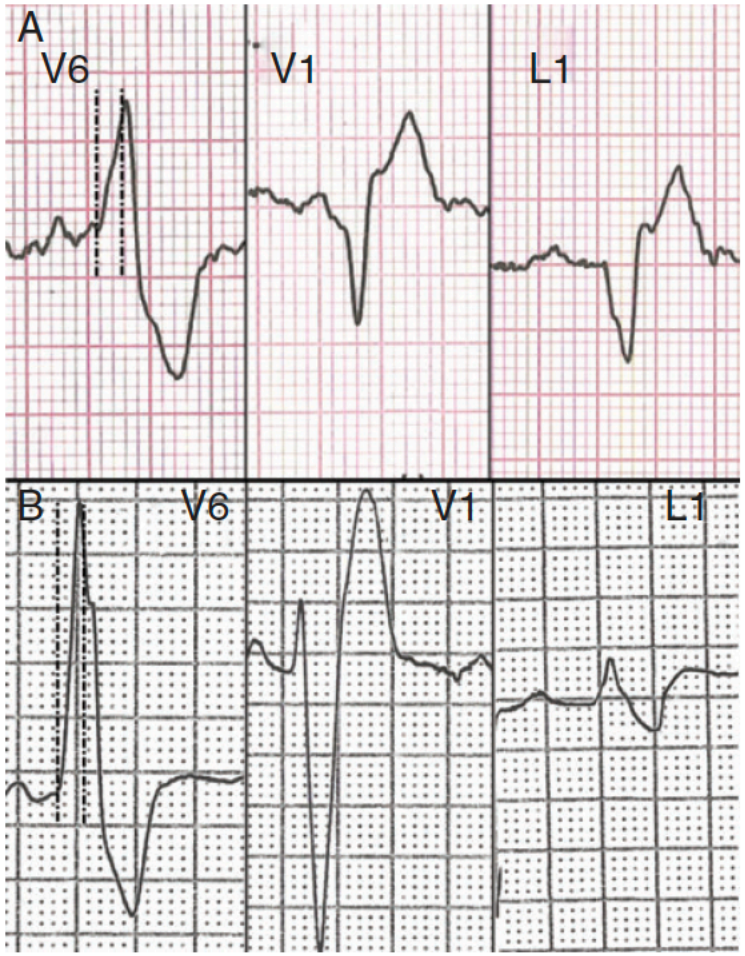
Conclusions In patients with RVOT VEBs and no major electrocardiographic or echocardiographic abnormalities, the ectopic QRS morphology aids in the differential diagnosis between idiopathic RVOT arrhythmias and early ARVC.

Keywords Arrhythmogenic cardiomyopathy • Cardiomyopathy • ECG • Ventricular tachycardia • Ventricular ectopic beat

Table 2 **Comparison between electrocardiographic findings at admission in patients with early ARVC and idiopathic RVOT-VA**

	Early ARVC (*N*=20)	Idiopathic RVOT-VA (*N*=33)	*P*-value
Age (years)	43 (26–54)	39 (30–45)	0.82
Gender (male)	13 (70)	23 (70)	1.0
Ectopic morphology			
Maximal QRS duration >160 ms	12 (60)	9 (27)	**0.02**
QRS axis >90°	12 (60)	8 (24)	**0.01**
QRS notching in one or more leads	14 (70)	26 (79)	0.47
QRS notching in two or more leads	10 (50)	15 (45)	0.75
Intrinsicoid deflection time >80 ms	12 (60)	8 (24)	**0.01**
Initial slurring (pseudo-delta)	8 (40)	4 (12)	**0.04**
Precordial transition ≥V4	11 (55)	17 (52)	1.0
Precordial transition ≥V5	3 (15)	4 (12)	1.0
QS morphology in lead V1	18 (90)	12 (36)	**<0.001**
QS morphology in lead V2	10 (50)	8 (24)	0.06
Q-wave in lead 1	5 (25)	10 (30)	0.76
QRS duration >120 ms in lead 1	6 (30)	7 (21)	0.52
Ectopic coupling			
Max interval sQRS-eQRS (ms)	540 (500–600)	480 (440–560)	0.12
Min interval sQRS-eQRS (ms)	420 (360–500)	400 (380–420)	0.23
Max–min sQRS-eQRS (ms)	100 (40–140)	60 (40–150)	0.71
Variance (ms)	32 (15–54)	24 (15–41)	0.65

ARVC, arrhythmogenic right ventricular cardiomyopathy; eQRS, QRS of the ventricular ectopic beat; sQRS, QRS at sinus rhythm.
Bold values depict characteristics with significant *P*-values.



One representative example of ECG leads V6, V1, and 1 in a patient with early ARVC (A) and in a patient with idiopathic RVOT arrhythmia (B). The intrinsicoid deflection time is >80 ms in the early ARVC patient, whereas it is ≤80 ms in the patient with idiopathic RVOT. In lV1, there is a QS morphology in the early ARVC patient but not in the idiopathic RVOT. In lead 1, a Q-wave is observed only in the early ARVC patient. The co-existence of all three factors has a sensitivity of 55% and a specificity of 91% for early ARVC.

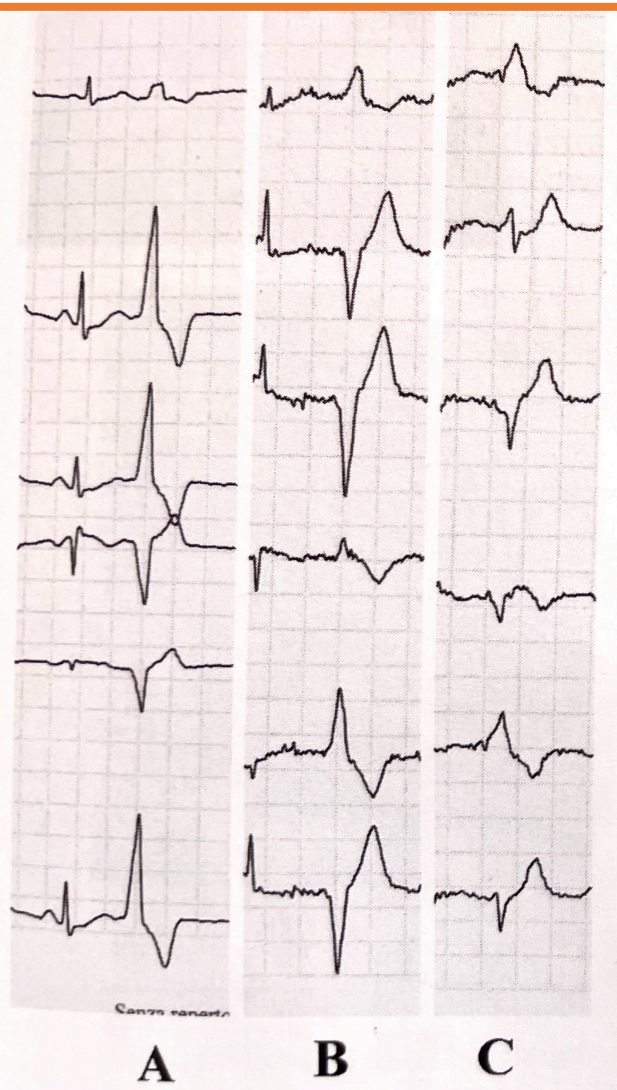
Table 3 Multivariable ECG predictors for the diagnosis of early arrhythmogenic cardiomyopathy

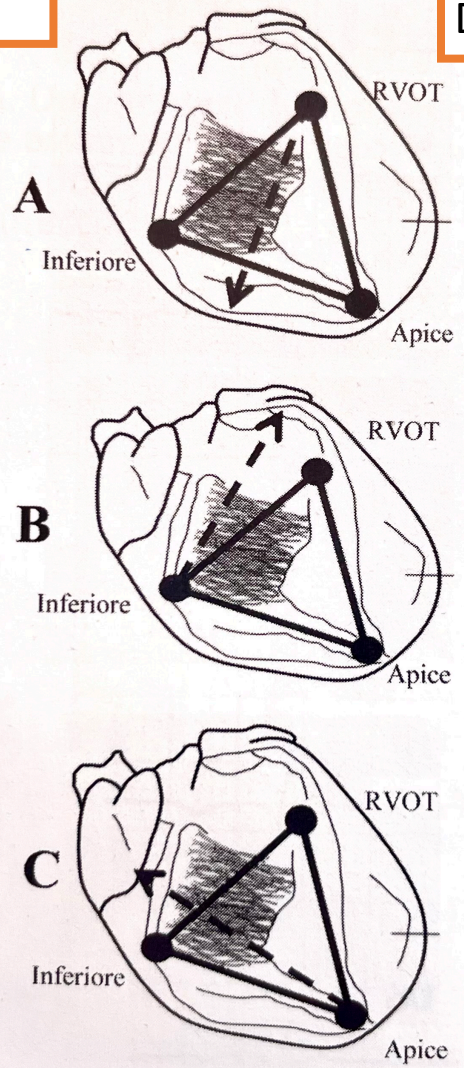
	OR	95% CI	*P*-value
QRS >160 ms	1.3	0.2–8.6	0.8
QRS axis >90°	5.7	1.0–32	**0.048**
Intrinsicoid deflection >80 ms	9.9	1.1–90	**0.037**
Initial slurring (pseudo-delta)	2.9	0.3–24	0.3
QS morphology in lead V1	27.8	3.0–255	**0.003**

Bold values depict characteristics with significant *P*-values.

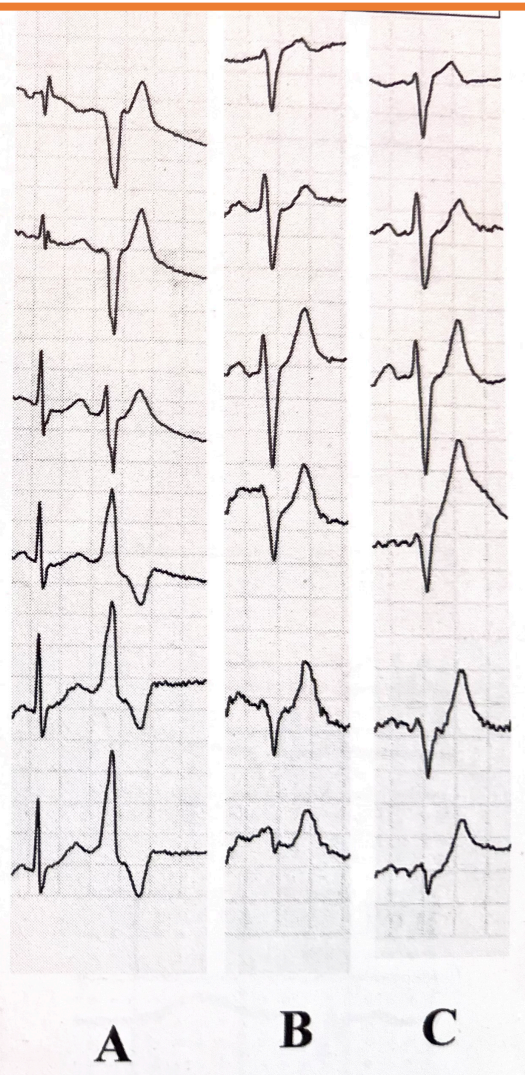
ARITMIE VENTRICOLARI NELLA CARDIOMIOPATIA ARITMOGENA DEL VDX

DERIVAZIONI PERIFERICHE





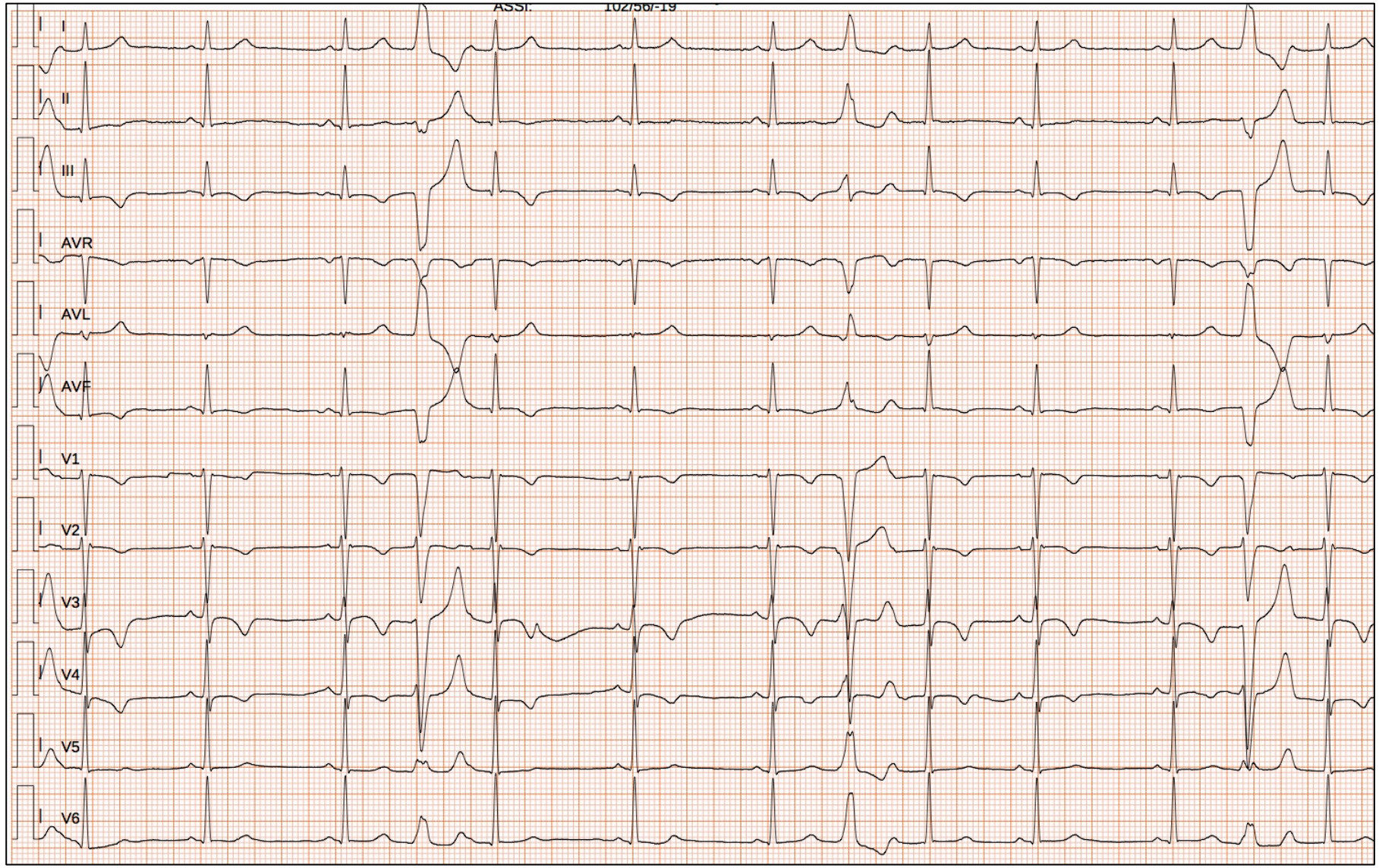
DERIVAZIONI PRECORDIALI

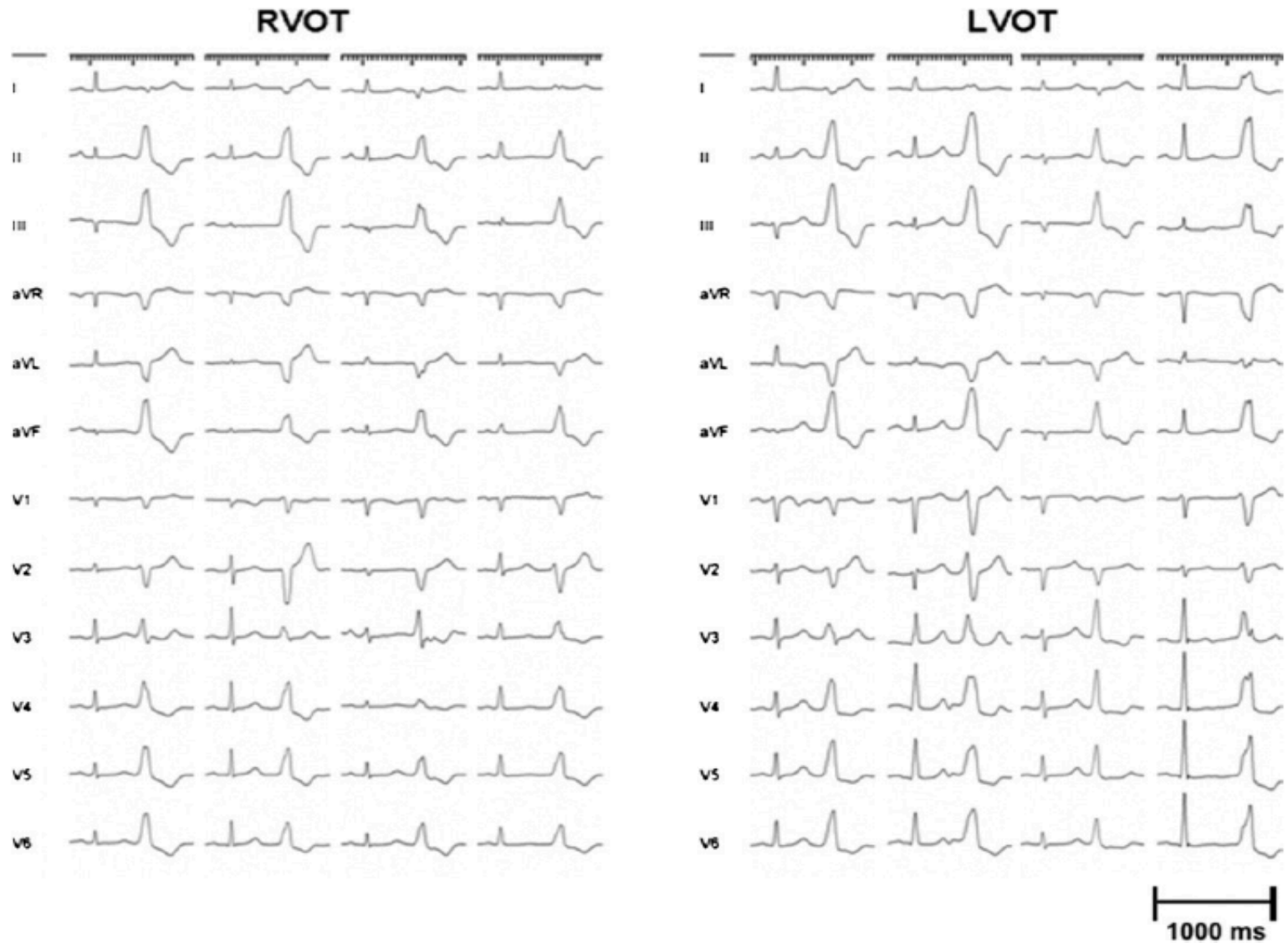


Modified From P.Delise Elettrocardiografia 2.0

Alice, 19 anni.
Ginnastica ritmica a livello agonistico
17 anni stop idoneità. Riscontro di anomalie ECG e Aritmie ventricolari.

Mutazione
Gene DSP




RVOT
LVOT
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
1000 ms

Journal of the American College of Cardiology
© 2011 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 57, No. 22, 2011
ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2011.01.035

The V_2 Transition Ratio

A New Electrocardiographic Criterion for Distinguishing Left From Right Ventricular Outflow Tract Tachycardia Origin

Brian P. Betensky, MD, Robert E. Park, Francis E. Marchlinski, MD, Matthew D. Hutchinson, MD, Fermin C. Garcia, MD, Sanjay Dixit, MD, David J. Callans, MD, Joshua M. Cooper, MD, Rupa Bala, MD, David Lin, MD, Michael P. Riley, MD, PHD, Edward P. Gerstenfeld, MD

Philadelphia, Pennsylvania

Objectives We sought to develop electrocardiography (ECG) criteria for distinguishing left ventricular outflow tract (LVOT) from right ventricular outflow tract (RVOT) origin in patients with idiopathic outflow tract ventricular tachycardia (OTVT) and lead V_3 R/S transition.

Background Several ECG criteria have been proposed for differentiating left from right OTVT origin; ventricular tachycardias (VTs) with left bundle branch block and V_3 transition remain a challenge.

Methods We analyzed the surface ECG pattern of patients with OTVT with a precordial transition in lead V_3 who underwent successful catheter ablation. Sinus and VT QRS morphologies were measured in limb and precordial leads with electronic calipers. The V_2 and V_3 transition ratios were calculated by computing the percentage R-wave during VT $(R/R+S)_{VT}$ divided by the percentage R-wave in sinus rhythm $(R/R+S)_{SR}$.

Results We retrospectively analyzed ECGs from 40 patients (mean age 44 ± 14 years, 21 female) with outflow tract premature ventricular contractions (PVCs)/VT. Patients with structural heart disease, paced rhythms, and bundle branch block during sinus rhythm were excluded. The V_2 transition ratio was significantly greater for LVOT PVCs compared with RVOT PVCs (1.27 ± 0.60 vs. 0.23 ± 0.16; $p < 0.001$) and was the only independent predictor of LVOT origin. In 21 prospective cases, a V_2 transition ratio ≥0.60 predicted an LVOT origin with 91% accuracy. A PVC precordial transition occurring later than the sinus rhythm transition excluded an LVOT origin with 100% accuracy.

Conclusions The V_2 transition ratio is a novel electrocardiographic measure that reliably distinguishes LVOT from RVOT origin in patients with lead V_3 precordial transition. This measure might be useful for counseling patients and planning an ablation strategy. (J Am Coll Cardiol 2011;57:2255–62) © 2011 by the American College of Cardiology Foundation

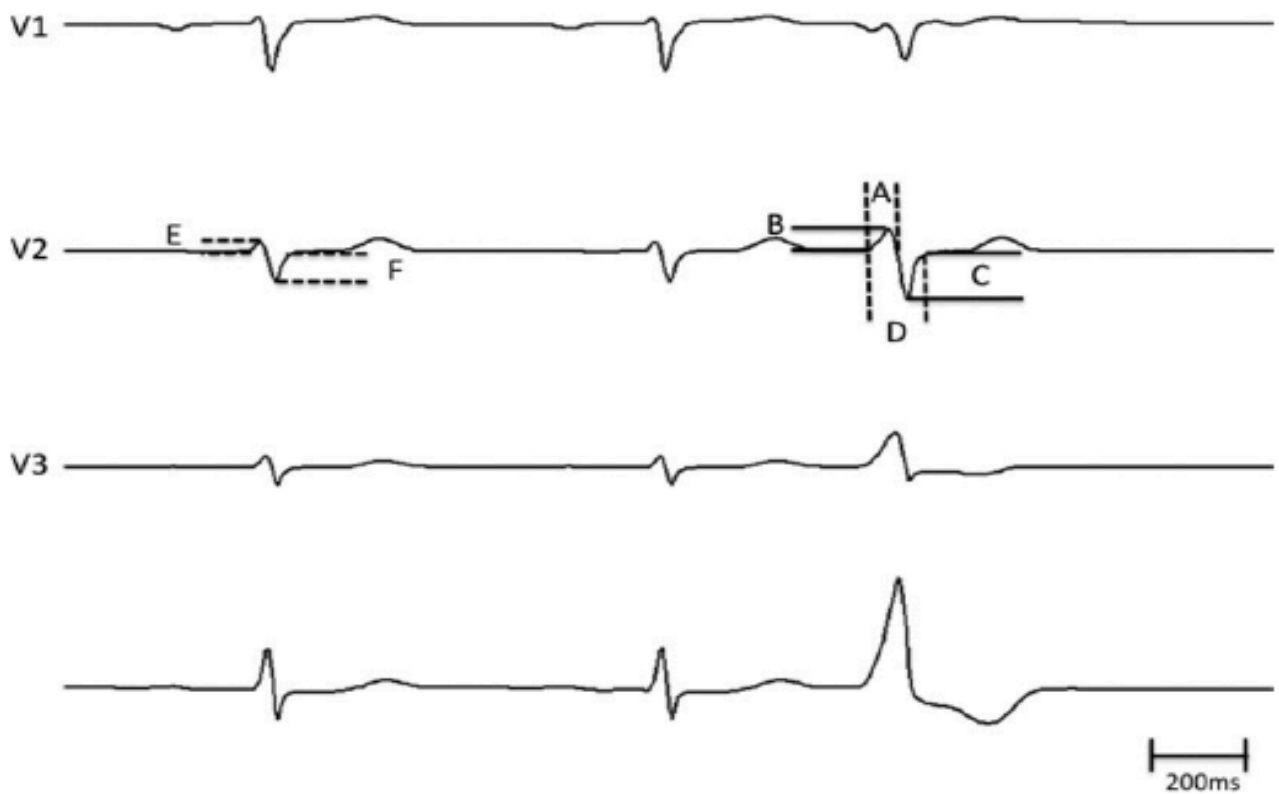


Figure 2 **Electrocardiographic Measurements**

Leads V_2 and V_3 of normal sinus beat followed by a premature ventricular contraction (PVC) representative of the clinical outflow tract ventricular tachycardia. Measurements are as follows: **A** = PVC R-wave duration (ms); **B** = PVC R-wave amplitude (mV); **C** = PVC S-wave amplitude (mV); **D** = PVC QRS duration (ms); **E** = sinus rhythm R-wave amplitude (mV); and **F** = sinus rhythm S-wave amplitude (mV). The transition ratio was calculated in each lead with the following formula: $[B/(B+C)_{VT} \div E/(E+F)_{SR}]$.

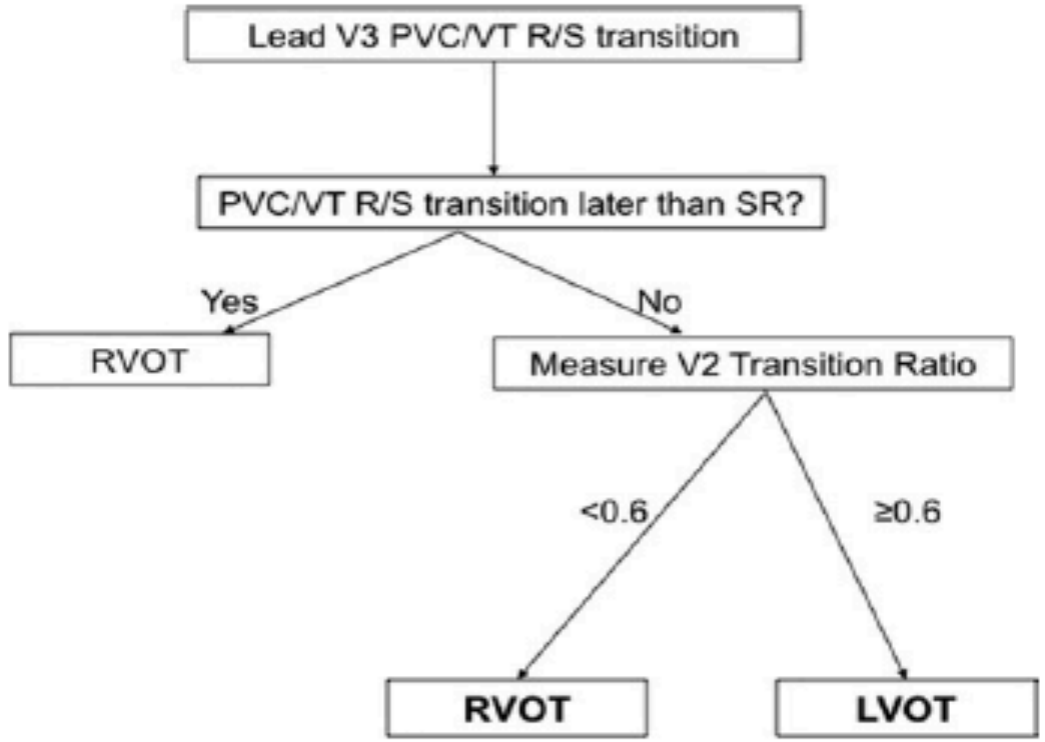


Figure 7 **Diagnostic Algorithm for Outflow Tract VT With Lead V_3 PVC/VT R/S Transition**

If the PVC/ventricular tachycardia (VT) transition to an R>S occurs later than the SR transition (i.e., SR transition lead V_1 or V_2), then the PVC origin is the RVOT (100% specificity). If the PVC transition occurs at or earlier than the SR transition (i.e., SR transition lead V_3 or later), then the V_2 transition ratio is measured. If the transition ratio is <0.6, then RVOT origin is likely. If the transition ratio is ≥0.6, then LVOT origin is likely (sensitivity 95%, specificity 100%). Abbreviations as in Figures 3 and 4.

Background

Evaluation of morphology /site of origin of ventricular arrhythmias



Another pattern consistent with idiopathic and benign PVBs is ***'fascicular'*** pattern, characterised by a typical ***right bundle branch block*** (RBBB), superior QRS axis morphology and QRS duration <130ms.

Characteristics of Patients With RVOT Versus Purkinje Premature Beats

	Sex, Female/Male	Age, y	Family History of Sudden Death	Number of VF Before Ablation	Persistent/ Episodic Arrhyth-mias	Polymorphic/ Monomorphic Premature Beats	Ectopic QRS Durations, ms	Coupling Interval Initiating VF or Polymorphic VT, ms
RVOT (n=4)	3/1	27±8	0	2±2	4/0	1/3	145±12	355±30
Purkinje (n=23)	11/12	43±14	6	10±13	4/19	18/5	126±18	280±26
P	NS	0.02	NS	0.03	<0.01	0.06	0.04	0.01

RVOT indicates right ventricular outflow tract; VF, ventricular fibrillation; and VT, ventricular tachycardia.

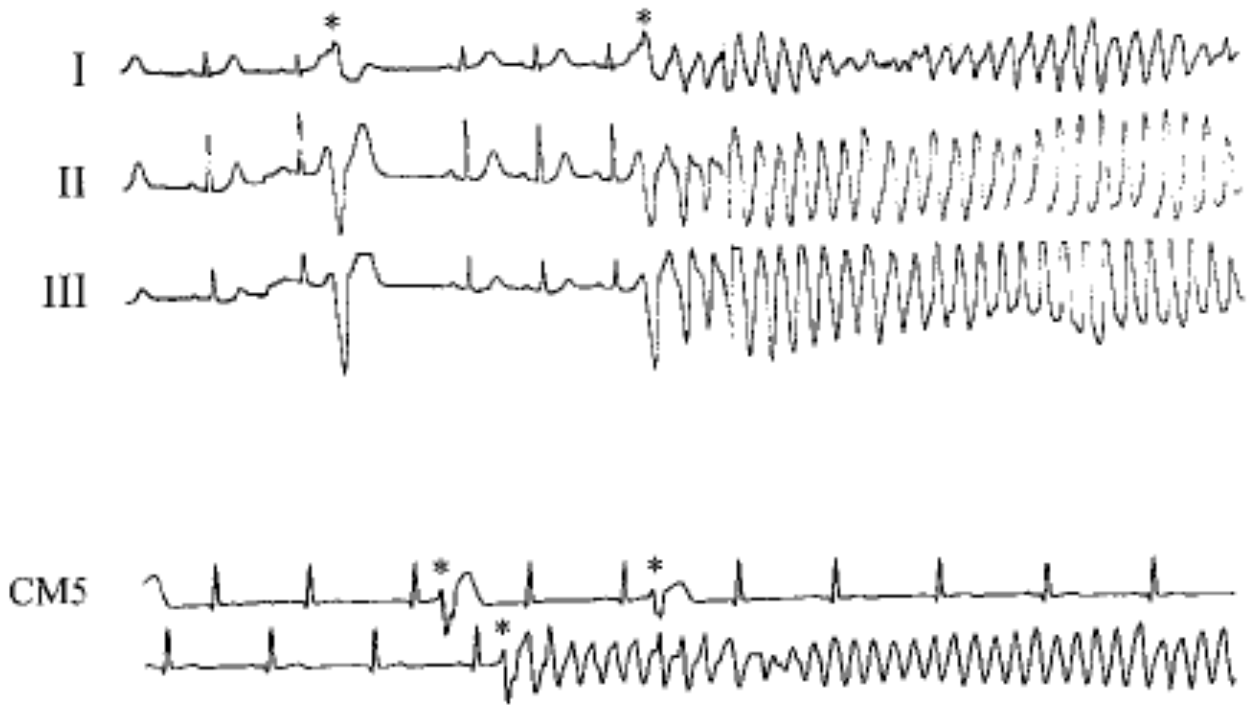
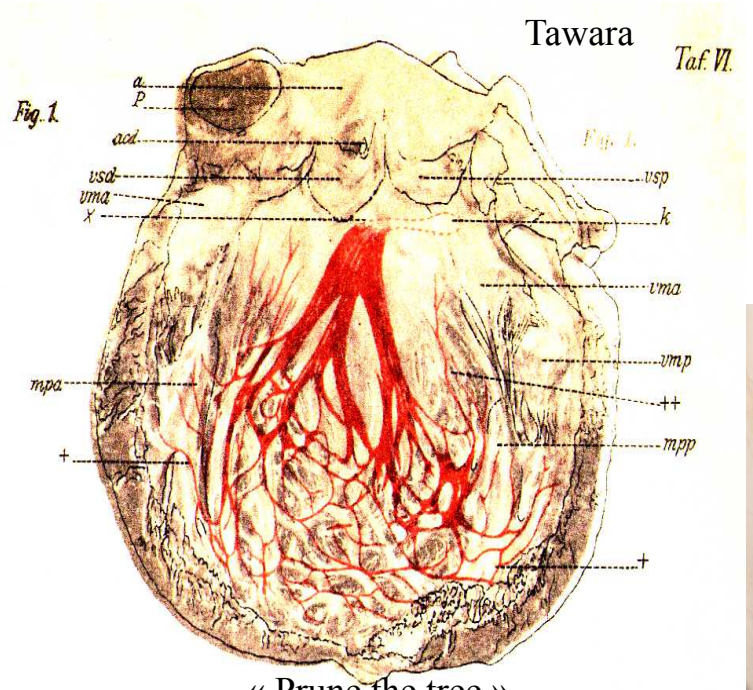
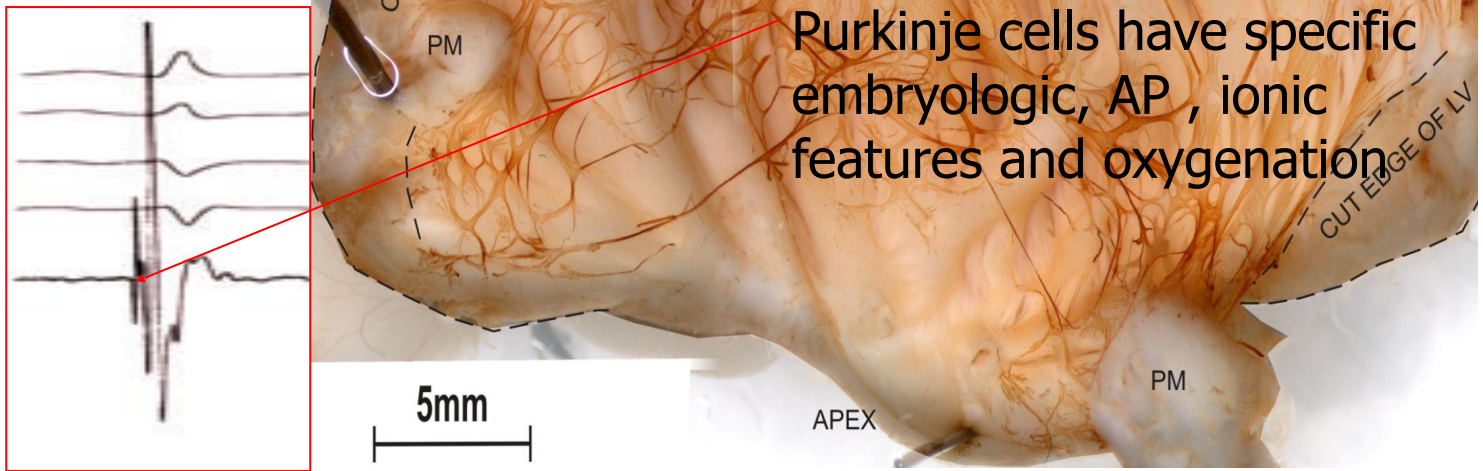


Figure 1. Examples of VF initiation by premature beats later found to originate from the right (top) or left (bottom) ventricle.



« Prune the tree »

Human Ventricular Fibrillation is mostly initiated from Purkinje cells (<2 % of cardiac mass)



Journal Pre-proof



Malignant Purkinje Ectopy induced by Sodium-channel Blocker

William Escande, MD, Jean-Baptiste Gourraud, MD, PhD, Michel Haissaguerre, MD, Estelle Gandjbakhch, MD PhD, Thomas Lavergne, MD, Raphael Martins, MD, PhD, Ghassen Cheniti, MD, Philipp Krisai, MD, Jean Sylvain Hermida, MD, PhD, Philippe Maury, MD, PhD, Jose-Louis Merino, MD, PhD, Jean-Luc Pasquié, MD, PhD, Nicolas Combes, MD, Elodie Surget, MD, Josselin Duchateau, MD, PhD, Thomas Pambrun, MD, Nicolas Derval, MD, Meleze Hocini, MD, Pierre Jais, MD PhD, Pieter G. Postema, MD, PhD, Koonlawee Nademanee, MD, PhD, Ed Vigmond, PhD, Olivier Bernus, PhD, Frederic Sacher, MD, PhD, Vincent Probst, MD, PhD

PII: S1547-5271(22)02169-5

DOI: https://doi.org/10.1016/j.hrthm.2022.06.034

Reference: HRTHM 9476

To appear in: *Heart Rhythm*

Received Date: 20 December 2021

Pharmacological testing with infusion of a sodium-channel blocker (SCB) is usually performed to exclude BrS according to current guidelines to define IVF.

In a subset of pts without Brugada pattern, SCB may still be proarrhythmic with a incidence of PVCs of 1.8 to 2.4%.

Background: Sodium-Channel Blocker (SCB) infusion is used to unmask the ECG pattern of Brugada syndrome. The test may also induce premature ventricular complexes (PVCs) in individuals without Brugada pattern, the clinical relevance of which is little known.

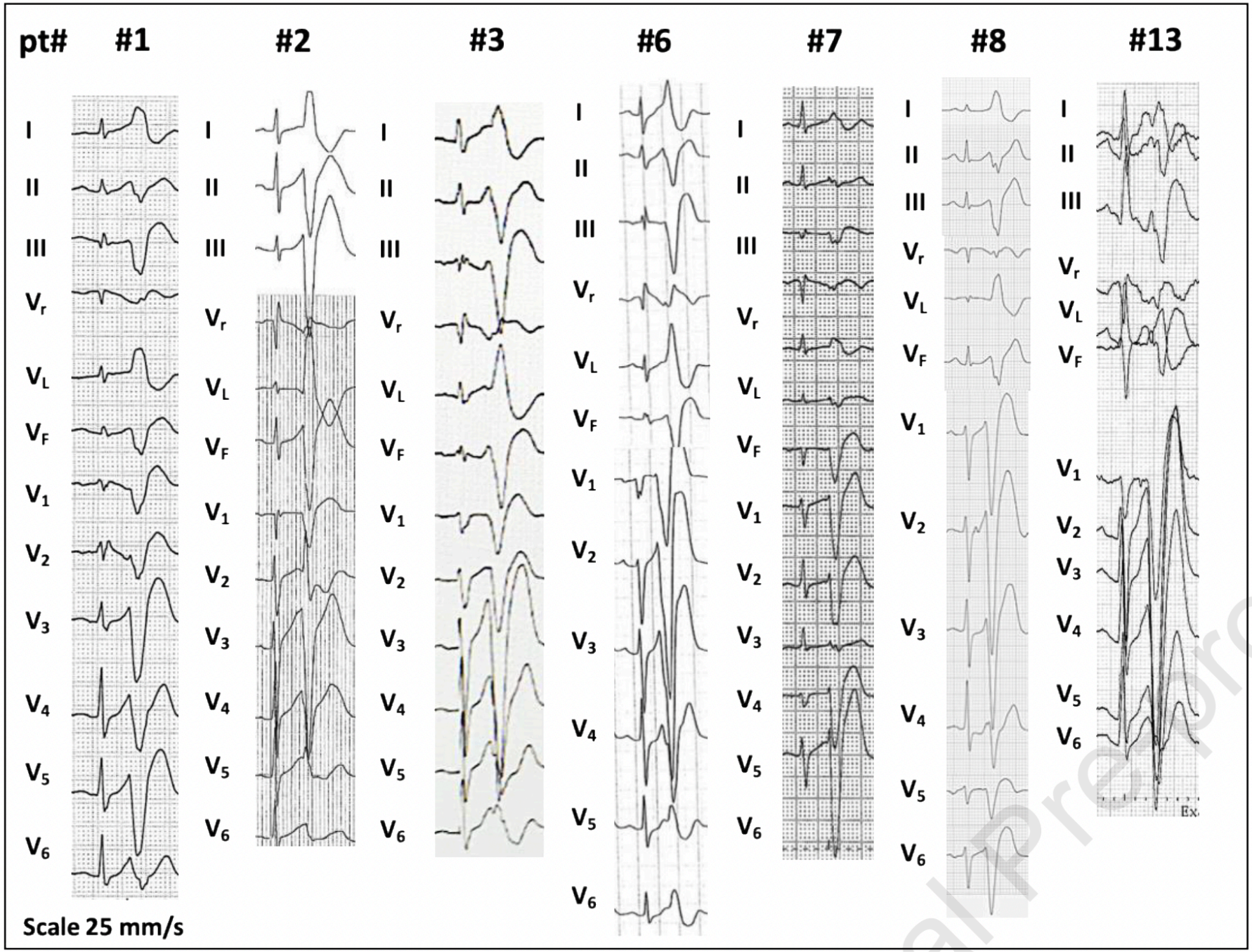
Objective: To describe the prevalence of short-coupled (Sc) PVCs induced by ajmaline or flecainide in patients with suspected or documented severe ventricular arrhythmias.

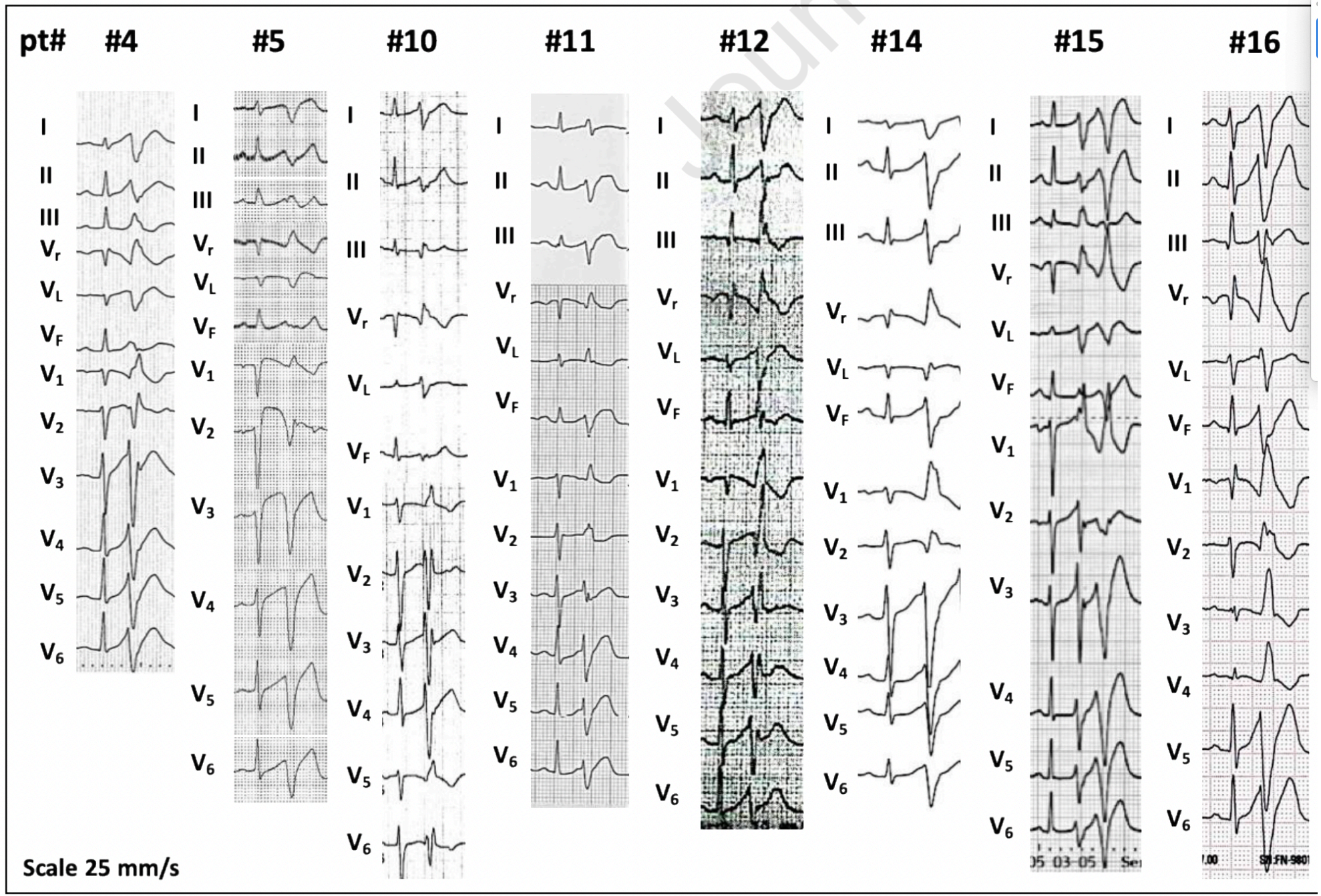
Methods: We reviewed the SCB tests performed in 335 patients with suspected ventricular arrhythmias and structurally normal hearts in 9 centers. ScPVCs were defined as frequent and repetitive PVCs with an R-on-T pattern on SCB tests. Repeated SCB tests were performed in seven patients and electrophysiological mapping of ScPVCs in nine.

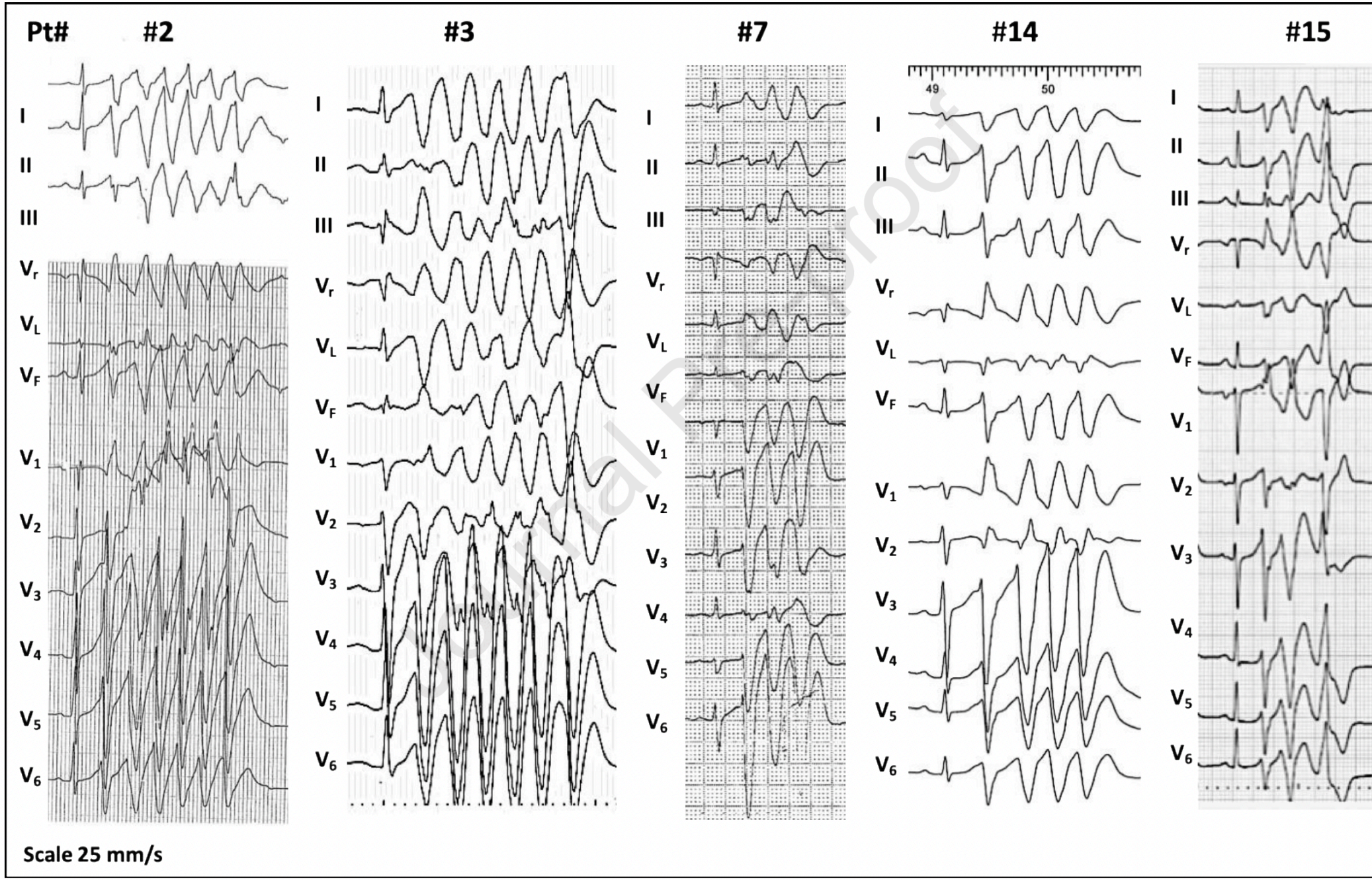
Results: Sixteen patients (8 males, 36±11 years) showed ScPVCs and were included. ScPVCs appeared 229±118 sec after the start of the infusion and displayed coupling intervals of 288±28 ms. ScPVC patterns were monomorphic in 10 and polymorphic in 5 patients, originating from the Purkinje system in mapped patients. Repetitive PVCs were induced in 15 (94%) patients including polymorphic ventricular tachycardias in 9 (56%). SCB was repeated 45 (IQR 0.6-46) months later and induced identical ScPVC in all. SCB test was the only mean to reveal the malignant arrhythmia in six patients. Catheter ablation was performed in 9 patients, resulting in arrhythmia elimination in 8 with a follow-up of 6 (IQR 2-9) years.

Conclusion: SCB can induce ScPVC, mostly from Purkinje tissue, in a small subset of patients with idiopathic ventricular arrhythmias. Its high reproducibility suggests a distinct individual mechanism.

Pre-proof


pt#
#1
#2
#3
#6
#7
#8
#13
I
II
III
Vr
VL
VF
V1
V2
V3
V4
V5
V6
Scale 25 mm/s


pt#
#4
#5
#10
#11
#12
#14
#15
#16
I
II
III
Vr
VL
VF
V1
V2
V3
V4
V5
V6
Scale 25 mm/s

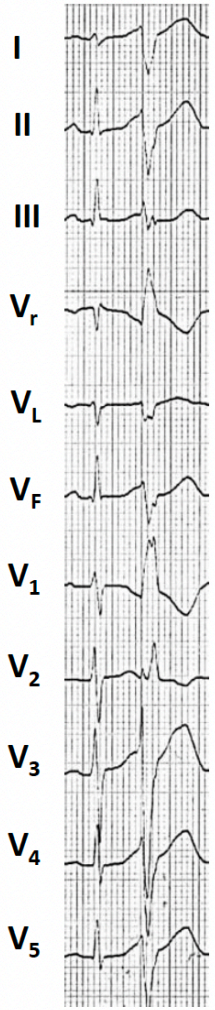


Journal Proof

#14

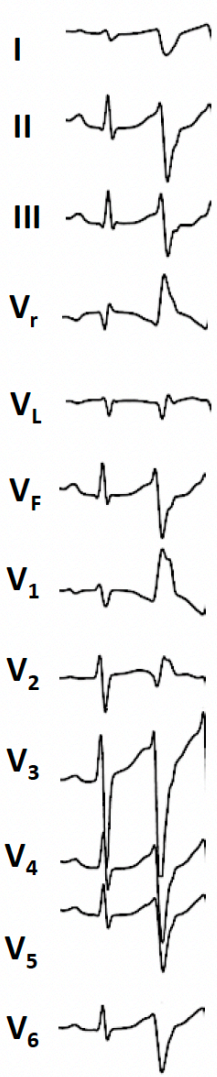
Spont.

CI 360 ms



SCB

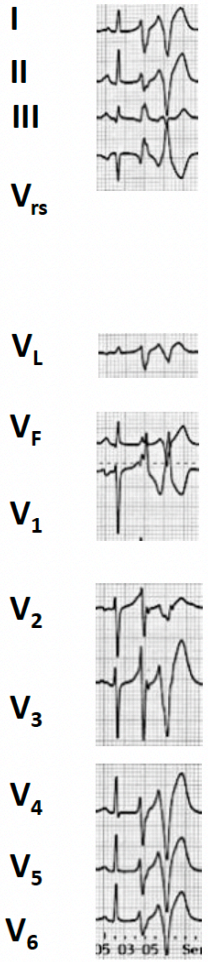
CI 320 ms



#15

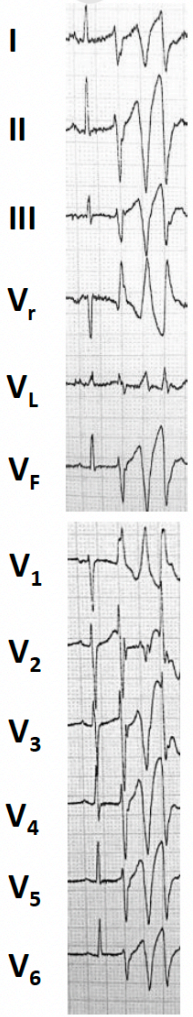
Spont.

CI 280 ms



SCB

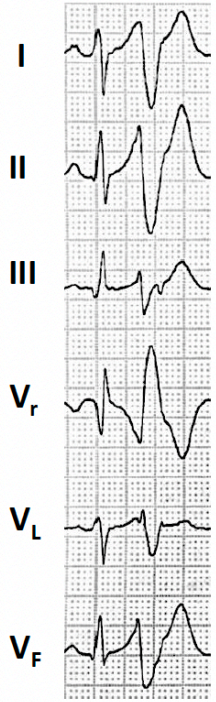
CI 280 ms



#16

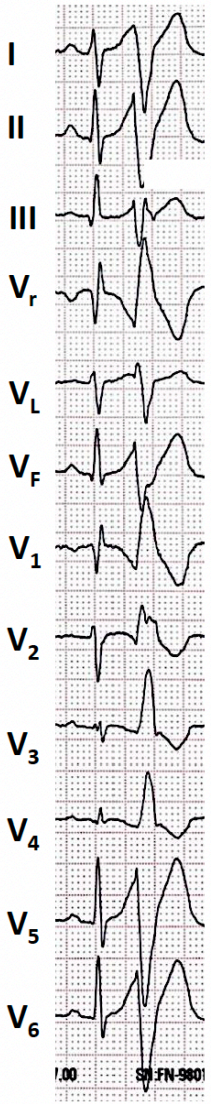
Spont.

CI 280 ms



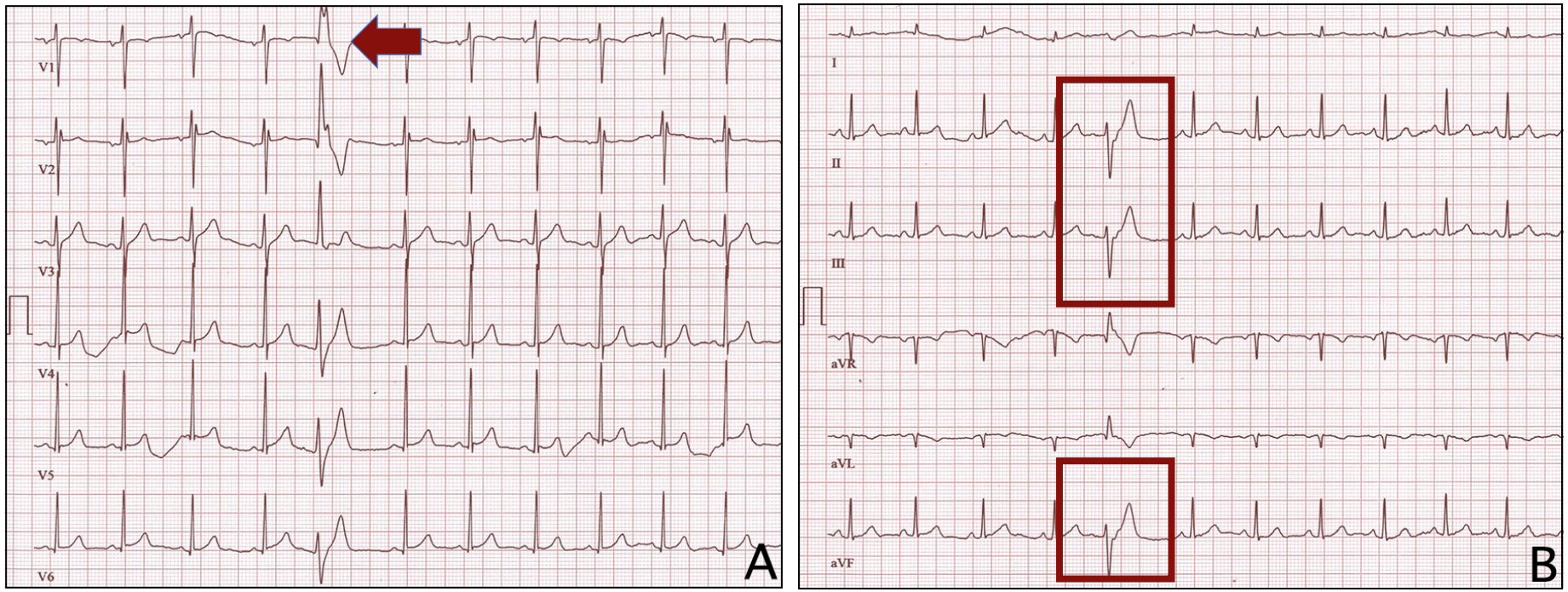
SCB

CI 280 ms



Results

PVBs with RBBB and superior axis morphology



n = 38

53.5 %

Risk Stratification of Patients With Apparently Idiopathic Premature Ventricular Contractions

A Multicenter International CMR Registry

Daniele Muser, MD,[a,b,*] Pasquale Santangeli, MD, PhD,[a,*] Simon A. Castro, MD,[a] Ruben Casado Arroyo, MD, PhD,[c] Shingo Maeda, MD,[d] Daniel A. Benhayon, MD,[e] Ioan Liuba, MD,[f] Jackson J. Liang, DO,[a] Mouhannad M. Sadek, MD,[g] Anwar Chahal, MD,[a] Silvia Magnani, MD,[h] Maurizio Pieroni, MD,[i] Elena Santarossa, MD,[b] Benoit Desjardins, MD, PhD,[j] Sanjay Dixit, MD,[a] Fermin C. Garcia, MD,[a] David J. Callans, MD,[a] David S. Frankel, MD,[a] Abass Alavi, MD, PhD,[j] Francis E. Marchlinski, MD,[a] Joseph B. Selvanayagam, MBBS (Hons), DPhil,[k] Gaetano Nucifora, MD, PhD[k,l]

ABSTRACT

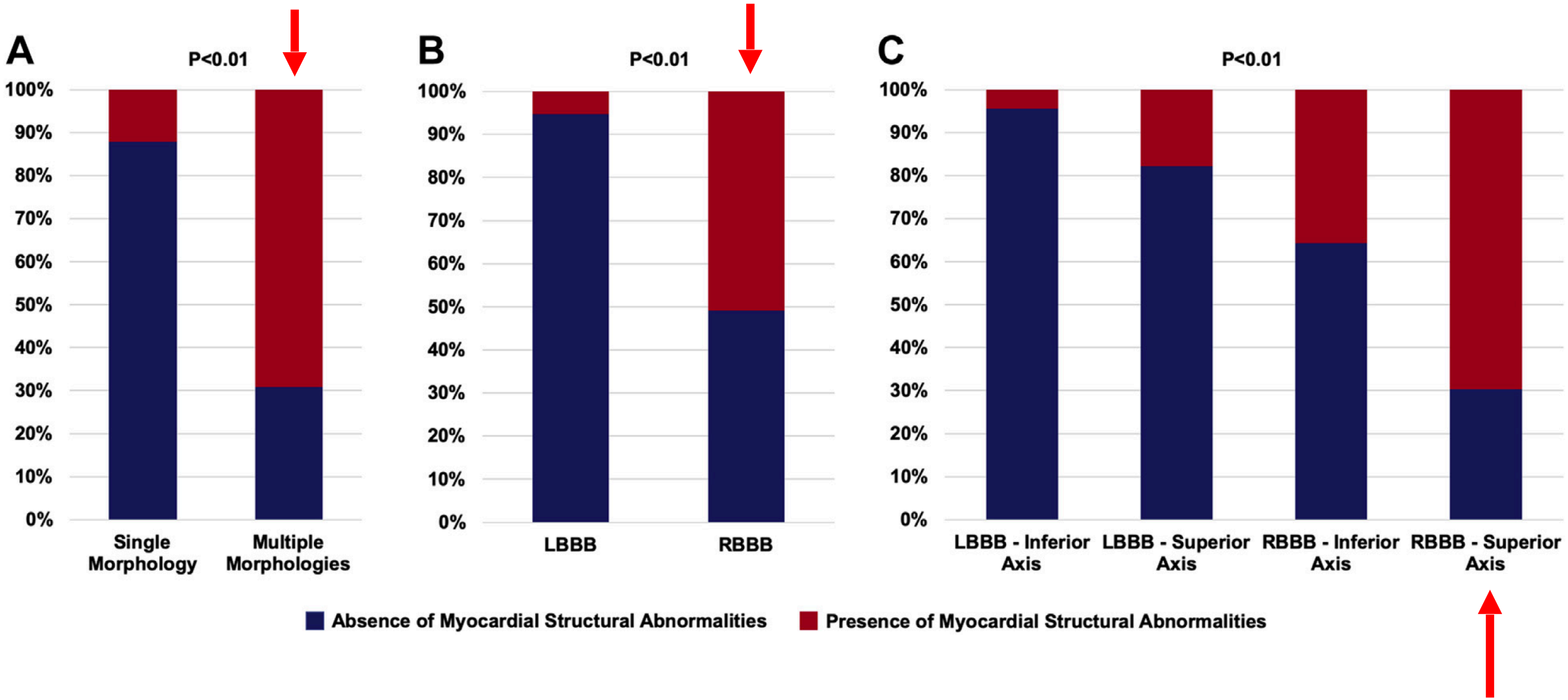
OBJECTIVES This study investigated the prevalence and prognostic significance of concealed myocardial abnormalities identified by cardiac magnetic resonance (CMR) imaging in patients with apparently idiopathic premature ventricular contractions (PVCs).

BACKGROUND The role of CMR imaging in patients with frequent PVCs and otherwise negative diagnostic workup is uncertain.

METHODS This was a multicenter, international study that included 518 patients (44 ± 15 years; 57% men) with frequent (>1,000/24 h) PVCs and negative routine diagnostic workup. Patients underwent a comprehensive CMR protocol including late gadolinium enhancement imaging for detection of necrosis and/or fibrosis. The study endpoint was a composite of sudden cardiac death, resuscitated cardiac arrest, and nonfatal episodes of ventricular fibrillation or sustained ventricular tachycardia that required appropriate implantable cardioverter-defibrillator therapy.

RESULTS Myocardial abnormalities were found in 85 (16%) patients. Male gender (odds ratio [OR]: 4.28; 95% confidence interval [CI]: 2.06 to 8.93; $p = 0.01$), family history of sudden cardiac death and/or cardiomyopathy (OR: 3.61; 95% CI: 1.33 to 9.82; $p = 0.01$), multifocal PVCs (OR: 11.12; 95% CI: 4.35 to 28.46; $p < 0.01$), and non–left bundle branch block inferior axis morphology (OR: 14.11; 95% CI: 7.35 to 27.07; $p < 0.01$) were all significantly related to the presence of myocardial abnormalities. After a median follow-up of 67 months, the composite endpoint occurred in 26 (5%) patients. Subjects with myocardial abnormalities on CMR had a higher incidence of the composite outcome ($n = 25$; 29%) compared with those without abnormalities ($n = 1$; 0.2%; $p < 0.01$).

CONCLUSIONS CMR can identify concealed myocardial abnormalities in 16% of patients with apparently idiopathic frequent PVCs. Presence of myocardial abnormalities on CMR predict worse clinical outcomes.
(J Am Coll Cardiol EP 2019;■:■-■) © 2019 by the American College of Cardiology Foundation.

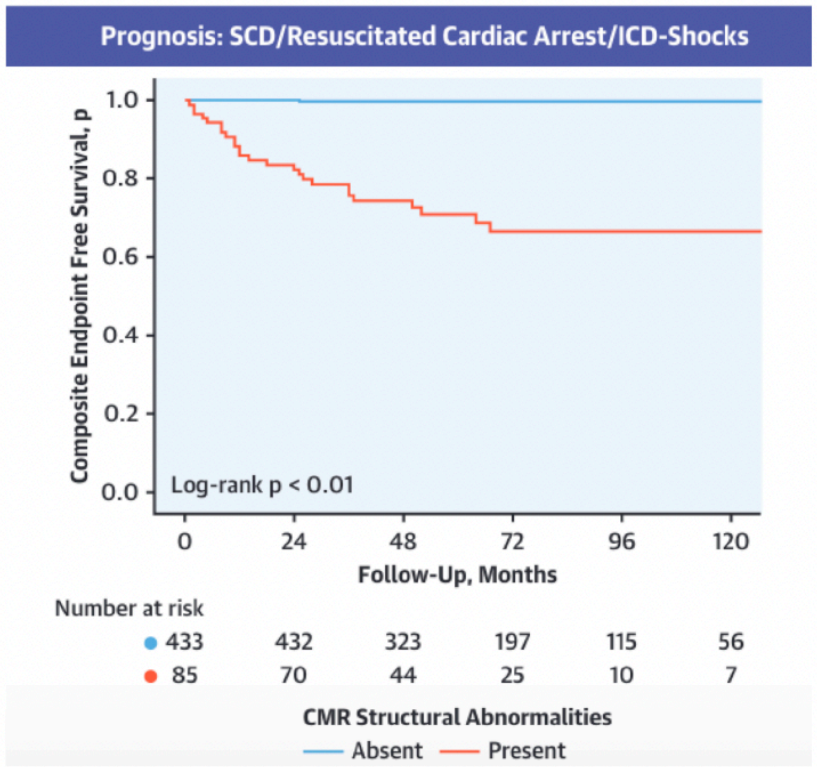


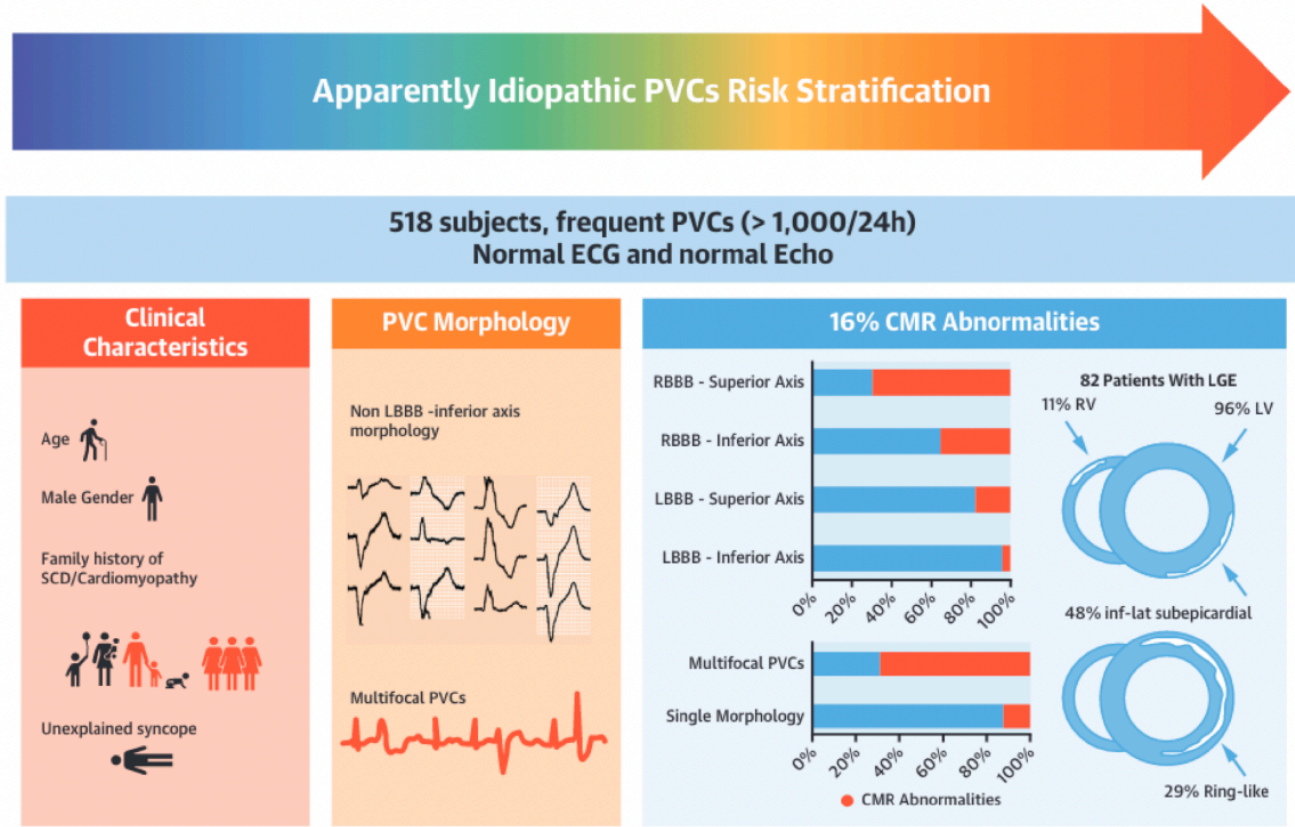
Prevalence of CMR Abnormalities

Risk Stratification of Patients With Apparently Idiopathic Premature Ventricular Contractions

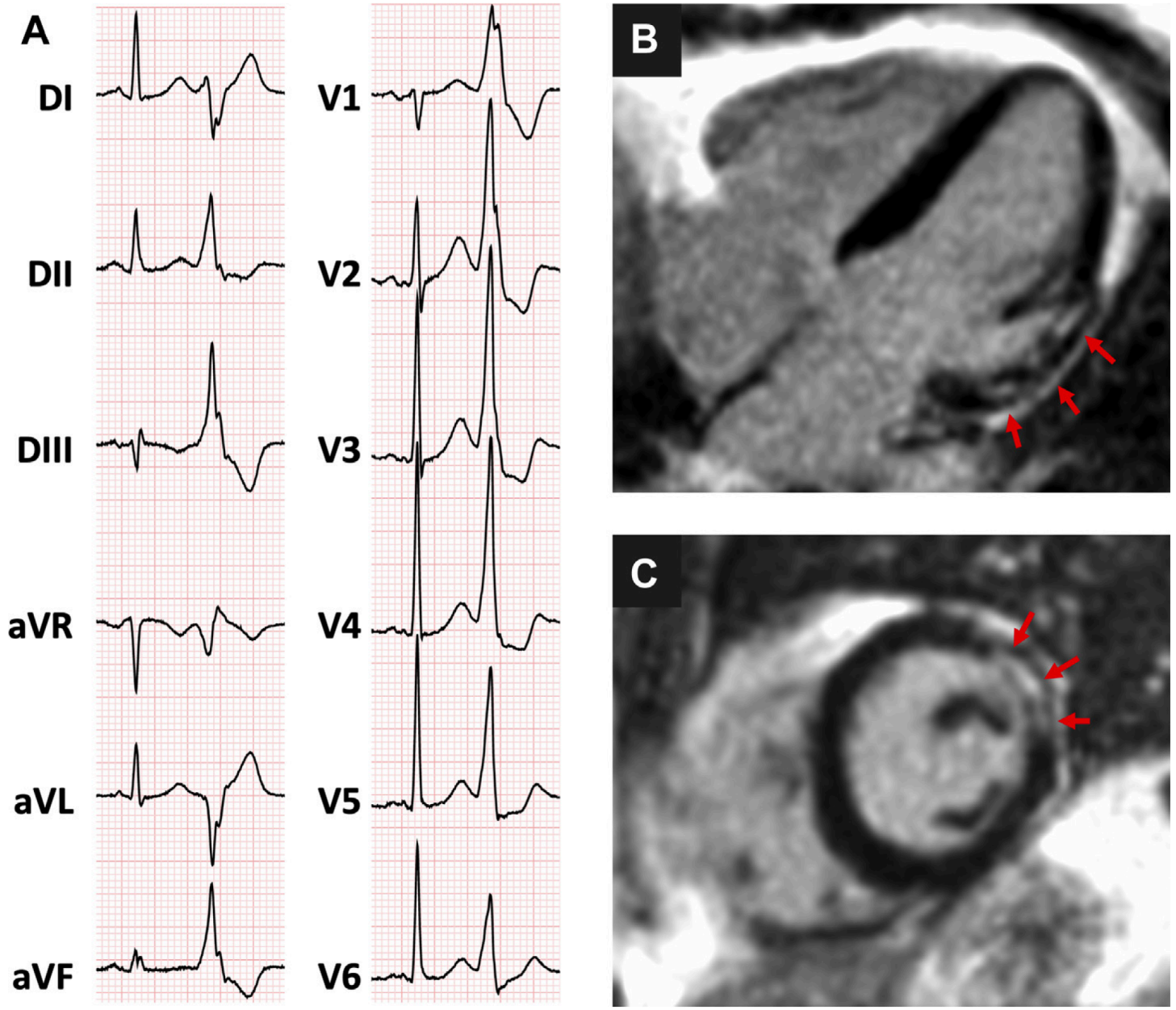
A Multicenter International CMR Registry

Muser D et al. Jacc: Clinical and Elecrtophysiology 2020

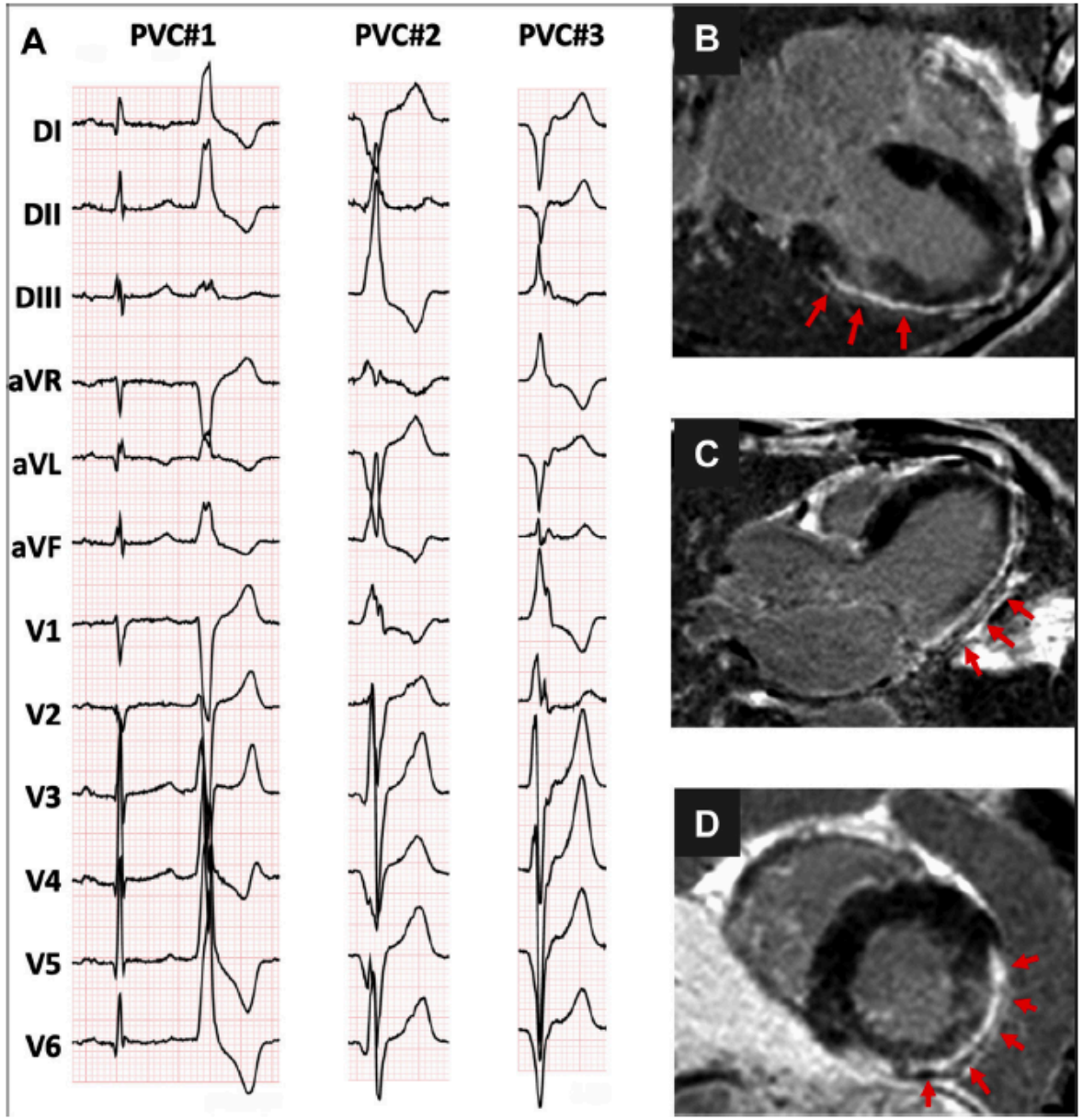




- During a median follow-up of **67 months**, we observed **a 5% (0.9%/year)** incidence of **malignant arrhythmic events**
- The prognostic relevance of CMR was confirmed among patients with baseline high-risk features



(A) A 36-year old woman presenting with frequent PVCs with RBBB inferior axis morphology and **(B and C)** evidence on CMR of a patchy area of subepicardial late gadolinium enhancement involving the basal anterolateral left ventricular segment **(arrows)**.



(A) A 35-year-old man presenting with multifocal frequent PVCs and **(B to D)** evidence on CMR of ring-like subepicardial and mid-myocardial late gadolinium enhancement involving the left ventricular free wall **(arrows)**.

ORIGINAL ARTICLE

Long-Term Risk Assessment in Athletes With Complex Ventricular Arrhythmias

Paolo Compagnucci, MD, PhD; Michela Casella, MD, PhD; Maria Lucia Narducci, MD, PhD; Edoardo Conte, MD; Michela Cammarano, MD; Gemma Pelargonio, MD, PhD; Daniele Andreini, MD, PhD; Vincenzo Palmieri, MD; Giulia Stronati, MD, PhD; Gerardo V. Lo Russo, MD; Matteo Brusamolino, MD; Gianluca Pontone, MD, PhD; Federico Guerra, MD, MSc; Andrea Natale, MD; Claudio Tondo, MD, PhD; Filippo Crea, MD; Paolo Zeppilli, MD; Antonio Dello Russo, MD, PhD

Multicenter cohort study

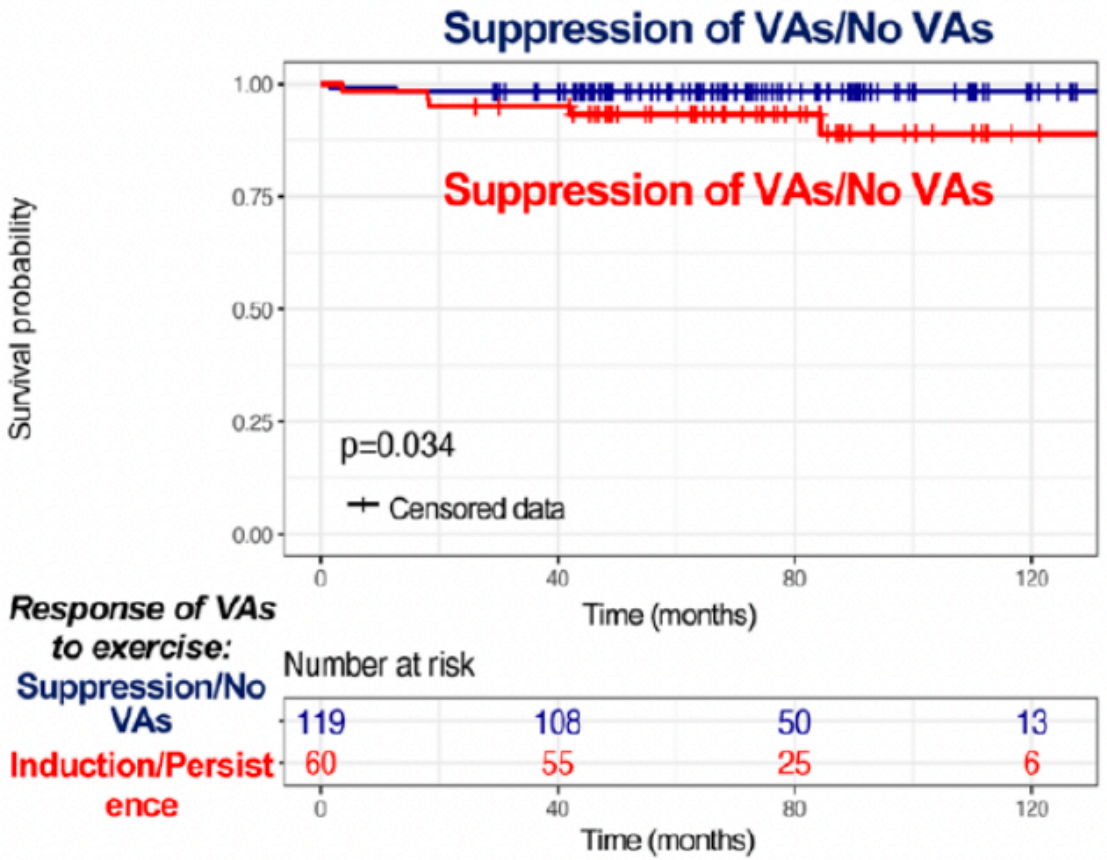
190 athletes (82% men; 28 [19–43] years; 148 [78%] competitive athletes) with frequent or exercise-induced premature ventricular complexes or nonsustained ventricular tachycardia

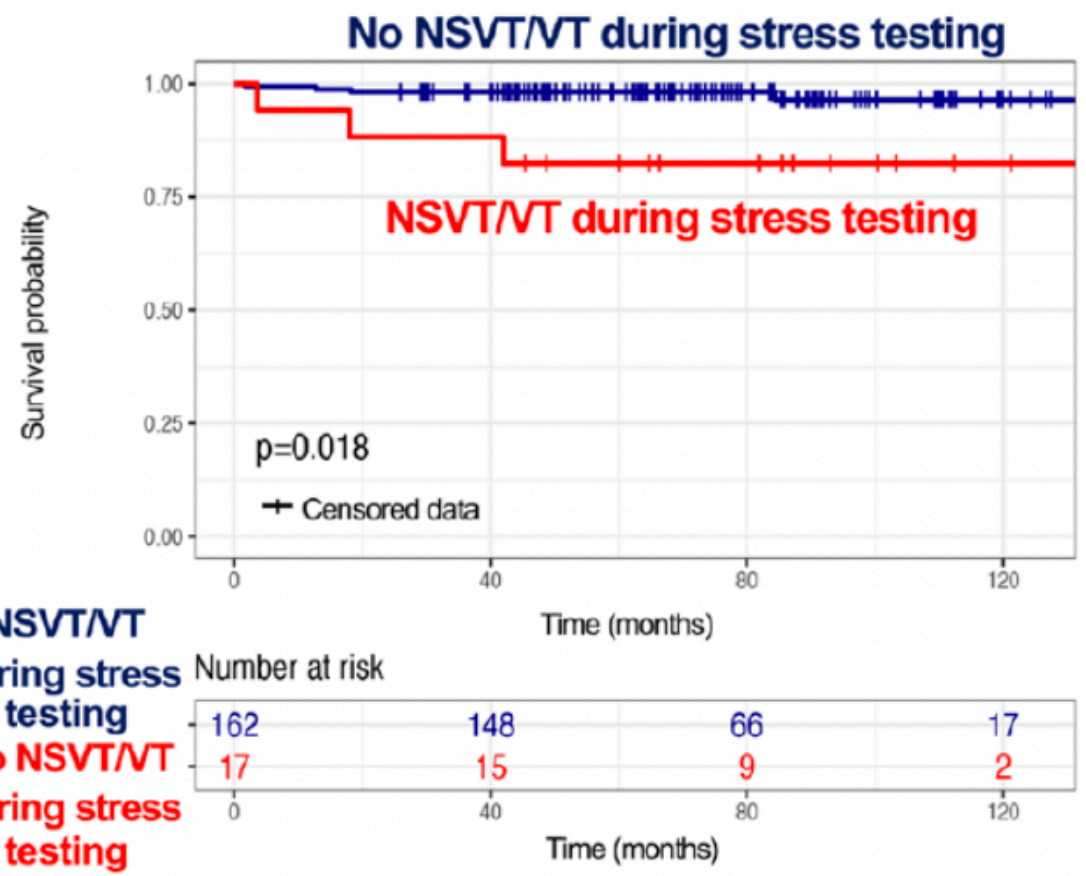
Categorized based on VA ECG morphology into **common** (n=99) and **uncommon** (n=91) VA groups.

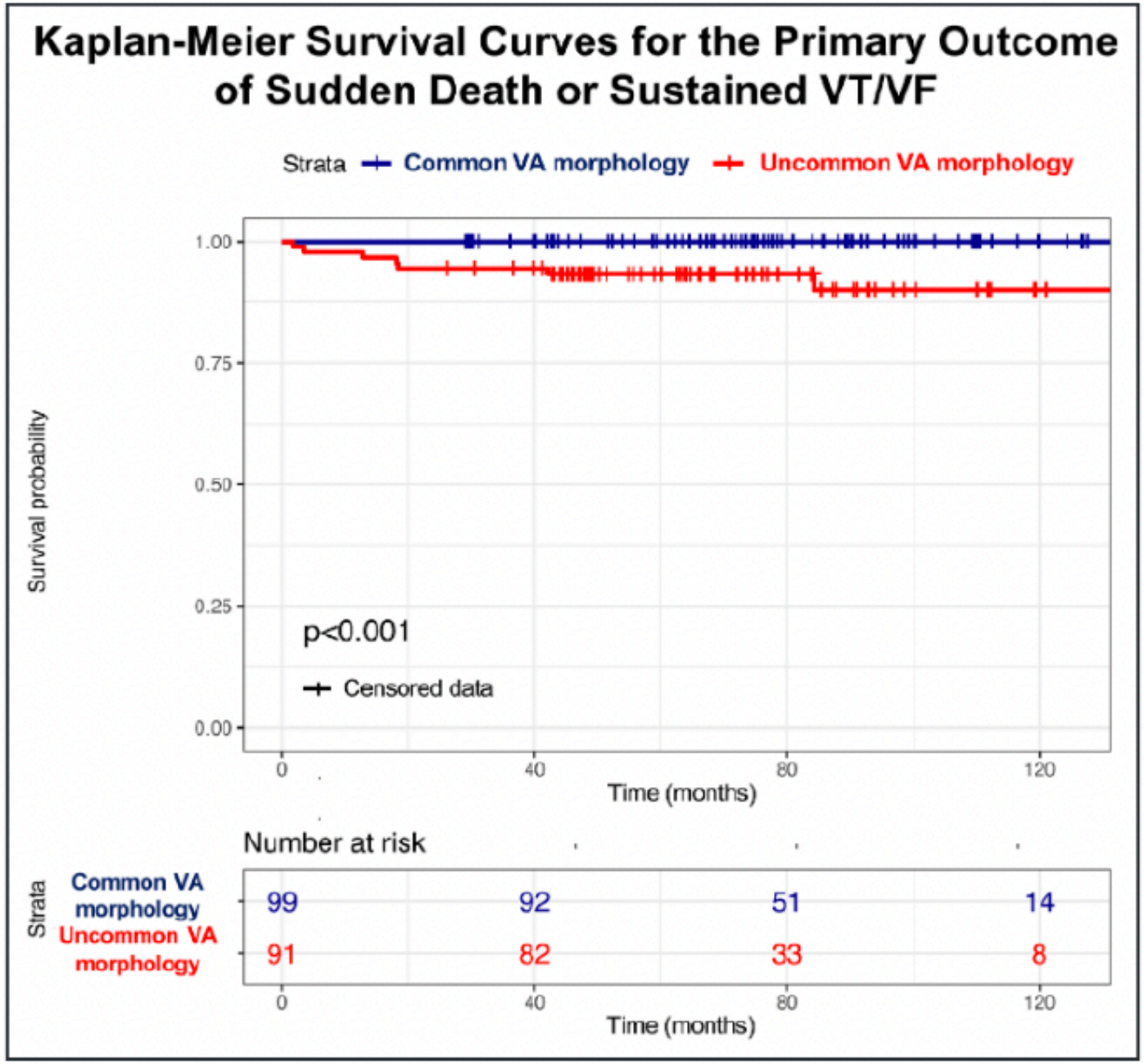
The primary end point was the **occurrence of sudden death or sustained VAs during long-term follow-up**

Stress Test/Echo Data

Exercise Stress Testing






Kaplan-Meier Survival Curves for the Primary Outcome of Sudden Death or Sustained VT/VF
Strata
Common VA morphology
Uncommon VA morphology
Survival probability
1.00
0.75
0.50
0.25
0.00
p<0.001
Censored data
0
40
80
120
Time (months)
Number at risk
Strata
Common VA morphology
Uncommon VA morphology
99
92
51
14
91
82
33
8
0
40
80
120
Time (months)

ESC European Society of Cardiology

Europace (2023) **25**, 1–10
https://doi.org/10.1093/europace/euad217

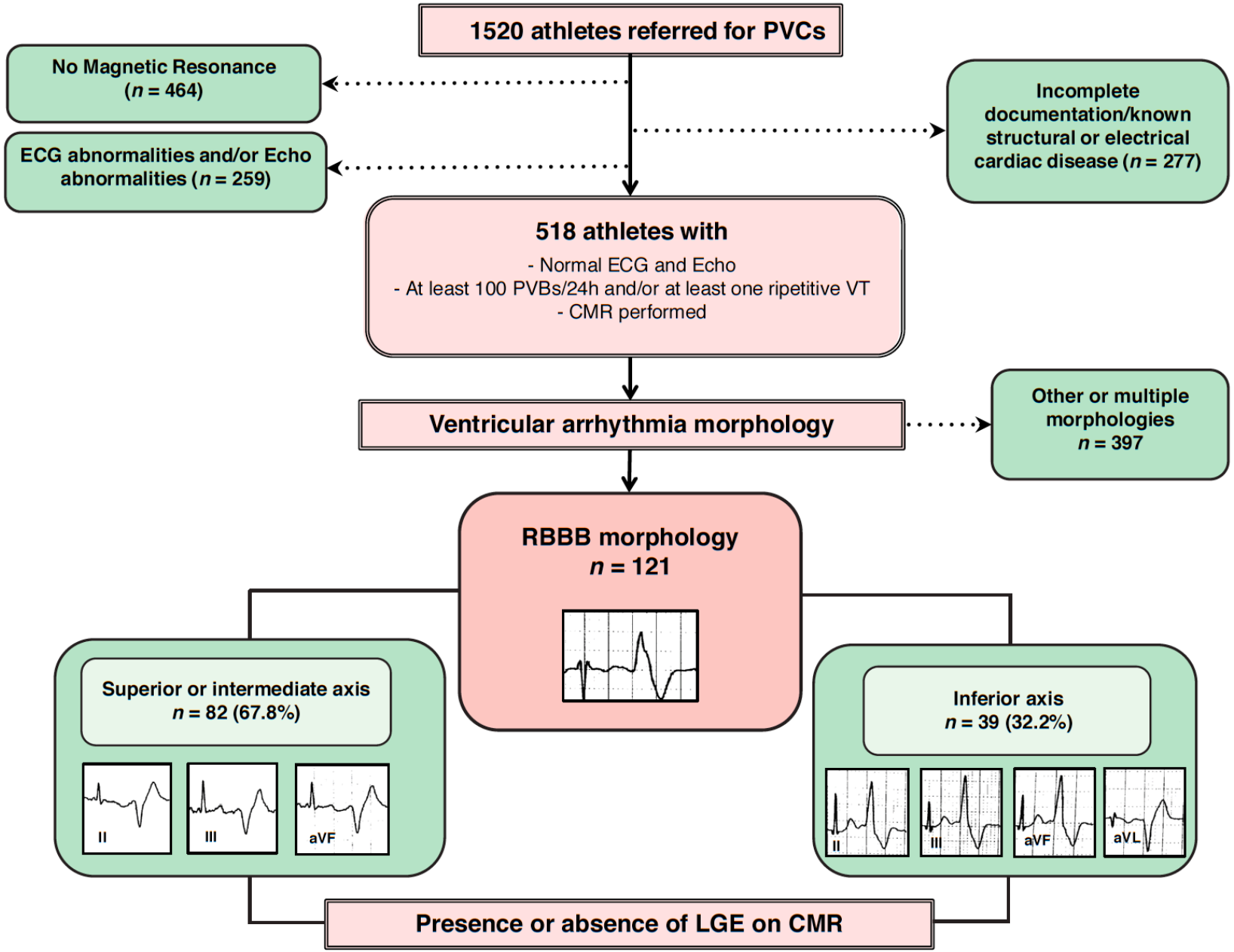
CLINICAL RESEARCH

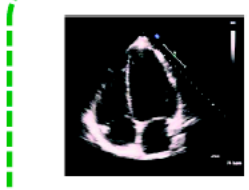
Electrocardiographic characteristics of right-bundle-branch-block premature ventricular complexes predicting absence of left ventricular scar in athletes with apparently structural normal heart

Leonardo Calò [1†], Germana Panattoni [1*†], Mario Tatangelo [1], Giulia Brunetti [2], Francesca Graziano [2], Luca Monzo [1,3], Maria Ludovica Danza [1], Elisa Fedele [1], Domenico Grieco [1], Cinzia Crescenzi [1], Marco Rebecchi[1], Alessandra Stazi [1], Edoardo Bressi [1], Ermenegildo De Ruvo[1], Paolo Golia [1], Fiorenzo Gaita [4], Domenico Corrado [2], and Alessandro Zorzi [2]

[1]Division of Cardiology, Policlinico Casilino, Via Casilina 1049, 00169, Rome, Italy; [2]Department of Cardiac, Thoracic and Vascular Sciences and Public Health, University of Padova, Italy; [3]Université de Lorraine INSERM, Centre d' Investigations Cliniques Plurithématique, Nancy, France; and [4]Division of Cardiology, Department of Medical Sciences, AOU Città della Salute e della Scienza Hospital, University of Turin, Italy

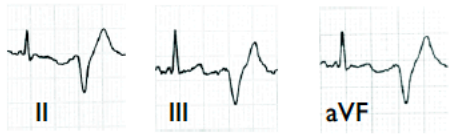
Received 3 May 2023; accepted after revision 29 June 2023; online publish-ahead-of-print 19 July 2023


1520 athletes referred for PVCs
No Magnetic Resonance
(n = 464)
ECG abnormalities and/or Echo
abnormalities (n = 259)
Incomplete
documentation/known
structural or electrical
cardiac disease (n = 277)
518 athletes with
- Normal ECG and Echo
- At least 100 PVBs/24h and/or at least one ripetitive VT
- CMR performed
Ventricular arrhythmia morphology
Other or multiple
morphologies
n = 397
RBBB morphology
n = 121
Superior or intermediate axis
n = 82 (67.8%)
II
III
aVF
Inferior axis
n = 39 (32.2%)
II
III
aVF
aVL
Presence or absence of LGE on CMR

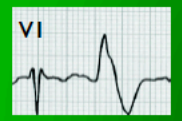


Absence of structural heart disease

Superior or intermediate axis
n = 82 (67.8%)



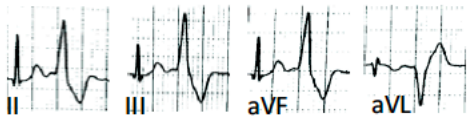
Frequent and apparently idiopathic PVCs with RBBB morphology
n = 121



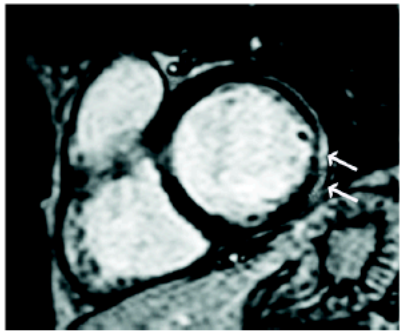


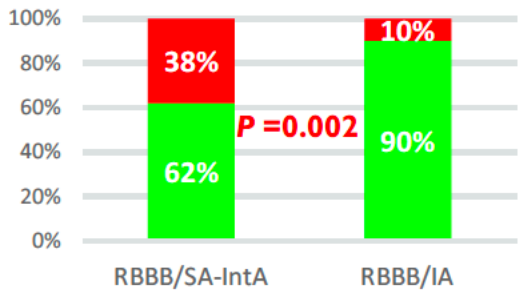
Fulfillment of contrast-enhanced CMR

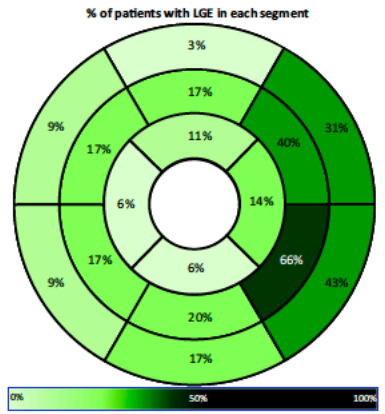
Inferior axis
n = 39 (32.2%)



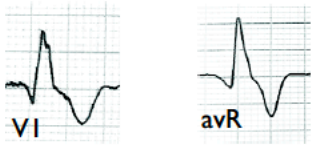
28.9% CMR Abnomalities





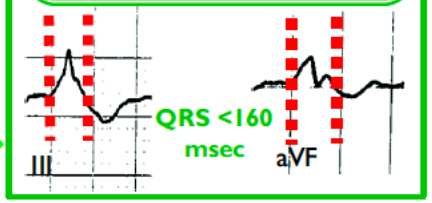


Superior or intermediate axis
LGE *n* = 31 (88.6%)



LGE absence correlates with presence of a qR pattern in V1 and aVR
P <0.0001

Inferior axis
LGE *n* = 4 (11.4%)



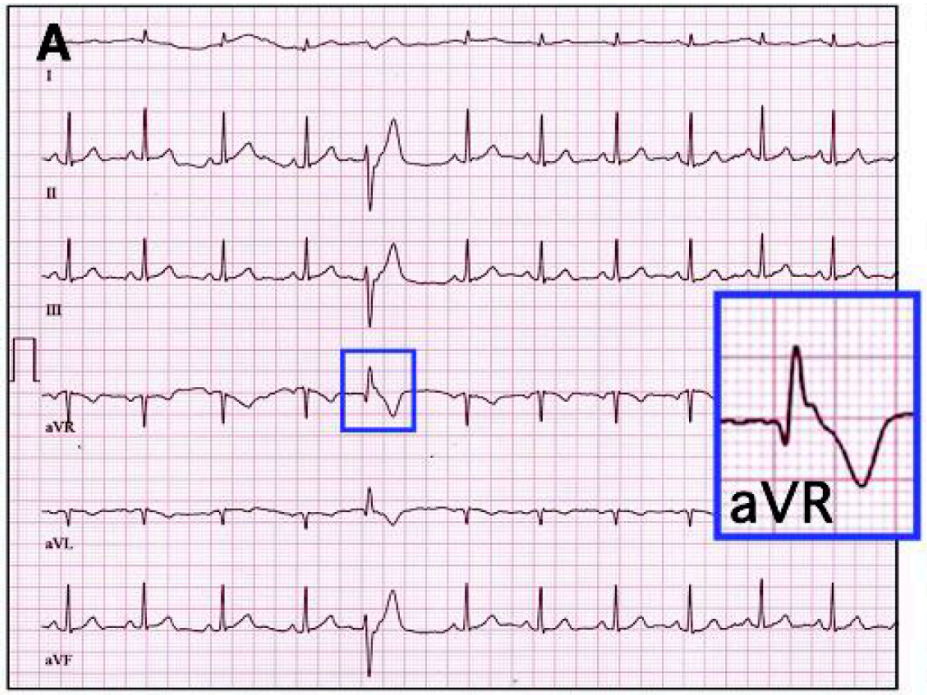
LGE absence correlates with a narrow QRS duration
P <0.0001

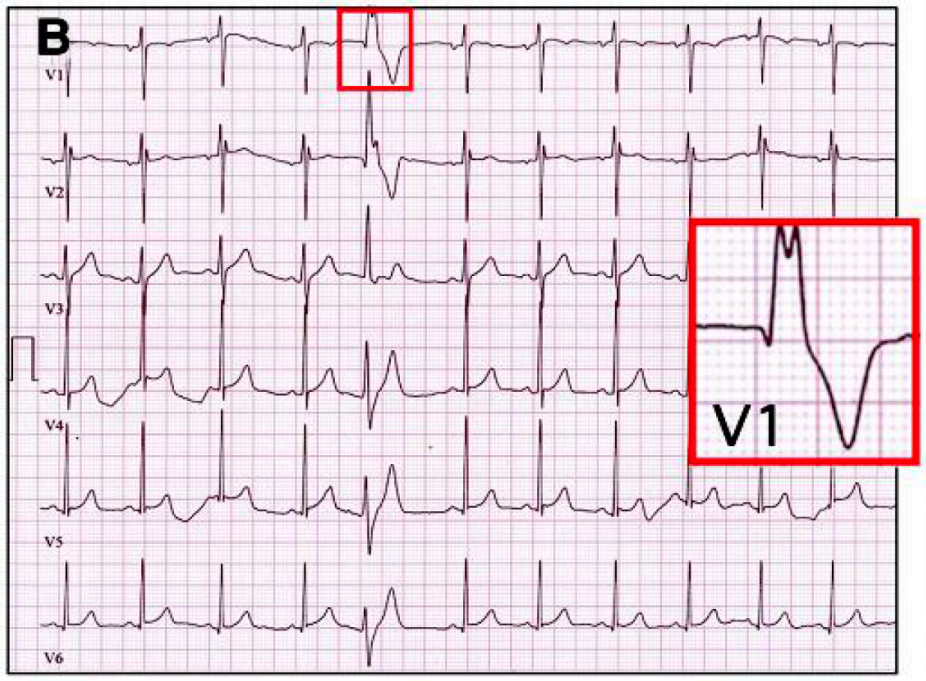
Table 1 ECG findings and CMR in patients with RBBB IA PVCs

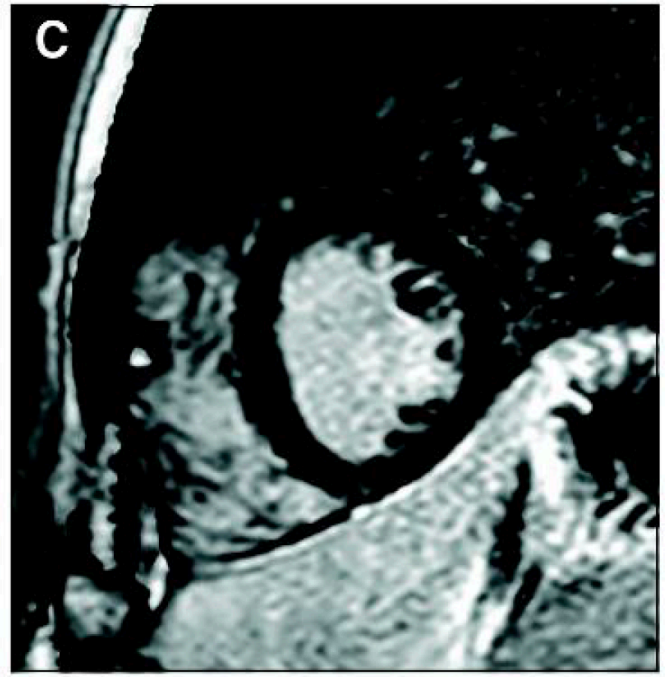
Variable	RBBB IA		*P*
	LGE + ***n* = 4**	**LGE −** ***n* = 35**	
QRS, msec	186.3 ± 24.9	144.2 ± 16.5	0.0001
QRS notching in one or more leads, *n* (%)	4 (100)	24 (68.6)	0.461
QRS ≥ 120 msec in lead I, *n* (%)	4 (100)	15 (42.9)	0.101
Maximal QRS duration >160 msec, *n* (%)	3 (75)	13 (37.1)	0.357
Intrinsicoid deflection >80 msec, *n* (%)	2 (50)	16 (45.7)	0.999
Initial slurring (pseudo-delta), *n* (%)	2 (50)	15 (42.8)	0.999

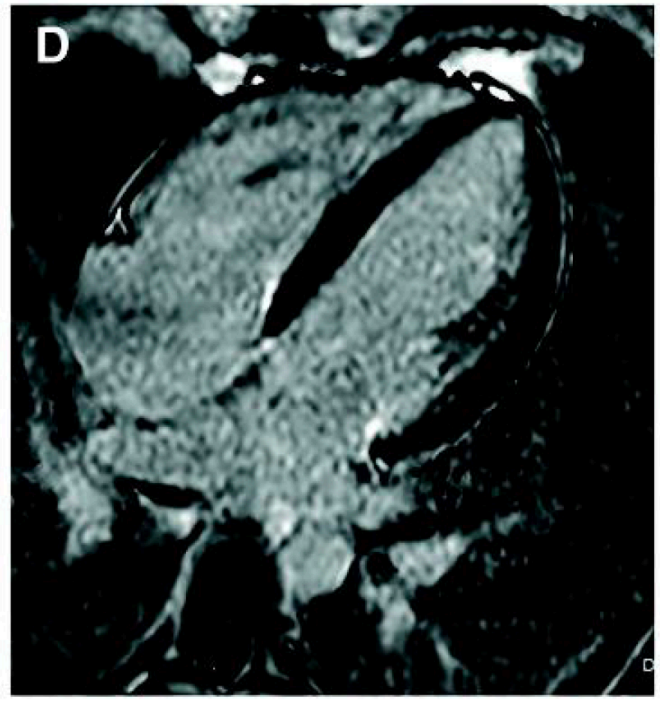
Table 2 ECG findings and CMR in patients with RBBB superior or intermediate axis PVCs

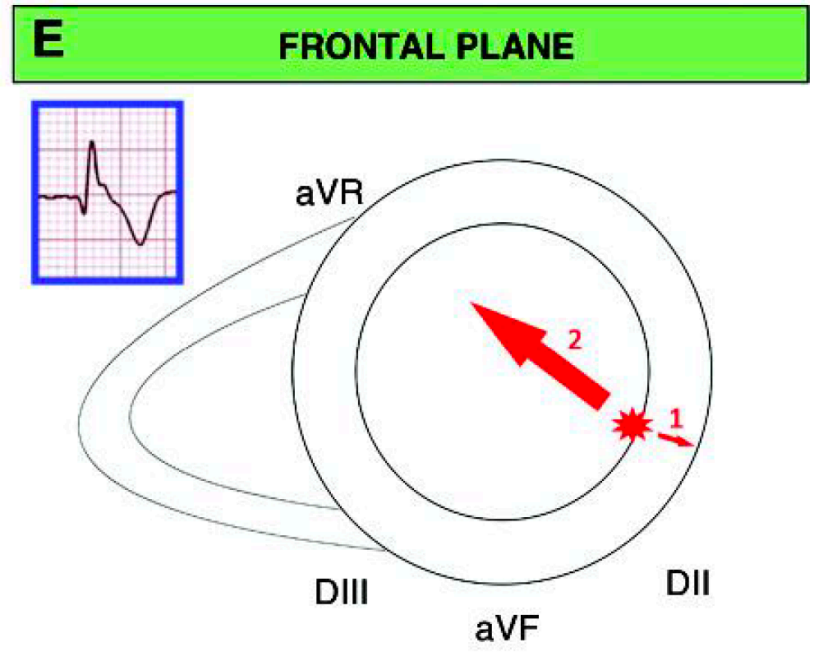
Variable	RBBB superior or intermediate axis		*P*
	LGE + *n* = 31	LGE − *n* = 51	
QRS, msec	139.5 ± 19.9	145.4 ± 16.4	0.150
QRS notching in one or more leads, *n* (%)	11 (35.5)	25 (49)	0.259
QRS ≥ 120 msec in lead I, *n* (%)	19 (61.3)	27 (52.9)	0.499
Maximal QRS duration >160 msec, *n* (%)	10 (32.3)	19 (37.3)	0.812
Intrinsicoid deflection >80 msec, *n* (%)	8 (25.8)	14 (27.5)	0.925
Initial slurring (pseudo-delta), *n* (%)	7 (22.6)	15 (29.4)	0.610
Q-wave in lead I, *n* (%)	10 (32.3)	8 (15.7)	0.101
qR morphology in lead V1, *n* (%)	2 (6.4)	27 (52.9)	<0.0001
qR morphology in lead aVR, *n* (%)	4 (12.9)	40 (78.4)	<0.0001
qR morphology in lead aVR and V1, *n* (%)	0 (0)	26 (51)	<0.0001
QS morphology in lead aVR, *n* (%)	0 (0)	0 (0)	1.000

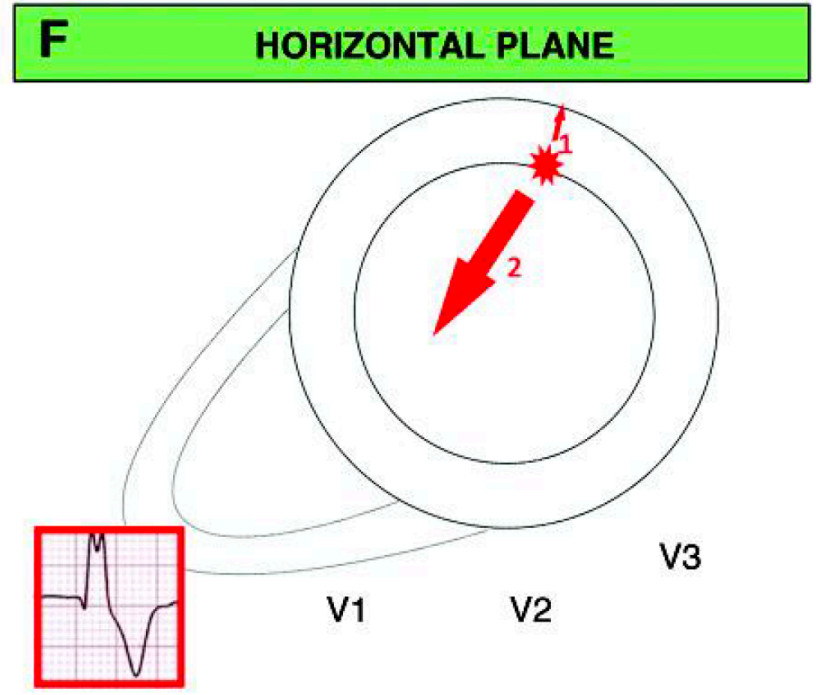

A
I
II
III
aVR
aVL
aVF
aVR

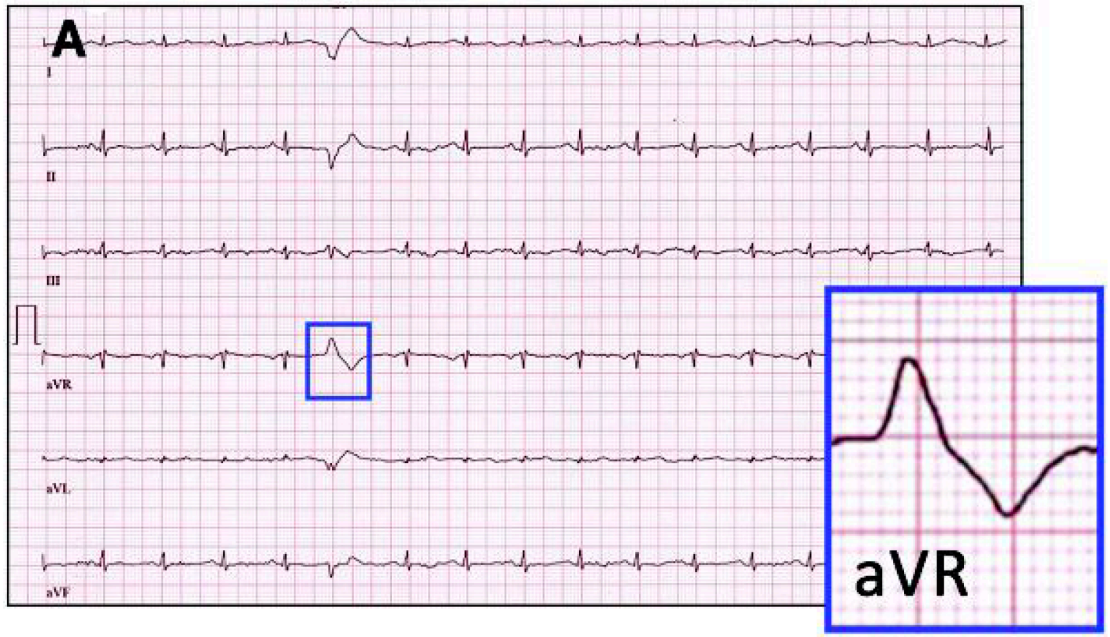

B
V1
V2
V3
V4
V5
V6
V1

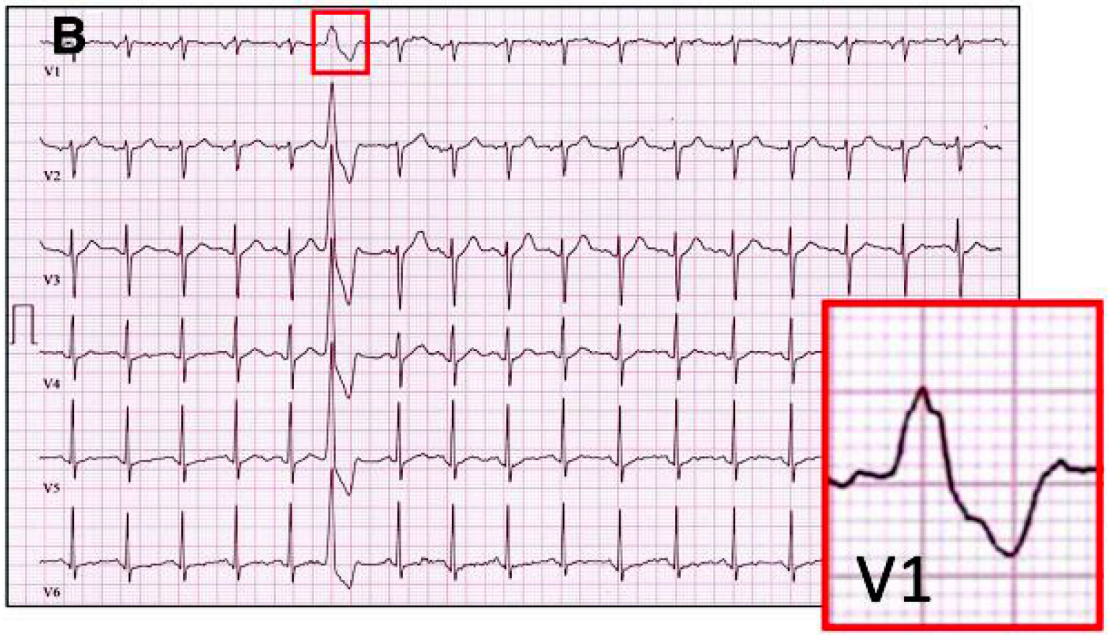

C

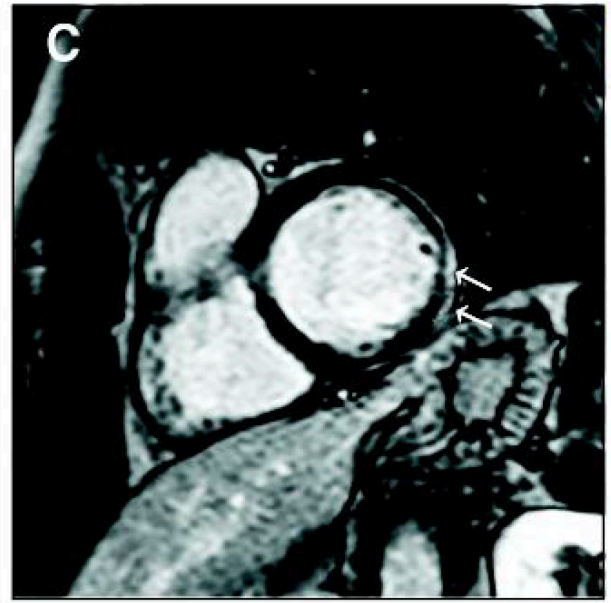

D

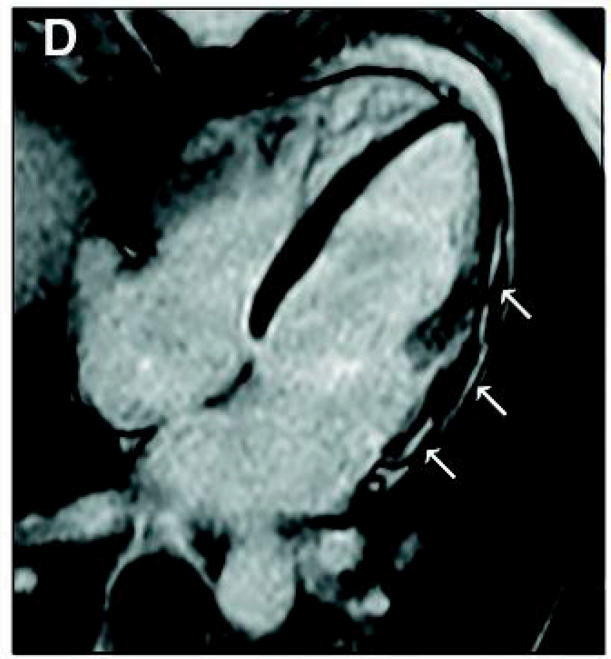

E
FRONTAL PLANE
aVR
2
1
DIII
DII
aVF

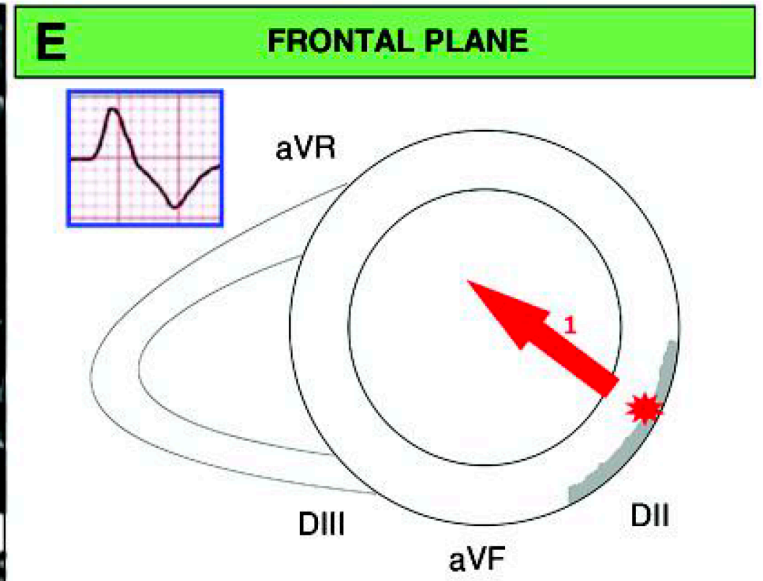

F
HORIZONTAL PLANE
1
2
V3
V1
V2

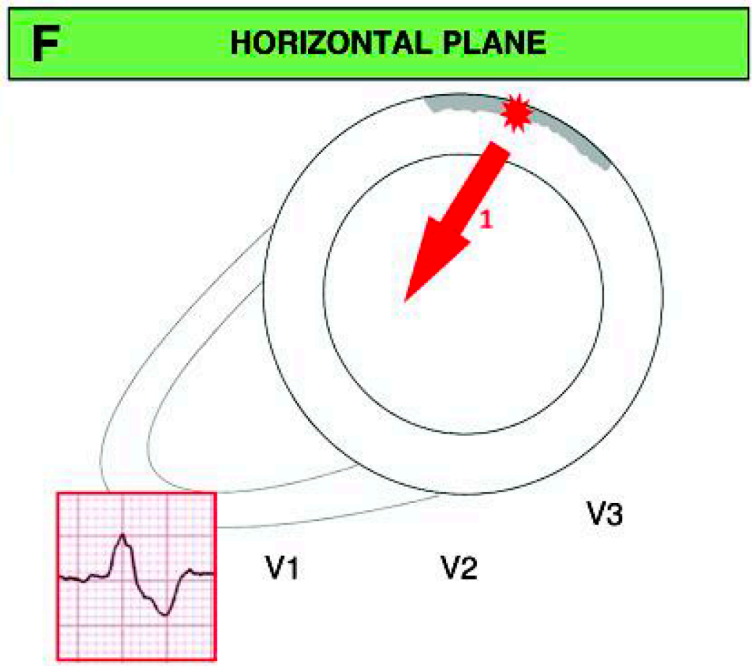

A
I
II
III
aVR
aVL
aVF
aVR

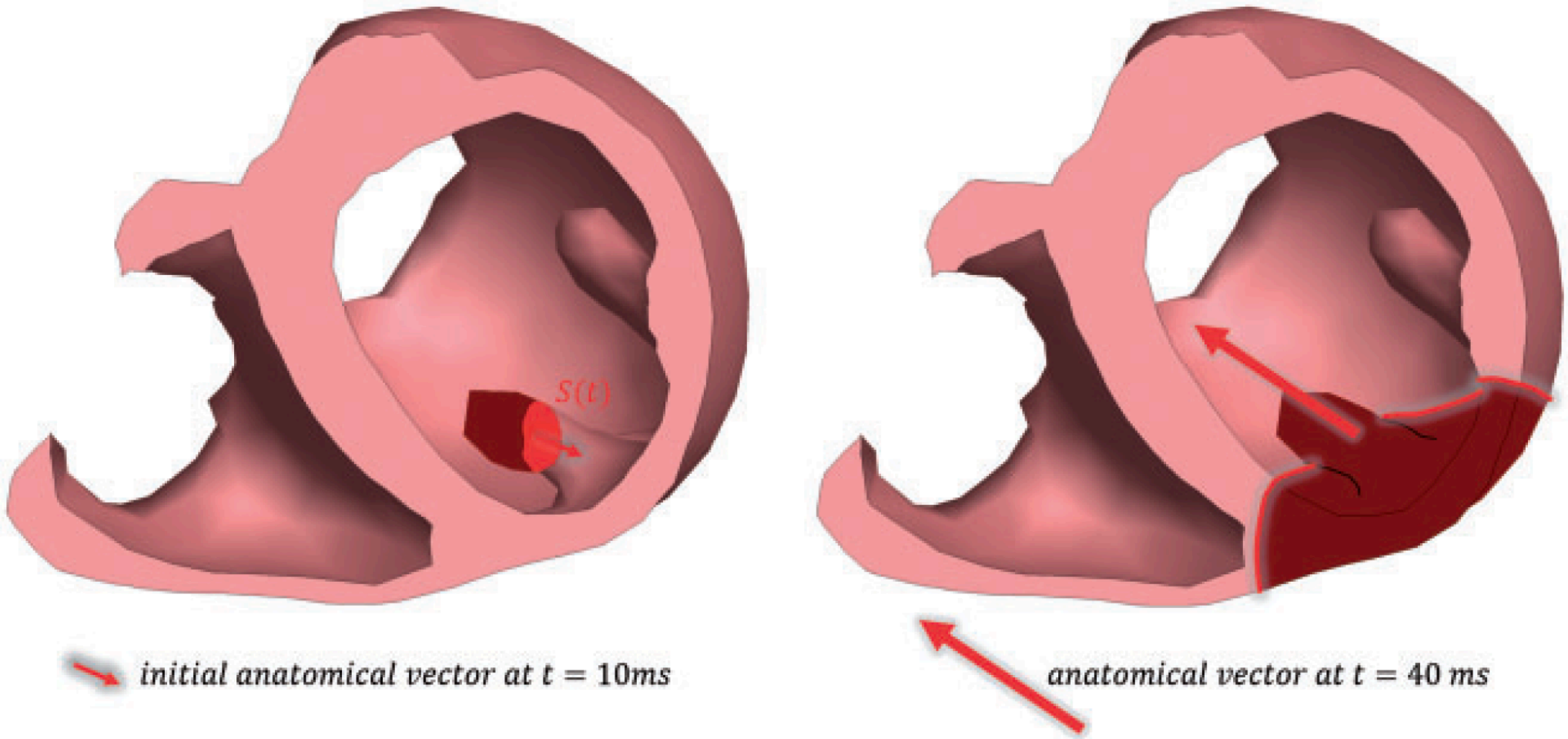

B
V1
V2
V3
V4
V5
V6
V1

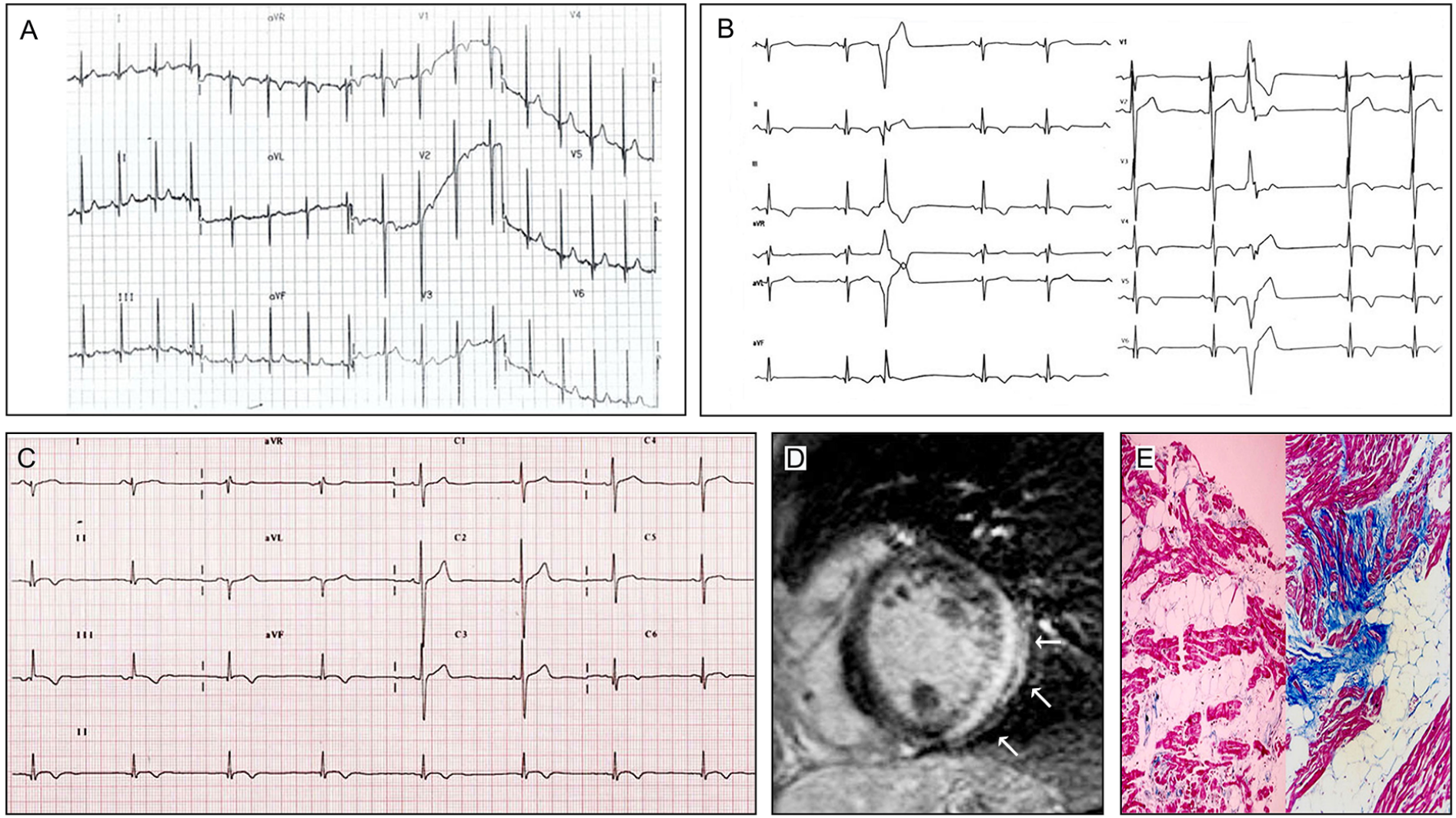

C


D


E
FRONTAL PLANE
aVR
1
DIII
DII
aVF


F
HORIZONTAL PLANE
1
V3
V1
V2


S(t)
initial anatomical vector at t = 10ms
anatomical vector at t = 40 ms


A
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
B
V1
II
V2
III
V3
aVR
V4
aVL
V5
aVF
V6
C
I
aVR
C1
C4
II
aVL
C2
C5
III
aVF
C3
C6
II
D
E

Left-Dominant Arrhythmogenic Cardiomyopathy With Heterozygous Mutations in *DSP* and *MYBPC3*

Sakamoto N. et al. Circ Cardiovasc Imaging. 2019;12:e008913

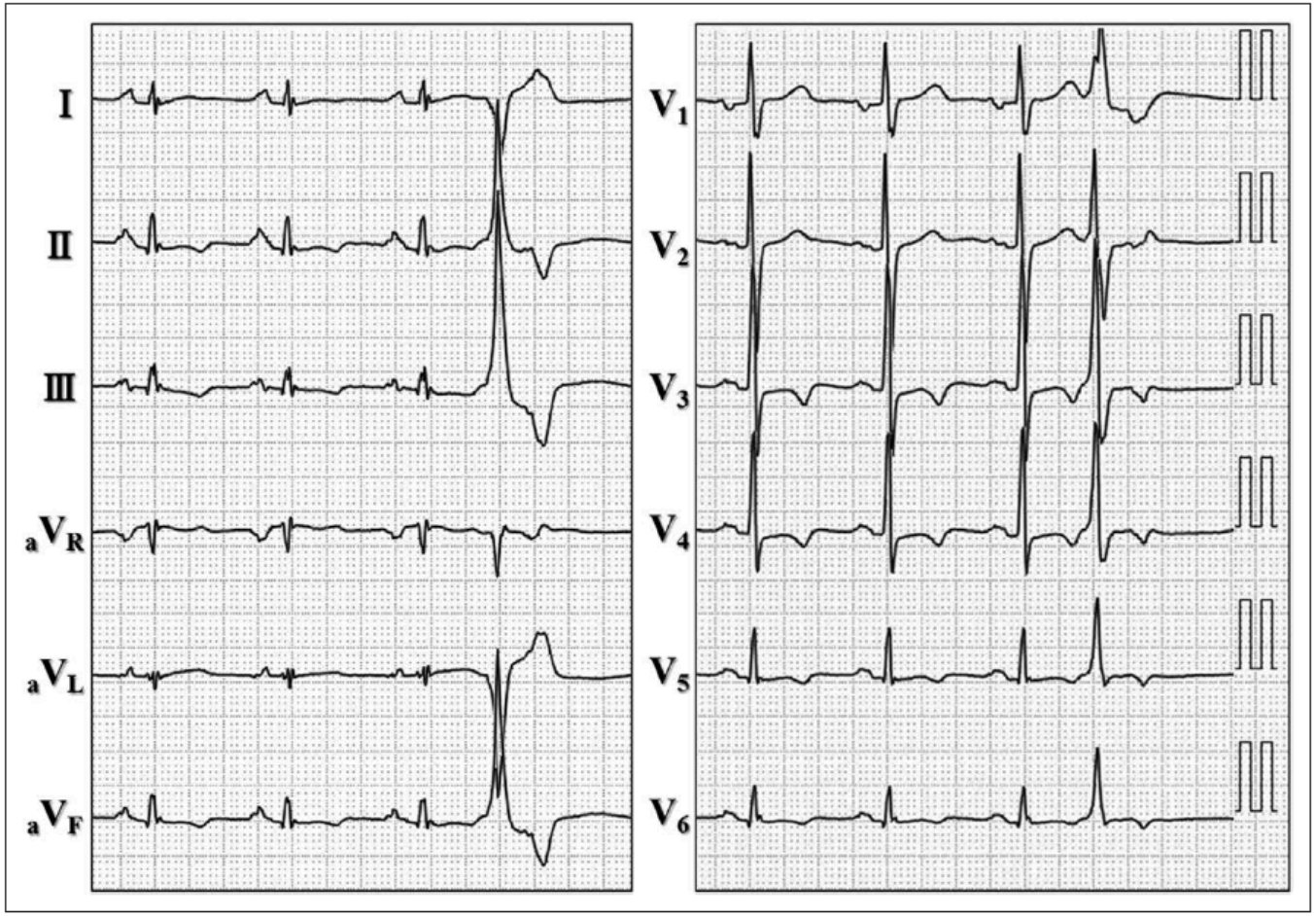
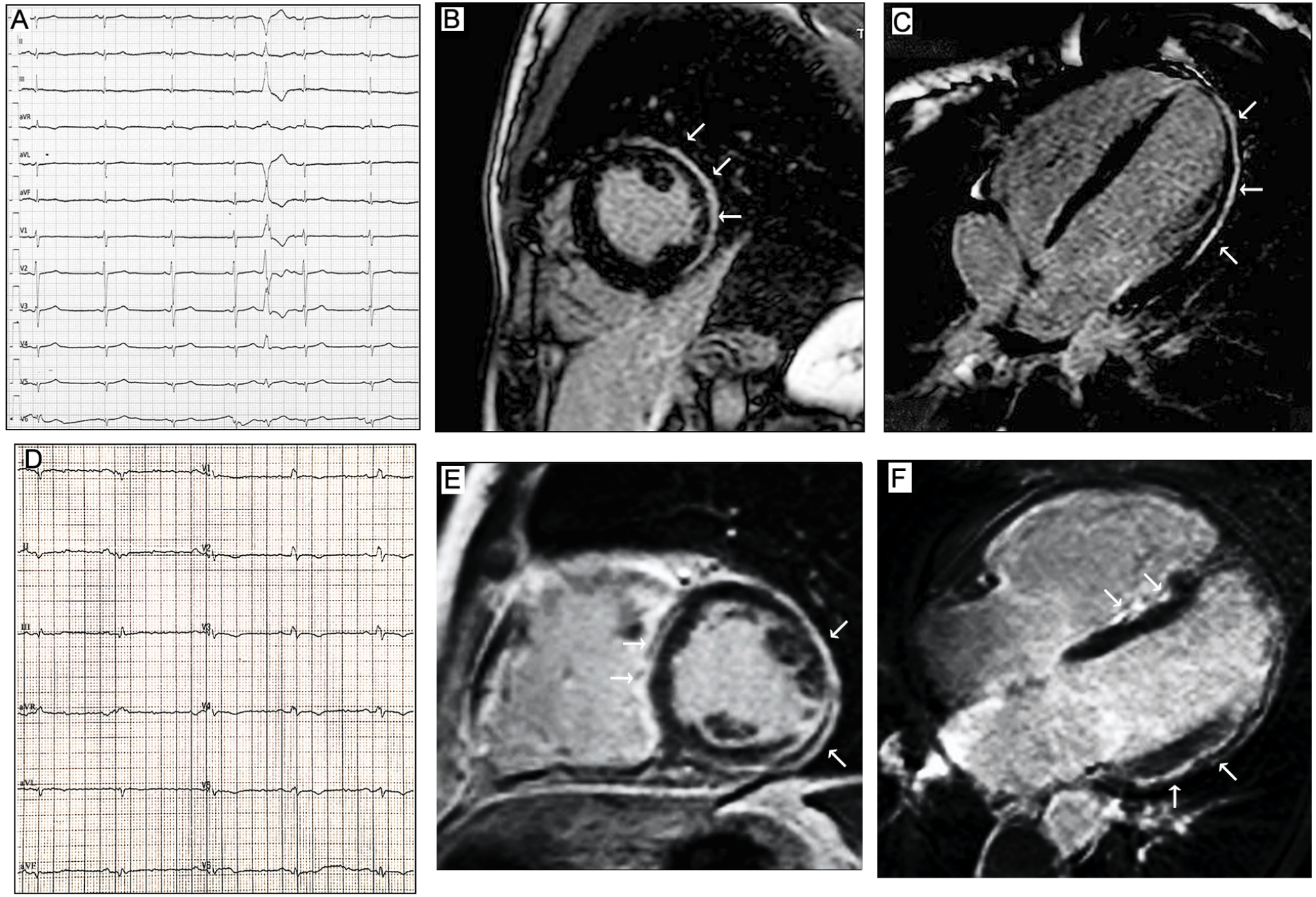
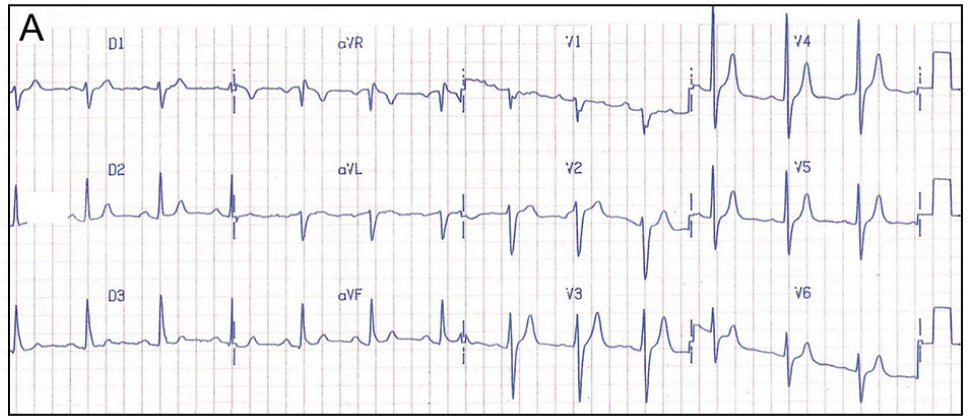
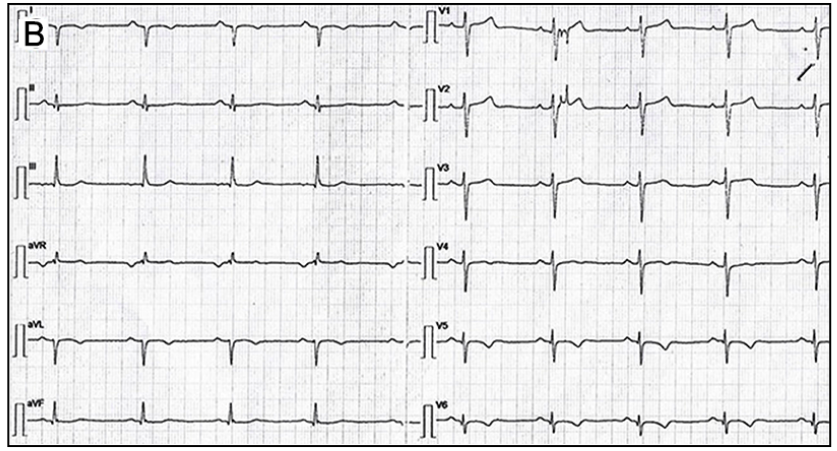


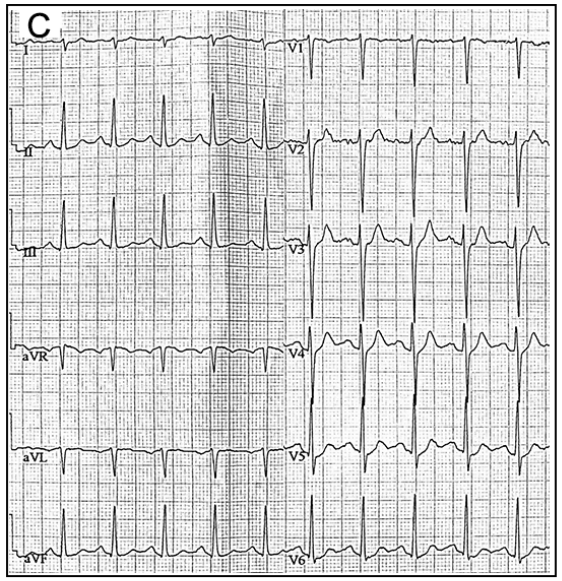
Figure 1. ECG showing T-wave inversion in the left-sided leads and a premature ventricular complex of left ventricular origin.

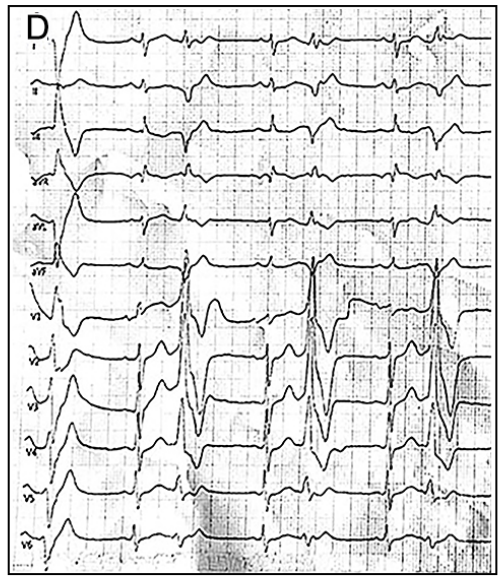
Pathogenic mutations in desmoplakin (c.4650delTG, p.V1551E fs74X) and myosin-binding protein C gene (c.2459G>A, p.R820Q)

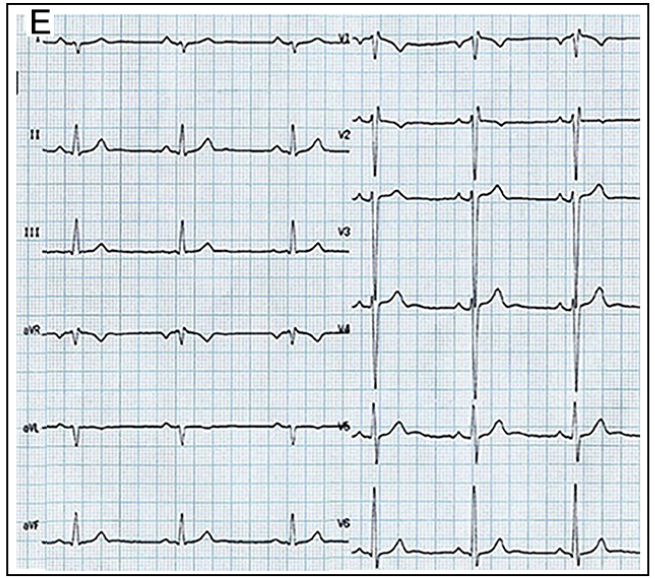

A
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
B
C
D
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
E
F


A
D1
aVR
V1
V4
D2
aVL
V2
V5
D3
aVF
V3
V6


B
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

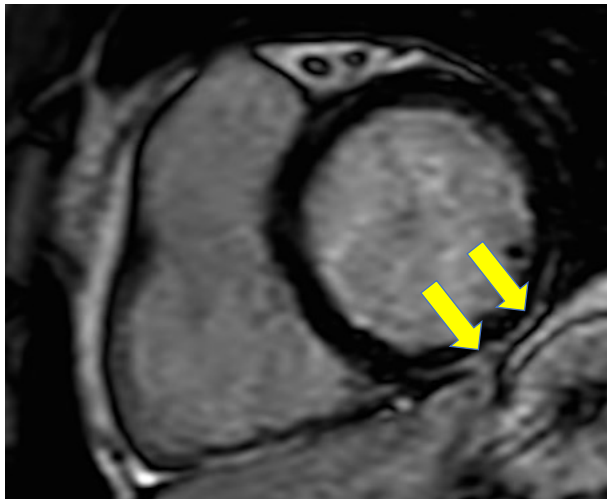

C
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

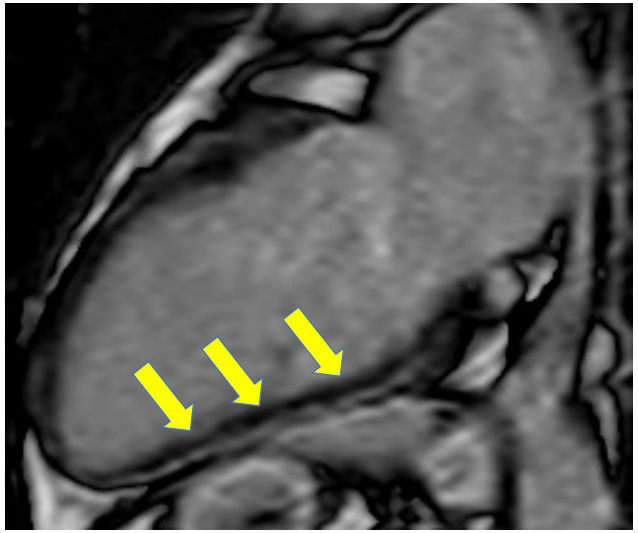

D


E
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

Alessandro, 32 anni

RMN cardiaca VS con volumi ai limiti alti, non anomalie della cinetica, **FE 53%**. **LGE subepicardico inferiore ed inferolaterale basale** , ventricolo destro nella norma.







Alessandro, 32 anni

TEST GENETICO*: variante probabilmente patogenetica gene DSP*

Minor

- Frequent (>500 per 24 h) or exercise-induced ventricular extrasystoles with a RBBB morphology or multiple RBBB morphologies (excluding the "fascicular pattern")
- Non-sustained or sustained ventricular tachycardia with a RBBB morphology (excluding the "fascicular pattern")
- History of cardiac arrest due to ventricular fibrillation or sustained ventricular tachycardia of unknown morphology

Minor

- LV LGE (subepicardial or midmyocardial stria pattern) of 1 or 2 Bull's Eye segment(s) (in 2 orthogonal views) of the free wall, septum, or both (excluding patchy, focal or septal junctional LGE**)

Major

- Low QRS voltages (<0.5 mV peak to peak) in all limb leads in the absence of other causes (e.g. cardiac amyloidosis, obesity, emphysema, or pericardial effusion)

Minor

- Identification of a likely-pathogenic ACM-gene variant in the patient under evaluation
- History of ACM in a first-degree relative in whom it is not possible or practical to determine whether the
- Premature sudden death (<35 years of age) due to suspected ACM in a first-degree relative
- ACM confirmed pathologically or by diagnostic criteria in second-degree relative

major or minor structural (tissue-characterization) **LV criterion**

YES

Consider the total number of criteria from **only** the left ventricle

1 major *or* 2 minor	1 major + 1 minor *or* 3 minor	2 major *or* 1 major + 2 minor *or* 4 minor
POSSIBLE ALVC	BORDERLINE ALVC	DEFINITE ALVC

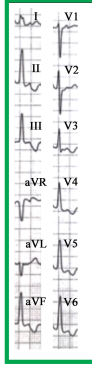
DIAGNOSI DEFINITIVA DI CARDIOMIOPATIA ARITMOGENA A **DOMINANZA SINISTRA**

Posto in terapia con Nadololo.

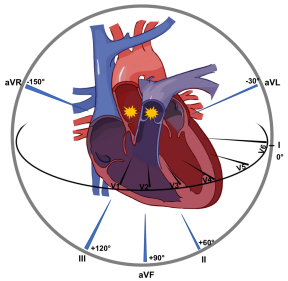
Restrizione dall'attività sportiva.

Regolare follow-up.

LBBB inferior axis



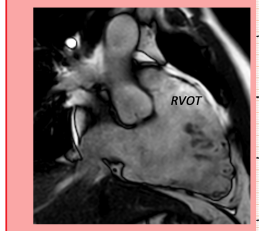
- Outflow tract origin
- Sensitive to adenosine
- Frequently elevated 24-h PVC burden
- Generally suppressed during exercise

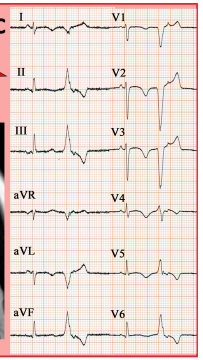


DISCRIMINATE FOR PVC RELATED TO ARVC

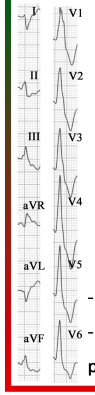
Hoffmayer et al [7]

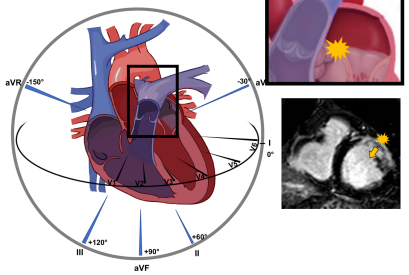
Novak et al [2] *(Table 1)*





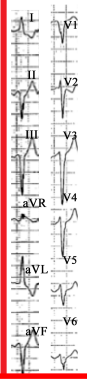
RBBB inferior axis

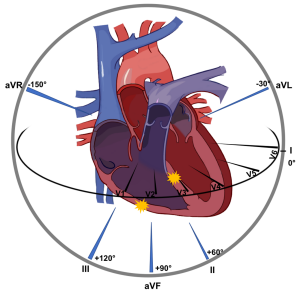




- Anterior mitral anulus/LVOT most common origin
- A relatively narrow QRS of PVCs could predict the absence of LGE *

LBBB superior/intermediate axis

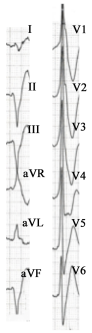


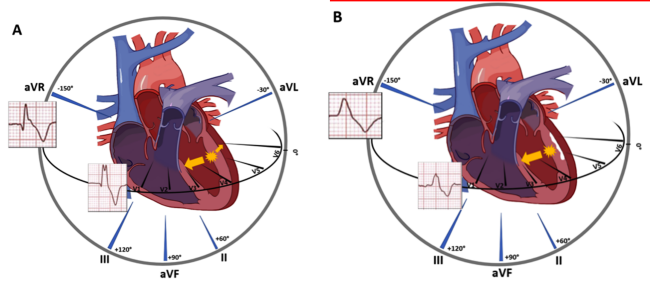


- Possible origin from the free wall of the right ventricle and septum

PVCs without an infundibular pattern are more likely to be associated with an underlying cardiac substrate

RBBB superior/intermediate axis







- PVCs with RBBB/superior axis morphology are frequently related to the precence of LGE on the LV lateral/posterior wall
- A contemporary precence of a qR pattern in lead V1 and aVR has been identified as predictors for absence of LGE *

**Calò et al* [8]

Calò L et al. E Heart J 2024

Case 3

#CVP: 4 Ø(FC): 139bpm max(FC): 139bpm Durata: 2" Attivazione: ESV

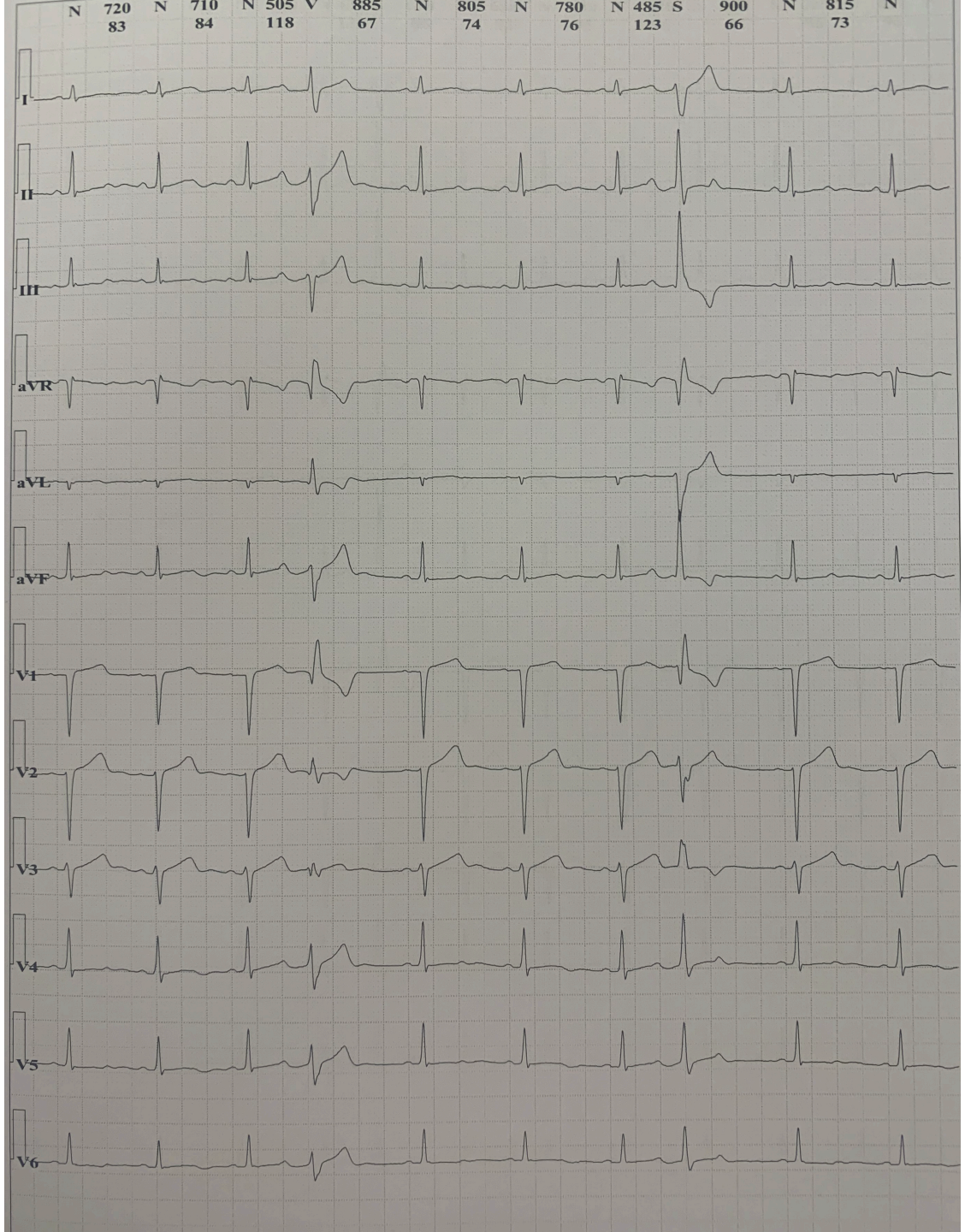


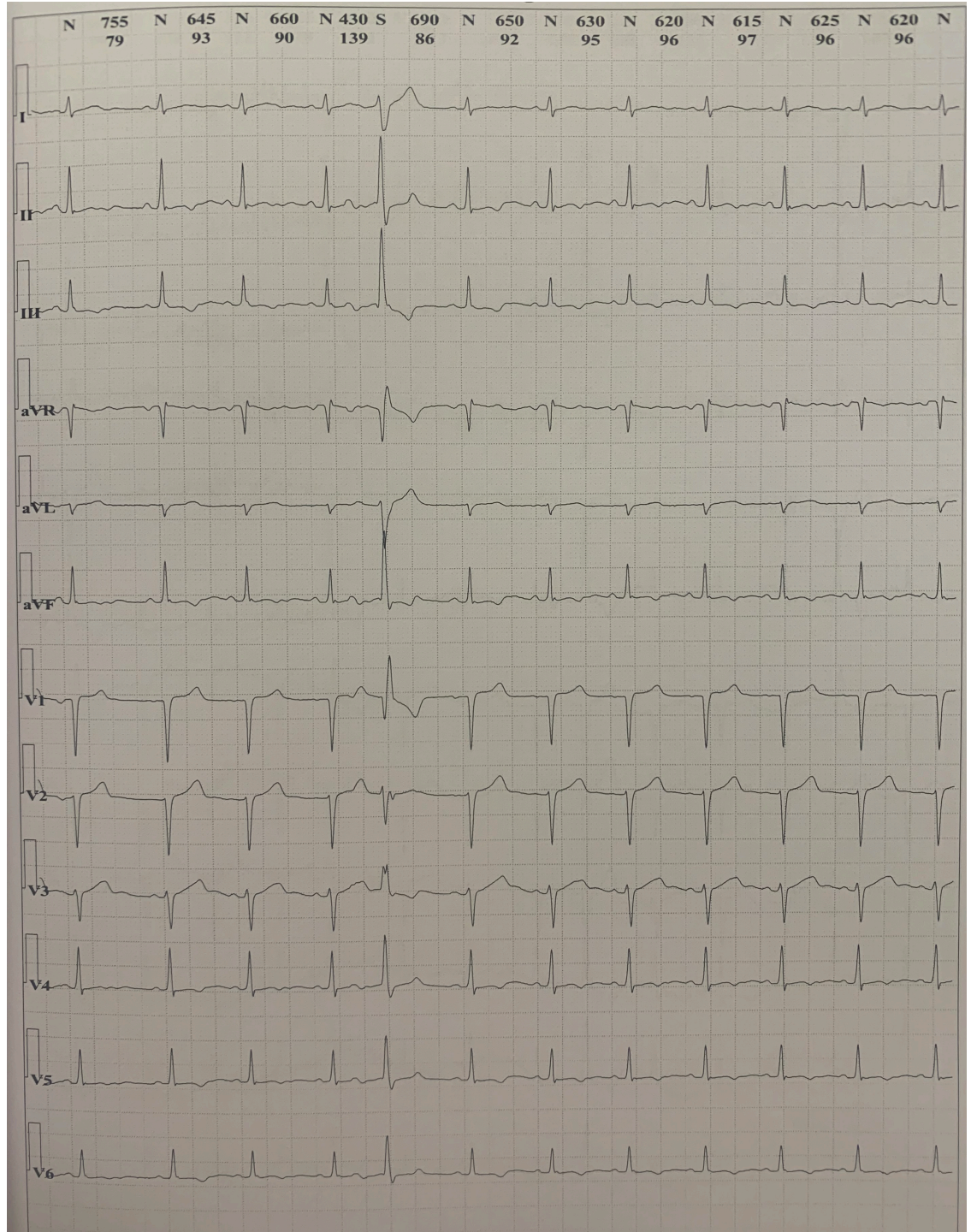
02.12.2022 04:25 (1") Tachicardia ventricolare

#CVP: 2 Ø(FC): 88bpm max(FC): 88bpm Durata: 1" Attivazione: ESV



Case 11


N 720 83
N 710 84
N 505 118
V 885 67
N 805 74
N 780 76
N 485 123
S 900 66
N 815 73
N
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

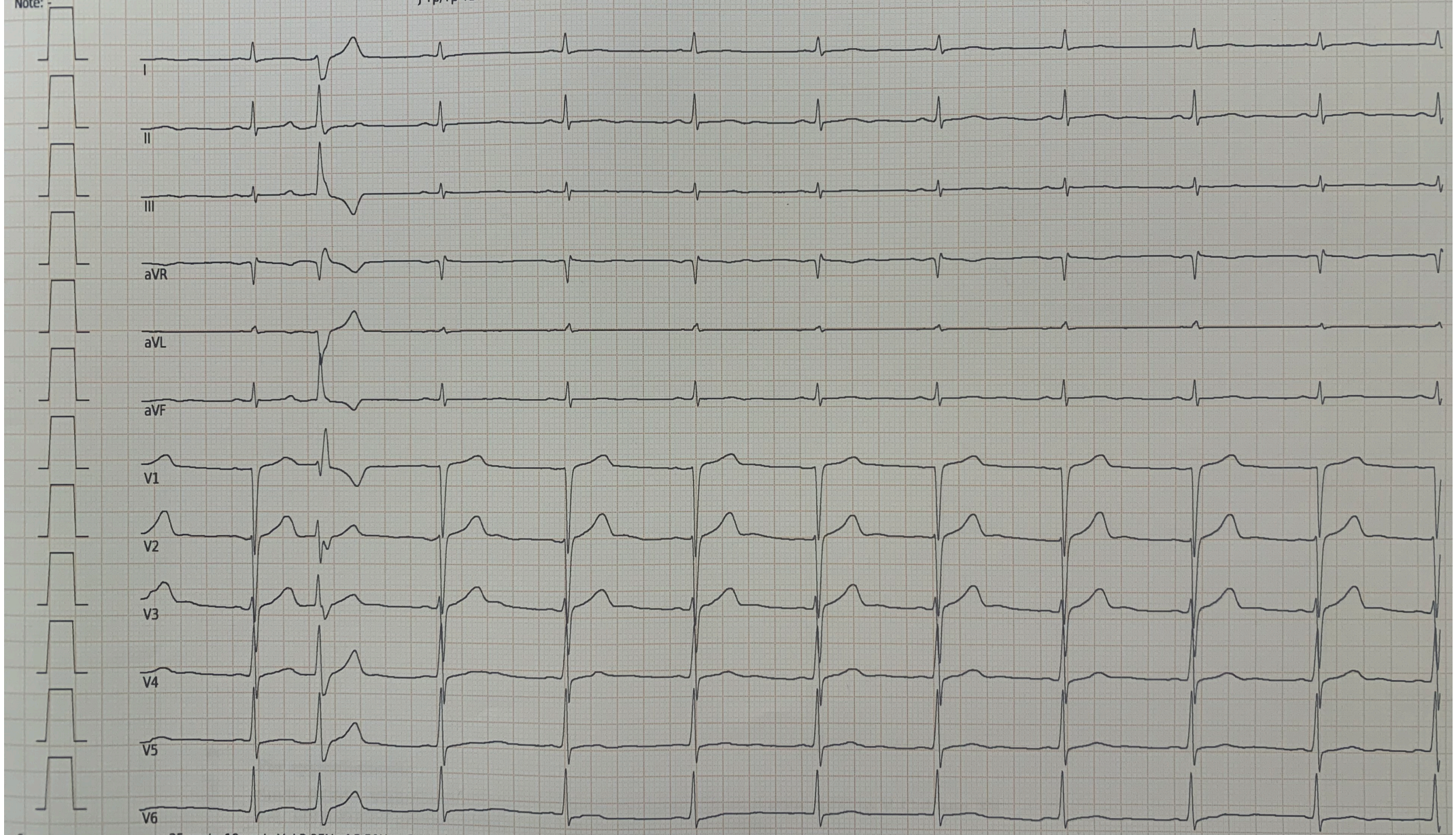

N 755 79
N 645 93
N 660 90
N 430 139
S 690 86
N 650 92
N 630 95
N 620 96
N 615 97
N 625 96
N 620 96
N
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

Di LUZIO^FEDERICO, -
Maschio 05/04/2001 (21 aa) Sconosciuto
Altezza:-- cm Peso:-- kg PA: 0/0 mmHg

Med.:
Tecnico:
Note: -

FC:	65 bpm (910ms)	R_{V5-6}/S_{V1}:	1.36/1.67 mV
PR:	148 ms	Sok-Lyon:	3.03 mV
QRS:	94 ms	Assi:	46/55/55 °
QT/QTcH:	410/414 ms		
QTcB/QTcF:	417/415 ms		
J-Tp/Tp-Te	208/108 ms		

REPORT NON CONFERMATO

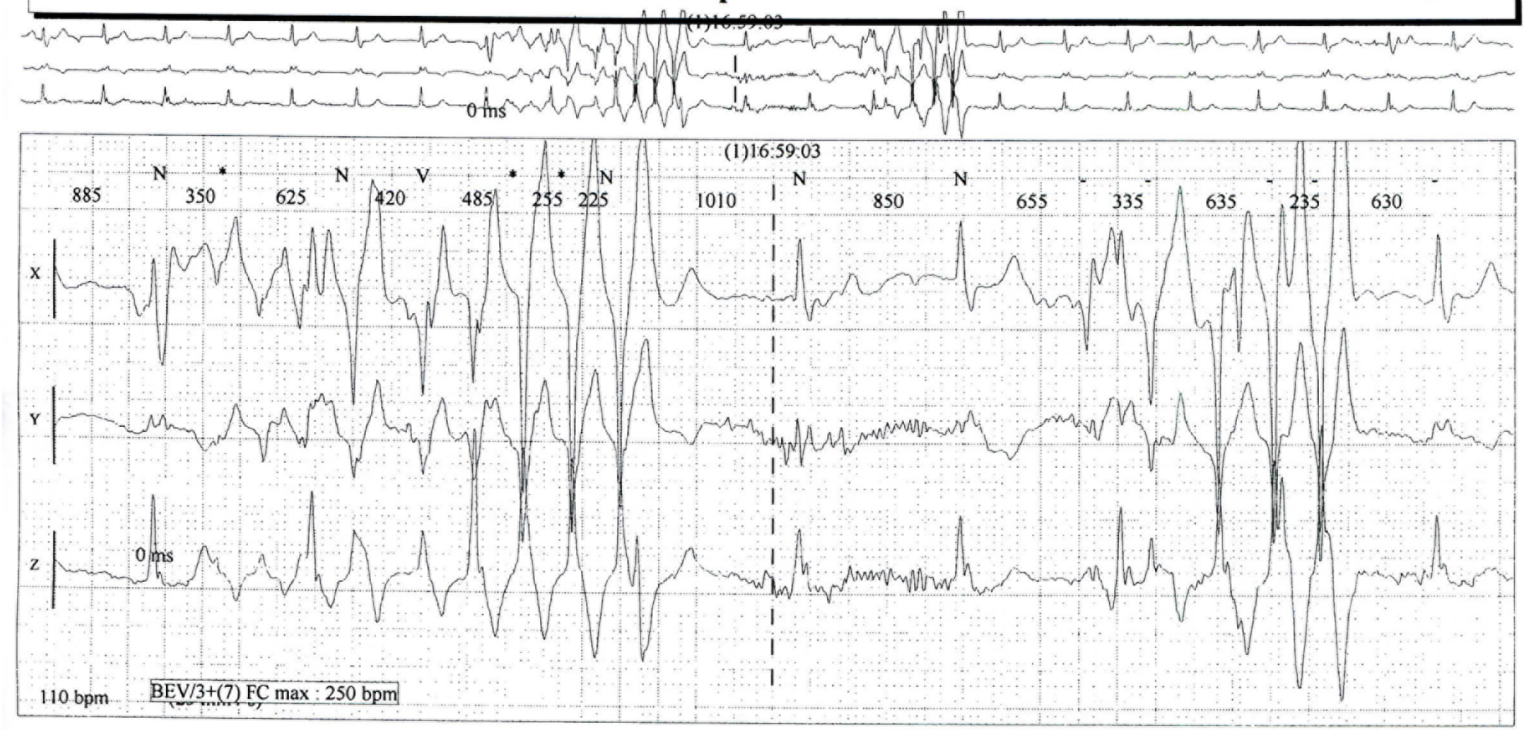


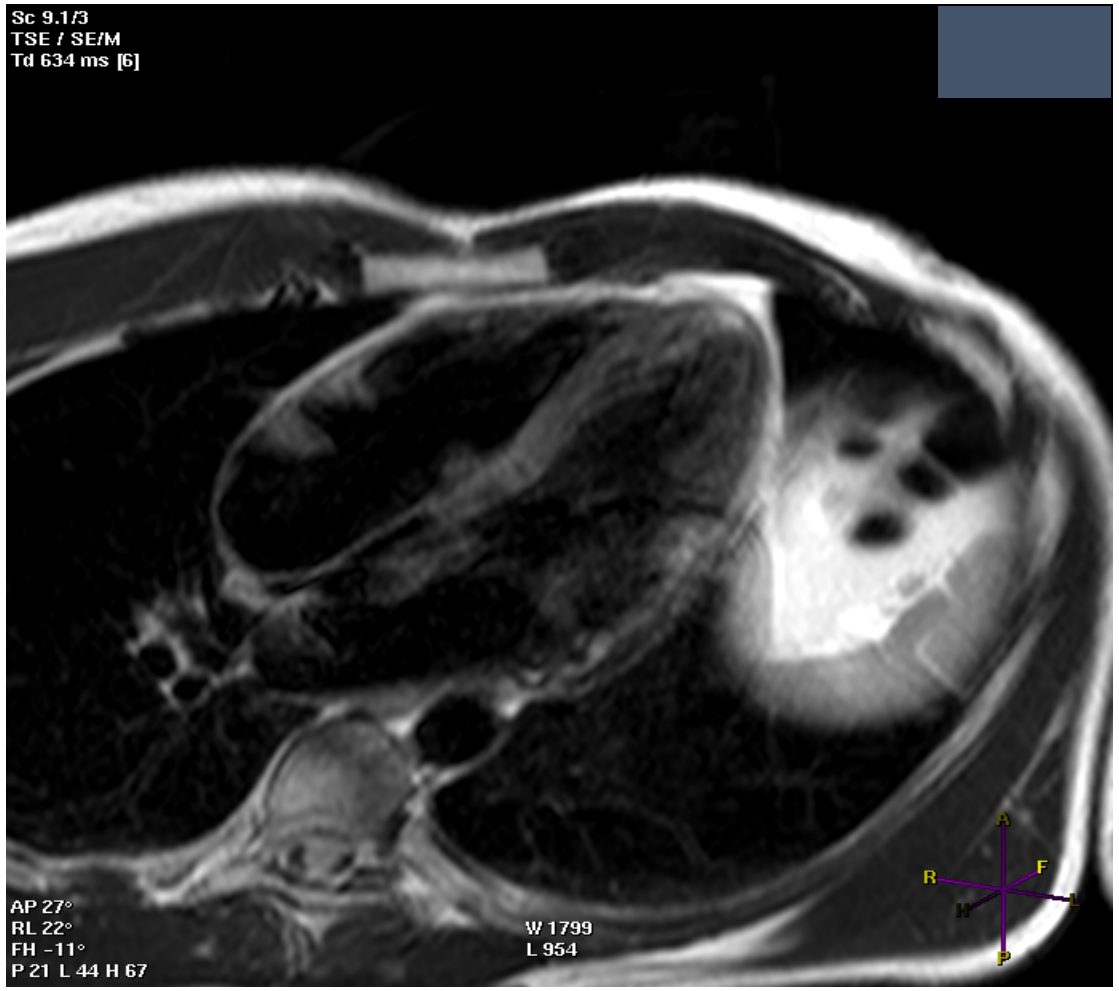
Rep.:

25mm/s 10mm/mV LP:25Hz AC:50Hz Cardioline ECG200+ v.2.30.13975

Case 20

Stampa Schermo **06/10/2013**

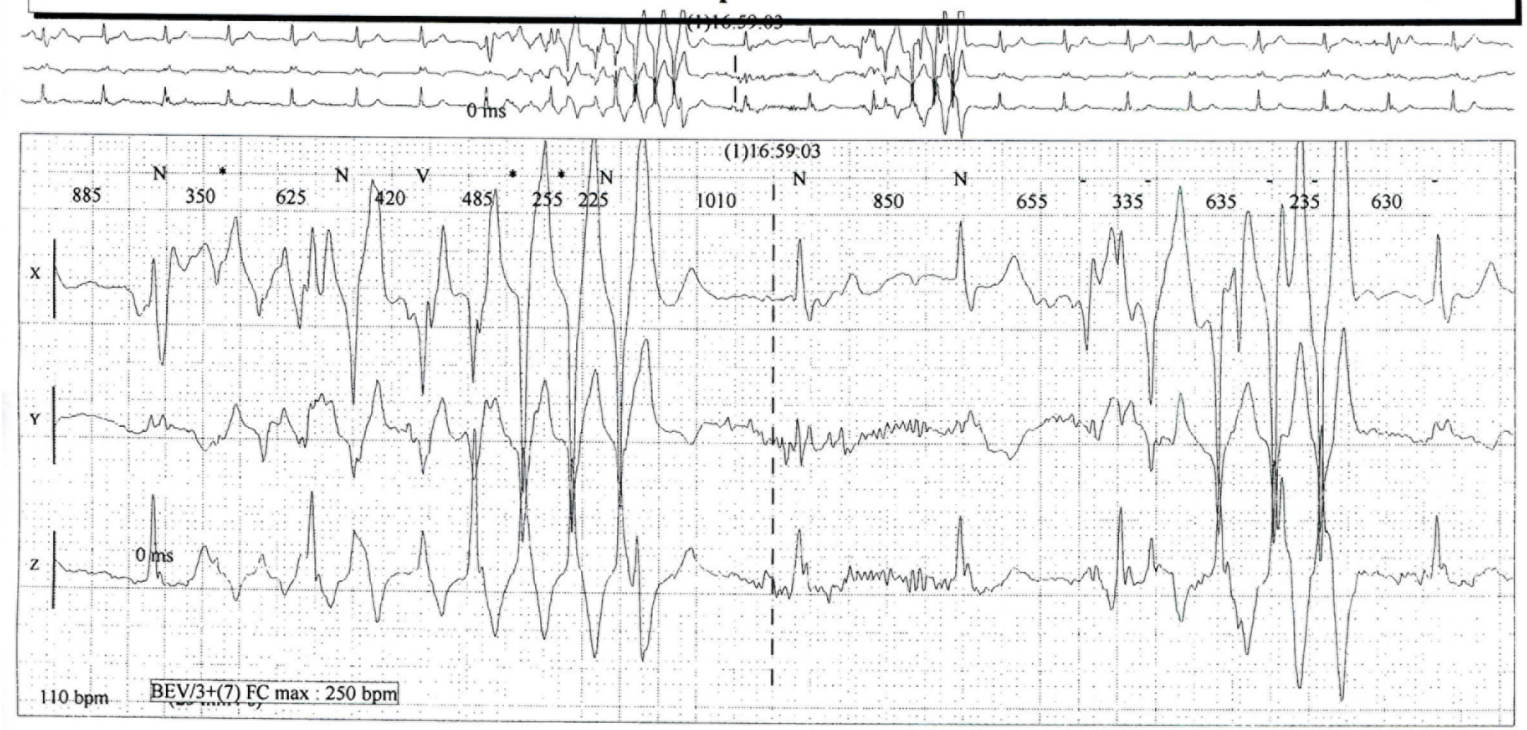




MRI absence of heart disease

EPS no inducibility of arrhythmias
No low voltage areas during electroanatomical mapping

Stampa Schermo **06/10/2013**

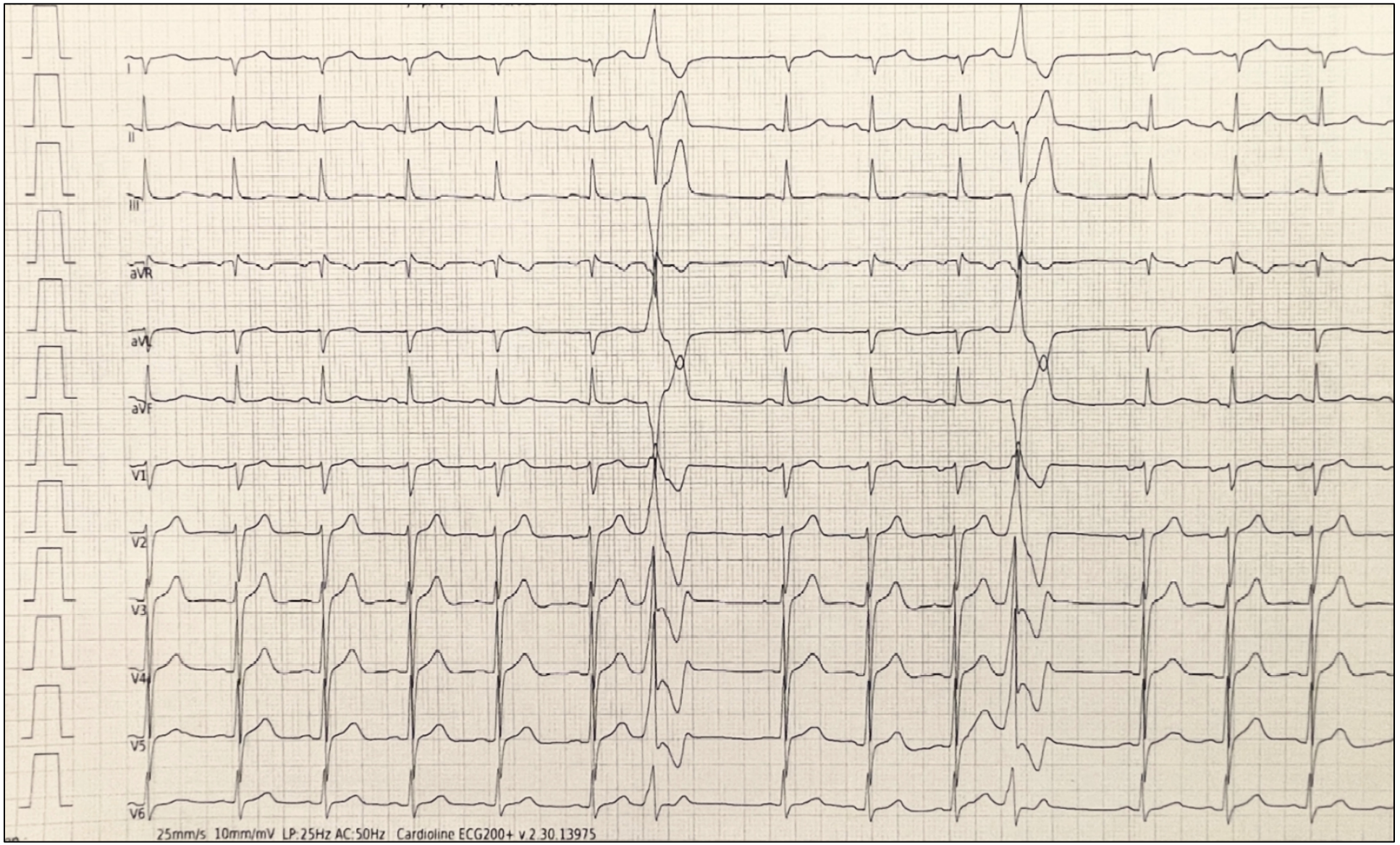


Caso 4.

- Marco, 23 anni
- Sportivo agonista (Calcio)
- Storia negativa familiare per MCI/Cardiomiopatie
- Asintomatico
- Accertamenti per idoneità medico-sportiva

Caso 4. Marco

L'ECG DI MARCO



Caso 4. Marco

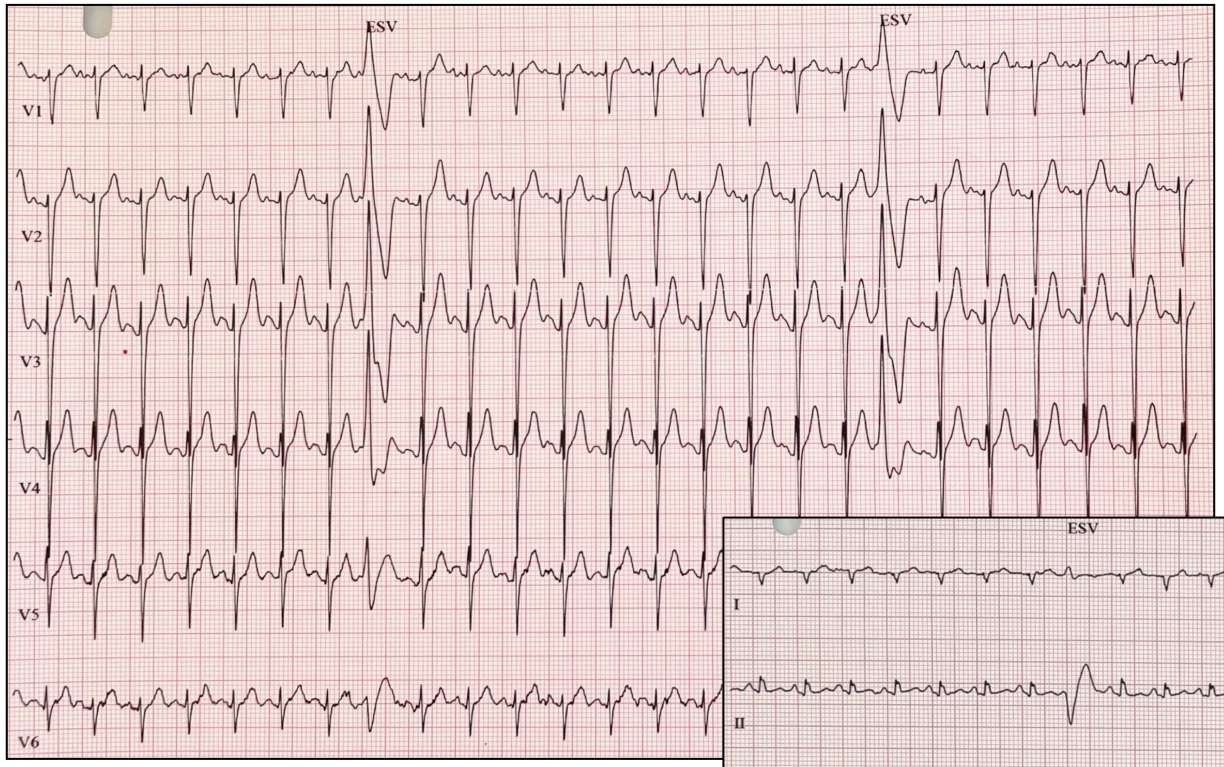
GLI ACCERTAMENTI STRUMENTALI DI MARCO

- *EcocardiogrammaColorDoppler*: ventricolo sinistro di normali dimensioni, volumi, spessori e funzione. Non deficit della cinesi. Ventricolo destro nella norma

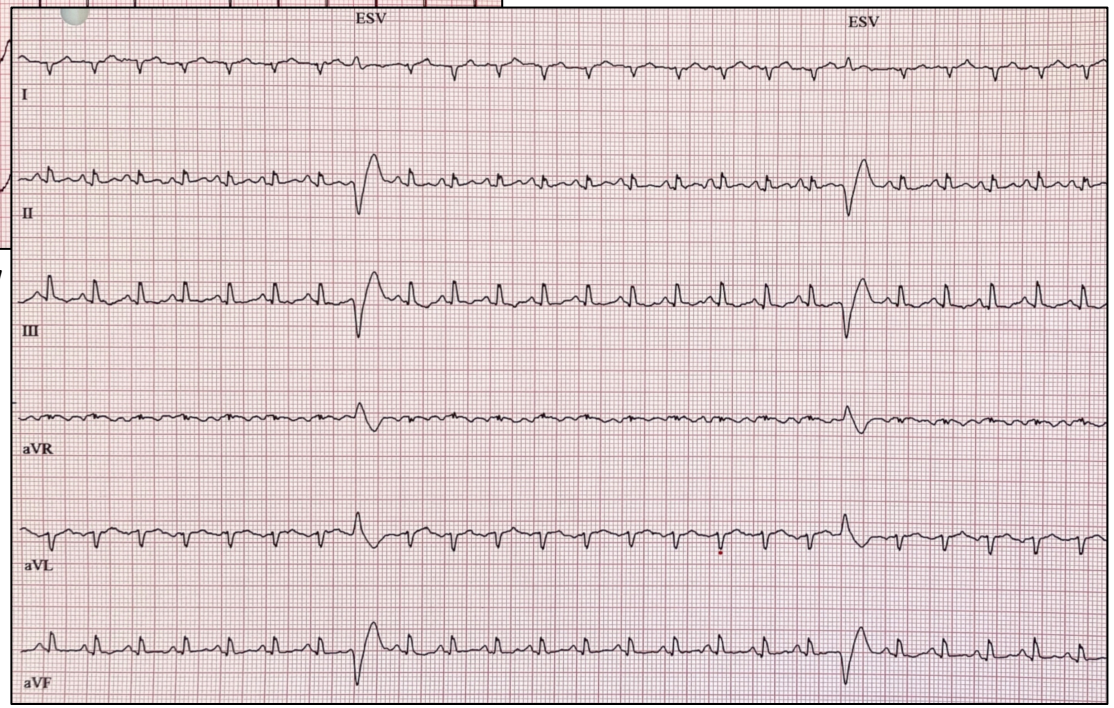
- *ECG Holter delle 24h*: RS costante, **46 BEV isolati monomorfi e tardivi**

Caso 4. Marco

Test Ergometrico



75-100 W



Rari BEV isolati

indotti da sforzo

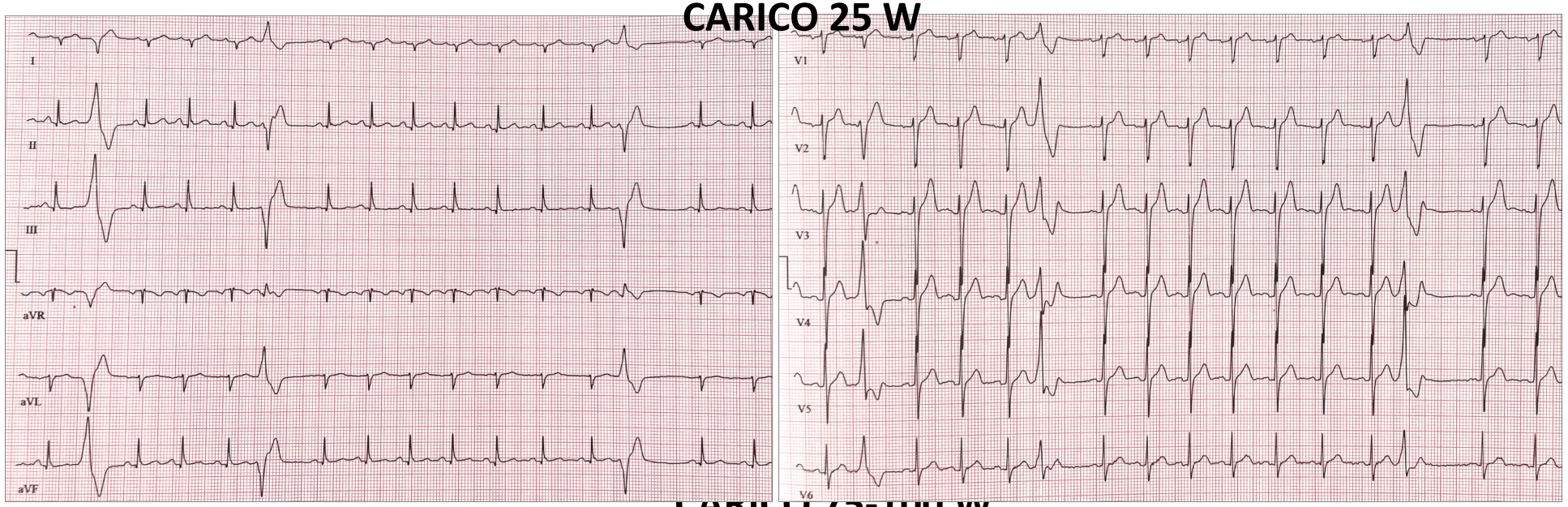
morfologia **BBDX**

asse superiore

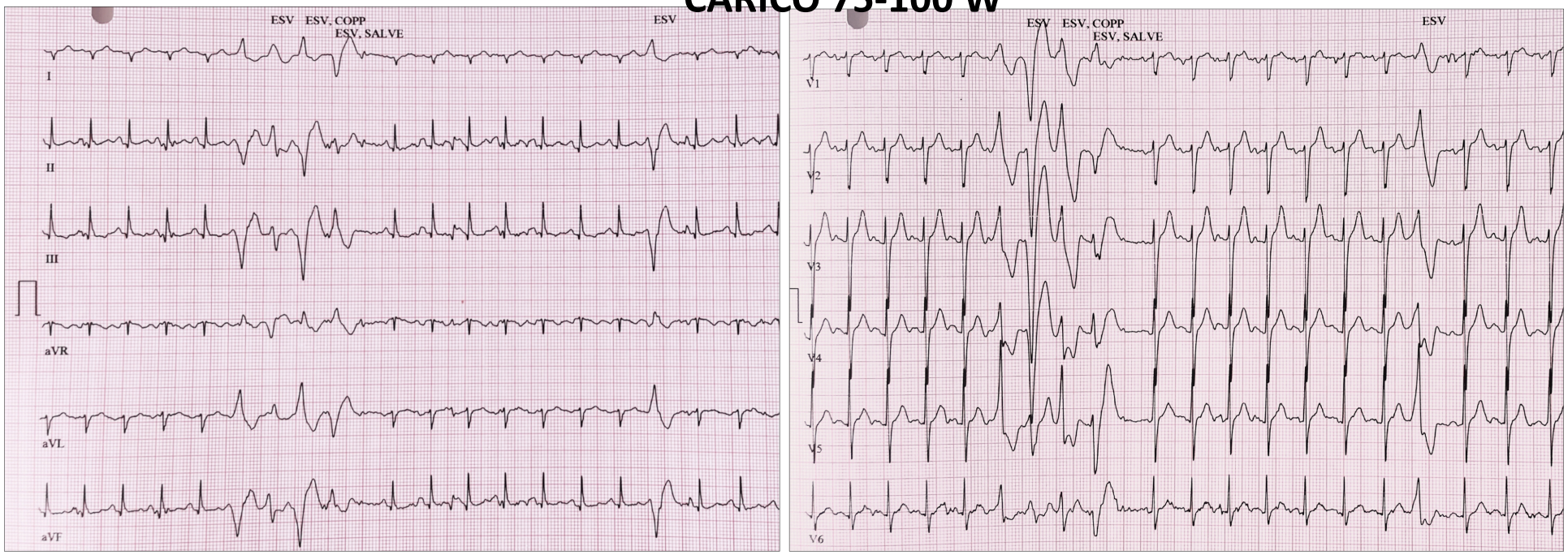
Caso 4. Marco

Quattro anni dopo …… Test ergometrico

CARICO 25 W



CARICO 75-100 W



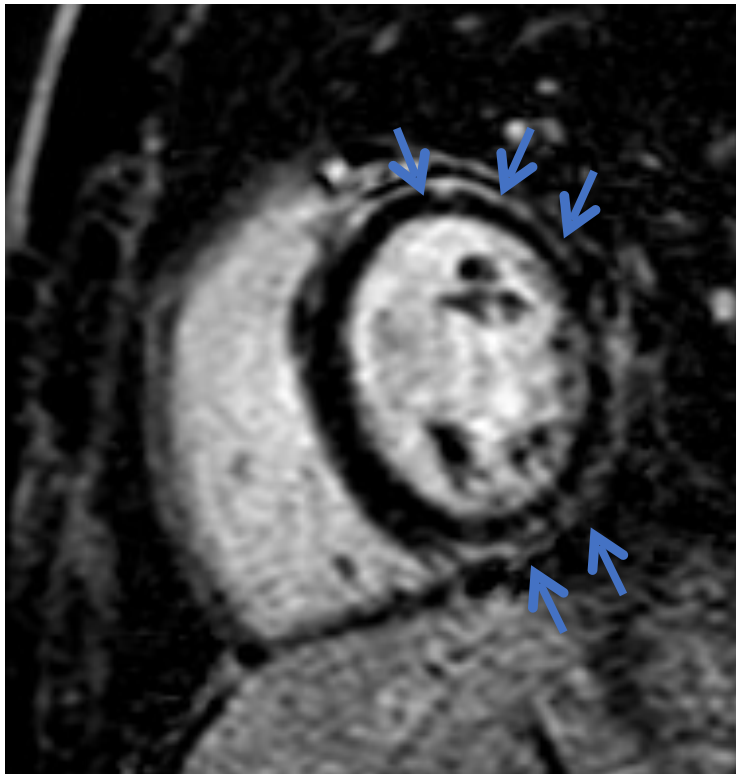
Caso 4. Marco

Quattro anni dopo ……

- *EcocardiogrammaColorDoppler*: invariato
- *ECG Holter delle 24h*: RS costante, frequenti BEV polimorfi, anche in coppie

Variante Patogenetica a carico gene DSP

Nessun criterio ECG identificava la presenza di ALVC !

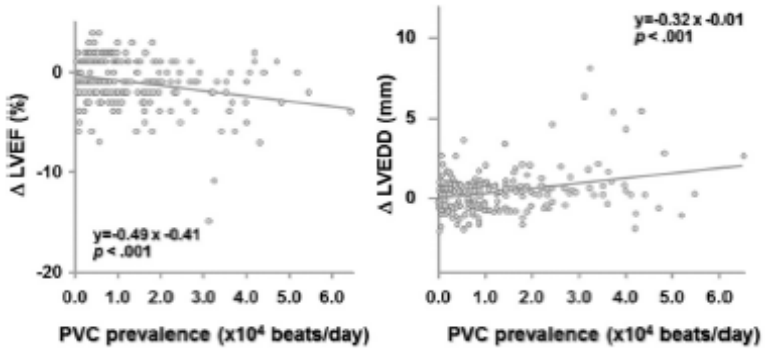


Tachycardia-Related Cardiomyopathy

- The threshold of ectopy needed to result in TCM has been evaluated by many authors:
  - Yarlagadda et al. PVC > 17,000 daily
  - Takemoto et al. PVC > 20% daily
  - Baman et al. PVC > 24% daily
  - Hasdemir et al. PVC > 16% daily
  - Niwano et al. PVC > 31,268 daily
- Thus, patients likely need to have > 10,000 PVCs daily over a substantial period (≈4 years) to cause TCM
- TCM is uncommon and occurred in 5-6% of patients

Eric N. Prystowsky et al. J Am Coll Cardiol 2012;59:1733–44

PVCs number

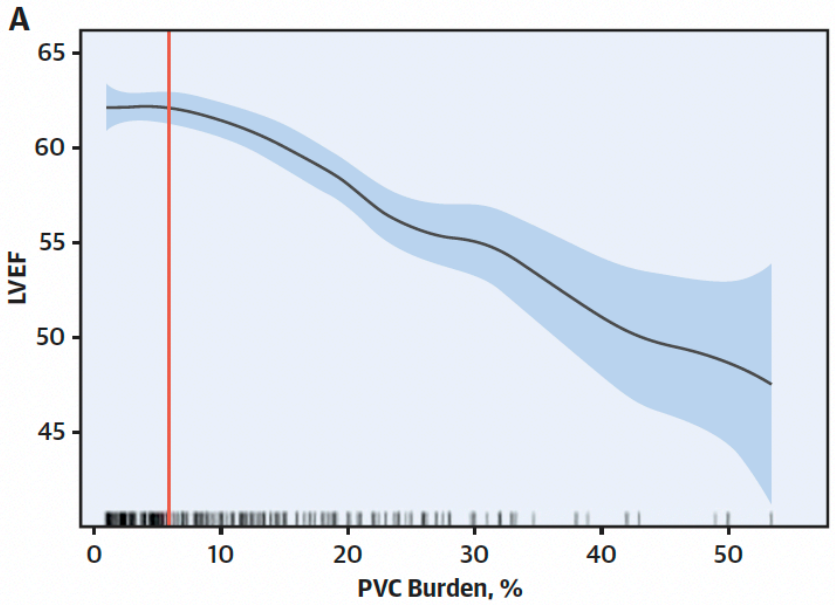


Cut point 20000/24h

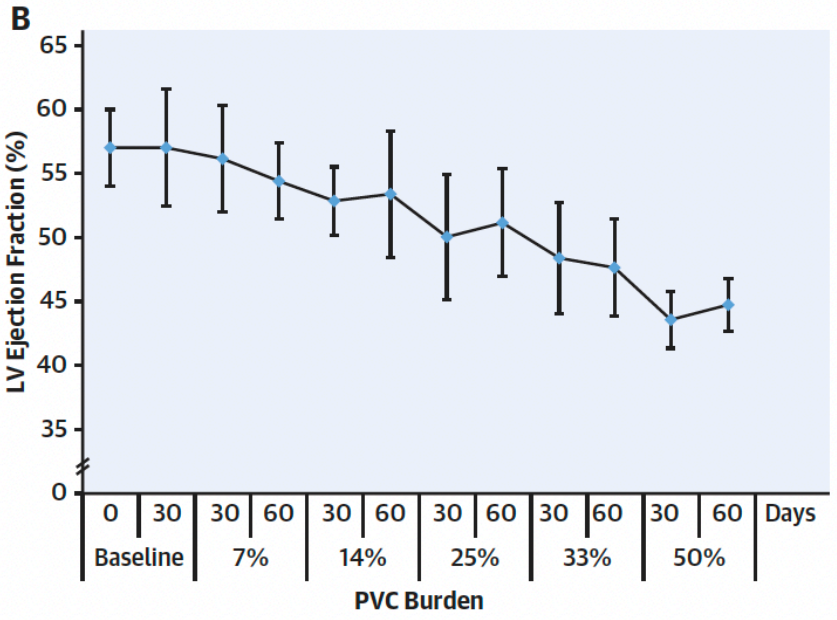
Niwano et al Heart 2009

Linear Decline of LVEF Appears Proportional to PVC Burden

Clinical setting



Translational animal model



Impact of QRS duration of frequent premature ventricular complexes on the development of cardiomyopathy

Miki Yokokawa, MD, Hyungjin Myra Kim, ScD, Eric Good, DO, Thomas Crawford, MD, Aman Chugh, MD, Frank Pelosi Jr, MD, Krit Jongnarangsin, MD, Rakesh Latchamsetty, MD, William Armstrong, MD, Craig Alguire, MD, Hakan Oral, MD, Fred Morady, MD, Frank Bogun, MD

From the Division of Cardiovascular Medicine, University of Michigan, Ann Arbor, Michigan.

BACKGROUND Patients with frequent premature ventricular complexes (PVCs) are at risk of developing reversible PVC-induced cardiomyopathy (rPVC-CMP). Not all determinants of rPVC-CMP are known.

OBJECTIVE To assess the impact of the QRS duration of PVCs on the development of rPVC-CMP.

METHODS In a consecutive series of 294 patients with frequent idiopathic PVCs referred for PVC ablation, the width of the PVC-QRS complex was assessed. The QRS width was correlated with the presence of rPVC-CMP.

RESULTS The PVC-QRS width was significantly greater in patients with rPVC-CMP than in patients without rPVC-CMP (164 $\pm$ 20 ms vs 149 $\pm$ 17 ms; $P < .0001$). The site of origin of the PVC had an impact on the PVC-QRS width, with epicardial PVCs having the broadest QRS complexes. Patients with PVCs originating from the right ventricular outflow tract or the fascicles had the narrowest QRS complexes. After adjusting for PVC burden, symptom duration, and PVC site of origin, PVC-QRS width and an epicardial PVC origin were independently associated with rPVC-CMP. Based on receiver operator characteristics analysis, a QRS duration of >150 ms best differentiated patients with and without rPVC-CMP (area under the curve 0.66; sensitivity 80%; specificity 52%). The PVC burden for developing rPVC-CMP is significantly lower in patients with a PVC-QRS width of $\geq$150 ms than in patients with a narrower PVC-QRS complex (22% $\pm$ 13% vs 28% $\pm$ 12%; $P < .0001$).

CONCLUSION Broader PVCs and an epicardial PVC origin are associated with the development of rPVC-CMP independent of the PVC burden.

KEYWORDS Premature ventricular complexes; Cardiomyopathy; QRS width

ABBREVIATIONS **PVC** = premature ventricular complex; **rPVC-CMP** = reversible PVC-induced cardiomyopathy

(Heart Rhythm 2012;9:1460–1464) © 2012 Heart Rhythm Society. Published by Elsevier Inc. All rights reserved.

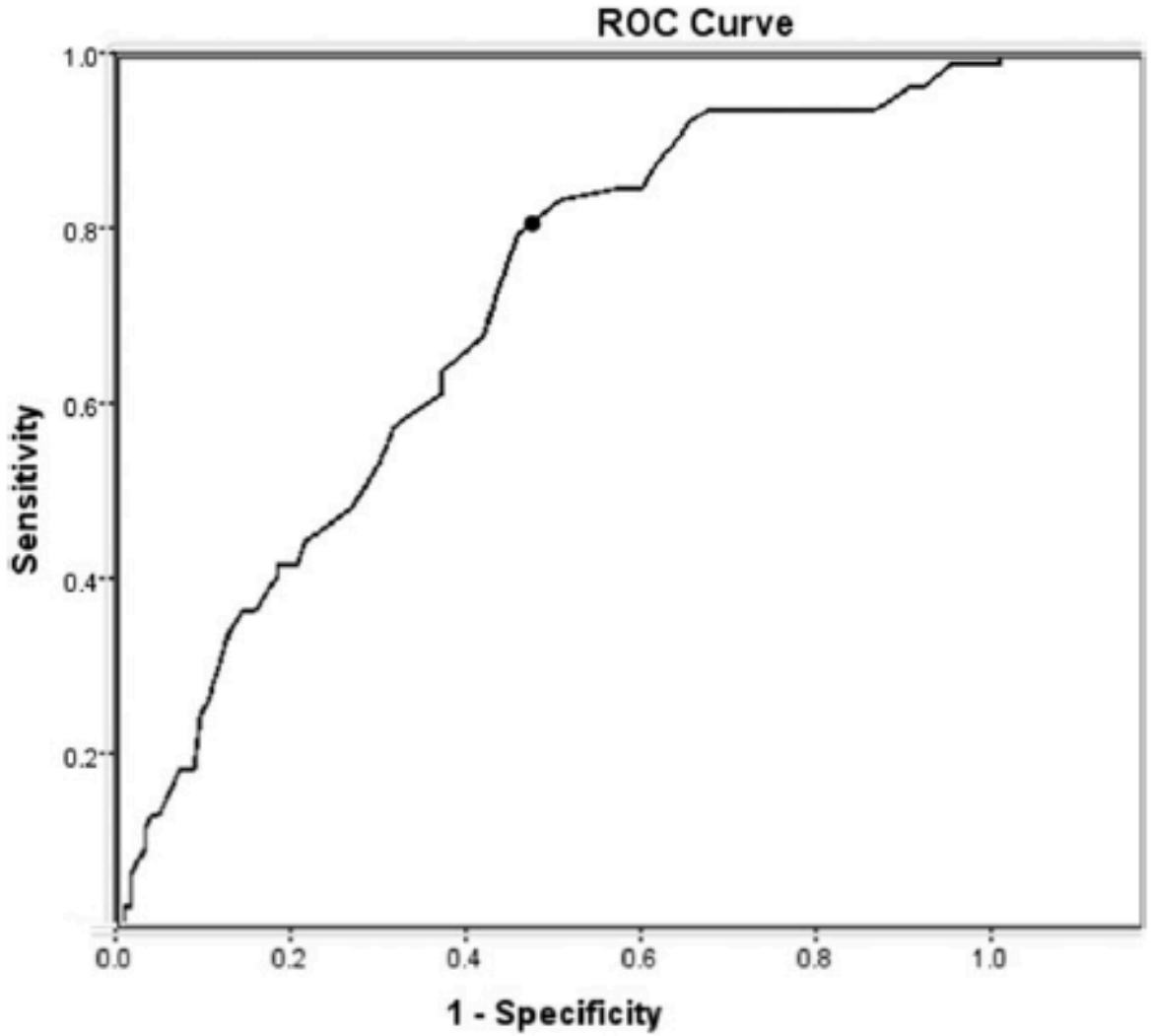


Figure 1 Receiver operator characteristics curve of the PVC-QRS width differentiating patients with vs patients without reversible PVC-induced cardiomyopathy. The black point indicates the PVC-QRS width of 150 ms. A PVC QRS width of ≥150 ms had a sensitivity of 80% and a specificity of 52% to differentiate patients with reversible PVC-induced cardiomyopathy from patients without reversible PVC-induced cardiomyopathy. PVC = premature ventricular complex.

Ventricular premature depolarization QRS duration as a new marker of risk for the development of ventricular premature depolarization–induced cardiomyopathy

Lidia Carballeira Pol, MD,* Marc W. Deyell, MD, MSc, FHRS,* David S. Frankel, MD, FHRS,* Daniel Benhayon, MD,* Fabien Squara, MD,*† William Chik, MD,* Maria Kohari, MD,* Rajat Deo, MD,* Francis E. Marchlinski, MD, FHRS*

*From the *Electrophysiology Section, Cardiovascular Division, Department of Medicine, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, and †Cardiology Department, Pasteur University Hospital, Nice, France.*

BACKGROUND Frequent ventricular premature depolarizations (VPDs) can cause cardiomyopathy (CMP). The mechanisms underlying its development remain unclear, with VPD burden being only a weak predictor of risk.

OBJECTIVE To determine whether VPD QRS duration at the time of initial presentation could predict risk for the subsequent development of CMP in patients with normal left ventricular ejection fraction (LVEF).

METHODS From consecutive patients referred for ablation between January 1, 2006, and April 2, 2013, with ≥10% VPDs on 24-hour Holter monitoring, we identified 45 patients with normal LVEF and an electrocardiogram of the targeted VPD, who were then followed for at least 6 months (median 14 months; interquartile range [IQR] 8–32 months) before intervention. We excluded patients with structural or genetic heart disease.

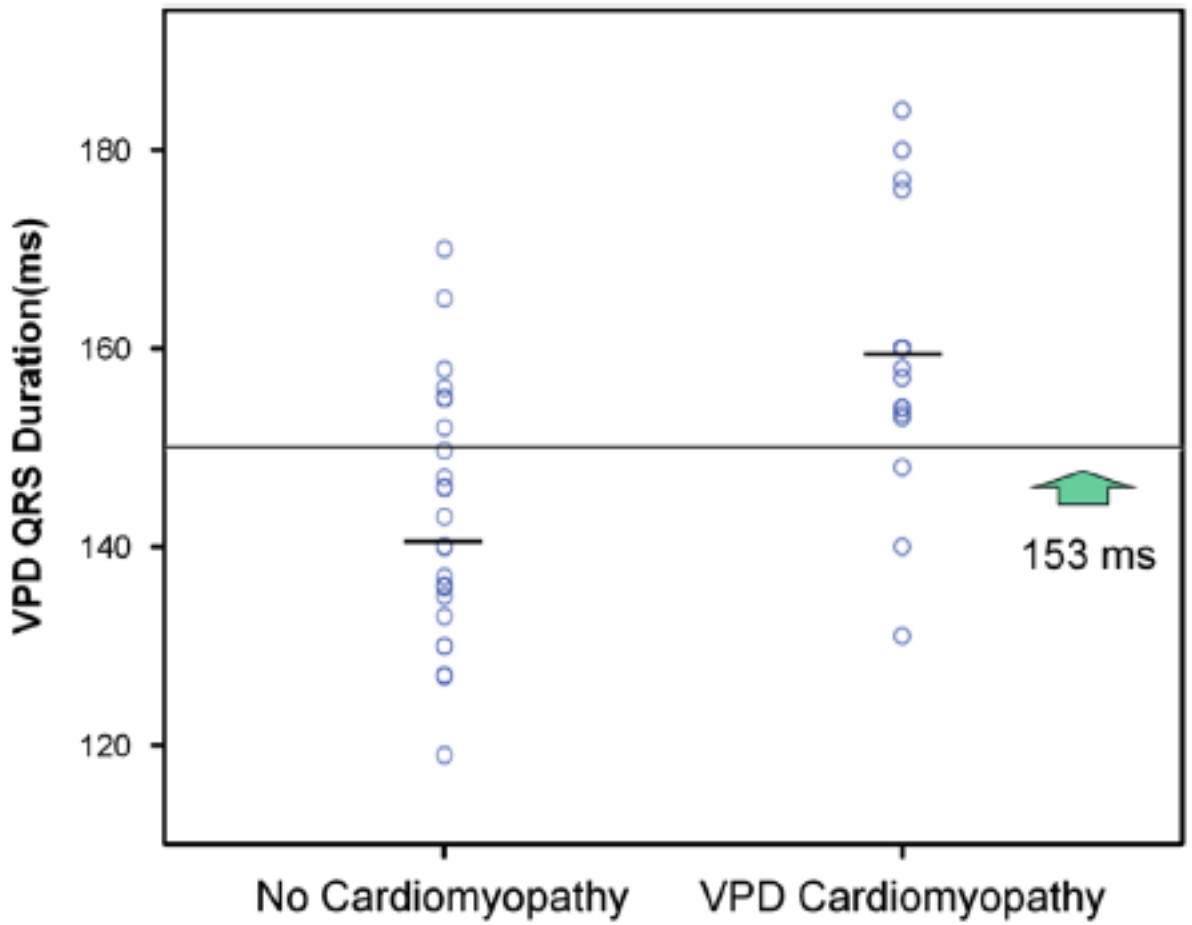
RESULTS Of the 45 patients, 28 (62%) maintained normal LVEF and 17(38%) developed VPD-induced CMP. VPD burden was similar (26.5% [IQR 19.3%–39.5%] vs 26.0% [IQR 16.4%–41.0%]; $P = 0.4$) between the 2 groups. Patients who developed VPD-induced CMP had significantly longer VPD QRS duration (159 ms vs 142 ms; $P < .001$) and a longer sinus QRS duration (97 ms vs 89 ms; $P = .04$). A VPD QRS duration of ≥153 ms best predicted development of VPD CMP (82% sensitivity and 75% specificity). Longer VPD QRS duration and a non–outflow tract site of VPD origin were independent risk factors for left ventricular dysfunction after multivariate analysis.

CONCLUSION VPD QRS duration longer than 153 ms and a non–outflow tract site of origin might be useful predictors of the subsequent development of VPD-induced CMP.

KEYWORDS Ventricular premature depolarizations; Cardiomyopathy; Ventricular outflow tract; Ventricular arrhythmia; Electrocardiogram

ABBREVIATIONS **CMP** = cardiomyopathy; **ECG** = electrocardiogram; **EF** = ejection fraction; **IQR** = interquartile range; **LV** = left ventricle/ventricular; **LVEDD** = left ventricular end-diastolic diameter; **LVEF** = left ventricular ejection fraction; **MRI** = magnetic resonance imaging; **VPD** = ventricular premature depolarization

(Heart Rhythm 2014;11:299–306) © 2014 Heart Rhythm Society. All rights reserved.


VPD QRS Duration(ms)
180
160
140
120
153 ms
No Cardiomyopathy
VPD Cardiomyopathy

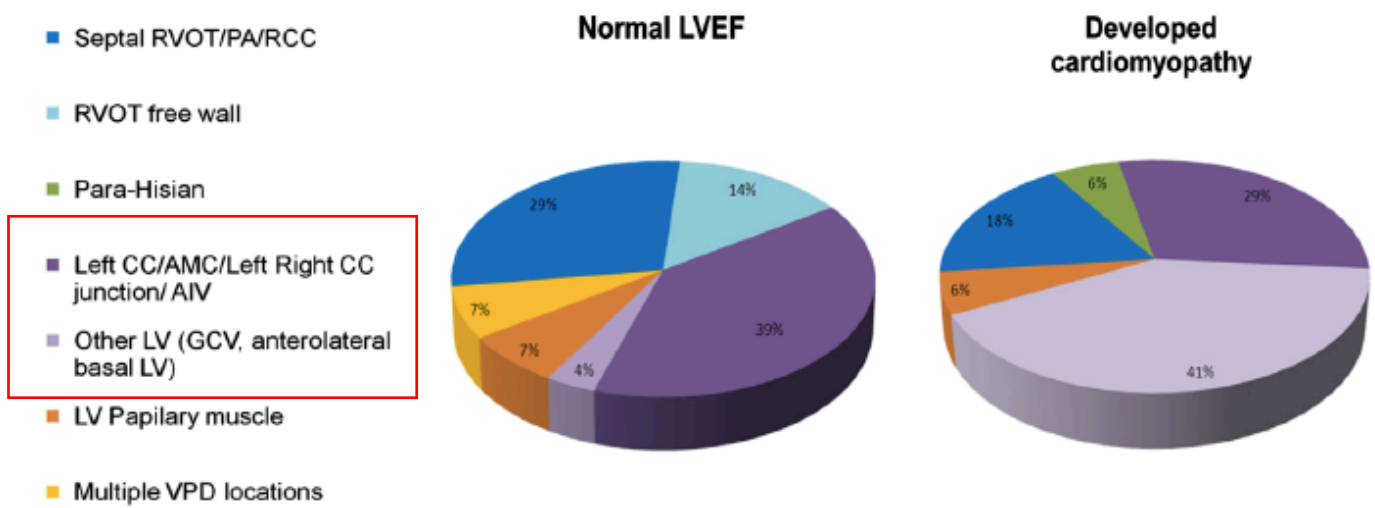
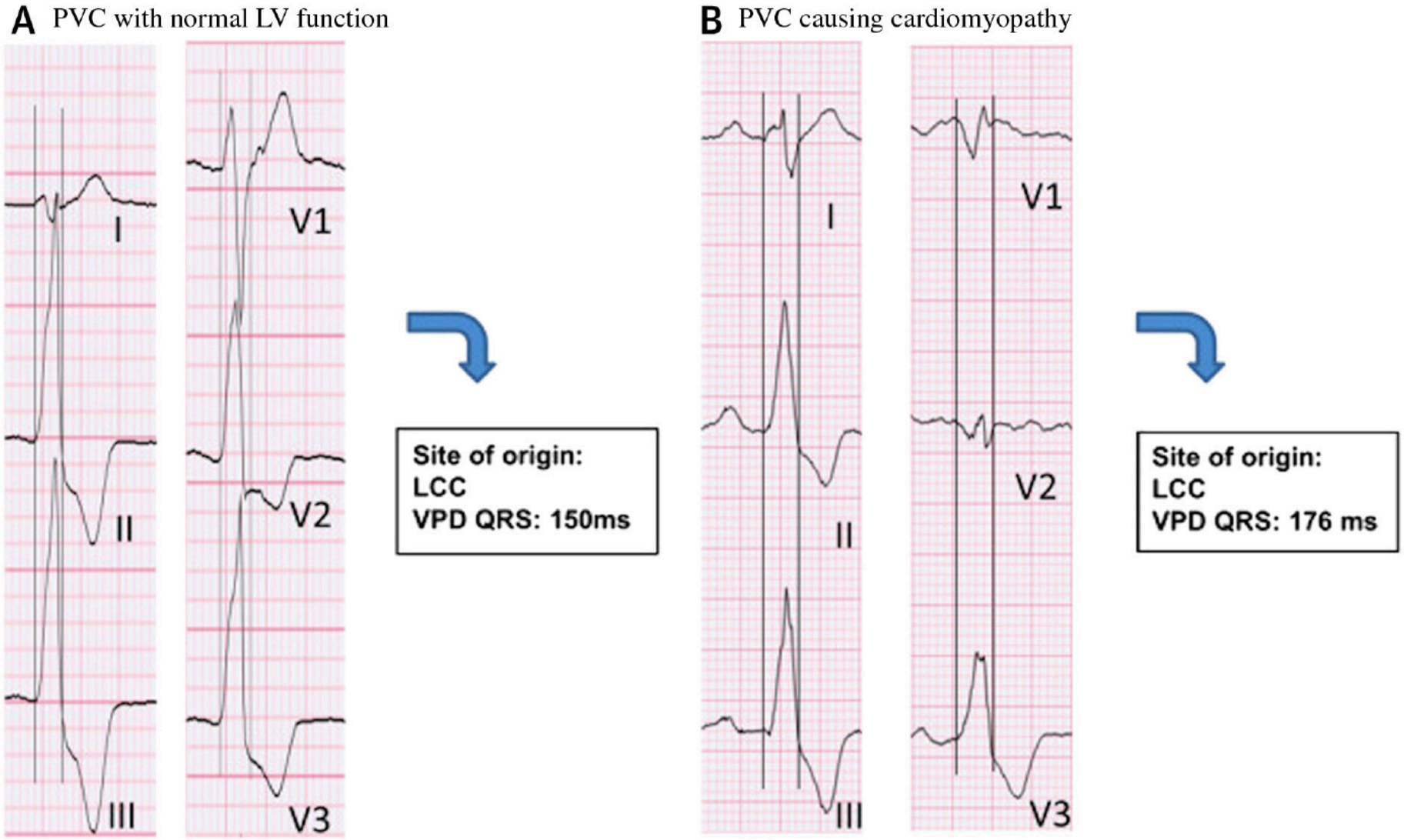
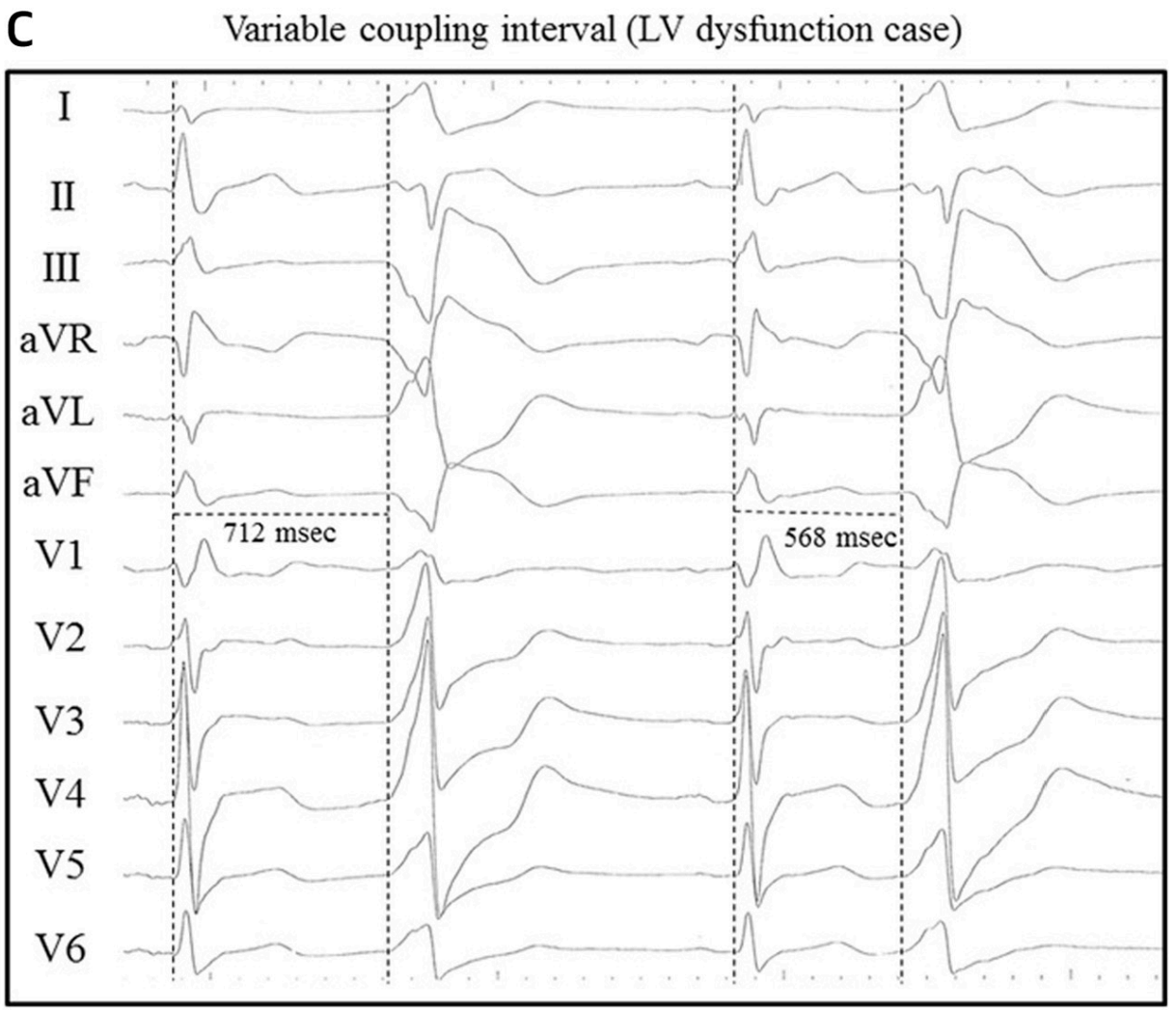


Figure 2 Anatomical distribution of VPD sites of origin across both groups, as determined at ablation sites. AIV = anterior interventricular vein; AMC = aortomitral continuity; CC = coronary cusp; GCV = great cardiac vein; LV = left ventricle; LVEF = left ventricle ejection fraction; PA = pulmonary artery; RVOT = right ventricular outflow tract; VPD = ventricular premature depolarization.



Carballeira Pol L et al. Ventricular premature depolarization QRS duration as a new marker of risk for the development of ventricular premature depolarization-induced cardiomyopathy. Heart Rhythm 2014;11:299–306.

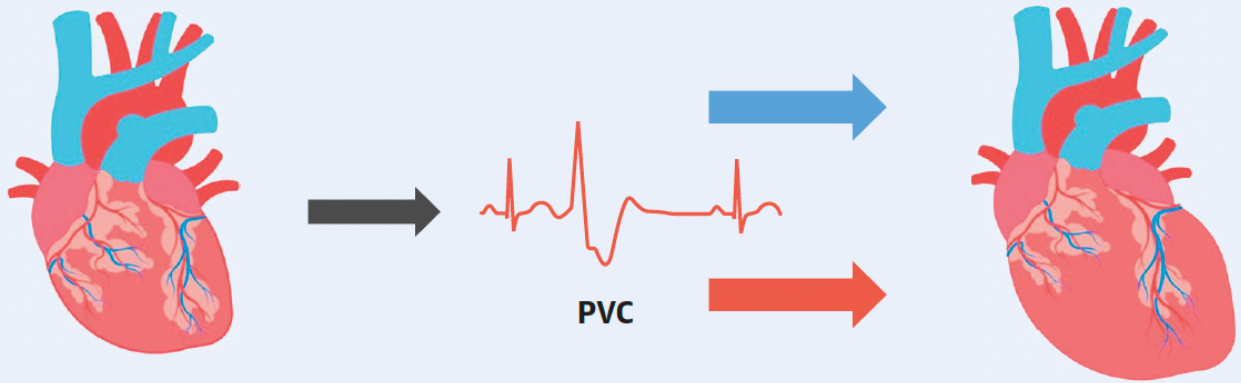


Representative case of PVC-CM with dispersion of CI of 144 ms (cutoff of CI dispersion >99 ms best identified patients with and without PVC-CM).

Kawamura M et al. Coupling interval dispersion and body mass index are independent predictors of idiopathic premature ventricular complex-induced cardiomyopathy. J Cardiovasc Electrophysiol 2014;25:756–62.

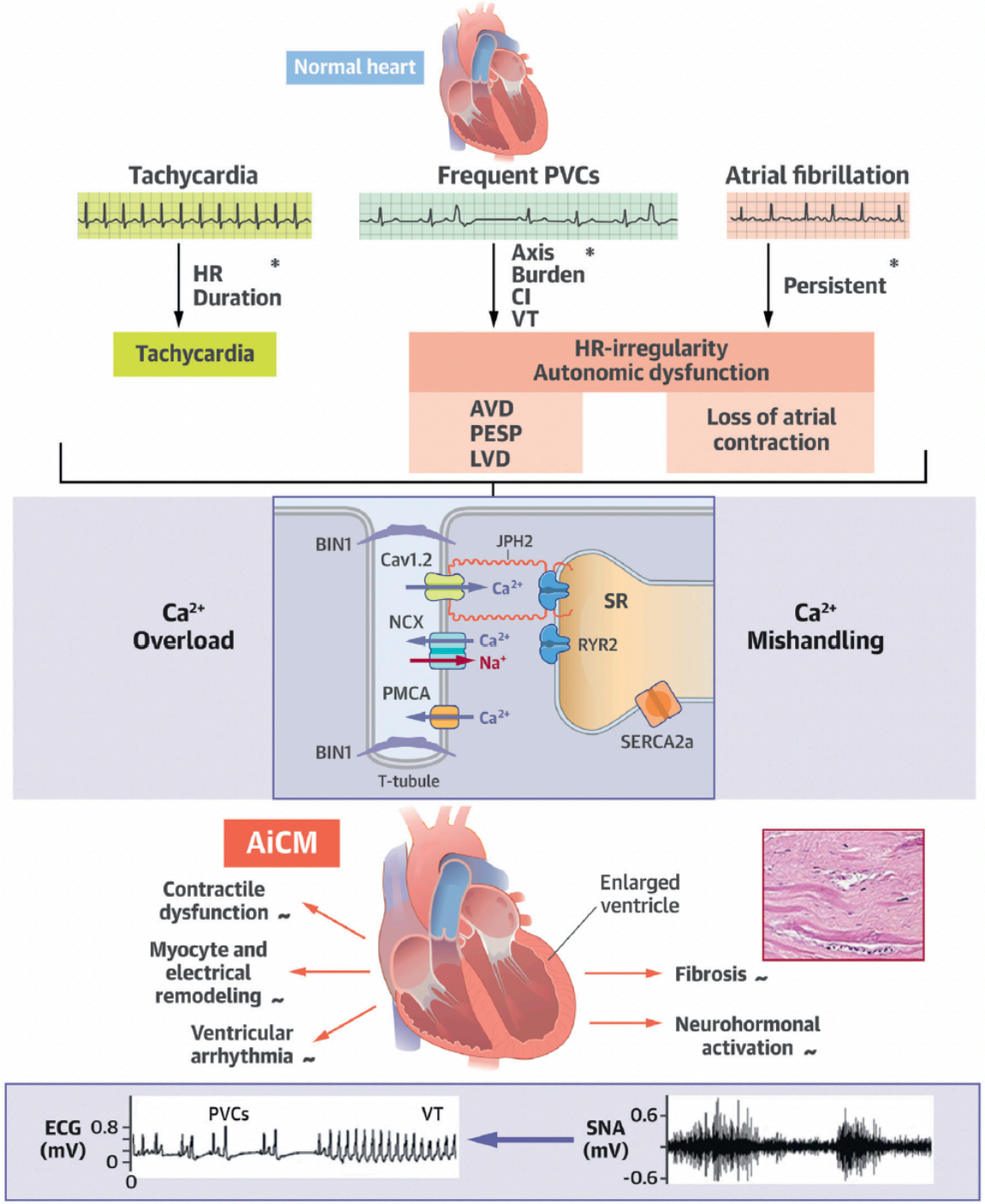
Intraventricular Effects

- **LV dyssynchrony:** Uncoordinated LV segment contractions. The level of dyssynchrony directly relates to the PVC CI; ↑ PVC CIs show more significant LV dyssynchrony.
- **PESP:** ↑ ventricular contractility, Linked to Ca^{2+} overload, Inversely related to PVC CI, ↑ VO_2, minimal CO change, ↓ LVEDP (average 13 mm Hg), and ↑ coronary flow.
- **Tachycardia:** normal mean HR, likely due to compensatory pauses.



Extraventricular Effects

- **AV dissociation and hemodynamic impairment:** When atrial contraction takes place against a closed AV valve during PVC → prominent "a" wave in PCWP. PVC-PCWP augmentation (defined as prominent a wave >15 mm Hg) was associated with a lower LVEF and shorter CI.
- **Autonomic dysfunction:** PVCs ↑ sympathetic activity both in the heart and peripherally. PVCs, with variable CI trigger the most sympathetic and parasympathetic changes.


Normal heart
Tachycardia
Frequent PVCs
Atrial fibrillation
HR
Duration
*
Axis
Burden
CI
VT
*
Persistent
*
Tachycardia
HR-irregularity
Autonomic dysfunction
AVD
PESP
LVD
Loss of atrial contraction
Ca2+ Overload
BIN1
Cav1.2
JPH2
Ca2+
SR
NCX
Ca2+
Na+
RYR2
PMCA
Ca2+
SERCA2a
BIN1
T-tubule
Ca2+ Mishandling
AiCM
Contractile dysfunction
Myocyte and electrical remodeling
Ventricular arrhythmia
Enlarged ventricle
Fibrosis
Neurohormonal activation
ECG (mV)
0.8
0
0
PVCs
VT
SNA (mV)
0.6
-0.6

Left Ventricular Dyssynchrony Predicts the Cardiomyopathy Associated With Premature Ventricular Contractions

Tomos E. Walters, MD, PhD, Dolkun Rahmutula, MD, PhD, Judit Szilagyi, MD, Christina Alhede, MD, PhD, Richard Sievers, BS, Qizhi Fang, MD, Jeffrey Olgin, MD, Edward P. Gerstenfeld, MS, MD

ABSTRACT

BACKGROUND The pathophysiology of cardiomyopathy associated with premature ventricular contractions (PVCs) remains unclear.

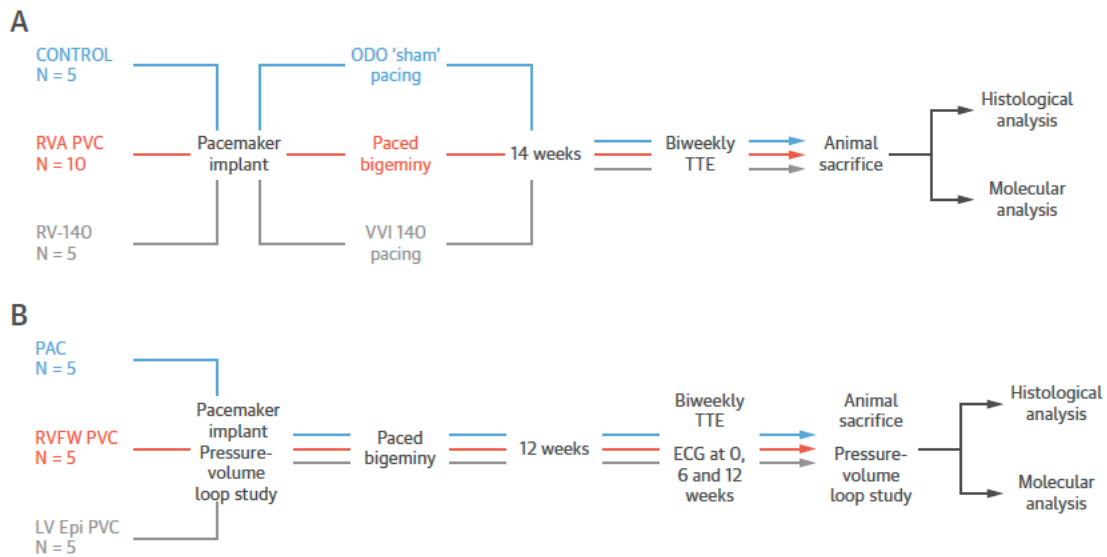
OBJECTIVES This study prospectively explored cardiomyopathy development in a swine model of paced ectopic beats.

METHODS A total of 35 swine underwent pacemaker implantation. A group exposed to paced bigeminy from the right ventricular apex (RVA) for 14 weeks (RVA PVC) ($n = 10$) were compared with a group exposed to regular pacing from the RVA at 140 beats/min (RV-140) ($n = 5$) and a control group ($n = 5$). To test the role of ectopic beat dyssynchrony, further groups were exposed for 12 weeks to bigeminy from the right ventricular free wall (RVFW PVC) ($n = 5$), the left ventricular epicardium (LV Epi PVC) ($n = 5$) or the right atrium (premature atrial complex) ($n = 5$).

RESULTS After 14 weeks, the mean left ventricular ejection fraction (LVEF) was significantly lower in the RVA PVC group than in the RV-140 or control groups ($p < 0.05$). LVEF declined significantly in the LV Epi PVC (65.2 ± 2.4% to 39.7 ± 3.0%; $p < 0.01$) and RVFW PVC (66.1 ± 2.6% to 48.6 ± 2.7%; $p < 0.01$) groups, with final LVEF significantly lower and ventricular fibrosis significantly higher in the LV Epi PVC group compared with all others ($p < 0.05$). Protein levels of pRyR2, NCX-1, CaMKII-α, and PLN were up-regulated and levels of SERCA2a were down-regulated in the LV Epi PVC group compared with the control group ($p < 0.05$). Longer ectopic beat QRS duration and greater LV dyssynchrony were significantly associated with larger declines in LV systolic function.

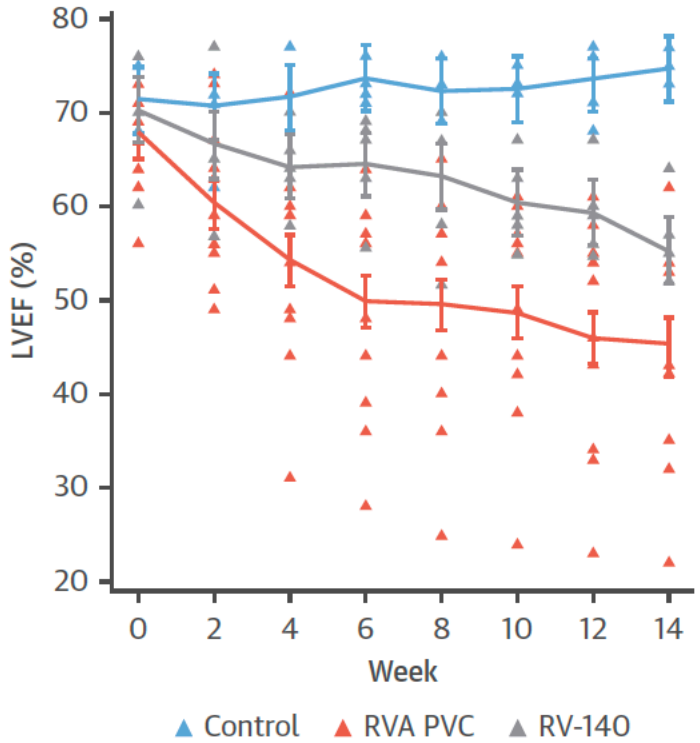
CONCLUSIONS In a swine model of paced ectopic beats, PVC-induced cardiomyopathy is phenotypically distinct from a tachycardia-induced cardiomyopathy. Cardiomyopathy severity is strongly associated with severity of the hemodynamic derangement associated with the paced ectopic beats, particularly the extent of LV dyssynchrony.
(J Am Coll Cardiol 2018;72:2870-82) © 2018 by the American College of Cardiology Foundation.

FIGURE 1 Schematic Depicting the Study Protocol



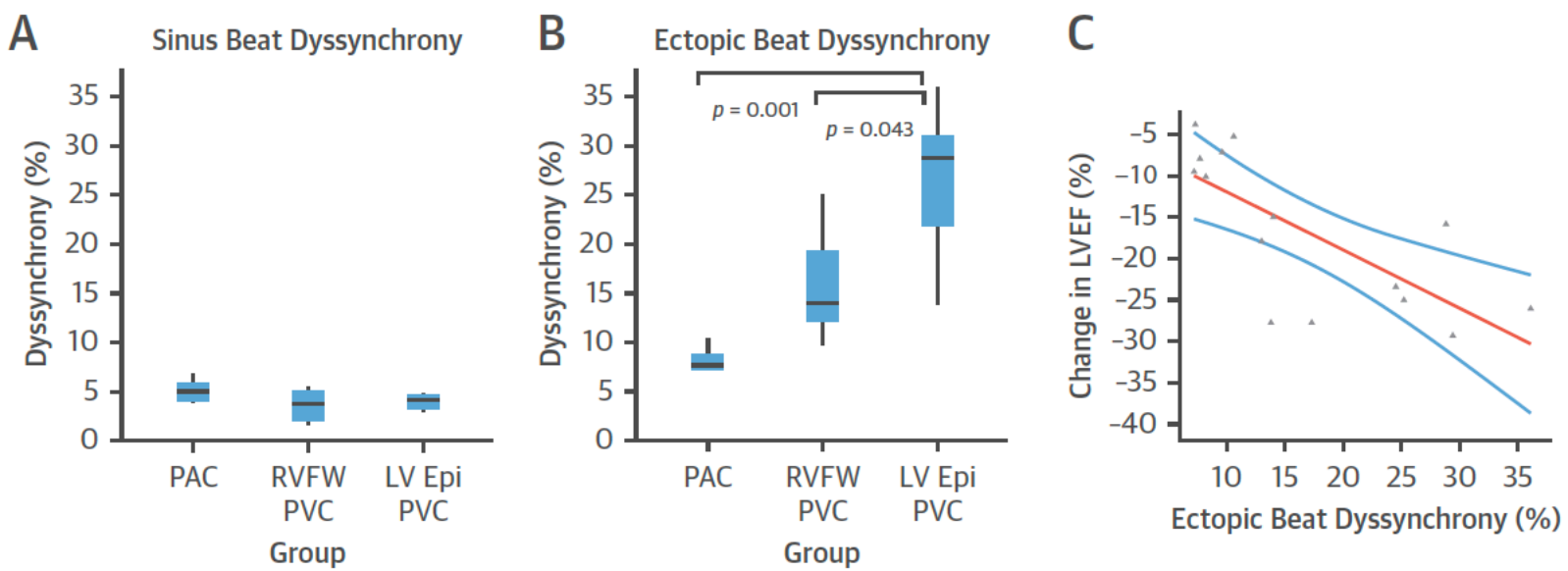
(A) Phase 1; **(B)** Phase 2. ECG = echocardiogram; ODO = sensing only mode; LV Epi PVC = left ventricular epicardium premature ventricular contraction; PAC = premature atrial complex; RV-140 = right ventricular apex at 140 beats/min; RVA PVC = right ventricular apex premature ventricular contraction; RVFW PVC = right ventricular free wall premature ventricular contraction; TTE = transthoracic echocardiogram.

FIGURE 2 **Change in LV Systolic Function Over 14-Week Pacing Protocol in Phase 1 of the Study**



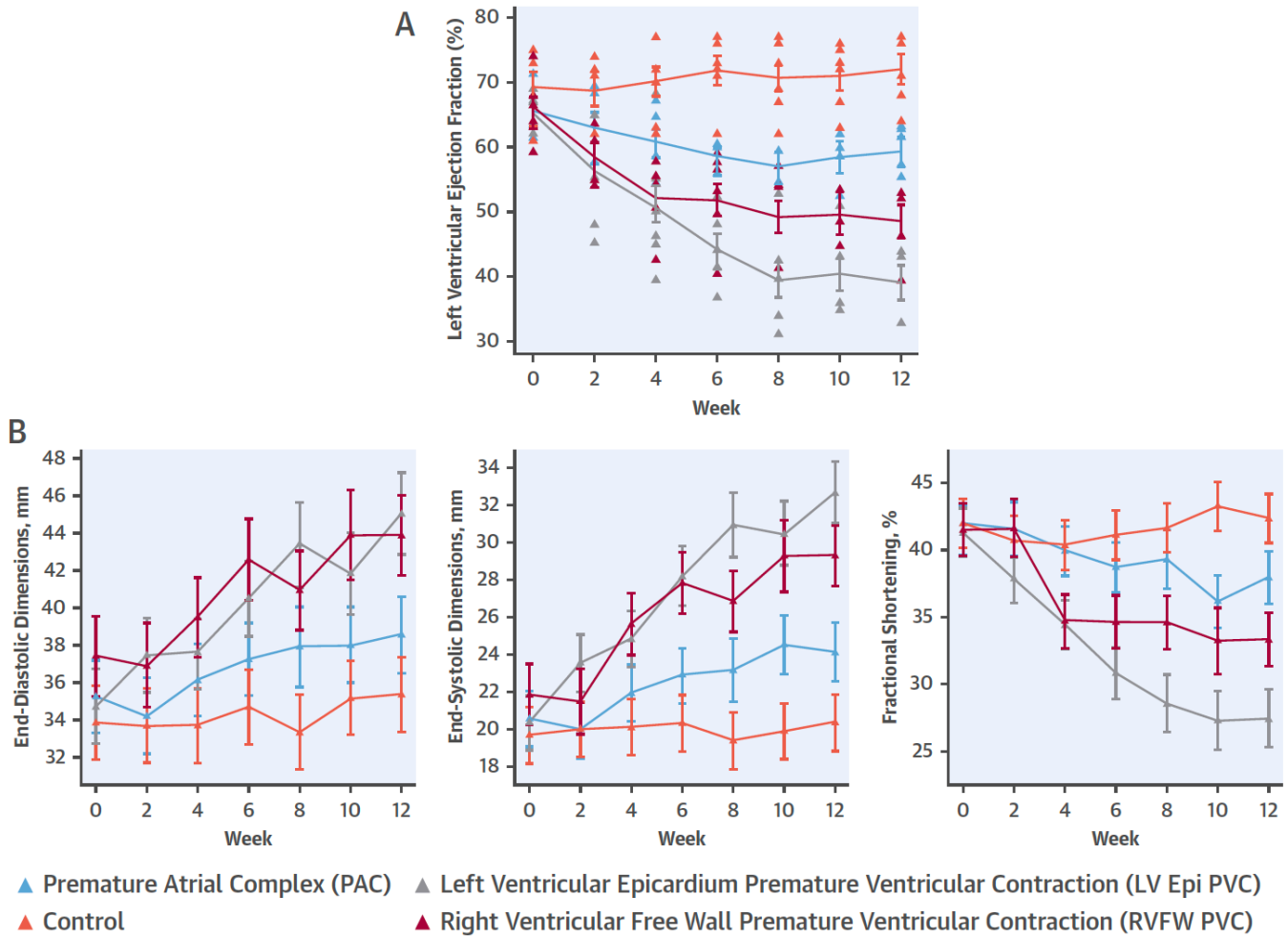
A significant decline in left ventricular (LV) systolic function was seen in both the right ventricular apical (RVA) premature ventricular contraction (PVC) and the right ventricular (RV)-140 groups, with the greatest decline measured in the RVA PVC group, but with marked between-animal heterogeneity in the rate and severity of decline. Raw data for each animal are presented, plus estimates generated by a linear mixed model with **error bars** representing standard errors of the mean. LVEF = left ventricular ejection fraction.

FIGURE 4 **Baseline LV Intraventricular Dyssynchrony at the Study Coupling-Interval and the Relationship of Ectopic Beat Dyssynchrony to Change In LV Systolic Function**



(A) Dyssynchrony associated with sinus rhythm beats determined from baseline P-V loop studies. There were no between-group differences in dyssynchrony associated with sinus beats. **Box plots** represent the median, interquartile range (IQR), and data limits. **(B)** Dyssynchrony associated with paced ectopic beats during paced bigeminy determined from baseline P-V loop studies. Dyssynchrony associated with LV Epi PVCs was significantly greater than that seen with either right ventricular free wall (RVFW) PVCs or with PACs at the study coupling interval. **Box plots** represent the median, IQR, and data limits. **(C)** Significant linear relationship between ectopic beat dyssynchrony and the extent of change in LV systolic function after 12 weeks of paced bigeminy ($R^2 = 0.54$, ß $= -0.70 \pm 0.18$, t $= -3.87$, p $= 0.002$). Abbreviations as in Figures 1 and 2.

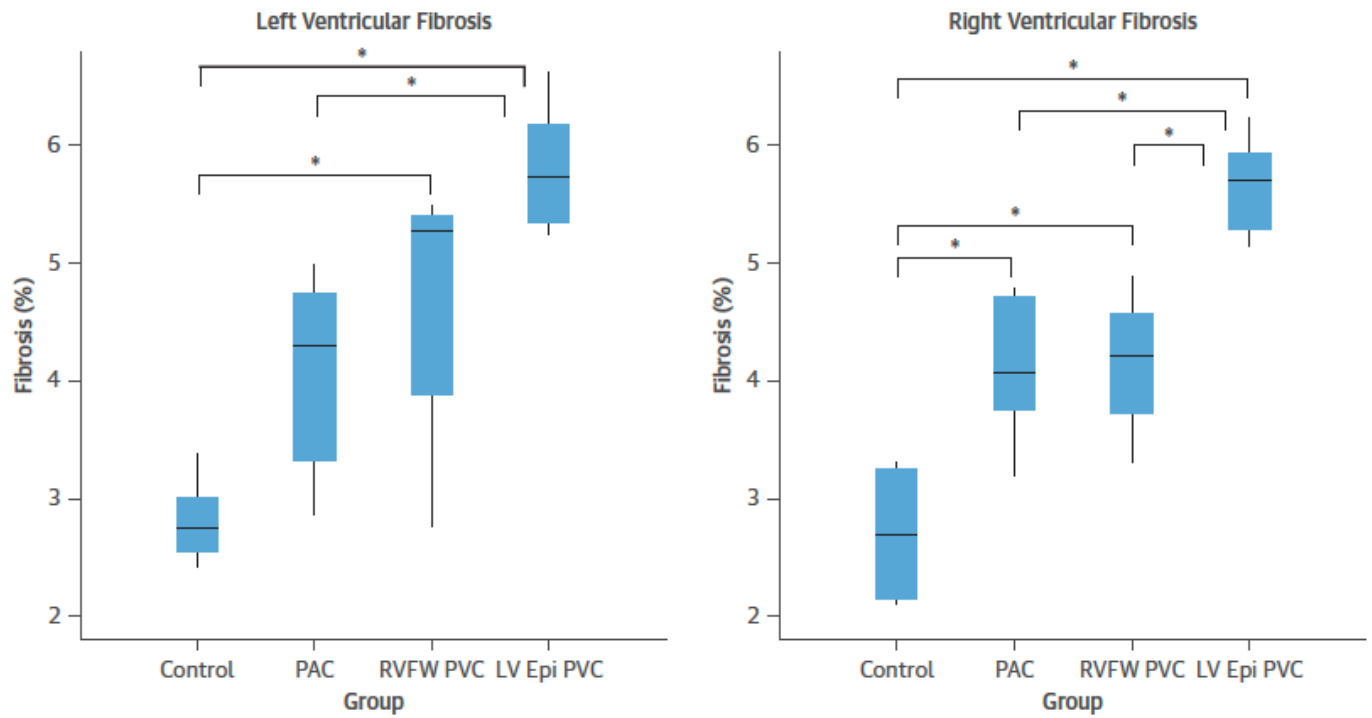
CENTRAL ILLUSTRATION **Change in Left Ventricular Systolic Function and Dimensions Over 12-Week Pacing Protocol in Study Phase 2**



Walters, T.E. et al. J Am Coll Cardiol. 2018;72(23):2870–82.

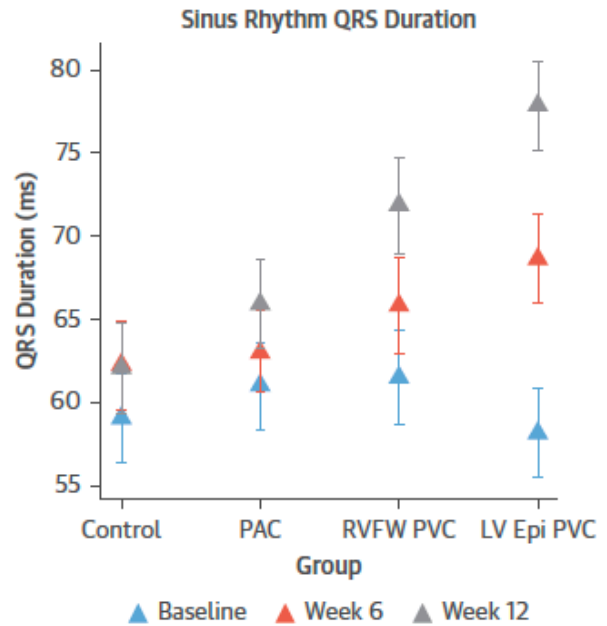
(A) Left ventricular (LV) systolic function determined from biweekly transthoracic echocardiograms. There was significant between-group divergence in left ventricular ejection fraction (LVEF). A significant decrease in LV systolic function was seen in both the right ventricular free wall (RVFW) premature ventricular contraction (PVC) and the LV epicardium (Epi) PVC groups, with a significantly lower LVEF value at 12 weeks in the LV Epi PVC group than in all other groups ($p < 0.05$). Raw data for each animal is presented, plus estimates generated by a linear mixed model, with **error bars** representing standard errors of the mean. **(B)** LV dimensions and fractional shortening from biweekly transthoracic echocardiograms. LV end-diastolic and end-systolic dimensions increased significantly, and fractional shortening fell significantly only in the LV Epi PVC and the RVFW PVC groups, with a significantly larger LV end-systolic dimension and a significantly smaller fractional shortening value at 12 weeks in the LV Epi PVC group than in all other animal groups. Estimates are generated by linear mixed models, with **error bars** representing standard errors of the mean.

FIGURE 6 **Ventricular Myocardial Interstitial Fibrosis After Completion of the Pacing Protocol in Study Phase 2**



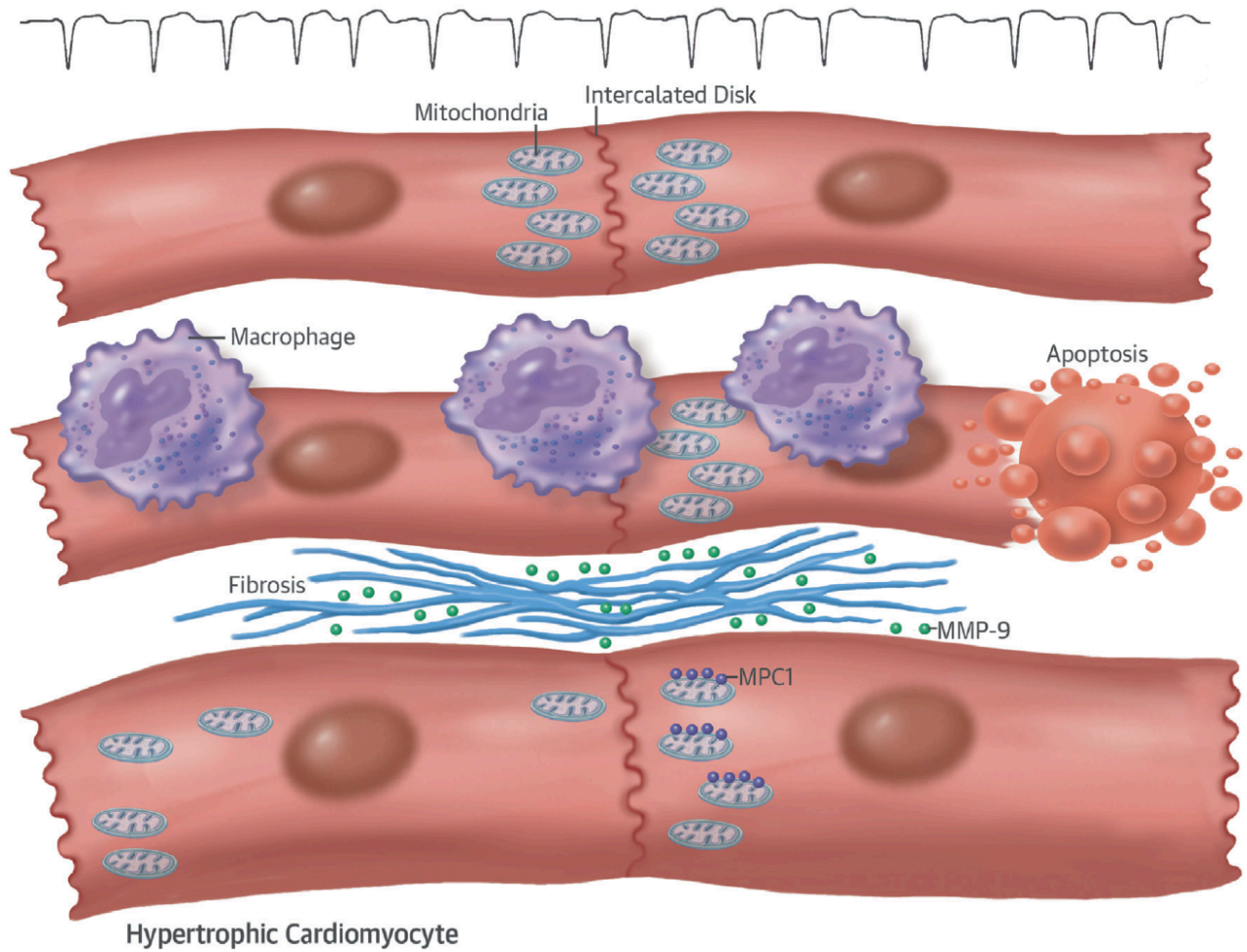
LV fibrosis was quantified after animal sacrifice from samples obtained from the RV free wall and from 4 left ventricular regions. Overall LV fibrosis was significantly greater in the LV Epi PVC group than in the PAC and control groups, whereas RV fibrosis was significantly greater in the LV Epi PVC group than in each of the other 3 groups. **Box plots** represent the median, IQR, and data limits. Abbreviations as in Figures 1 and 2.

FIGURE 5 Change in QRS Duration in Study Phase 2



Sinus rhythm QRS duration increased significantly in the LV Epi PVC ($p < 0.05$) and the RVFW PVC ($p < 0.05$) groups but not in the PAC or control groups. The QRS duration in the LV Epi PVC group at 12 weeks was significantly greater than that measured in the control and PAC groups ($p < 0.05$) but not the RVFW PVC group. Estimates generated by the linear mixed model are presented, with **error bars** representing standard errors of the mean. Abbreviations as in Figure 1.

CENTRAL ILLUSTRATION **Molecular Characteristics of Human TCM**



Mueller, K.A.L. et al. J Am Coll Cardiol. 2017;69(17):2160–72.

Tachycardiomyopathy (TCM) is characterized by changes in cardiomyocyte morphology and mitochondrial distribution, accompanied by a macrophage-dominated cardiac inflammation. Compared with patients with dilated cardiomyopathy, patients with tachycardiomyopathy demonstrated stronger myocardial expression of major histocompatibility complex class II molecule and enhanced infiltration of $CD68^{+}$ macrophages; compared with patients with ischemic cardiomyopathy, the presence of T cells and macrophages was significantly reduced in tachycardiomyopathy. Myocardial fibrosis was detected to a significantly lower degree in patients with tachycardiomyopathy compared with dilated cardiomyopathy and inflammatory cardiomyopathy. MPC = mitochondrial pyruvate carrier; MMP = matrix metalloproteinase.

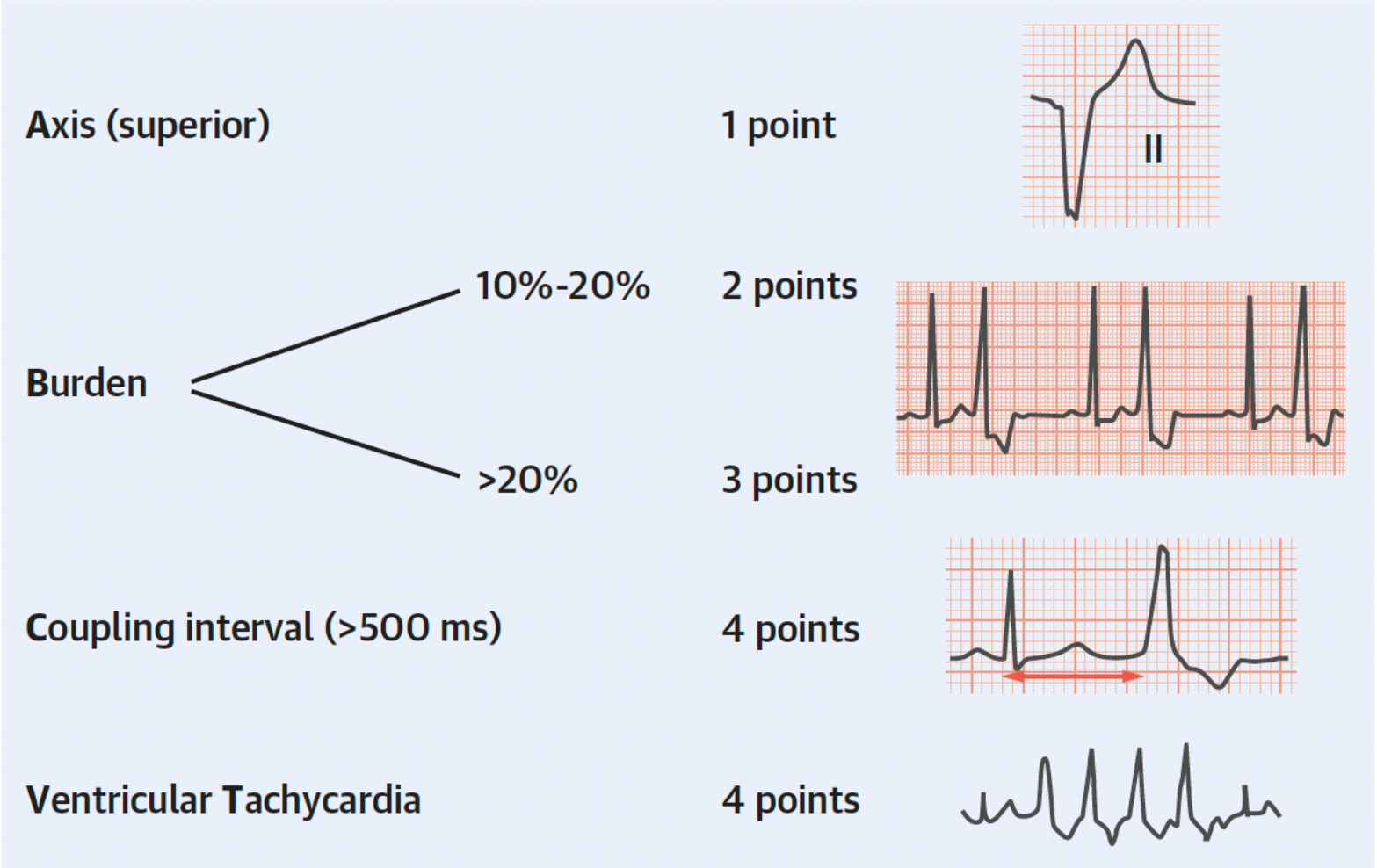
The derivation cohort comprised 206 patients with a mean PVC burden of 11.6% ± 6.2% and considerable daily fluctuation (minimum burden 7.3% ± 6.2% vs maximum 17.9% ± 8.0%).

Independent predictors of adverse remodeling were as follows:

1) superiorly directed PVC axis (OR 2.7; 1 point)
2) PVC burden 10%–20% (OR 3.5; 2 points) and >20% (OR 4.4; 3 points)
3) PVC coupling interval >500 ms (OR 4.7; 4 points)
4) nonsustained ventricular tachycardia (OR 5.3; 4 points), which form the ABC-VT risk score.

Hamon D et al. Circ Arrhythm Electrophysiol. 2017;10.

Risk stratification tool to predict the development of LV remodeling and subsequent cardiac adverse events (minimum 24-h burden over the 14-day monitoring period)



Hamon D et al. Circ Arrhythm Electrophysiol. 2017;10.



φεστινα λεντε

Vedo un falchetto roteare lentamente ed elegantemente nel cielo,
sembra esplorare il suolo col suo occhio acutissimo,
e vaga, vaga con infinita pazienza,
poi improvvisamente si precipita verso terra a grande velocità...
risale lentamente con una preda.

Ha pensato, ripensato, analizzato
e poi con rapidità
ha dato seguito alla decisione presa
con sapienza efficiente,
come se *festina lente* fosse la sua strategia di pensiero.