



Tachicardia Ventricolare nell'Atleta: Quando l'Intervento Ablativo Consente il Ritorno all'Attività Agonistica?

Paolo Compagnucci, MD, PhD, FEHRA

Clinica di Cardiologia e Aritmologia – AOU delle Marche - Ancona

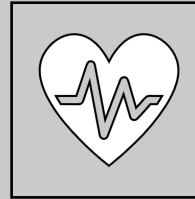
Membro del Consiglio Direttivo Nazionale SICSPORT

Task Force AIAC - Telecardiologia e E-Health

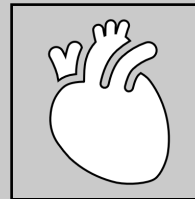
Membro dell'Editorial Board – Heart Rhythm Journal, EP Europace & JICE

Ancona, 30 Maggio 2026

ATHLETES AND VENTRICULAR ARRHYTHMIAS: A COMMON AND POTENTIALLY WORRISOME ASSOCIATION



Ventricular arrhythmias (VAs) are a **common finding** and a **critical issue** with regards to sports eligibility assessment in competitive athletes.



In a large, unselected population of young athletes undergoing pre-participation screening with ECG in Italy, **premature ventricular complexes (PVCs)** were observed in **1.1% of cases (349/32652)** and were the most common arrhythmia detected after premature atrial complexes, whereas ventricular tachycardias were rarer



EPIDEMIOLOGY OF VAs IN ATHLETES

TABLE I.—Incidence and characteristics of premature ventricular beats in the overall study sample and according to the age group.

Parameters	Total population N.=1431	Under 35 years old N.=1167 (82%)	Over 35 years old N.=264 (18%)	P
Male	1079 (75%)	856 (74%)	223 (85%)	<0.01
Age*	19 (14-31)	17 (13-24)	47 (40.25-54)	<0.01
Skill	60 (4.3%)	55 (4.7%)	5 (2.1%)	<0.01
Power	70 (5%)	56 (4.8%)	14 (5.8%)	<0.01
Mixed	1013 (71%)	903 (77%)	110 (42%)	<0.01
Endurance	288 (21%)	153 (13%)	135 (56%)	<0.01
Presence of PVBs	208 (15%)	118 (10%)	90 (34%)	<0.01
Morphology				
Infundibular	46 (3.2%)	33 (2.8%)	13 (5.0%)	0.081
Fascicular	44 (3.1%)	35 (3.0%)	9 (3.4%)	0.728
LBBB/not inferior axis	34 (2.4%)	23 (2.0%)	11 (4.2%)	0.034
RBBB/inferior axis	15 (1%)	6 (0.5%)	9 (3.4%)	<0.01
RBBB/not inferior axis	50 (3.5%)	14 (1.2%)	36 (13.6%)	<0.01
Polymorphic	19 (1.3%)	7 (0.6%)	12 (4.5%)	<0.01
Number				
<5 PVBs	176 (12.3%)	101 (8.7%)	75 (28.4%)	<0.01
≥5PVBs	32 (2.2%)	14 (1.2%)	18 (6.8%)	<0.01
Repetitivity				
Couplets	26 (1.8%)	7 (0.6%)	19 (7.2%)	<0.01
NSVT	7 (0.5%)	1 (0.1%)	6 (2.3%)	<0.01
Phase of the test [#]				
Low workload/recovery	75 (5.2%)	49 (4.2%)	26 (9.8%)	<0.01
High workload	118 (8.2%)	64 (5.5%)	54 (20.5%)	<0.01
Both phases	15 (1.0%)	5 (0.4%)	10 (3.8%)	<0.11

Categorical variables are compared with the χ^2 test or the Fisher's Exact Test as appropriate.

LBBB: left bundle branch block; NSVT: non-sustained ventricular tachicardia; PVBs: premature ventricular beats; RBBB: right bundle branch block.

*Data are shown as median (1st-3rd quartiles) and compared with the rank sum test; [#]the cut-off between low and high workload was arbitrarily defined as the 70% of the theoretical maximal heart rate.



EPIDEMIOLOGY OF VAs IN ATHLETES

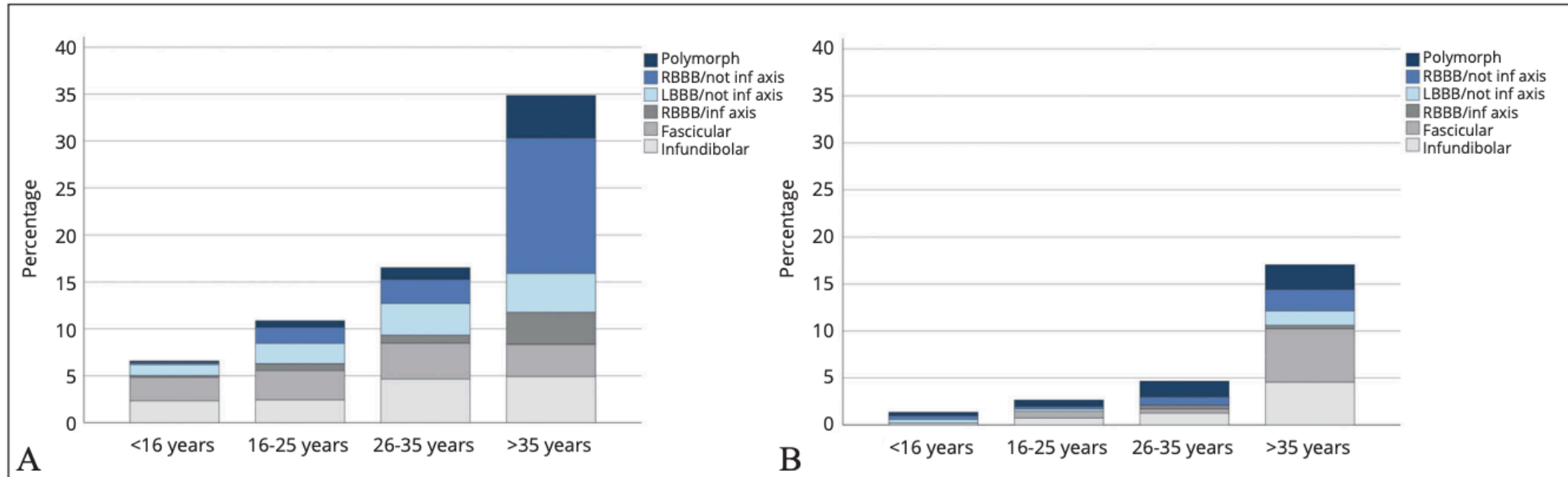


Figure 1.—Incidence and type of premature ventricular beats according to the age group: A) all athletes with at least 1 PVB were counted; B) only athletes with at least 5 isolated PVBs or at least 1 repetitive ventricular arrhythmia (couplet or run of ≥ 3) were counted.



Risk Stratification of VT in the Athlete

1. The prognosis of VAs in the athlete generally depends on the underlying substrate
2. However, ventricular tachycardia identifies a high-risk subgroup which always requires in depth investigations
3. Once a substrate has been ruled out, the athlete can be reassured, and ablation can be considered to allow arrhythmia control
4. Patients with idiopathic VTs s/p successful ablation can return to play with close follow-up



Raccomandazioni per la concessione dell'idoneità agonistica nei soggetti con aritmie ventricolari in assenza di cardiopatia sottostante

	CLASSE	LOE
Nei soggetti con BPV o TVNS sporadiche, l'idoneità può essere concessa in assenza di: • Sintomi maggiori (es. pre-sincope o sincope) • BPV molto precoci (R/T) e/o con coppie strette e/o TVNS numerose, indotte dallo sforzo o ad alta frequenza; • Riduzione della FE <50%.	I	C
L'idoneità è normalmente negata, salvo eccezioni da valutare su base individuale, nei soggetti con: • BPV molto precoci (R/T) e/o con coppie strette e/o TVNS numerose, favorite dallo sforzo o ad alta frequenza; • Storia di aritmia ventricolare sostenuta.	II	C
L'idoneità deve essere negata nei soggetti con BPV frequenti in cui si documenti una riduzione della FE (<50%)	III	B

Table 16 Risk features from history and tests used to identify structural or electrical heart disease

Low-risk features	Higher-risk features
Clinical Asymptomatic Palpitations suggestive of simple PVCs No history suggestive of inherited heart disease	Presyncope, syncope, dyspnea, or sudden-onset exercise intolerance Sustained rapid palpitations Family history of collapse, syncope, sudden death, or cardiomyopathy
Electrocardiographic Monomorphic PVCs with outflow tract or fascicular morphology ("typical morphology") Normal 12-lead ECG (other than PVCs) Normal PVC coupling interval Single PVCs Low burden of PVCs on Holter ECG	Polymorphic PVCs or with non-outflow-tract or fascicular morphology ("atypical morphology") Abnormal ECG (in addition to PVCs), eg, low voltage Short PVC coupling interval Couplets, triplets, or nonsustained ventricular tachycardia High-burden PVCs (> 10% burden)
Exercise stress testing Suppression of PVCs with exercise No symptoms and normal hemodynamics	Nonsuppression or emergence of PVCs with exercise or emergence of PVCs during recovery Symptoms of sudden-onset exercise intolerance associated with emergence of arrhythmias
Echocardiography/stress echocardiography Normal cardiac structure and function for an athlete (ie, inclusive of athlete's heart changes) Clear augmentation of biventricular function with exercise	Increased wall thickness or excessive ventricular dilation, reduced systolic function, or segmental abnormalities Reduced contractile reserve during exercise (of the left or right ventricle)
Cardiac magnetic resonance imaging Normal structure and function No evidence of post-contrast enhancement	Increased wall thickness or excessive ventricular dilation, reduced systolic function, or segmental abnormalities Delayed gadolinium enhancement, particularly mid-wall or epicardial enhancement
Invasive electrophysiology Focal arrhythmogenic site Catecholamine triggering of focal site Normal electroanatomical mapping	Multiple inducible arrhythmias Catecholamine triggering of rapid polymorphic arrhythmias Low-voltage regions (noting a tendency to epicardial pathology in endurance athletes)

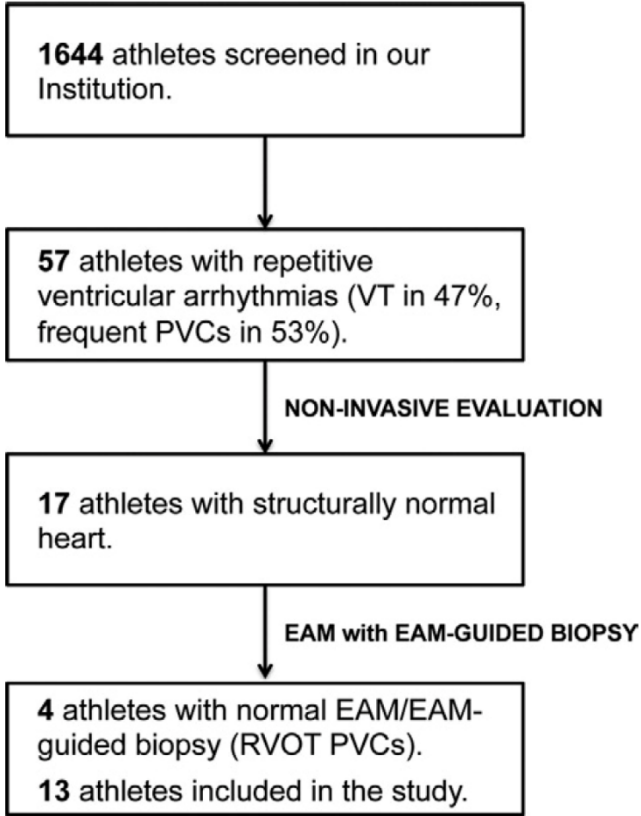
ECG = electrocardiogram; PVC = premature ventricular contraction; RVOT = right ventricular outflow tract.

Recommendations for the evaluation of ventricular arrhythmias in athletes

COR	LOE	Recommendations
1	B-NR	1. In athletes with symptoms suspicious for ventricular arrhythmias, a resting 12-lead ECG and ambulatory ECG monitor are recommended to assess ventricular arrhythmia burden and complexity. ^{310,311}
2a	B-NR	2. In athletes with symptoms suspicious for suspected ventricular arrhythmias, exercise stress testing is reasonable to assess ventricular arrhythmia occurrence, characteristics, and morphology. ^{255,312}
1	C-EO	3. In athletes with ventricular arrhythmias, taking a history of supplements and performance-enhancing drug use is recommended to identify potential triggers for ventricular arrhythmias.
1	C-LD	4. In athletes with 2 or more asymptomatic typical PVCs, or 1 atypical PVC, on a 12-lead ECG, further evaluation with ambulatory monitoring and cardiac imaging is recommended. ²⁹²
2b	C-EO	5. In athletes with 1 asymptomatic typical PVC (single outflow tract or fascicular morphology) on a 12-lead ECG, further evaluation may be considered.
1	C-EO	6. In athletes with PVCs of a single outflow tract or fascicular morphology, assessment of cardiac structure and function with echocardiography is recommended to exclude underlying pathology.
1	B-NR	7. In athletes with higher-risk ventricular arrhythmias and/or abnormal primary testing, comprehensive cardiac imaging including CMR and exercise stress testing is recommended to assess for underlying structural heart disease and behavior of PVCs with exercise. ^{88,313,314}
2b	C-LD	8. In adult athletes with ventricular arrhythmias with higher-risk but nondiagnostic features after comprehensive examination, EP study with voltage mapping may be useful in defining the extent and location of the arrhythmogenic substrate. ^{307,315}
1	C-EO	9. In athletes with ventricular arrhythmias with higher-risk features, withholding from sports participation pending evaluation is recommended.

Concealed cardiomyopathies in competitive athletes with ventricular arrhythmias and an apparently normal heart: role of cardiac electroanatomical mapping and biopsy

Antonio Dello Russo, MD, PhD,* Maurizio Pieroni, MD, PhD,[†] Pasquale Santangeli, MD,[§] Stefano Bartoletti, MD,*^{||} Michela Casella, MD, PhD,* Gemma Pelargonio, MD, PhD,[†] Costantino Smaldone, MD,[†] Massimiliano Bianco, MD,[‡] Luigi Di Biase, MD PhD,^{§¶} Fulvio Bellocci, MD, Paolo Zeppilli, MD,[‡] Cesare Fiorentini, MD,*^{||} Andrea Natale, MD, FACC, FHRS,[§] Claudio Tondo, MD, PhD*

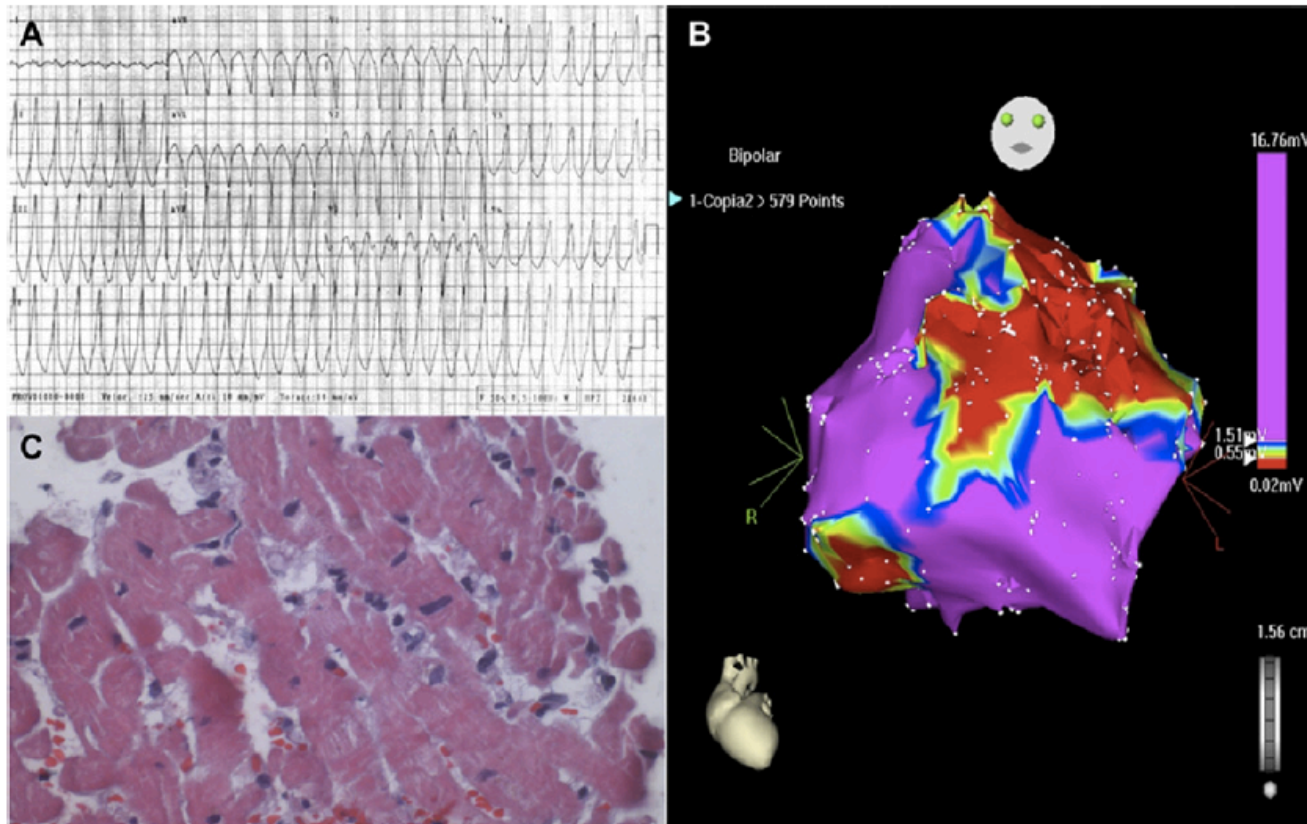


Patient no.	Age/sex	Type of sport	Family history of SCD	Baseline ECG	Index VA	ECG features of VA	Diagnosis of VA	Symptoms
1	45/M	Kickboxing	No	Normal	Nonsustained VT	LBBB; inferior axis	24-hour Holter ECG	Syncope
2	51/M	Cycling	No	Normal	Nonsustained VT	RBBB; superior axis	ECG stress testing	Syncope
3 ^a	36/M	Volley	Yes	Incomplete RBBB	Frequent VPBs	LBBB; inferior axis	24-hour Holter ECG	Palpitations
4	19/M	Skiing	No	Normal	Frequent VPBs	LBBB; inferior axis	24-hour Holter ECG	Palpitations
5 ^b	29/M	Soccer	Yes	Incomplete RBBB	Nonsustained VT	LBBB; superior axis	12-lead ECG	Dizziness
6	25/M	Cycling	No	Normal	Sustained VT	LBBB; inferior axis	ECG stress testing	Dizziness
7	19/M	Soccer	No	Normal	Nonsustained VT	RBBB; intermediate axis	ECG stress testing	Palpitations
8	16/M	Soccer	No	Normal	Nonsustained VT	RBBB; superior axis	ECG stress testing	Dizziness
9	16/M	Soccer	No	Normal	Frequent VPBs	LBBB; intermediate axis	24-hour Holter ECG	Palpitations
10	42/M	Cycling	No	Normal	Sustained VT	LBBB; inferior axis	12-lead ECG	Dizziness
11	44/M	Marathon	No	Normal	Sustained VT	LBBB; inferior axis	12-lead ECG	Dizziness
12	31/M	Skating	No	Normal	Nonsustained VT	LBBB; inferior axis	24-hour Holter ECG	Palpitations
13	15/F	Skiing	No	Normal	Nonsustained VT	LBBB; intermediate axis	12-lead ECG	Syncope

Patient no.	Mapping system	Ventricle mapped	Electroanatomical scar localization	Endomyocardial biopsy
1 ^a	CARTO	Right	Outflow tract; inferior-posterior wall; free wall	ARVC
2	CARTO	Left	Apex	Myocarditis
3	CARTO	Right	Outflow tract; apex	ARVC
4	CARTO	Right	Outflow tract; free wall	ARVC
5 ^a	CARTOSOUND	Right	Inferior-posterior wall; apex	ARVC
6 ^b	CARTO	Right	Outflow tract	Contraction band necrosis ^c
7	CARTOSOUND	Left	—	Myocarditis
8	CARTO	Left	Inferior wall	Myocarditis
9	CARTO	Right	Free wall; inferior-posterior wall	Myocarditis
10 ^b	CARTO	Right	Outflow tract; inferior-posterior wall; free wall	Myocarditis
11 ^b	CARTOSOUND	Right	Outflow tract	Myocarditis
12	CARTO	Right	Outflow tract; inferior-posterior wall	ARVC
13	CARTO	Right	Outflow tract; inferior-posterior wall; free wall	Myocarditis

Concealed cardiomyopathies in competitive athletes with ventricular arrhythmias and an apparently normal heart: role of cardiac electroanatomical mapping and biopsy

Antonio Dello Russo, MD, PhD,* Maurizio Pieroni, MD, PhD,[†] Pasquale Santangeli, MD,[§] Stefano Bartoletti, MD,*^{||} Michela Casella, MD, PhD,* Gemma Pelargonio, MD, PhD,[†] Costantino Smaldone, MD,[†] Massimiliano Bianco, MD,[‡] Luigi Di Biase, MD PhD,^{§¶} Fulvio Bellocci, MD,[†] Paolo Zeppilli, MD,[‡] Cesare Fiorentini, MD,*^{||} Andrea Natale, MD, FACC, FHRS,[§] Claudio Tondo, MD, PhD*



A 42-year-old male cyclist (patient no. 10) presenting with dizziness.

A: Twelve-lead ECG demonstrated sustained VT with left bundle branch morphology and inferior axis.

B: RV EAM showed scars in the outflow tract, in the free wall, and in the inferior-posterior wall.

C: Endomyocardial biopsy guided by EAM demonstrated myocarditis. The patient underwent successful ablation.

FULL LENGTH ARTICLE | [ARTICLES IN PRESS](#)

Ventricular Arrhythmias in Athletes: Role of a Comprehensive Diagnostic Workup

[Antonio Dello Russo, MD, PhD](#) • [Paolo Compagnucci, MD](#)  •  • [Michela Casella, MD, PhD](#) •

[Alessio Gasperetti, MD](#) • [Stefania Riva, MD](#) • [Maria Antonietta Dessanai, MD](#) • [Francesca Pizzamiglio, MD](#) •

[Valentina Catto, PhD](#) • [Federico Guerra, MD](#) • [Giulia Stronati, MD](#) • [Daniele Andreini, MD PhD](#) •

[Gianluca Pontone, MD, PhD](#) • [Alice Bonomi, PhD](#) • [Stefania Rizzo, MD](#) • [Luigi Di Biase, MD, PhD](#) •

[Alessandro Capucci, MD](#) • [Andrea Natale, MD](#) • [Cristina Basso, MD, PhD](#) • [Cesare Fiorentini, MD](#) •

[Paolo Zeppilli, MD](#) • [Claudio Tondo, MD, PhD](#) • [Show less](#) • [Show footnotes](#)

Published: September 15, 2021 • DOI: <https://doi.org/10.1016/j.hrthm.2021.09.013>



Ventricular Arrhythmias in Athletes: Role of a Comprehensive Diagnostic Workup

Methods

Design, Inclusion Criteria and Primary Endpoint

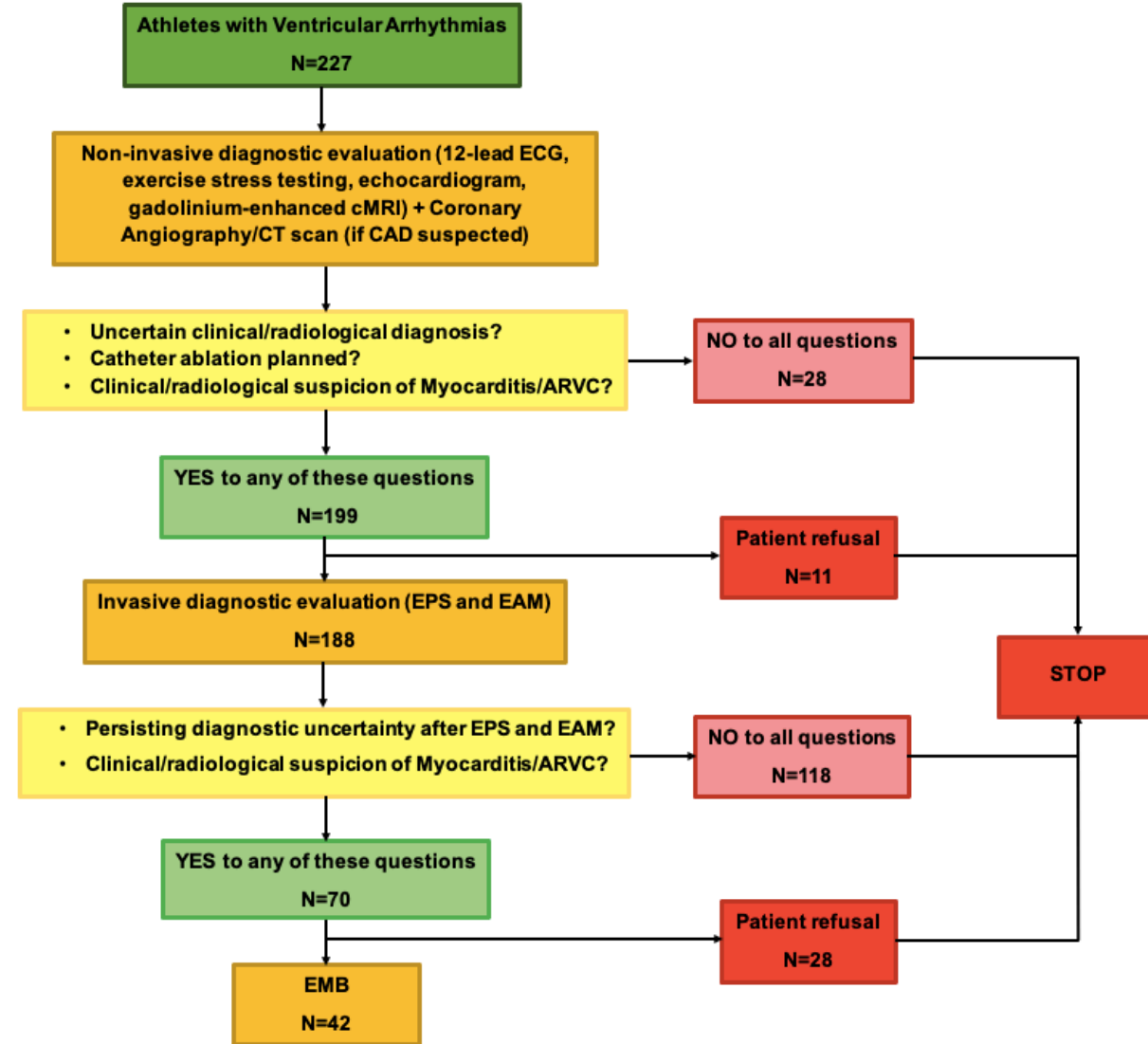
Dual-center retrospective analysis of prospectively enrolled pts

227 consecutive competitive athletes who were disqualified from participating in competitive or leisure-time sports because of **complex repetitive VAs (nonsustained or sustained VTs), frequent (>500/day) or exercise-related PVCs, or resuscitated ventricular fibrillation (VF)**

1) Heart Rhythm Center, Monzino Cardiology Center, IRCCS, Milan, Italy

2) Cardiology and Arrhythmology Clinic, University Hospital "Ospedali Riuniti", Ancona, Italy

Primary endpoint: return to play at 6-mo follow-up



Dello Russo A, Compagnucci P et al. Heart Rhythm 2021

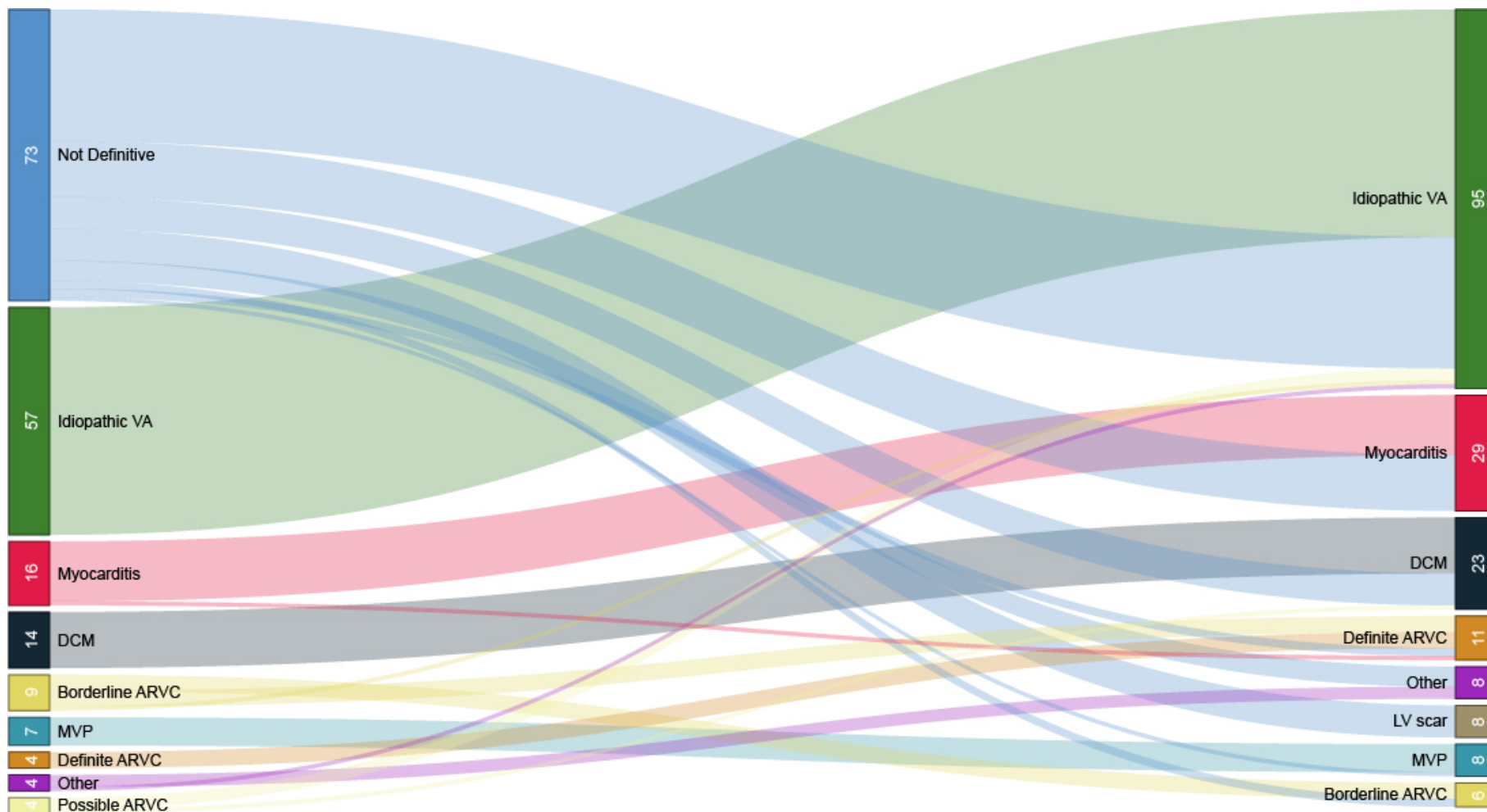


Ventricular Arrhythmias in Athletes: Role of a Comprehensive Diagnostic Workup

Results - Diagnostic reclassification before and after invasive tests

Diagnoses before EAM, EPS and EMB

Diagnoses after EAM, EPS and EMB





High prevalence of right ventricular involvement in endurance athletes with ventricular arrhythmias

Role of an electrophysiologic study in risk stratification

Hein Heidbüchel^{a,*}, Jan Hoogsteen^{b,d}, Robert Fagard^a, L. Vanhees^a, Hugo Ector^a, Rik Willems^a, Johan Van Lierde^{c,d}

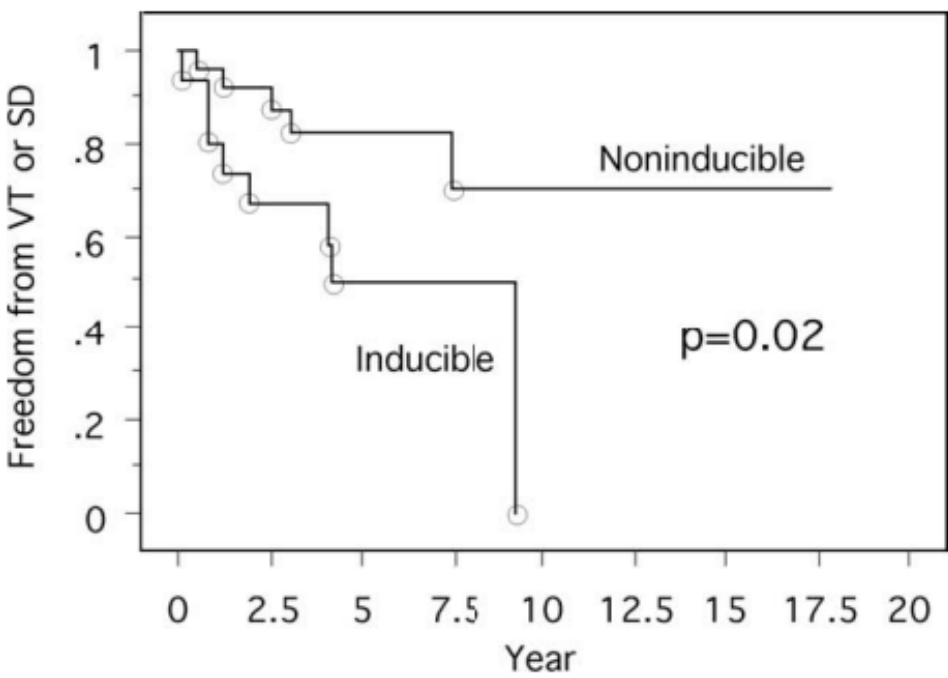


Fig. 1 Kaplan–Meier curves showing freedom from a major arrhythmia (sustained VT or sudden death) during follow-up in 40 of the 46 athletes in whom an EP study was performed during initial evaluation. Athletes with inducible sustained VT or VF (*n*=15) had a significantly higher risk for developing major arrhythmias during follow-up (RR 3.4; *P*=0.02).

Table 1 Data at presentation and initial electrophysiological evaluation

Baseline variables	No. of pts (%)	Initial evaluation	No. of pts (%)
Male	45 (98%)	Holter (<i>n</i> =43)	
Age, years (median & range)	31 (16–53)	Single PVC or couplets	21 (49%)
Type of sports		Non-sustained VT (120–308 bpm, 3–19 beats)	21 (49%)
Cycling	37 (80%)	Sustained monomorphic VT	1 (2%)
Running	8 (17.5%)	Bicycle test (<i>n</i> =44)	
Kayaking	1 (2.5%)	No VT	16 (36%)
Level of sports activity		Non-sustained VT	15 (34%)
Professional	17 (37%)	Sustained VT (175–300 bpm)	13 (30%)
Semi-professional	20 (43%)	Non-invasive evaluation	
Recreational	9 (20%)	Single PVC or couplets	5 (11%)
Presenting symptoms		Non-sustained VT	24 (52%)
Aborted sudden death (Pre)syncope	1 (2%)	Sustained monomorphic VT ^a	17 (37%)
Palpitations or none	30 (65%)	Electrophysiological study (<i>n</i> =40)	
Baseline 12-lead ECG		Negative	10 (25%)
Normal or LVH	15 (33%)	Non-sustained VT	15 (38%)
Negative T V1–V2	23 (50%)	Monomorphic	8
Negative T ≥V3	4 (9%)	Polymorphic	5
Pathologic Q waves	10 (26%)	Both	2
Epsilon waves	1 (2%)	Sustained VT (all monomorphic)	15 (38%)
Signal averaged ECG (<i>n</i> =38)	9 (19.5%)	PVC/VT morphology (<i>n</i> =46)	
≤1 positive criterium	23 (61%)	LBB	37 (80%)
2 positive criteria	5 (13%)	RBB	3 (7%)
3 positive criteria	10 (26%)	Polymorph	2 (4%)
Filtered QRS duration (40–250 Hz)		Unknown	4 (9%)
≥120 ms	124±7 ms		
Low amplitude signals ≤40 µV	39 (84%)		
≥40 ms	33±13 ms		
RMS last 40 ms	21 (35%)		
≤20 µV	32±21 µV		
	14 (31%)		

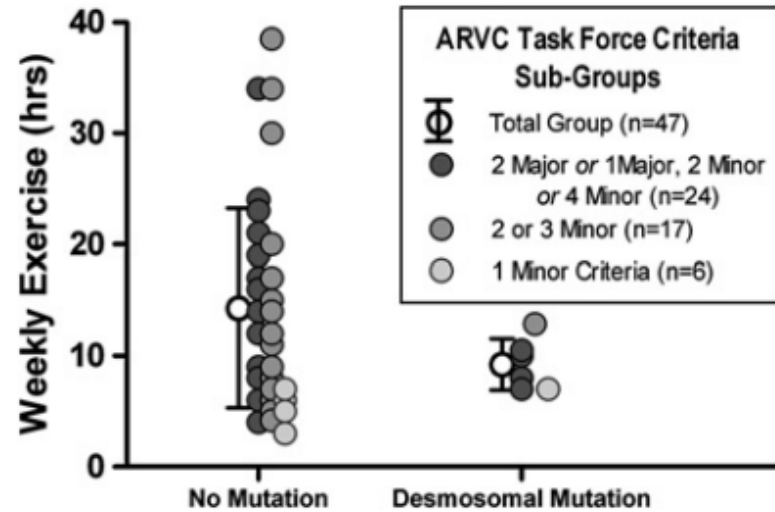
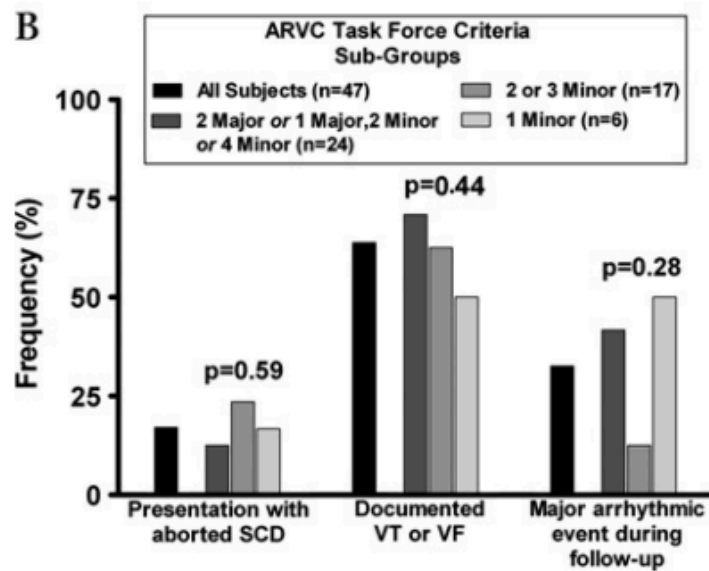
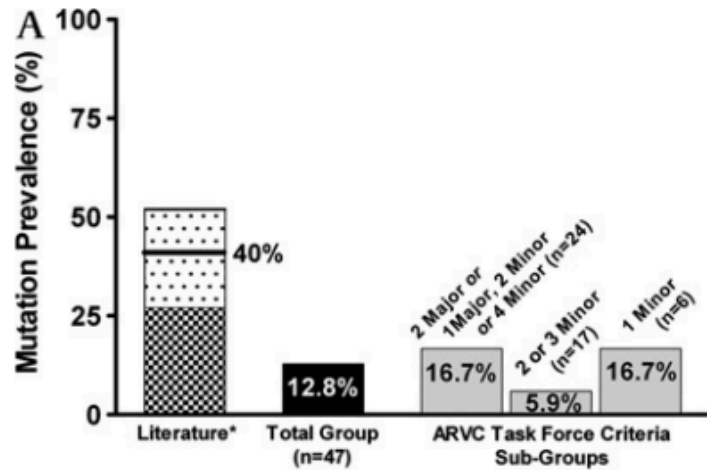
Table 2 Morphological data

Continuous variables	Mean±SD (range) (<i>n</i> =34)
LV internal diameter (mm)	52.7±5.3 (43–66)
Septal wall thickness (mm)	11.8±2.1 (7–17)
Posterior wall (mm)	10.5±1.7 (8–15)
Categorical variables	No. of pts (%)
Transthoracic echocardiography (<i>n</i> =46)	
RV structural abnormalities	5 (11%)
LV angiography (<i>n</i> =36)	
Regional hypokinesia	1 (3%)
Normal	35 (97%)
Coronary angiography (<i>n</i> =36)	
Bridging of the LAD ^a	1 (3%)
Normal	35 (97%)
RV angiography (<i>n</i> =27)	
Global dilatation (more than the LV)and/or hypokinesia	12 (44%)
Regional dilatation and/or hypokinesia	6 (23%)
Normal	9 (33%)
Cardiac MRI (<i>n</i> =28)	
Concentric LVH	1 (4%)
Global RV dilatation or hypokinesia	2 (7%)
Regional RV dilatation and/or hypokinesia and/or fat	10 (36%)
Normal	15 (53%)
Myocardial biopsy (<i>n</i> =8)	
Fibrosis (with fat in 1 pt)	3 (38%)
Cellular disarray	1 (12%)
Normal	4 (50%)

^aLAD: left anterior descending artery; MRI: magnetic resonance imaging; RV/LV: right/left ventricle.

Lower than expected desmosomal gene mutation prevalence in endurance athletes with complex ventricular arrhythmias of right ventricular origin

A La Gerche,^{1,3} C Robberecht,² C Kuiperi,² D Nuyens,¹ R Willems,¹ T de Ravel,² G Matthijs,² H Heidbüchel^{1,3}



Patients Forty-seven consecutive athletes (age 42 (11) years) with complex VA of RV morphology (excluding idiopathic right ventricular outflow tract ventricular tachycardia), who performed 14 (9) h/week of moderate to intense sport practise for 19 (9) years.

Interventions Clinical evaluation (detailed sports history, multi-modality imaging, electrophysiological study) and sequencing of five candidate desmosomal genes.

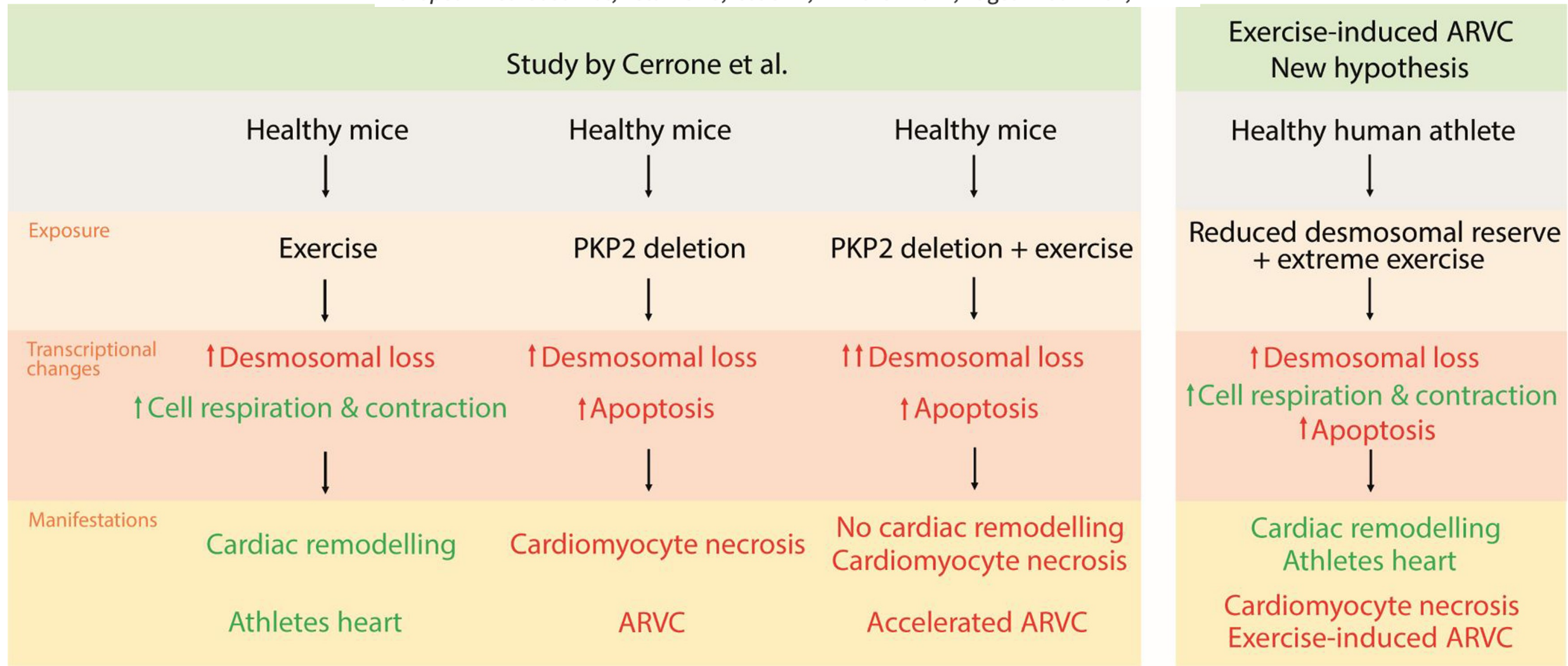
Results A clinical diagnosis of definite or suspected ARVC by task force criteria (TFC) was met in 24 (51%) and 17 (36%), respectively. ARVC classification was not related to the rate of major arrhythmic events ($p=0.28$). Pathogenic mutations (four novel) were identified in six athletes (12.8%), which is below published rates for familial ARVC (27–52%). Moreover, only two athletes had a suggestive family history. Severe RV dysfunction was more frequent in mutation carriers (33% vs 2%, $p=0.04$), but otherwise TFC features were similar to those without mutations. No mutations were found in the 20 athletes performing more than average weekly exercise, yet all met the criteria for definite or suspected ARVC.

Conclusions In this athletic cohort, we found lower than expected rates of desmosomal gene mutations, particularly among those performing the most exercise. This adds further weight to the hypothesis that an ARVC-like phenotype may be acquired through intense exercise without an identifiable genetic predisposition.

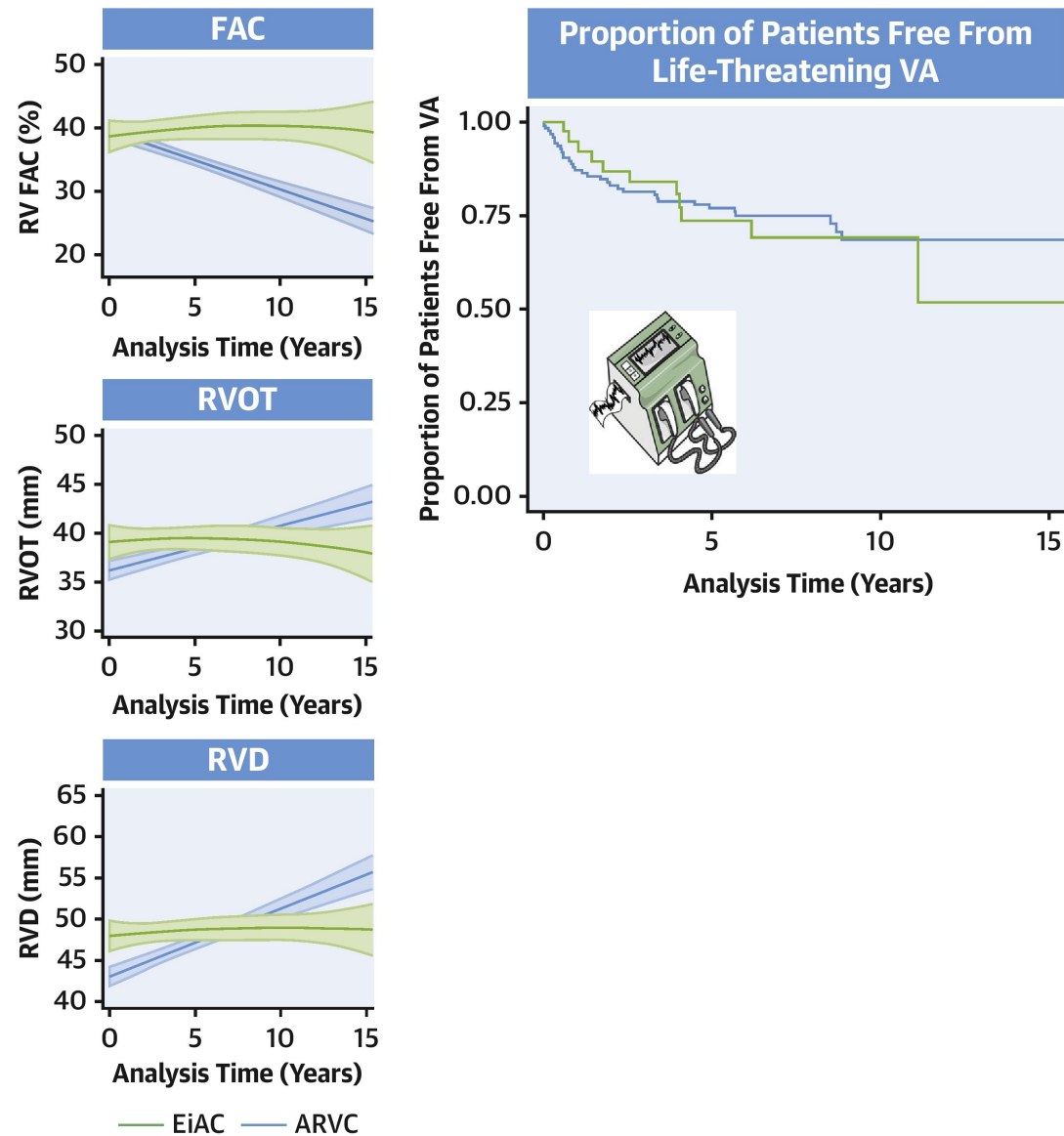
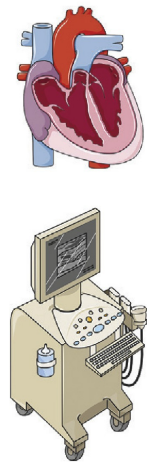
Cardiac desmosomal reserve: another piece of the exercise-induced arrhythmogenic cardiomyopathy puzzle?

[Kristina H. Haugaa](#) ✉, [Christine Rootwelt-Norberg](#) [Author Notes](#)

European Heart Journal, Volume 43, Issue 12, 21 March 2022, Pages 1265–1267,



CENTRAL ILLUSTRATION: Disease Progression in Exercise-Induced Arrhythmogenic Cardiomyopathy and Arrhythmogenic Right Ventricular Cardiomyopathy



At baseline, 33 (26%) patients with ARVC and 10 (24%) patients with EiAC had experienced life-threatening VA. **Recurrent life-threatening VA occurred in 21 (64%) ARVC patients and 4 (40%) EiAC patients during follow-up ($P = 0.325$).** Among patients without previous life-threatening VA, first-time VA occurred in 12 (13%) ARVC patients and 7 (23%) EiAC patients during follow-up ($P = 0.256$). **In total, 45 (36%) ARVC patients and 17 (41%) EiAC patients had experienced life-threatening VA by the last follow-up visit ($P = 0.580$).**

Methods

This longitudinal cohort study included EiAC patients who were competitive endurance athletes (>24 MET-hours/week for >6 consecutive years) referred due to ventricular arrhythmias (VA), without inherited or genetic factors or other evident causes, and genotype-positive ARVC patients with a definite diagnosis and their genotype-positive family members for comparison. Disease progression was assessed by repeated echocardiographic examinations and incident VA during long-term follow-up.

Results

The authors included 125 ARVC patients (61 women, aged 38 ± 17 years) and 41 EiAC patients (6 women, aged 45 ± 13 years) and followed them for 96 months (Q1-Q3: 73-132 months) and 82 months (Q1-Q3: 50-118 months), respectively. The authors analyzed 730 echocardiographic examinations (538 ARVC, 192 EiAC). Right ventricular (RV) structure and function remained stable in EiAC patients, whereas those in ARVC patients deteriorated during follow-up. The 5-year and 10-year cumulative incidences of VA were similar between EiAC and ARVC patients.

Conclusions

RV structure and function deteriorated in ARVC patients but remained stable in EiAC patients during follow-up. The incidence of VA was high in both populations. These results indicate that EiAC patients should be followed closely over time regardless of structural and functional progression.

Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE

Long-Term Risk Assessment in Athletes With Complex Ventricular Arrhythmias

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

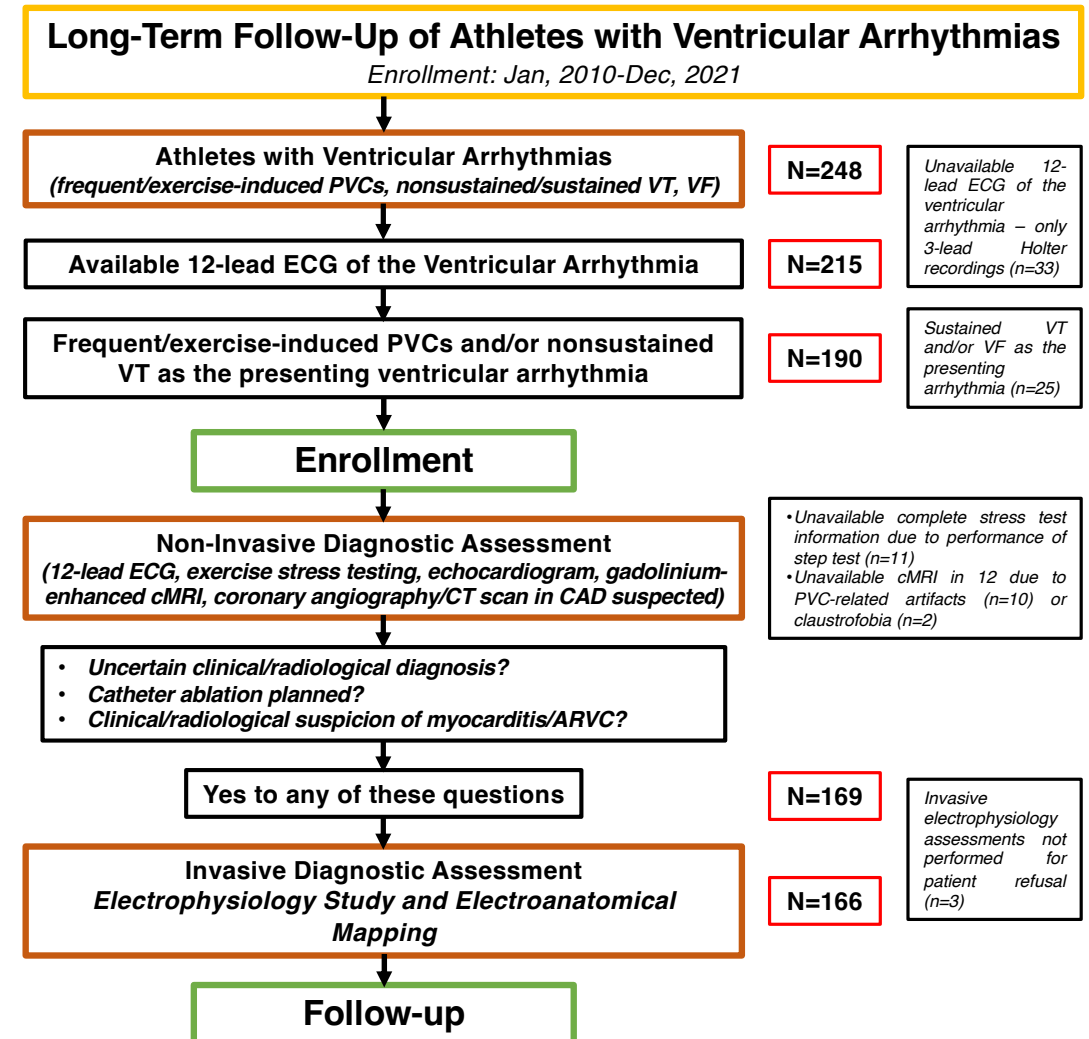
Compagnucci P, et al. Circ Arrhythm Electrophysiol 2025;18(6):e013480



Long-term Risk Assessment in Athletes with Ventricular Arrhythmias: The Key Roles of Arrhythmia **Morphology**, **Complexity**, and **Substrate**



- Prospective, Observational Study
- Multicenter Design:
 - 1) Università Politecnica delle Marche, **Ancona**;
 - 2) Centro Cardiologico Monzino IRCCS, **Milan**;
 - 3) Fondazione Policlinico A. Gemelli IRCCS, **Rome**.



Clinical characteristics

Table 1. Baseline Clinical, Electrocardiographic, Imaging, and Electrophysiological Characteristics of Patients in the Overall Study Population and According to the Morphology of Ventricular Arrhythmias (Common vs Uncommon)

	Overall (n=190)	Common ventricular arrhythmias (n=99)	Uncommon ventricular arrhythmias (n=91)	P value*
Age, median (1st–3rd quartile)	28 (19–43)	25 (18–41)	29 (20–46)	0.143
Male sex, n (%)	156 (82)	77 (78)	79 (87)	0.156
Level of training				
Leisure-time athlete, n (%)	42 (23)	22 (22)	20 (22)	1.000
Competitive athlete, n (%)	125 (66)	71 (72)	54 (59)	0.100
Professional athlete, n (%)††	23 (12)	6 (6)	17 (19)	0.015
Type of sport				
Cycling, n (%)††	28 (15)	8 (8)	20 (22)	0.013
Soccer, n (%)	54 (28)	27 (27)	27 (30)	0.838
Athletics, n (%)	43 (23)	25 (25)	18 (20)	0.467
Swimming, n (%)	12 (6)	7 (7)	5 (5)	0.883
Basketball, n (%)	14 (7)	7 (7)	7 (8)	1.000

Symptoms				
None, n (%)	100 (53)	49 (49)	51 (56)	0.449
Palpitations, n (%)	79 (42)	47 (47)	32 (35)	0.116
Syncope, n (%)	11 (6)	3 (3)	8 (9)	0.122
Arrhythmia morphology				
Infundibular, n (%)††	91 (48)	91 (92)	0 (0)	...
Fascicular, n (%)††	8 (4)	8 (8)	0 (0)	...
Polymorphic, n (%)††	49 (26)	0 (0)	49 (54)	...
LBBB superior/intermediate axis, n (%)††	17 (9)	0 (0)	17 (19)	...
Atypical RBBB, n (%)††	25 (13)	0 (0)	25 (27)	...
Arrhythmia at baseline				
Frequent PVCs, n (%)	168 (88)	89 (90)	79 (87)	0.662
NSVT, n (%)	93 (49)	47 (47)	46 (51)	0.781



Results of non-invasive and invasive tests

12-lead ECG				
Normal, n (%)††	108 (57)	70 (71)	38 (42)	<0.001
Borderline, n (%)	32 (17)	18 (18)	14 (15)	0.749
Abnormal, n (%)††	50 (26)	11 (11)	39 (43)	<0.001
Exercise stress test, n (%)††	179 (94)	89 (90)	90 (99)	0.011
PVC suppression/absent arrhythmias, n (%)†	119 (66)	67 (75)	52 (58)	0.177
PVC persistence/induction, n (%)†,††	43 (24)	16 (18)	27 (30)	0.040
Nonsustained VT, n (%)†	15 (8)	6 (7)	9 (10)	0.479
Sustained VT, n (%)†	2 (1)	0 (0)	2 (2)	0.228
Echocardiogram				
Normal, n (%)††	133 (70)	83 (84)	50 (55)	<0.001
Abnormal, n (%)††	57 (30)	16 (16)	41 (45)	<0.001
LVEF<50%, n (%)	17 (9)	6 (6)	11 (12)	0.230
MVP, n (%)	17 (9)	7 (7)	10 (11)	0.490
LV RWMA, n (%)††	13 (7)	1 (1)	12 (13)	<0.001
RV RWMA, n (%)	7 (4)	4 (4)	3 (3)	1.000
CMR				
CMR performed, n (%)	178 (94)	91 (92)	87 (96)	0.377
LGE, n (%)‡, ††	62 (33)	14 (15)	48 (53)	<0.001
LV LGE, n (%)‡, ††	56 (31)	13 (14)	43 (49)	<0.001
Stria, n (%)††	37 (21)	11 (12)	26 (30)	0.006
Patchy, n (%)††	19 (11)	2 (2)	17 (20)	<0.001

	Overall (n=190)	Common ventricular arrhythmias (n=99)	Uncommon ventricular arrhythmias (n=91)	P value*
RV LGE, n (%)‡, ††	9 (5)	1 (1)	8 (9)	0.016
Edema, n (%)‡, ††	5 (3)	0 (0)	5 (6)	0.026
Fat infiltration, n (%)‡, ††	8 (4)	1 (1)	7 (8)	0.032
Programmed electrical stimulation, n (%)	166 (87)	84 (85)	82 (90)	0.383
Inducibility of sustained VT/VF, n (%)§, ††	7 (4)	0 (0)	7 (8)	0.002
Catheter ablation, n (%)††	84 (44)	57 (58)	27 (30)	<0.001
Electroanatomical mapping, n (%)	166 (87)	84 (85)	82 (90)	0.383
RV electroanatomical mapping performed, n (%)	143 (75)	76 (77)	67 (74)	0.739
Bipolar RV scar, n (%)¶	28 (20)	10 (13)	18 (27)	0.064
Unipolar RV scar, n (%)¶, ††	31 (22)	10 (13)	21 (31)	0.015
Regional distribution of RV scar, n (%)¶				
RVOT	21 (15)	9 (12)	12 (18)	0.432
Subtricuspid RV††	16 (11)	3 (4)	13 (19)	0.006
RV apex††	9 (6)	1 (1)	8 (12)	0.013
RV septum††	4 (3)	0 (0)	4 (6)	0.046
LV electroanatomical mapping performed, n (%)††	62 (33)	24 (24)	38 (42)	0.016
Bipolar LV scar, n (%)#, ††	17 (27)	2 (8)	15 (39)	0.009
Unipolar LV scar, n (%)#	22 (35)	5 (21)	17 (45)	0.064
Regional distribution of LV scar, n (%)#				
LV inferolateral wall	18 (29)	4 (17)	14 (37)	0.150
LV septum	10 (16)	1 (4)	9 (24)	0.073
LVOT	2 (3)	1 (4)	1 (3)	1.000
LV anterior wall	2 (3)	0 (0)	2 (5)	0.518
LV apex	3 (5)	0 (0)	3 (8)	0.277
Epicardial mapping performed, n (%)	1 (1)	0 (0)	1 (1)	1.000
Late potentials, n (%)**, ††	10 (6)	0 (0)	10 (12)	<0.001



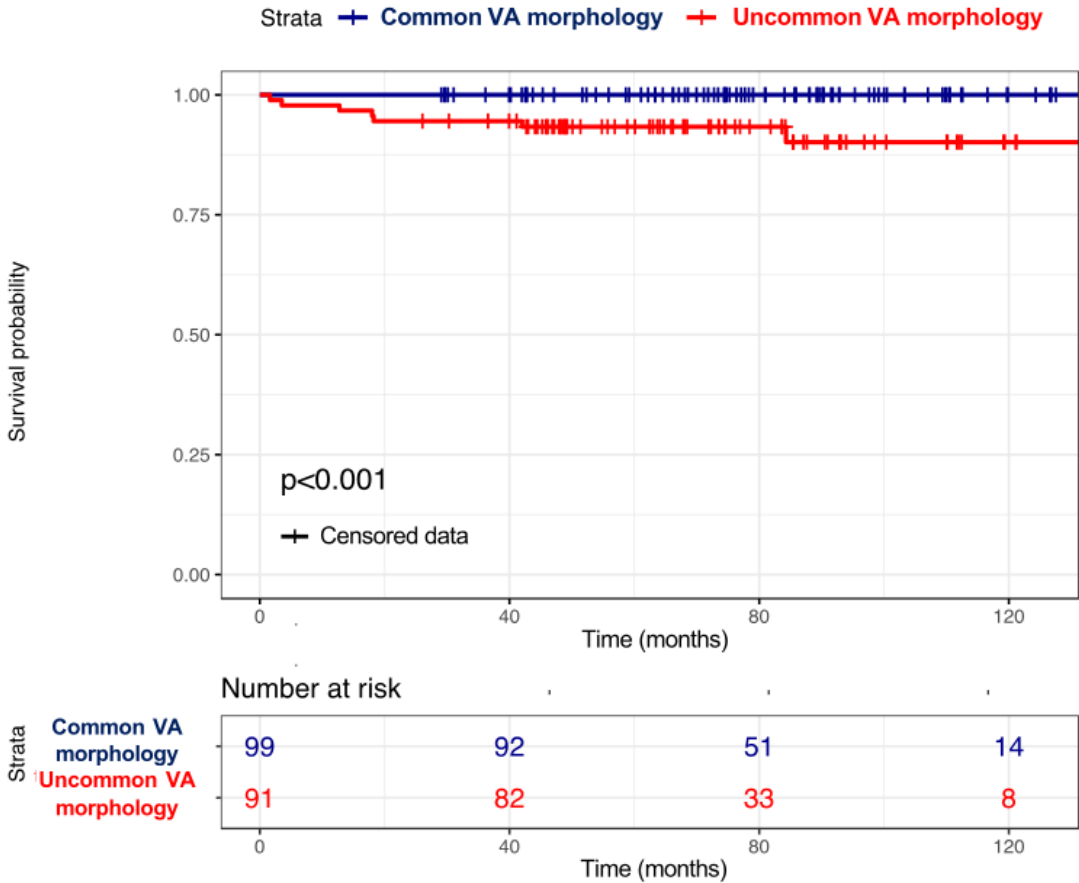
Final diagnoses

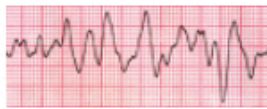
Final diagnoses				
Idiopathic VA, n (%)††	99 (52)	71 (72)	28 (31)	<0.001
Myocarditis, n (%)††	24 (13)	6 (6)	18 (20)	0.009
Arrhythmogenic cardiomyopathy, n (%)††	40 (21)	9 (9)	31 (34)	<0.001
Dilated cardiomyopathy, n (%)	12 (6)	7 (7)	5 (5)	0.883
Mitral valve prolapse, n (%)	12 (6)	6 (6)	6 (7)	1.000
Hypertrophic cardiomyopathy with gray-zone (13–14 mm) maximal septal thickness, n (%)	3 (2)	0 (0)	3 (3)	0.108
Left ventricular noncompaction, n (%)	1 (1)	0 (0)	1 (1)	0.479



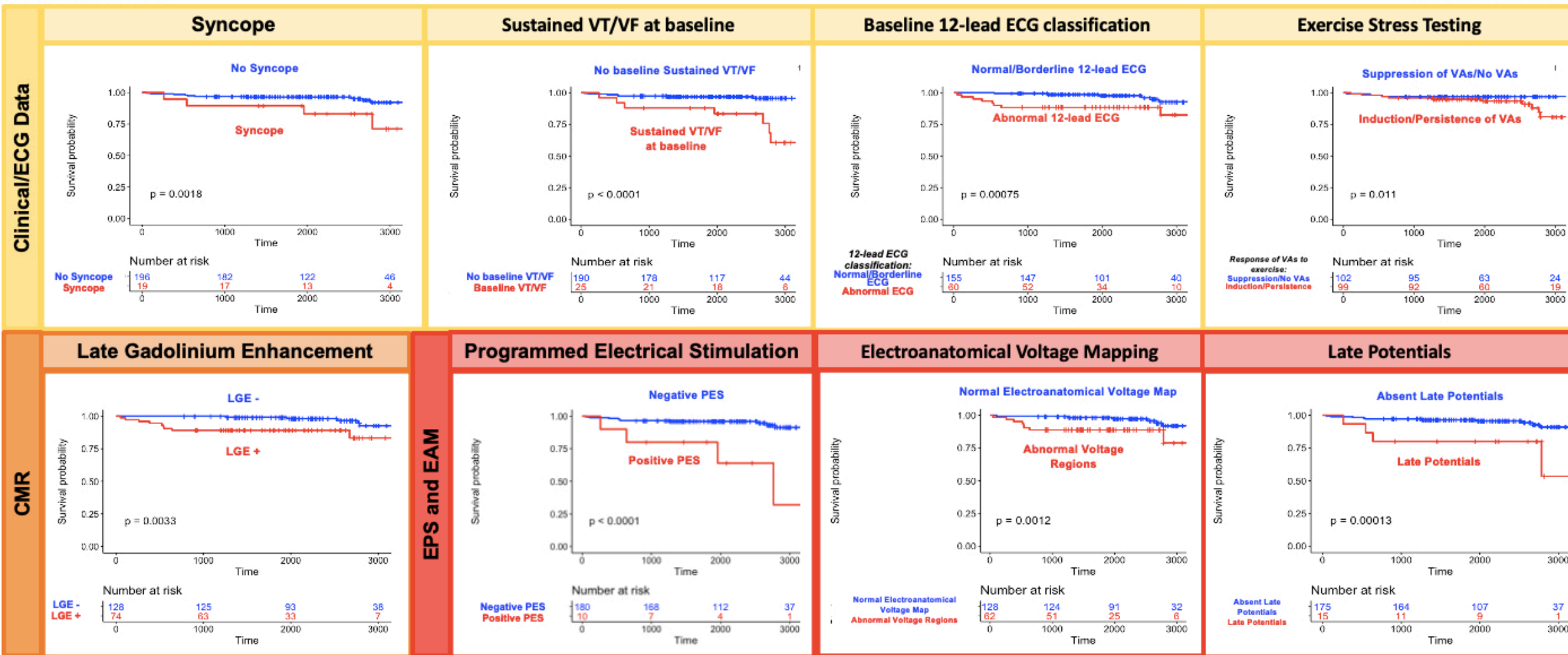
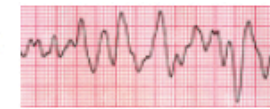
The Prognostic Role of Arrhythmia Morphology

Kaplan-Meier Survival Curves for the Primary Outcome of Sudden Death or Sustained VT/VF

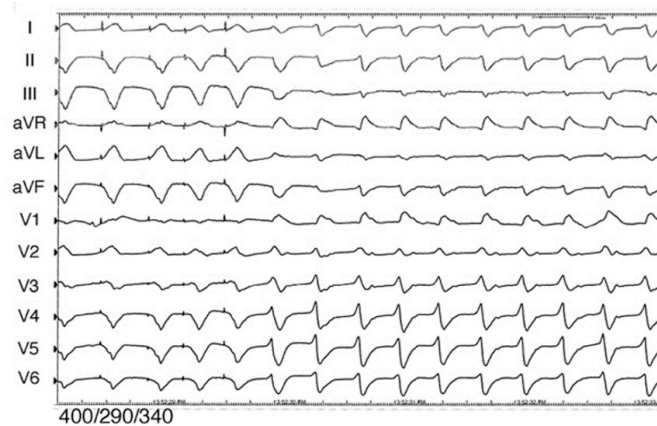
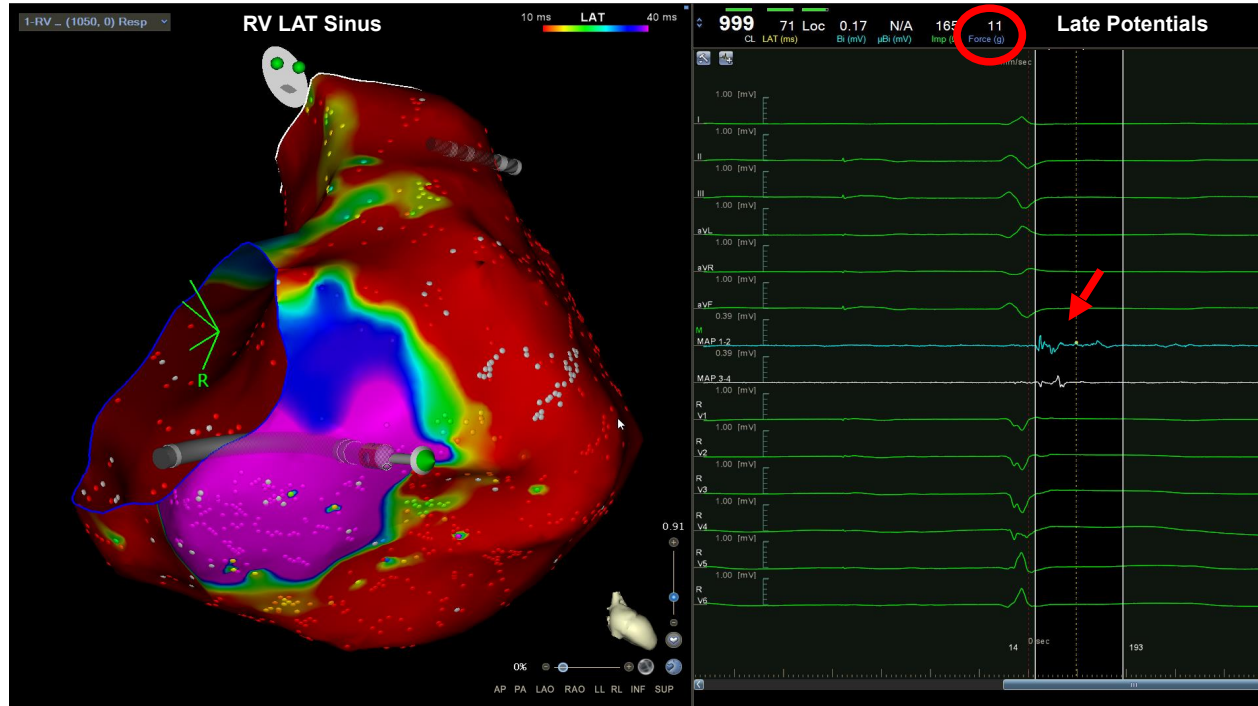




Predictors of the Primary Composite Outcome of *Sudden Death or Sustained VT/VF*

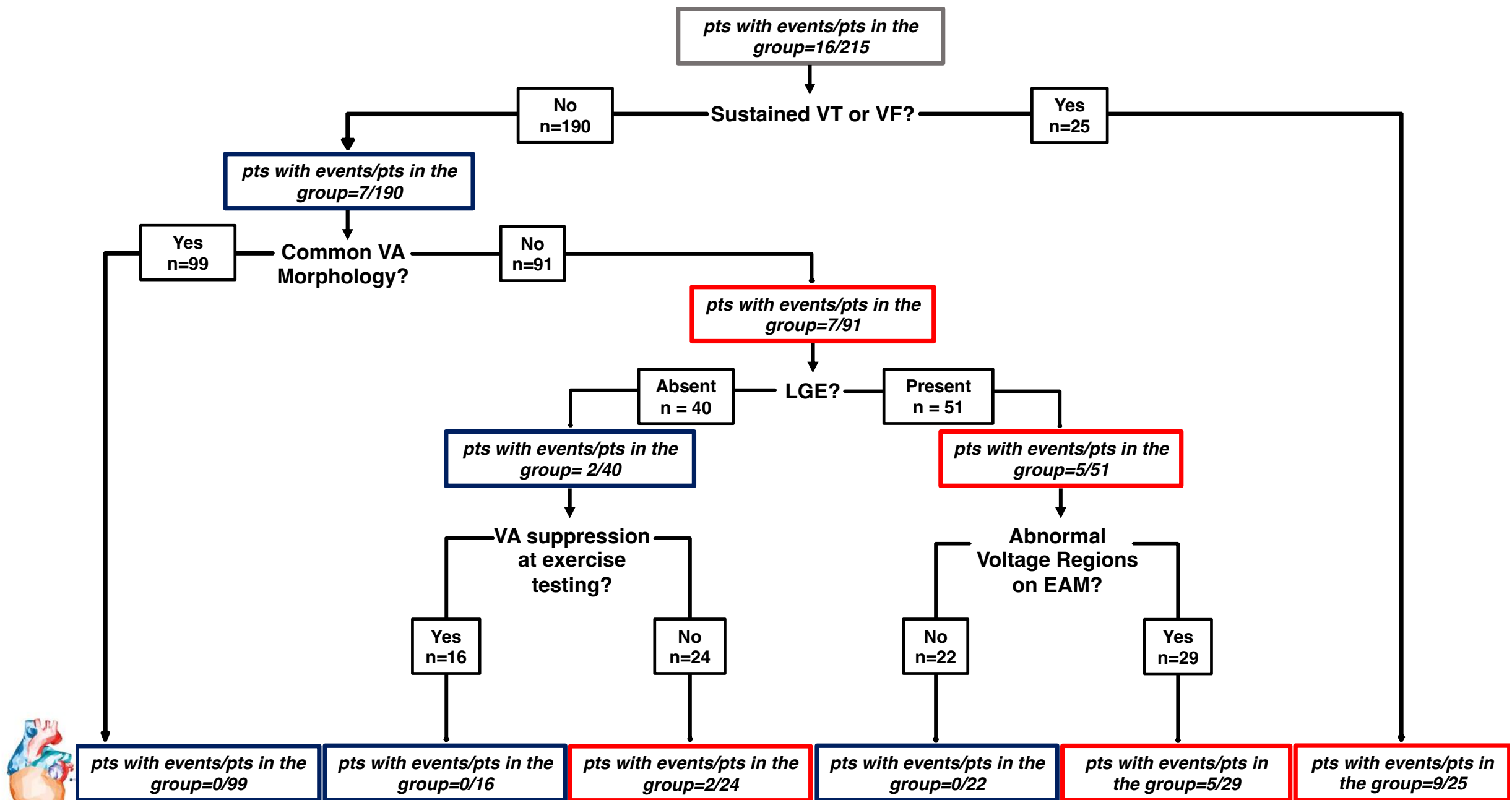


Prognostic Value of Invasive Tests



Compagnucci P, et al. Circ Arrhythm Electrophysiol 2025;18(6):e013480

Survival Tree Analysis



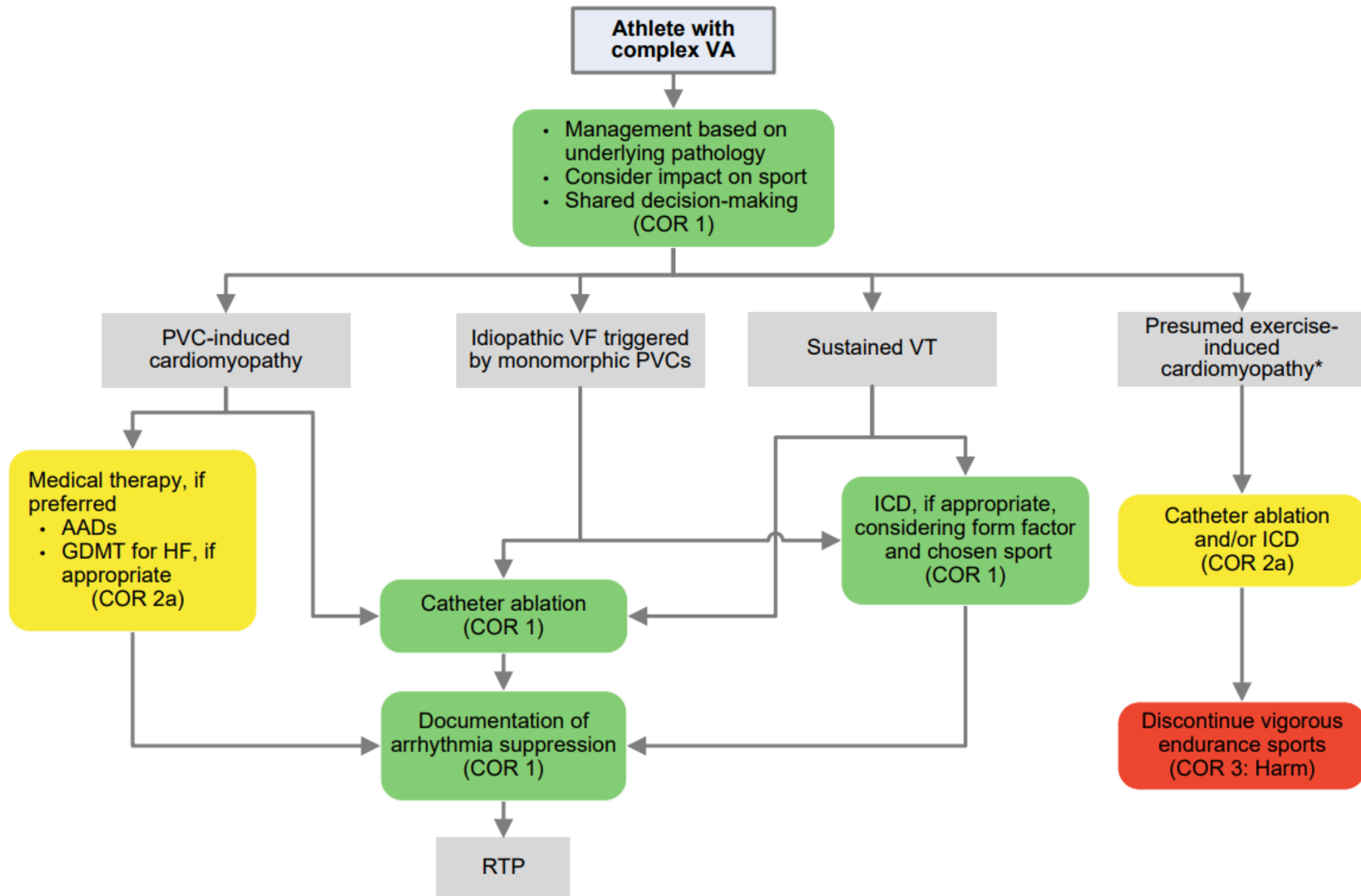
Sports Eligibility During Follow-up

Of the 148 athletes practicing competitive or professional sports at baseline, 101(68%) regained competitive sports eligibility according to Italian law after an initial 3-month detraining period, and 42 (28%) continued practicing competitive sports until the last follow-up. Among the 59 (40%) athletes who discontinued practicing competitive sports during follow-up, the reasons for the interruption included aborted cardiac arrest due to VF (n=1), ICD implantation (n=1), or personal preferences (n=57). Factors associated with long-term practice of competitive sports are reported in [Table S2](#).

Table S2. Univariable and multivariable predictors of long-term practice of competitive sports among competitive athletes at baseline assessment (n=148)

Variable	Univariable Analysis			Multivariable Analysis		
	OR	95% CI	P value	OR	95% CI	P value
Age (per year change)	0.97	0.94-1.00	0.051			
Sex (male vs female)	0.89	0.35-2.48	0.812			
Professional athlete (yes vs no)	4.26	1.70-10.98	0.002	4.69	1.71-13.56	0.003
VA characteristics:						
Uncommon morphology VA (vs common VA)	0.98	0.48-2.01	0.957			
NSVT (yes vs no)	0.46	0.722-0.95	0.039	0.39	0.17-0.89	0.027
PVC number (per unit change)	1.00	0.99-1.00	0.126			
Clinical presentation:						
Any symptoms (vs asymptomatic)	0.89	0.42-1.82	0.746			
Palpitations (yes vs no)	1.38	0.65-2.88	0.392			
Syncope (yes vs no)	0.41	0.02-2.48	0.411			
ECG:						
Borderline ECG (vs normal ECG)	0.71	0.25-1.84	0.499			
Abnormal ECG (vs normal ECG)	0.28	0.09-0.73	0.016	0.41	0.12-1.17	0.115
Exercise testing:						
Persistence/appearance of VAs (vs VAs suppression/absent VAs)	0.71	0.33-1.48	0.362			
Exercise-induced VT (yes vs no)	0.48	0.07-1.93	0.356			
Echocardiography:						
Any abnormalities (yes vs no)	0.44	0.17-1.05	0.079			
LVEF≤50% (vs >50%)	0.19	0.01-1.02	0.118			
Regional LV WMA (yes vs no)	0.14	0.01-1.14	0.070			
Mitral Valve Prolapse (yes vs no)	0.94	0.20-3.45	0.933			
LGE (yes vs no)	0.36	0.13-0.85	0.028	0.35	0.12-0.91	0.041
Sustained VA induction by PES (yes vs no)	0.22	0.01-2.01	0.214			
EAM details:						
Presence of electroanatomical scar (yes vs no)	0.60	0.23-1.41	0.259			
Late Potentials (yes vs no)	0.16	0.01-1.35	0.104			
Catheter ablation performed (yes vs no)	0.78	0.38-1.60	0.496			





L'ablazione ha un favorevole rapporto costo/beneficio nelle seguenti situazioni:

- tachicardia parossistica da rientro (in assenza di WPW), eccetto i casi con crisi rare e non sostenute e quelli in cui la frequenza della tachicardia è simile o inferiore alla frequenza sinusale massima per l'età;
- tachicardia atriale incessante o iterativa, eccetto i casi con crisi a bassa frequenza;
- WPW sintomatico;
- WPW asintomatico con aspetti elettrofisiologici "a rischio";
- flutter atriale destro istmo dipendente;
- tachicardia fascicolare e TV del cono d'efflusso sintomatiche;
- BPV frequenti e fortemente sintomatici o causa di depressione della funzione di pompa;
- FA parossistica.

COMITATO ORGANIZZATIVO CARDIOLOGICO
PER L'IDONEITÀ ALLO SPORT AGONISTICO
FMSI - SIC SPORT - ANCE - ANMCO - SIC

**Protocolli cardiologici
per il giudizio di idoneità
allo sport agonistico
(COCIS) 2023**



Casa Editrice Scientifica Internazionale



Casa Editrice Scientifica Internazionale



Article

Idiopathic Premature Ventricular Contraction Catheter Ablation, Sedentary Population vs. Athlete's Populations: Outcomes and Resumption of Sports Activity

Yari Valeri ^{1,2,*}, Paolo Compagnucci ^{1,2}, Giovanni Volpato ^{1,2}, Lara Luciani ^{1,2}, Eleonora Crepaldi ³, Francesco Maiorino ⁴, Quintino Parisi ¹, Laura Cipolletta ¹, Francesca Campanelli ^{1,2}, Leonardo D'Angelo ^{1,2}, Gemma Gaggiotti ^{1,2}, Alessio Gasperetti ^{5,6}, Andrea Giovagnoni ⁷, Antonio Curcio ⁸, Antonio Dello Russo ^{1,2} and Michela Casella ^{1,7,*}

	LEISURE-TIME (N = 23)	COMPETITIVE (N = 19)	<i>p</i> VALUE
AGE (YEARS)—MEAN (SD)	44 (12.5)	32.9 (12.9)	<i>p</i> = 0.004
MALE SEX—N (%)	13 (57%)	14 (74%)	<i>p</i> = 0.4
LVEF %—MEAN (SD)	56.7 (6.5)	56.6 (5)	<i>p</i> = 0.46
TAPSE (MM)—MEAN (SD)	25.2 (4.2)	24.2 (2.7)	<i>p</i> = 0.19
RDV1 (MM)—MEAN (SD)	36.4 (5)	37.1 (3.3)	<i>p</i> = 0.5
ILVEDV (ML/M2)—MEAN (SD)	61.9 (12.8)	64.8 (9.3)	<i>p</i> = 0.21
HYPERTENSION—N (%)	3 (13)	1 (5)	<i>p</i> = 0.74
DYSLIPIDEMIA—N (%)	2 (9)	2 (11)	<i>p</i> = 0.74
DIABETES MELLITUS—N (%)	0	0	
EGFR < 45 ML/MIN/M2—N (%)	0	0	
PRE-ABLATION AAD THERAPY- N (%)	7 (30)	7 (36)	<i>p</i> = 0.66
-BETA-BLOCKER—N (%)	4 (17)	4 (21)	<i>p</i> = 0.92
-FLECAINIDE—N (%)	2 (9)	3 (16)	<i>p</i> = 0.81
-AMIODARONE—N (%)	1 (4)	0	<i>p</i> = 0.9
N° WORKOUTS PER WEEK—MEDIAN [IQR]	3 (2–3)	4 (3–5)	<i>p</i> = 0.003
WORKOUTS HOURS PER WEEK—MEDIAN [IQR]	5 (3–6)	9 (7–12)	<i>p</i> < 0.001
SYMPTOMS DURING ACTIVITY—N (%)	9 (39)	5 (26)	<i>p</i> = 0.58
DECREASE OR INTERRUPTION OF PHYSICAL ACTIVITY—N (%)	18 (80%)	16 (85%)	<i>p</i> = 0.92



Table 4. Procedural data information. Values are counts, mean (SD), or median (first quartile, third quartile). RVOT (right ventricular outflow tract); N (number); LVOT (left ventricular outflow tract); PVC (premature ventricular complex); IQR (interquartile range).

	NON-ATHLETES (N = 37)	ATHLETES (N = 42)	<i>p</i> VALUE
SITE OF ORIGIN			
- RVOT- N (%)	23 (62)	34 (80)	<i>p</i> = 0.10
_SEPTAL RVOT—N (%)	14 (60)	23 (67)	<i>p</i> = 0.8
_FREE WALL RVOT—N (%)	9 (40)	11 (32)	<i>p</i> = 0.8
- LVOT- N (%)	12 (32)	7 (17)	<i>p</i> = 0.16
- FASCICULAR—N (%)	2 (5)	1 (3)	<i>p</i> = 0.91
PRE-PROCEDURE N° PVC—MEDIAN [IQR]	17,000 (10,000–30,000)	18,750 (10,000–30,700)	<i>p</i> = 0.12
ACUTE EFFECTIVENESS—N (%)	32 (86)	38 (90)	<i>p</i> = 0.83
MAJOR COMPLICATIONS—N (%)	0 (0)	0 (0)	
MINOR COMPLICATIONS—N (%)	2 (5)	2 (4)	<i>p</i> = 0.7
POST-PROCEDURE N° PVC—MEDIAN [IQR]	1000 (341-4916)	300 (167–851)	<i>p</i> = 0.09

Table 5. Procedural data information. Values are counts, mean (SD), or median (first quartile, third quartile). RVOT (right ventricular outflow tract); N (number); LVOT (left ventricular outflow tract); PVC (premature ventricular complex); IQR (interquartile range).

	LEISURE-TIME (N = 23)	COMPETITIVE (N = 19)	<i>p</i> VALUE
SITE OF ORIGIN			
- RVOT- N (%)	18 (78)	16 (84)	<i>p</i> = 0.92
_SEPTAL RVOT—N (%)	12 (67)	11 (68)	<i>p</i> = 0.81
_FREE WALL RVOT—N (%)	6 (33)	5 (32)	<i>p</i> = 0.81
- LVOT- N (%)	4 (17)	3 (16)	<i>p</i> = 0.78
- FASCICULAR- N (%)	1 (4)	0	<i>p</i> = 0.9
N° PRE-PROCEDURE PVC—MEDIAN [IQR]	26,500 (11,000–26,700)	12,000 (10,000–27,000)	<i>p</i> = 0.06
ACUTE EFFECTIVNESS—N (%)	20 (87)	18 (95)	<i>p</i> = 0.74
MINOR COMPLICATIONS—N (%)	1 (4)	1 (5)	<i>p</i> = 0.55
N° POST-PROCEDURE PVC—MEDIAN [IQR]	300 (230–800)	260 (160–1000)	<i>p</i> = 0.29



Ripresa attività sportiva a 3 mesi

Table 8. Post-ablation sport activity. Values are counts, mean (SD), or median (first quartile, third quartile). N (number); IQR (interquartile range).

	LEISURE-TIME (N = 23)	COMPETITIVE (N = 19)	<i>p</i> VALUE
RESUMPTION OF PHYSICAL ACTIVITY—N (%)	16 (70)	17 (90)	<i>p</i> = 0.24
RESUMPTION OF COMPETITIVE PHYSICAL ACTIVITY—N (%)		10 (59)	
WORKOUTS PER WEEK—N (%)	2.5 (2–4)	3 (2–4)	<i>p</i> = 0.3
WORKOUT HOURS PER WEEK—MEDIAN [IQR]	4 (3.25–6)	7 (6–8.5)	<i>p</i> = 0.007
IMPROVEMENT OF SYMPTOMS DURING SPORT ACTIVITY— N (%)	14 (88%)	12 (70%)	<i>p</i> = 0.44



Medical History

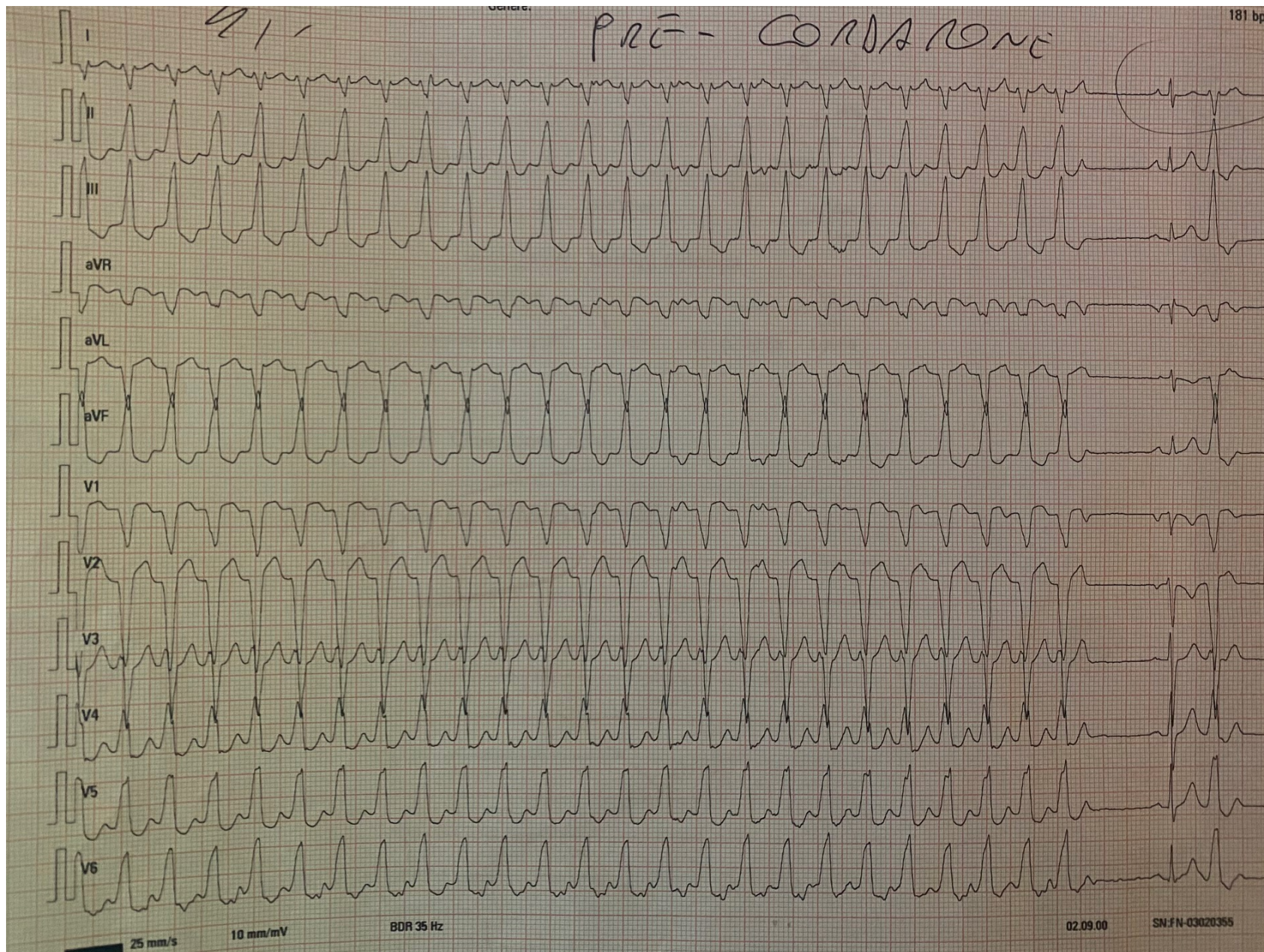
Male, 40 YO

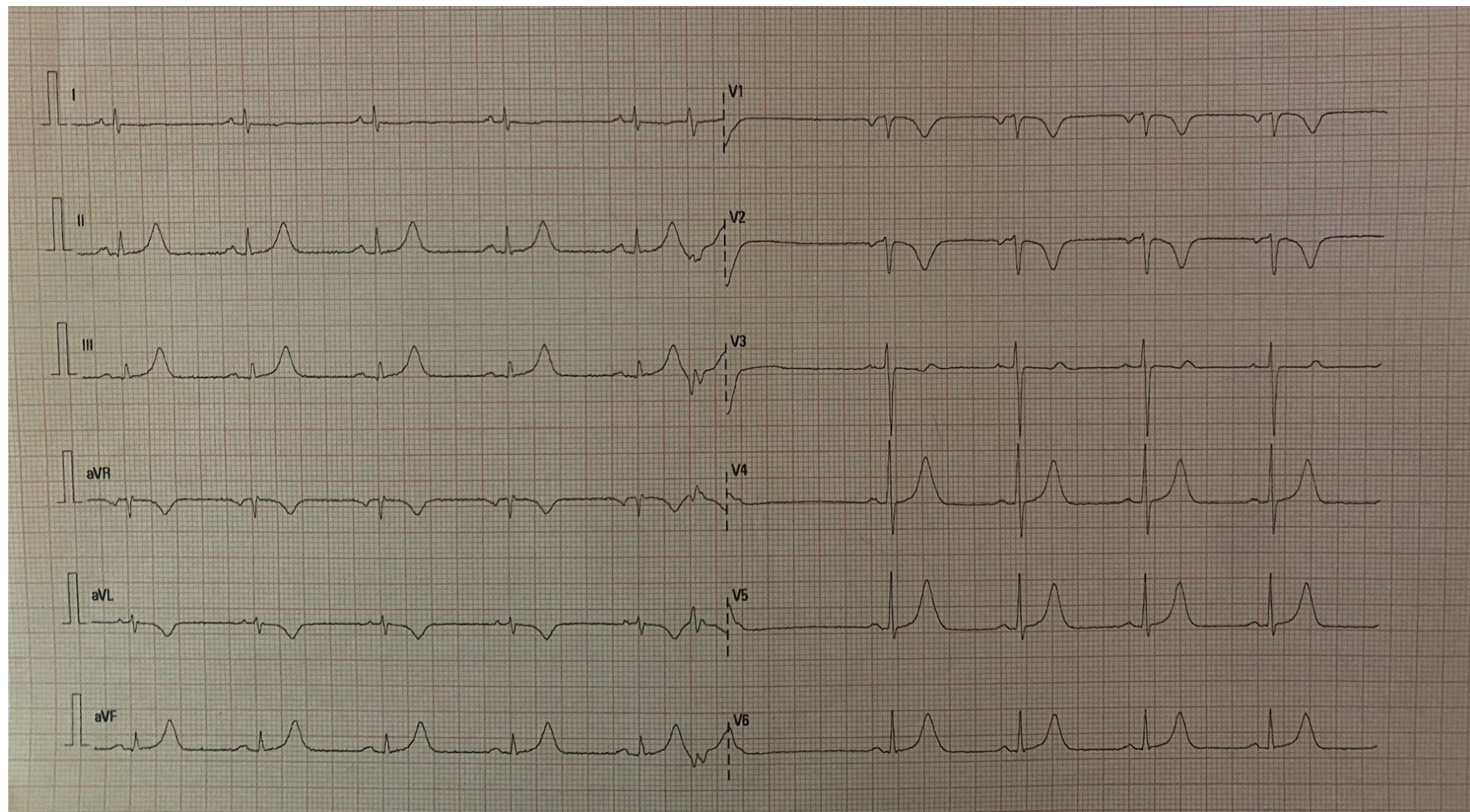
Leisure time cyclist – 8-10 hours of training per week, former competitive cyclist 2 years before

Mild SARS COV2 infection one year before

Worsened physical performance during the past 2 weeks

Comes to the ED for dyspnea

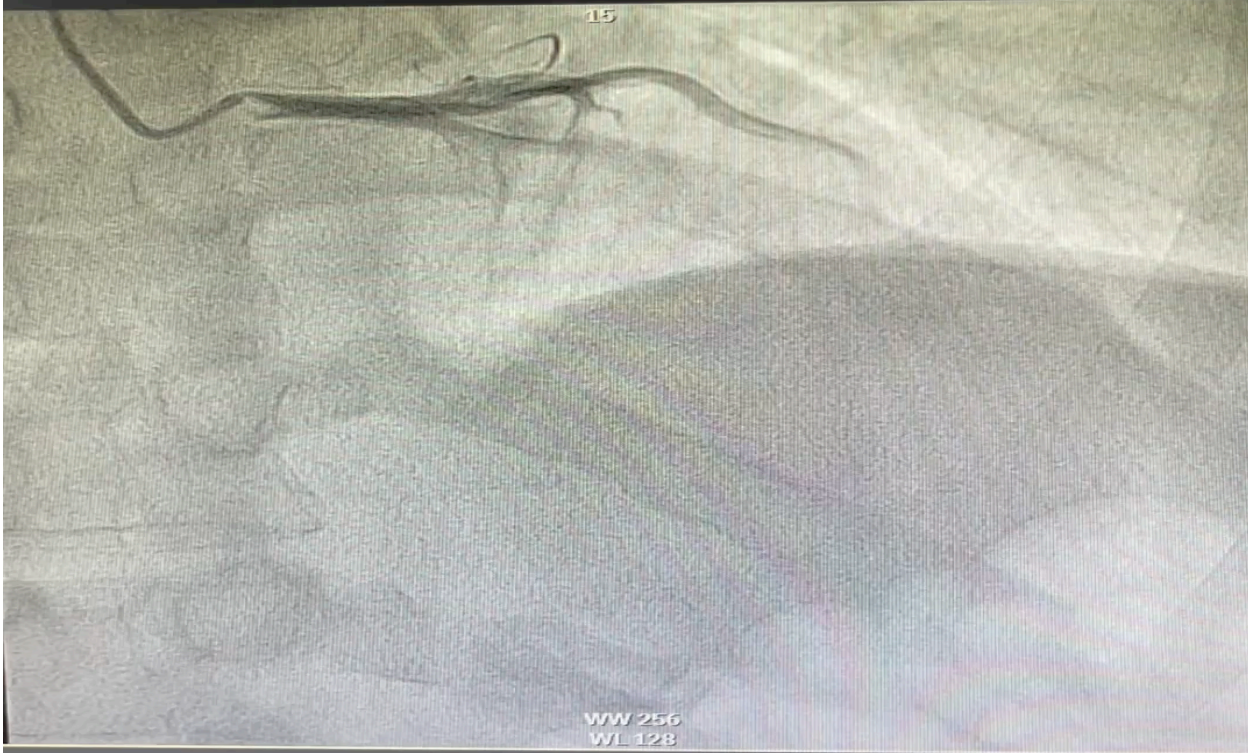




MRN 3069/23

* 16/05/1978 (48 Anni)

Maschio

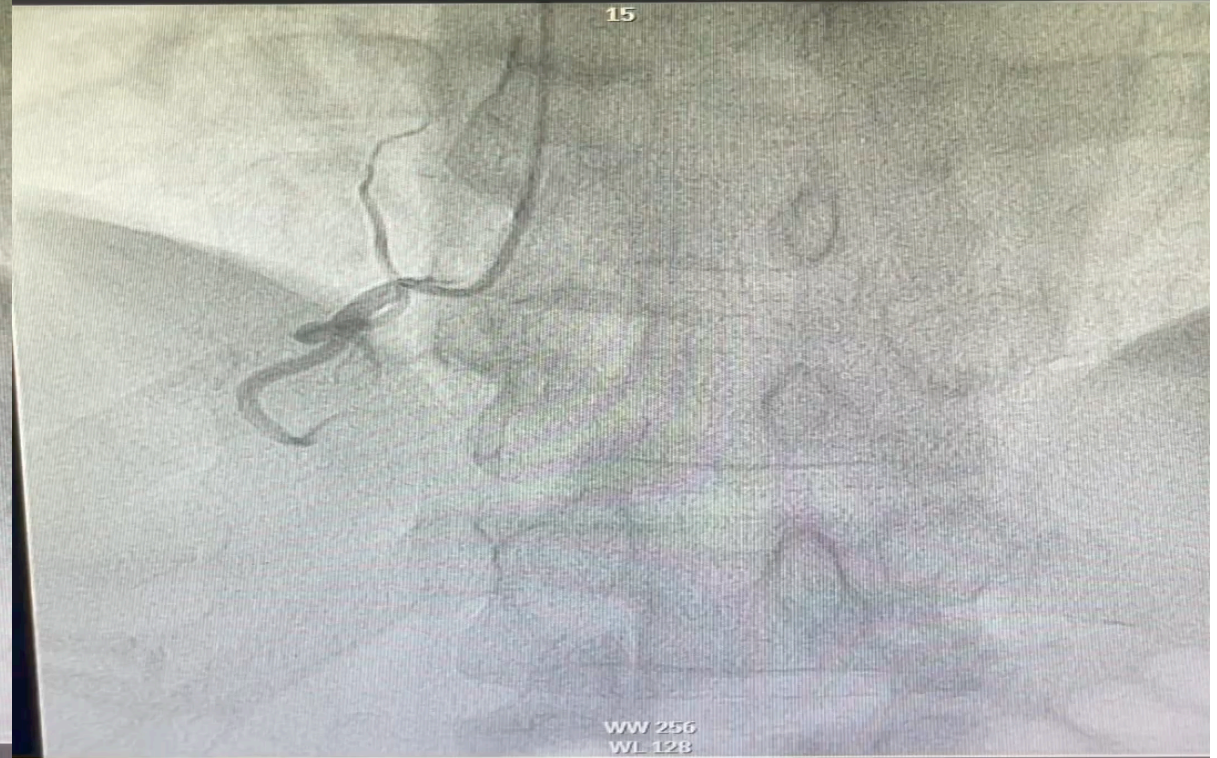


acer

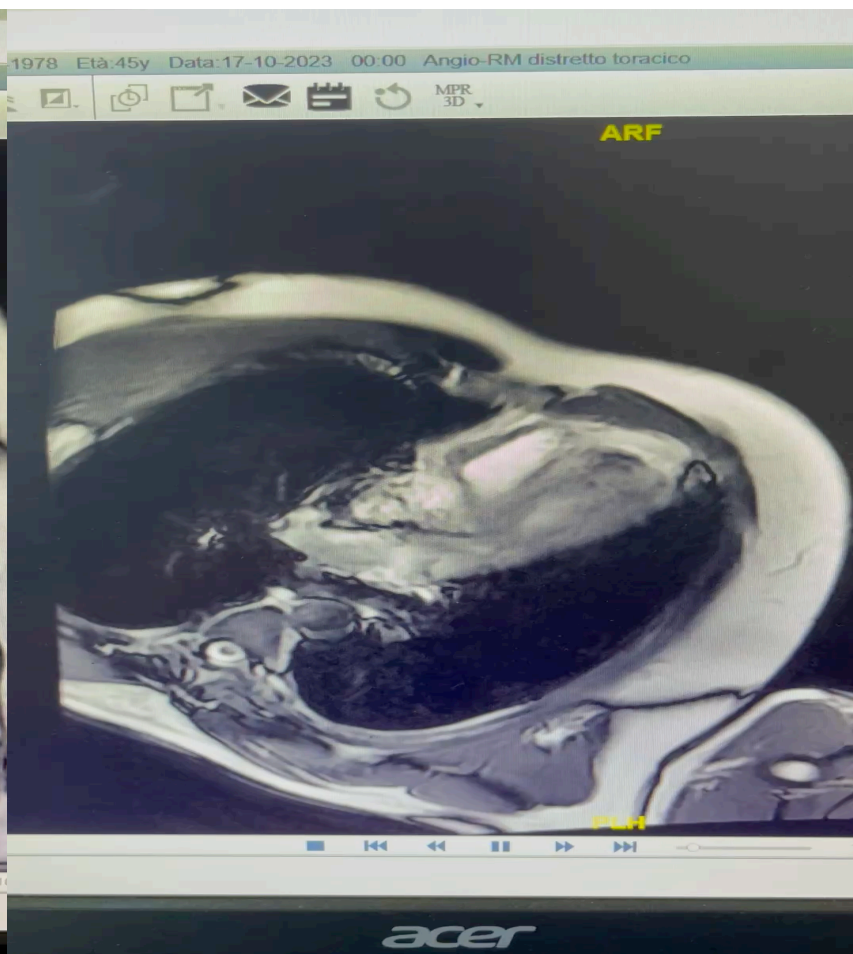
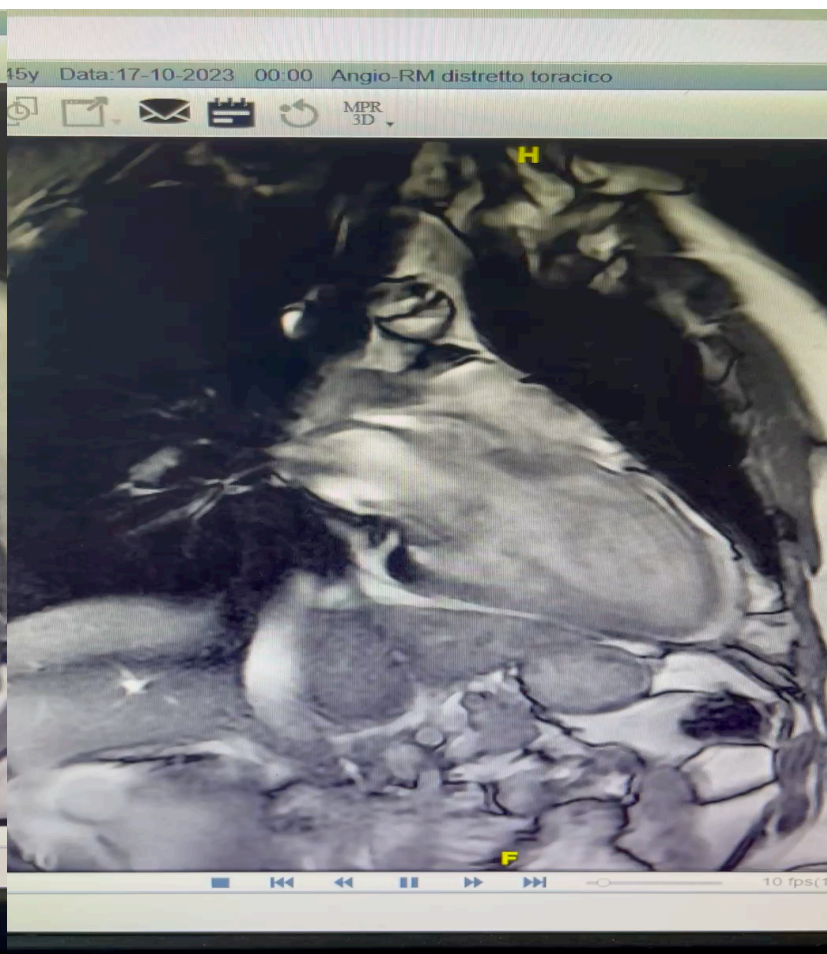
MRN 3069/23

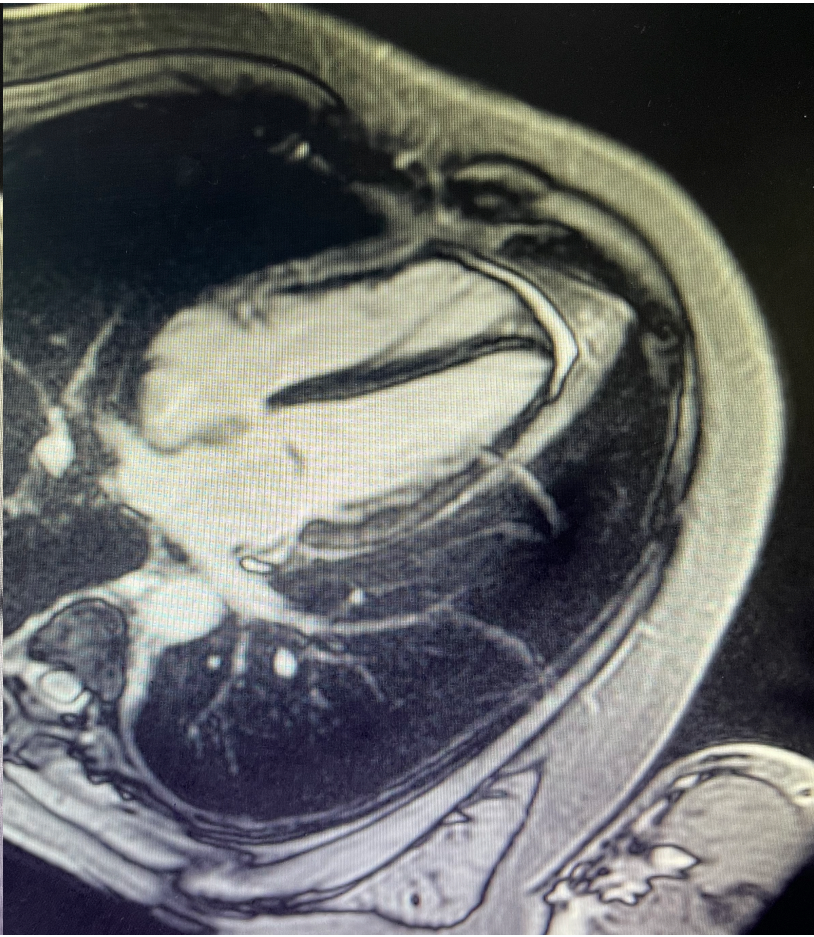
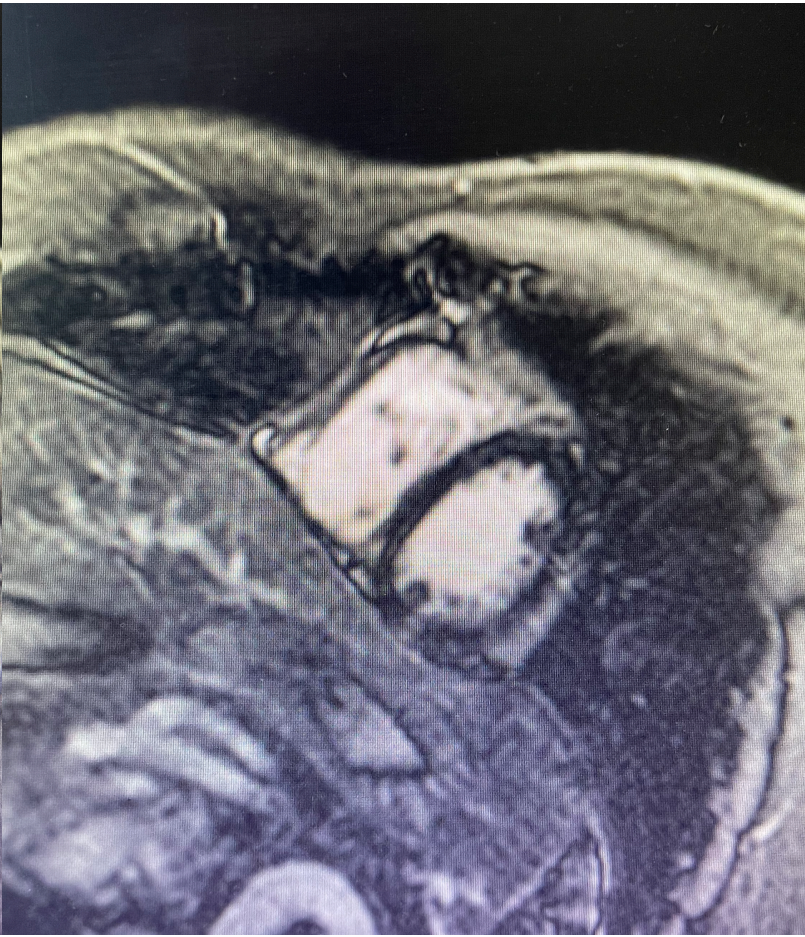
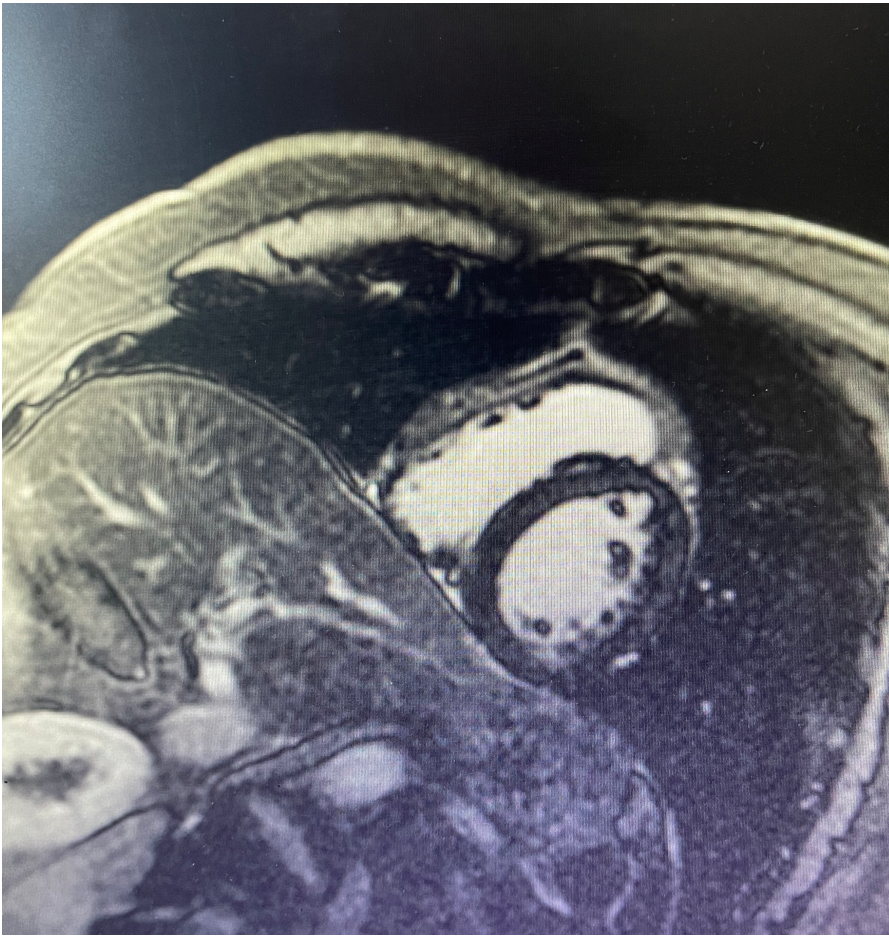
* 16/05/1978 (48 Anni)

Maschio



acer





1-RV BE... (43, 0) Resp

-127 ms LAT -93 ms

528

CL

Loc

1.16

N/A

178

10

N/A

LAT (ms)

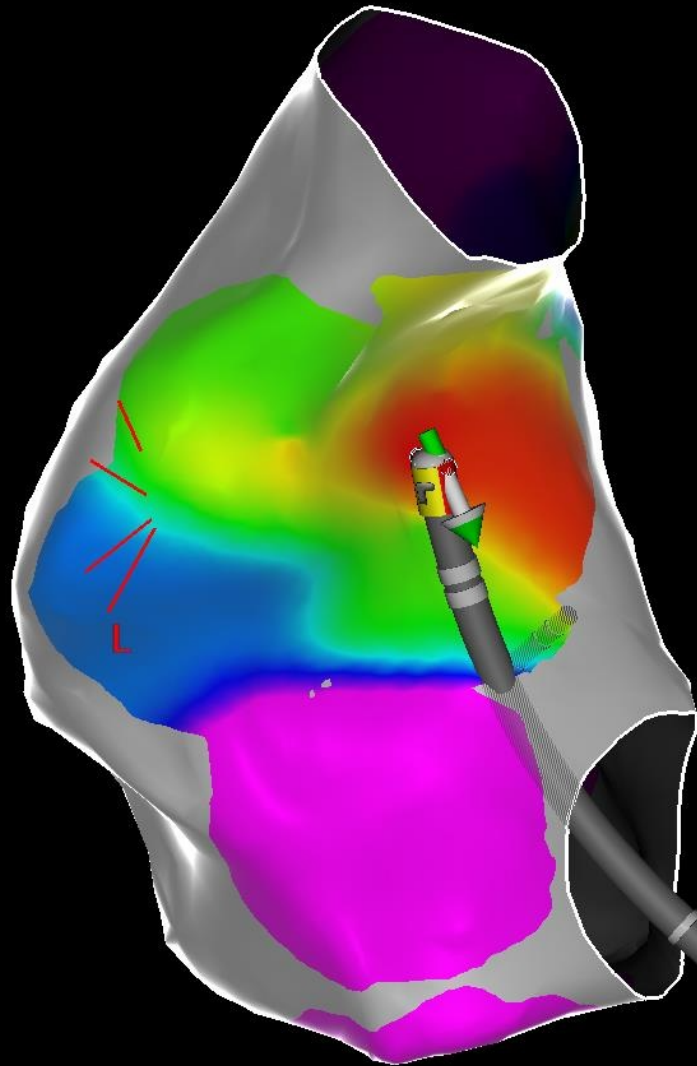
Bi (mV)

μ Bi (mV)

Imp (Ω)

Force (g)

Complex (ms)



R

1.10

0%

AP PA LAO RAO LL RL INF SUP



200 mm/sec

30ms

I

II

III

aVR

aVL

aVF

R

V1

R

V2

R

V3

R

V4

R

V5

R

V6

M

MAP 1-2

MAP 3-4

MAP 1

-170

50

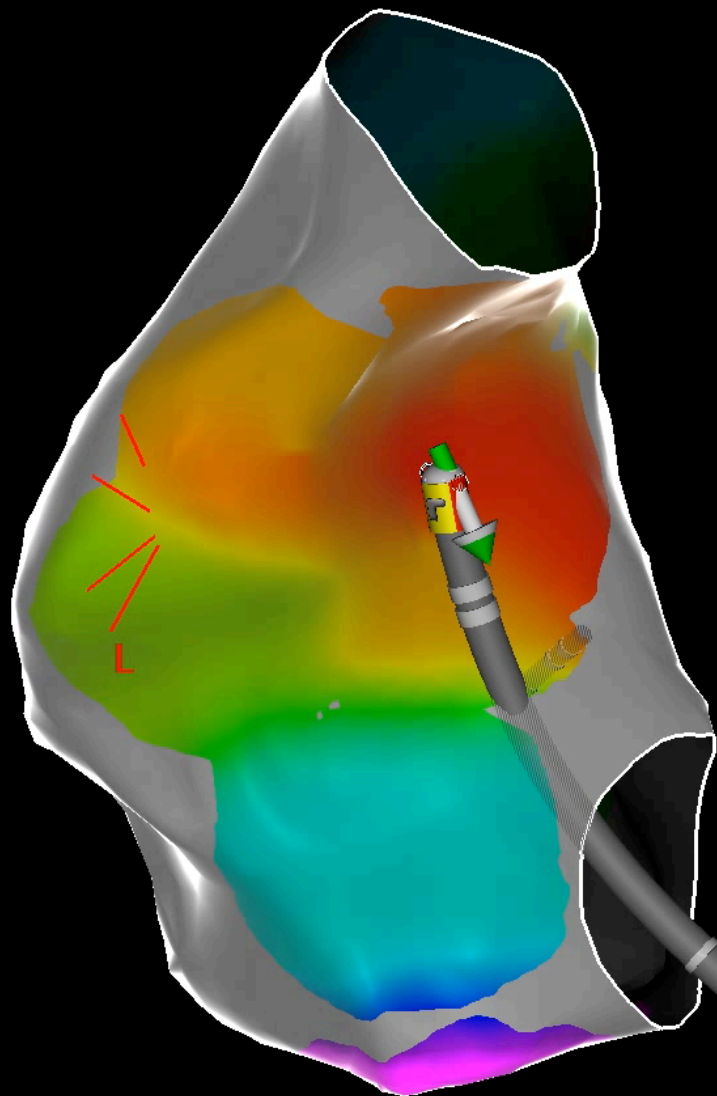
0s

1-RV BE... (43, 0) Resp

13:04:05.423 24.06.2026
-47.00
LAT

LAT
-127 ms -43 ms
-47 -39

LAT propagation



R

x

1.10

0% AP PA LAO RAO LL RL INF SUP

528

-127

Loc

1.16

N/A

178

10

N/A

CL

LAT (ms)

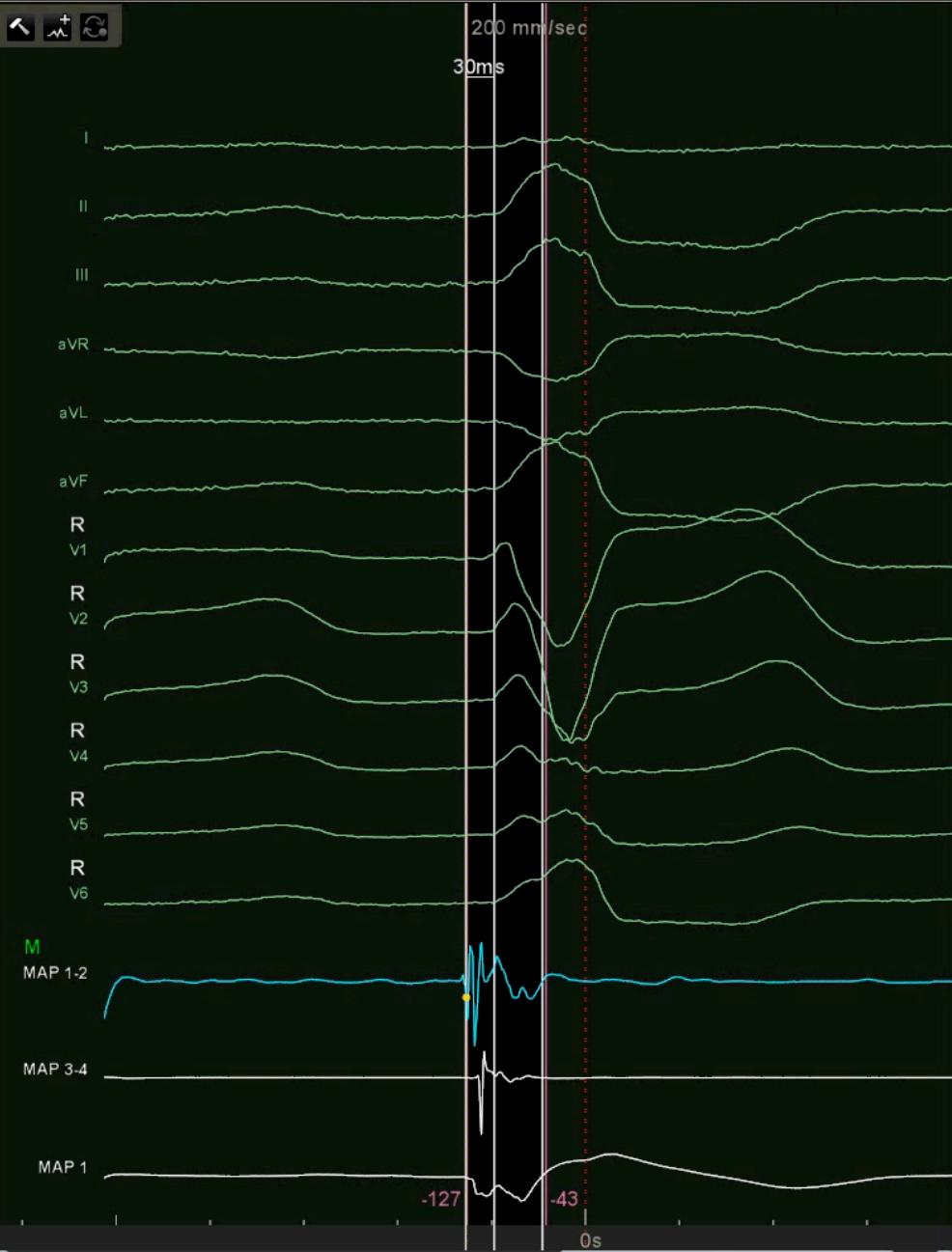
Bi (mV)

μ Bi (mV)

Imp (Ω)

Force (g)

Complex (ms)



200 mm/sec
30ms

-127 -43

0s

1-RV BE... (43, 0) Resp

-127 ms LAT -93 ms

Tag.Idx

528

-127

Loc

1.16

N/A

178

10

N/A

CL

LAT (ms)

Bi (mV)

μ Bi (mV)

Imp (Ω)

Force (g)

Complex (ms)

200 mm/sec

I

II

III

aVR

aVL

aVF

R

V1

R

V2

R

V3

R

V4

R

V5

R

V6

M

MAP 1-2

MAP 3-4

MAP 1

-170

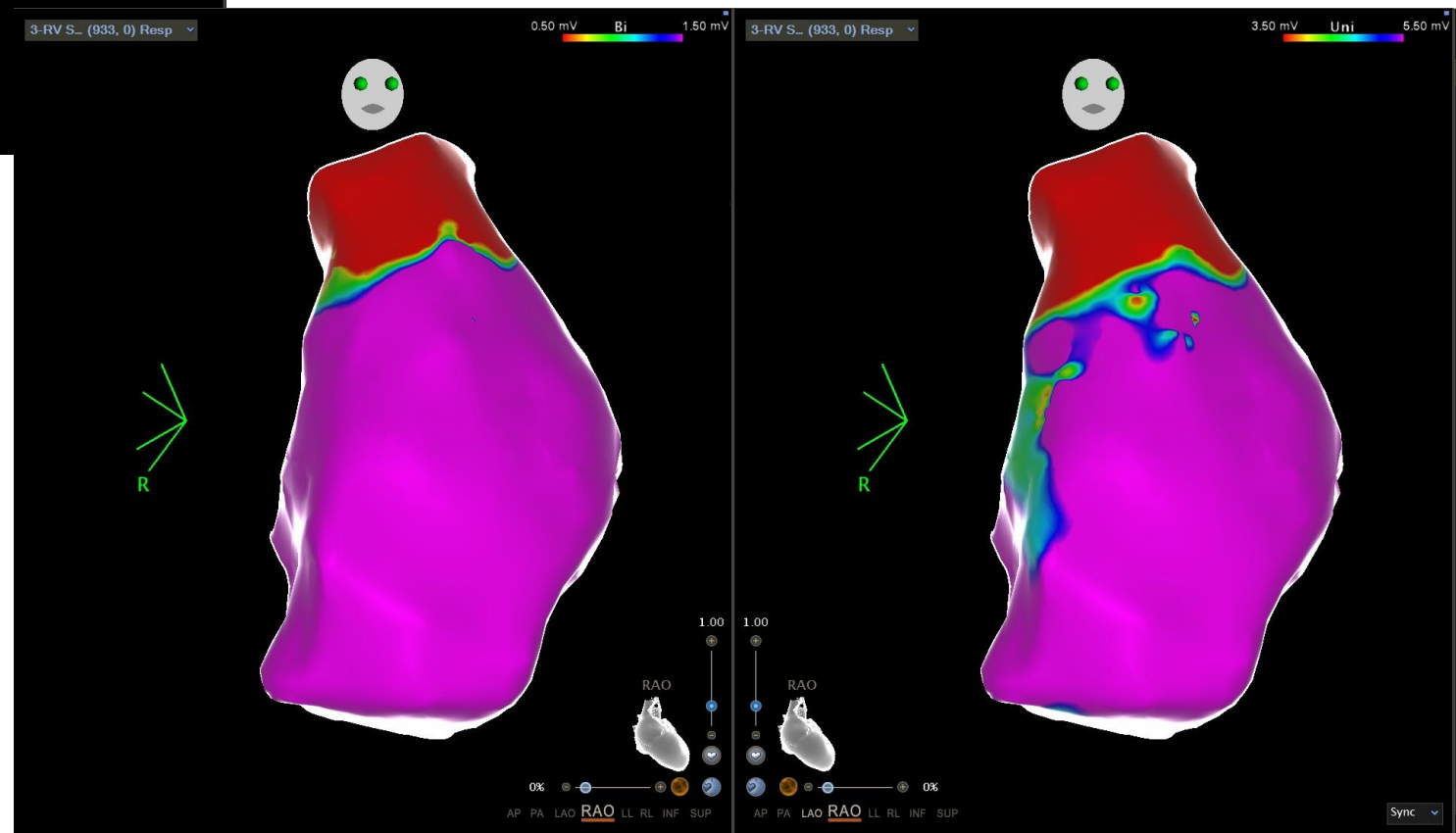
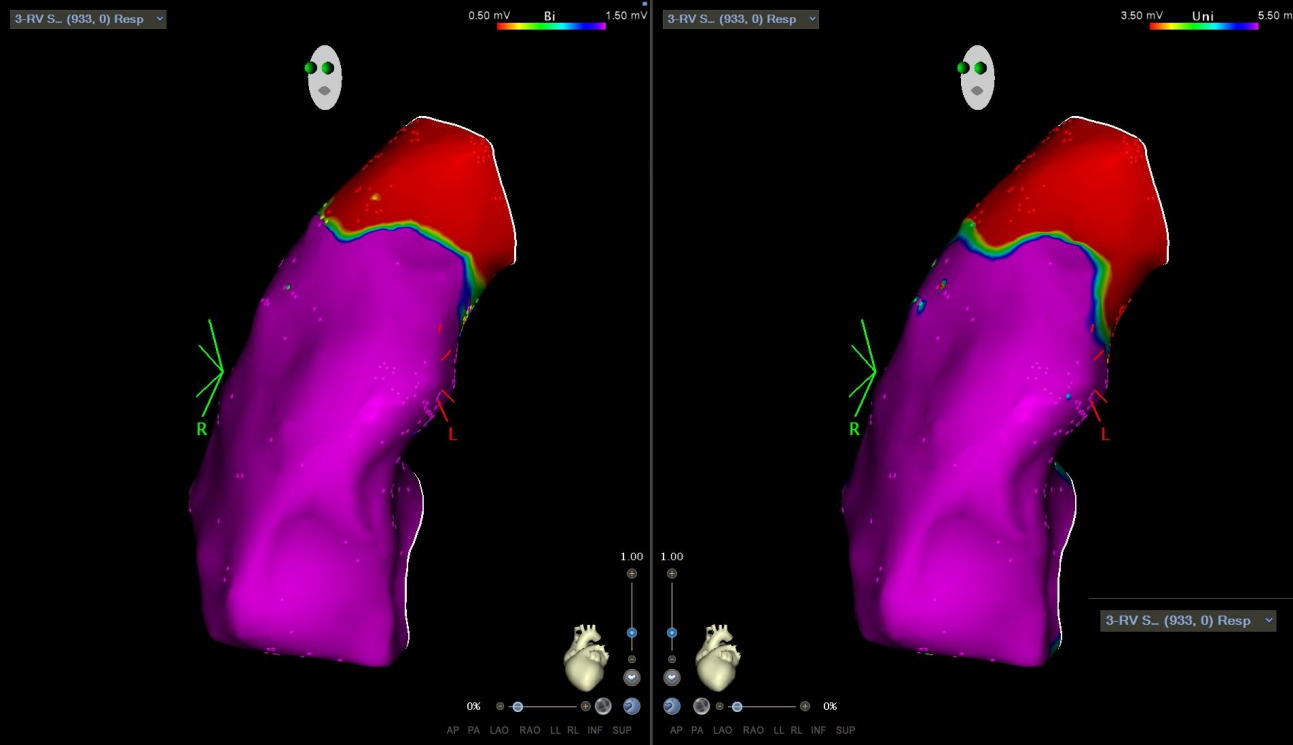
50

0s

0%

1.10

AP PA LAO RAO LL RL INF SUP



3 year FU

No arrhythmia recurrence

EF is 60%, ntpoBNP 35

Therapy has been downgraded, now still on sacubitril/valsartan but SGLT2inh and eplerenone were stopped. No beta blockers because of symptomatic bradycardia

The patient continues cycling, 60-80 km 4 times per week

Conclusions

- VT in athletes require a careful evaluation
- VT associated with structural heart disease implies sports ineligibility, and exercise prescription is limited in case of exercise-induced VT
- For idiopathic (infundibular and fascicular) VT, successful ablation may allow return to play with close follow-up

