PLACE

PLATFORM OF LABORATORIES FOR ADVANCES IN CARDIAC EXPERIENCE

ROMA
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Auditorium
della Tecnica

9ª Edizione

30 Settembre
1 Ottobre
2022

Prevenire la morte improvvisa

I nuovi criteri per la diagnosi di cardiomiopatia aritmogena applicati agli sportivi: cosa cambia?

Francesca Graziano

800 ANNI 1222·2022

UNIVERSITÀ DEGLI STUDI DI PADOVA

Br Heart J 1994;71:215–218

CRITERIA

Diagnosis of arrhythmogenic right ventricular dysplasia/cardiomyopathy

William J McKenna, Gaetano Thiene, Andrea Nava, Fabrice Fontaliran,
Carina Blomstrom-Lundqvist, Guy Fontaine,
Force of the Working Group Myocardial and
of Cardiology and of the Scientific Council on
Society and Federation of Cardiology, suppor

European Heart Journal (2010) **31**, 806–814
doi:10.1093/eurheartj/ehq025

SPECIAL REPORT

Diagnosis of arrhythmogenic right ventricular cardiomyopathy/dysplasia

Proposed Modification of the Task Force Criteria

Revision of the diagnostic criteria provides guidance on the role of emerging diagnostic modalities and advances in the genetics of ARVC/D. The criteria have been modified to incorporate new knowledge and technology to improve diagnostic sensitivity, but with the important requisite of maintaining diagnostic specificity. The approach of classifying structural, histological, electrocardiographic, arrhythmic, and genetic features of the disease as major and minor criteria has been maintained. In this modification of the Task Force criteria, quantitative criteria are proposed and abnormalities are defined on the basis of comparison with normal subject data.

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ESC European Society of Cardiology
European Heart Journal (2020) 41, 1414–1427
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CURRENT OPINION
Heart failure/cardiomyopathy

Arrhythmogenic right ventricular cardiomyopathy: evaluation of the current diagnostic criteria and differential diagnosis

Domenico Corrado [1]*, Peter J. van Tintelen [2,3], William J. McKenna [4,5], Richard N.W. Hauer [6], Aris Anastastakis [7], Angeliki Asimaki [8], Cristina Basso [1], Barbara Bauce [1], Corinna Brunckhorst [9], Chiara Bucciarelli-Ducci [10], Firat Duru [9], Perry Elliott [5], Robert M. Hamilton [11], Kristina H. Haugaa [12,13], Cynthia A. James [14], Daniel Judge [15], Mark S. Link [16], Francis E. Marchlinski [17], Andrea Mazzanti [18], Luisa Mestroni [19], Antonis Pantazis [20], Antonio Pelliccia [21], Martina Perazzolo Marra [1], Kalliopi Pilichou [1], Pyotr G.A. Platonov [22], Alexandros Protonotarios [23], Alessandra Rampazzo [24], Jeffry E. Saffitz [25], Ardan M. Saguner [9], Christian Schmied [9], Sanjay Sharma [26], Hari Tandri [14], Anneline S.J.M. Te Riele [27,28], Gaetano Thiene [1], Adalena Tsatsopoulou [29], Wojciech Zareba [30], Alessandro Zorzi [1], Thomas Wichter [31], Frank I. Marcus [32], and Hugh Calkins [14]

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Diagnosis of arrhythmogenic cardiomyopathy: The Padua criteria

Domenico Corrado [a,*], Martina Perazzolo Marra [a], Alessandro Zorzi [a], Giorgia Beffagna [a], Alberto Cipriani [a], Manuel De Lazzari [a], Federico Migliore [a], Kalliopi Pilichou [a], Alessandra Rampazzo [b], Ilaria Rigato [a], Stefania Rizzo [a], Gaetano Thiene [a], Aris Anastasakis [c], Angeliki Asimaki [d], Chiara Bucciarelli-Ducci [e], Kristine H. Haugaa [f], Francis E. Marchlinski [g], Andrea Mazzanti [h], William J. McKenna [i], Antonis Pantazis [j], Antonio Pelliccia [k], Christian Schmied [l], Sanjay Sharma [m], Thomas Wichter [n], Barbara Bauce [a], Cristina Basso [a]

1. Mancanza di criteri per le forme sinistre

2. Risonanza magnetica cardiaca

3. Uso del test genetico per raggiungere la diagnosi

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Category	Right ventricle (upgraded 2010 ITF diagnostic criteria)	Left ventricle (new diagnostic criteria)
I. Morpho-functional ventricular abnormalities	*By echocardiography, CMR or angiography:* *Major* • Regional RV akinesia, dyskinesia, or bulging *plus* one of the following: - global RV dilatation (increase of RV EDV according to the imaging test specific nomograms) - global RV systolic dysfunction (reduction of RV EF according to the imaging test specific nomograms) *Minor* • Regional RV akinesia, dyskinesia or aneurysm of RV free wall	*By echocardiography, CMR or angiography:Minor* • Global LV systolic dysfunction (depression of LV EF or reduction of echo-cardiographic global longitudinal strain), with or without LV dilatation (increase of LV EDV according to the imaging test specific nomograms for age, sex, and BSA) *Minor* • Regional LV hypokinesia or akinesia of LV free wall, septum, or both
II. Structural myocardial abnormalities	*By CE-CMR:Major* • Transmural LGE (stria pattern) of ≥1 RV region(s) (inlet, outlet, and apex in 2 orthogonal views) *By EMB (limited indications):Major* • Fibrous replacement of the myocardium in ≥1 sample, with or without fatty tissue	*By CE-CMR:Major* • LV LGE (stria pattern) of ≥1 Bull's Eye segment(s) (in 2 orthogonal views) of the free wall (subepicardial or midmyocardial), septum, or both (excluding septal junctional LGE)
III. Repolarization abnormalities	*Major* • Inverted T waves in right precordial leads (V_1,V_2, and V_3) or beyond in individuals with complete pubertal development (in the absence of complete RBBB) *Minor* • Inverted T waves in leads V1 and V2 in individuals with completed pubertal development (in the absence of complete RBBB) • Inverted T waves in V1,V2,V3 and V4 in individuals with completed pubertal development in the presence of complete RBBB.	*Minor* • Inverted T waves in left precordial leads (V_4-V_6) (in the absence of complete LBBB)
IV. Depolarization abnormalities	*Minor* • Epsilon wave (reproducible low-amplitude signalsbetween end of QRS complex to onset of the T wave) in the right precordial leads (V1 to V3) • Terminal activation duration of QRS ≥55 ms measured from the nadir of the S wave to the end of the QRS, including R', in V1, V2, or V3 (in the absence of complete RBBB)	*Minor* • Low QRS voltages (<0.5 mV peak to peak) in limb leads (in the absence of obesity, emphysema, or pericardial effusion)
V. Ventricular arrhythmias	*Major* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia of LBBB morphology *Minor* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia of LBBB morphology with inferior axis ("RVOT pattern")	*Minor* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia with a RBBB morphology (excluding the "fascicular pattern")
VI. Family history/genetics	*Major* • ACM confirmed in a first-degree relative who meets diagnostic criteria • ACM confirmed pathologically at autopsy or surgery in a first degree relative • Identification of a pathogenic or likely pathogenetic ACM mutation in the patient under evaluation *Minor* • History of ACM in a first-degree relative in whom it is not possible or practical to determine whether the family member meets diagnostic criteria • Premature sudden death (<35 years of age) due to suspected ACM in a first-degree relative • ACM confirmed pathologically or by diagnostic criteria in a second-degree relative	

Corrado D, Diagnosis of arrhythmogenic cardiomyopathy: The Padua criteria.
Int J Cardiol, 2020

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Category	2010 TF criteria	2020 International criteria
I. Global or regional dysfunction and structural alteration	*Major* *By 2D echocardiogram:* • Regional RV akinesia, dyskinesia, or aneurysm *and* one of the following (end diastole) - PLAX RVOT ≥32 mm (corrected for body size [PLAX/BSA] ≥19 mm/m^2) - PSAX RVOT ≥36 mm (corrected for body size [PSAX/BSA] ≥21 mm/m^2) - Fractional area change ≤33% *By MRI:* • Regional RV akinesia or dyskinesia or dyssynchronous RV contraction *and* one of the following: - Ratio of RV end-diastolic volume to BSA: ≥110 mL/m^2 (male) or ≥100 mL/m^2 (female) - *or* RV ejection fraction ≤40% *By RV angiography:* • Regional RV akinesia, dyskinesia, or aneurysm *Minor* *By 2D echocardiogram:* • Regional RV akinesia or dyskinesia *and* one of the following (end diastole): - PLAX RVOT ≥29–<32 mm; (corrected for body size [PLAX/BSA] ≥16–<19 mm/m^2) - PSAX RVOT ≥32–<36 mm; (corrected for body size [PSAX/BSA] ≥18–<21 mm/m^2) - or fractional area change >33%–≤40% *By MRI:* • Regional RV akinesia or dyskinesia or dyssynchronous RV contraction *and* one of the following: - Ratio of RV end-diastolic volume to BSA ≥100 to <110 mL/m^2 (male) or ≥90 to <100 mL/m^2 (female) - *or* RV ejection fraction >40% to ≤45%	*Major* *By 2D echocardiogram, CMR, or angiography:* • Regional RV akinesia, dyskinesia, or bulging *plus* 1 of the following: • Global RV dilatation (increase of RV EDV according to the imaging test specific nomograms for age, sex, and BSA) *or* • Global RV systolic dysfunction (reduction of RV EF according to the imaging test specific nomograms for age and sex) *Minor* *By 2D echocardiogram, CMR, or angiography:* • Regional RV akinesia, dyskinesia or aneurysm of RV free wall

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Major

By MRI:

- Regional RV akinesia or dyskinesia or dyssynchronous RV contraction
- *and* 1 of the following:
  - Ratio of RV end-diastolic volume to BSA ≥110 mL/m^2 (male) or ≥100 mL/m^2 (female)
  - *or* RV ejection fraction ≤40%

Minor

By MRI:

- Regional RV akinesia or dyskinesia or dyssynchronous RV contraction
- *and* 1 of the following:
  - Ratio of RV end-diastolic volume to BSA ≥100 to <110 mL/m^2 (male) or ≥90 to <100 mL/m^2 (female)
  - *or* RV ejection fraction >40% to ≤45%

Right ventricle ranges for adults aged 20–80 years

	Women 'Opposite'	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal	Men 'Opposite'	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal
20–68 years										
EDV (mL)	<77	77–201	202–232	233–263	>263	<118	118–250	251–283	284–316	>316
EDV /BSA (mL/m^2)	<48	48–112	113–128	129–144	>144	<61	61–121	122–136	137–151	>151
ESV (mL)	<24	24–84	85–99	100–114	>114	<41	41–117	118–136	137–155	>155
ESV/BSA (mL/m^2)[b]	<12	12–52	53–62	63–72	>72	<19	19–59	60–69	70–79	>79
EF (%)	>71	51–71	41–51	30–40	<30	>72	52–72	41–52	30–40	<30
Mass (g)[b]	<21	21–49	50–56	57–63	>63	<25	25–57	58–65	66–73	>73
Mass/BSA (g/m^2)[b]	<12	12–28	29–32	33–36	>36	<13	13–29	30–33	34–37	>37

European Heart Journal Cardiovascular Imaging (2019) 20, 1321–1331

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It is noteworthy that the cut-off values of RV dilatation may lack specificity in the athletic population because physiologic adaptive changes of the RV in athlete's heart may produce an increase of RV volume that goes well beyond the upper limit of normality reported in the general population [19]. In this regard, proper reference values for RV volume in the athlete's heart are currently available and should be used in the differential diagnosis of physiologic versus pathologic RV dilatation in athletes, especially if engaged in sports such as rowing or canoeing associated with the greatest RV dimensional remodeling [29].

ATLETI

CRITERI DI PADOVA

Table 3. Ventricular Dilatation and Systolic Dysfunction by CMR: 2010 TFC Versus 2020 IC

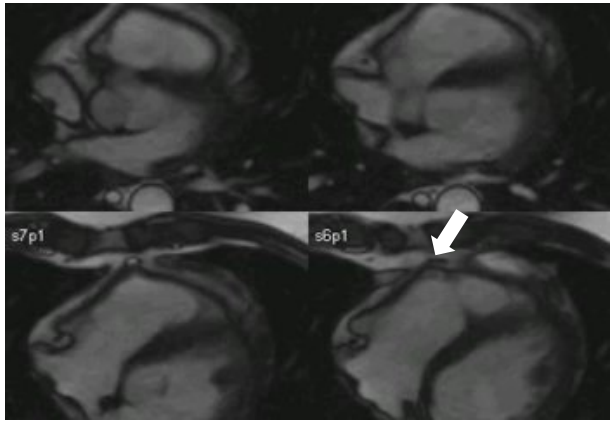
	Women		Men		Athletes	
	2010 TFC	2020 IC	2010 TFC	2020 IC	2010 TFC	2020 IC
Right ventricular dilatation and systolic dysfunction						
EDV/BSA, mL/m^2	≥90	>112	≥100	>121	…	>130
EF (%)	≤45	<51	≤45	<52	…	<52
Left ventricular dilatation and systolic dysfunction						
EDV/BSA, mL/m^2	…	>96	…	>105	…	>122
EF (%)	…	<57	…	<57	…	<58

Cardiac magnetic resonance (CMR) cutoff values of EDV and EF for nonathletes (±2 SD from the mean, respectively) derived from Petersen et al[33] and for athletes (99% CI) from D'Ascenzi et al.[34] BSA indicates body surface area; EDV, end-diastolic volume; EF, ejection fraction; IC, International Criteria; and TFC, Task Force Criteria

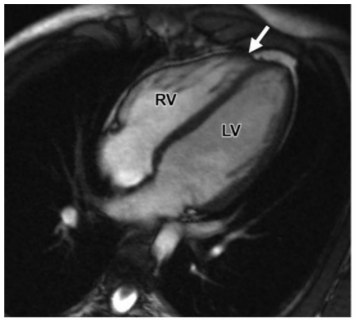
Corrado D Evolving Diagnostic Criteria for Arrhythmogenic Cardiomyopathy. *J Am Heart Assoc*. 2021

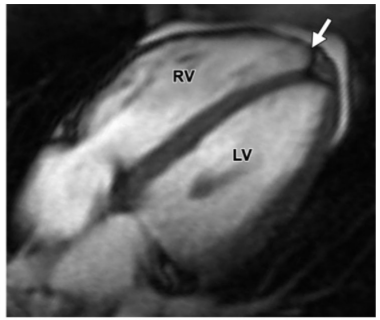
Il problema della overdiagnosi: RV cine pitfalls

Tethering parete libera

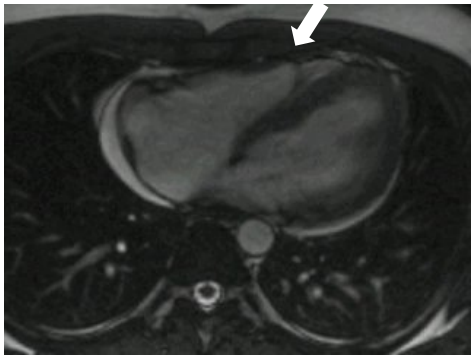


Normale *Butterfly apex*

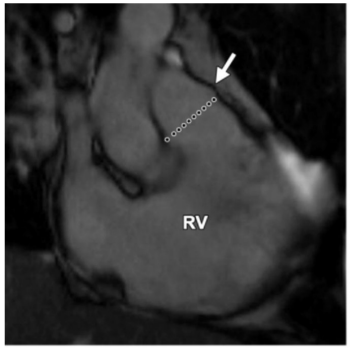


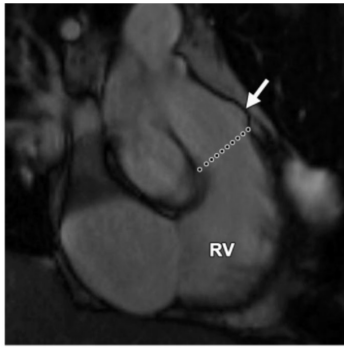


Bulge apico-laterale all'inserzione della banda moderatrice



Seno della valvola polmonare





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European Heart Journal (2018) **39**, 1949–1969
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CURRENT OPINION
Sports cardiology

European Association of Preventive Cardiology (EAPC) and European Association of Cardiovascular Imaging (EACVI) joint position statement: recommendations for the indication and interpretation of cardiovascular imaging in the evaluation of the athlete's heart

Antonio Pelliccia (Chairperson)[1], Stefano Caselli (Co-chairperson)[1]*, Sanjay Sharma[2], Cristina Basso[3], Jeroen J. Bax[4], Domenico Corrado[3], Antonello D'Andrea[5], Flavio D'Ascenzi[6], Fernando M. Di Paolo[1], Thor Edvardsen[7], Sabiha Gati[8], Maurizio Galderisi[9], Hein Heidbuchel[10], Alain Nchimi[11], Koen Nieman[12], Michael Papadakis[2], Cataldo Pisicchio[1], Christian Schmied[13], Bogdan A. Popescu[14], Gilbert Habib[15], Diederick Grobbee[16], and Patrizio Lancellotti (Chairperson)[17]

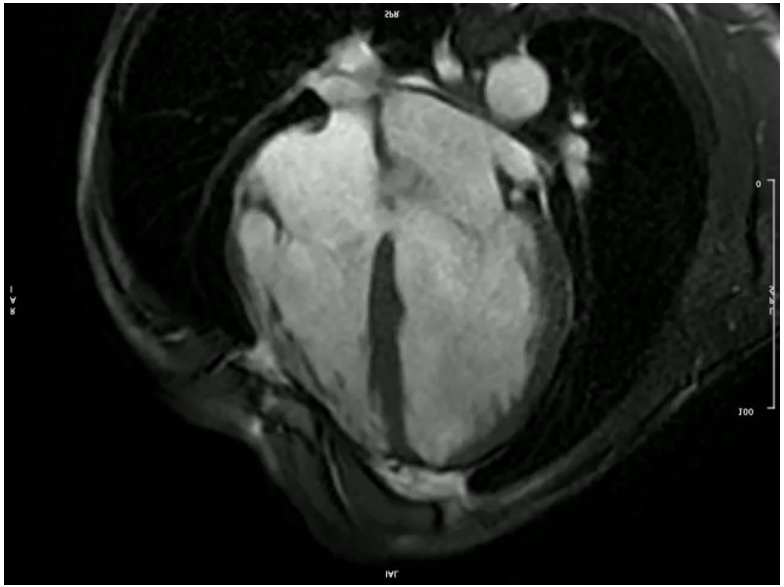
undergoes substantial remodelling.[29,47,76–78] A physiological RV enlargement (usually proportional with LV enlargement) was observed in both black and white athletes (*Table 3*).[18] Despite significant RV enlargement, athletes usually show normal RV systolic function, without significant differences compared with untrained subjects.[76,79] Only a small minority may present a mildly reduced RV fractional area change[76]; ambiguities in the interpretation of mildly reduced RV function may be resolved by assessing RV function during exercise inducing both pressure and volume overload.[80,81]

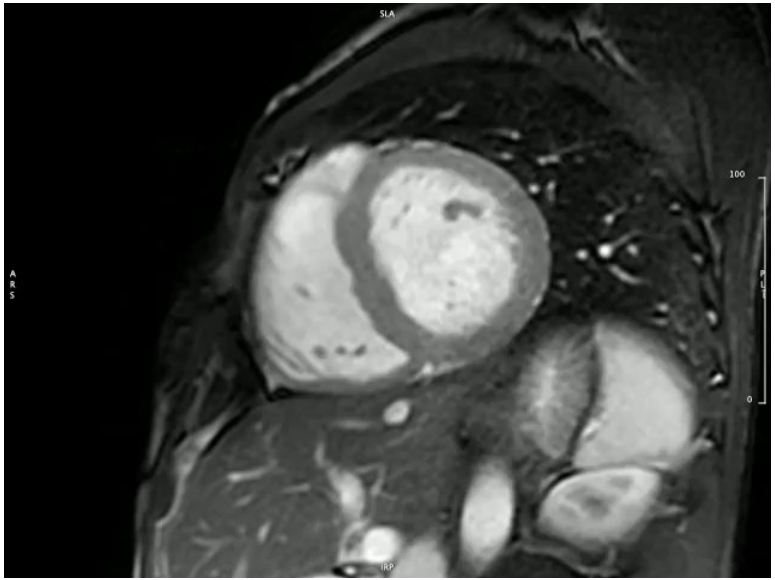
Table 3 Athlete's right heart morphologic and functional parameters including upper or lower limits

First author	Year	No. of athletes	Type of sport	Parameter	Gender	Mean value	Cut-off value
D'Andrea	2013	650	P E	RV diameter basal (mm)	♂	43.5	55
					♀	39	49
				RV diameter middle-ventricle (mm)	♂	34	47
					♀	32	43
				RV longitudinal diameter (base-to-apex; mm)	♂	89	109
					♀	82	100
Zaidi	2013	675	P E	RVOT proximal (mm)	♂	32	43
					♀	30	40
				RVOT distal mm	♂	23.5	32
					♀	21.5	29
Zaidi	2013	675	E	RA area (cm^2/m^2)	♂	19.5	28
					♀	15.5	24
D'Andrea	2011	650	P E	PASP (mmHg)	♂ and ♀	24	40
D'Andrea	2013	650	P E	TAPSE (cm)	♂ and ♀	2.1	2.0
				RV FAC (%)		48.5	47
Oxborough	2012	102	E	RV TDI s′ (cm/s)	♂ and ♀	11	8
				RV TDI e′ (cm/s)		10	6
D'Ascenzi	2016	1009	S P M E	RVOT proximal (mm)	♂	28.4	34
				RVOT proximal index (mm/m^2)	♀	26.1	32
					♂	14.4	18
					♀	15.3	19
				RVOT distal (mm)	♂	29.8	16
				RVOT distal index (mm/m^2)	♀	27.3	34
					♂	15	19
					♀	15.9	21
				RV diameter basal (mm)	♂	40.6	49
					♀	35.2	44
				RV diameter middle ventricle (mm)	♂	27.3	35
					♀	23.9	31
				RV diastolic area (cm^2) (male)	♂	25.1	33
					♀	19.3	27
				RV systolic area (cm^2) (male)	♂	12.1	18
					♀	9.0	14
				TAPSE (mm) (male)	♂ and ♀	24	19
				RA area (cm^2) (male)	♂	18.9	25
					♀	14.8	20
				s′ (cm/s)	♂	14.8	12
					♀	14.2	11
				RV FAC (%)	♂	52.0	39
					♀	53.4	38

FAC, fractional area change; RA, right atrium; PASP, pulmonary artery systolic pressure; RV, right ventricle; RVOT, right ventricular outflow tract; TDI, tissue Doppler imaging; TAPSE, tricuspid anulus peak systolic excursion. Type of sport: S, skill; P, power; M, mixed; E, endurance. ♀, female; ♂, male.

Ciclista professionista, M, 38 anni





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By echocardiography, CMR or angiography *Minor*

- Global LV systolic dysfunction (depression of LV EF or reduction of echocardiographic global longitudinal strain), with or without LV dilatation (increase of LV EDV according to the imaging test specific nomograms for age, sex, and BSA)

Minor

- Regional LV hypokinesia or akinesia of LV free wall, septum, or both

ATLETI

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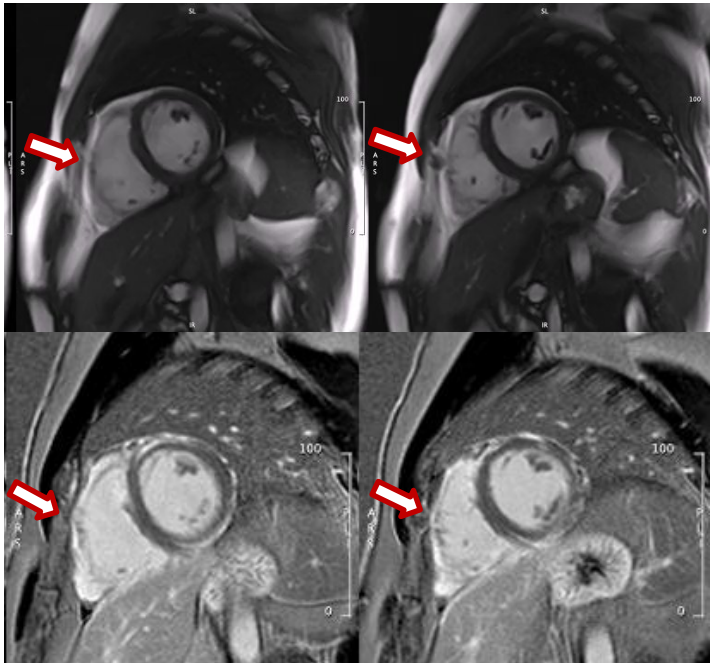
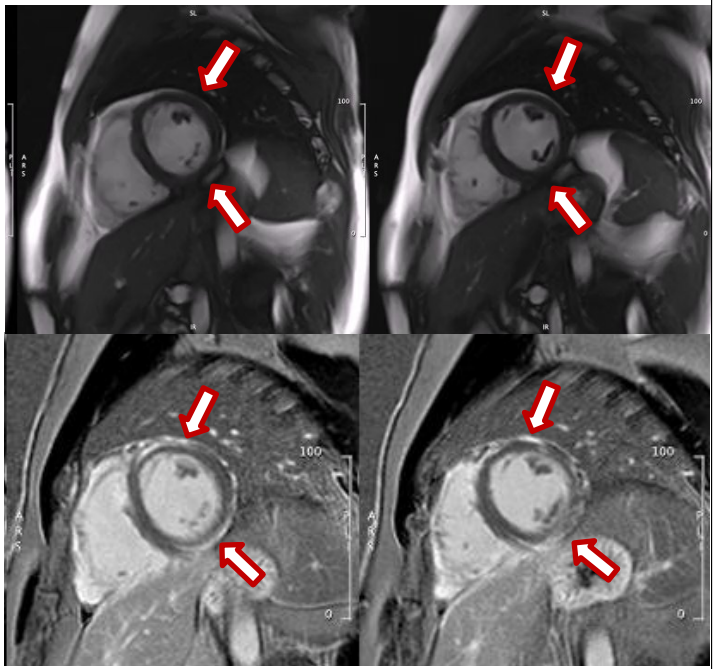
CONCORDANZA CINE-LGE



Cine asse corto

Asse corto post-contrasto



SI PER VDX

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VENTRICOLO SINISTRO

ESC European Society of Cardiology
European Heart Journal (2018) 39, 1949–1969
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CURRENT OPINION
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Table 2 Athlete's left heart morphologic and functional parameters including upper or lower limits

First author	Year	No. of athletes	Type of sport	Parameter	Gender	Mean value	Cut-off value
Pelliccia	1999	1309	S P M E	LV End diastolic diameter (mm)	♂	55	70
Whyte	2004	442	P E	LV End diastolic diameter (mm)	♀	49	65
Pelliccia	1996	600	S P M E	LV End diastolic diameter (mm)	♀	49	66
Makan	2005	900	E	LV End diastolic diameter (mm)	♂ and ♀ Adolescent	51	60
Spirito	1994	947	S P M E	LV wall thickness (mm)	♂	10	16
Rawlins	2010	440	P E	LV wall thickness (mm)	♀ Black	9.5	13
Sharma	2002	720	P E	LV wall thickness (adolescent) (mm)	♂ and ♀ Adolescent	9.5	12
Basavarajaiah	2008	300	P E	LV wall thickness (black athletes) (mm)	♂ Black	11.5	16
Caselli	2015	1145	S P M E	LV mass/BSA (g/m^2)	♂ and ♀	103	146
Finocchiaro	2016	1083	P M E	LV mass/BSA (g/m^2)	♂	83	117
					♀	101	143
Pelliccia	2005	1777	S P M E	LA antero-posterior diameter (mm)	♂	37	50
					♀	32	45
D'Andrea	2010	650	P E	LA volume index (mL/m^2)	♂	28	36
					♀	26.5	33
Pelliccia	2010	2317	P E	Aortic toot diameter (mm)	♂	32	40
					♀	28	34
D'Andrea	2010	615	P E	Proximal ascending aorta (mm)	♂ and ♀	28	34
Caselli	2015	1145	S P M E	LV ejection fraction (%)	♂ and ♀	64	55
				E/A		1.93	1.3
				TDI e′ septal (cm/s)		13.8	10.3
				TDI e′/a′ septal (cm/s)		2.04	1.23
				E/e′ septal		6.4	8.5
D'Andrea	2010	650	P E	TDI s′ septal (cm/s)	♂ and ♀	13	8
				TDI e′ septal (cm/s)		24	10
				TDI s′ lateral (cm/s)		15	9
				TDI e′ lateral (cm/s)		16	11
				TDI e′/a′ lateral		1.45	1.2
D'Andrea	2006	155	P	LV Intra-ventricular delay (ms)	♂ and ♀	9.5	45

BSA, body surface area; LA, left atrium; LV, left ventricle; TDI, tissue Doppler imaging. Type of sport: S, skill; P, power; M, mixed; E, endurance. ♀, female; ♂, male.

Category	Right ventricle (upgraded 2010 ITF diagnostic criteria)	Left ventricle (new diagnostic criteria)
I. Morpho-functional ventricular abnormalities	*By echocardiography, CMR or angiography:* *Major* • Regional RV akinesia, dyskinesia, or bulging *plus* one of the following: - global RV dilatation (increase of RV EDV according to the imaging test specific nomograms) - global RV systolic dysfunction (reduction of RV EF according to the imaging test specific nomograms)	*By echocardiography, CMR or angiography:Minor* • Global LV systolic dysfunction (depression of LV EF or reduction of echo-cardiographic global longitudinal strain), with or without LV dilatation (increase of LV EDV according to the imaging test specific nomograms for age, sex, and BSA) *Minor* • Regional LV hypokinesia or akinesia of LV free wall, septum, or both

By CE-CMR:Major

- Transmural LGE (stria pattern) of ≥1 RV region(s) (inlet, outlet, and apex in 2 orthogonal views)

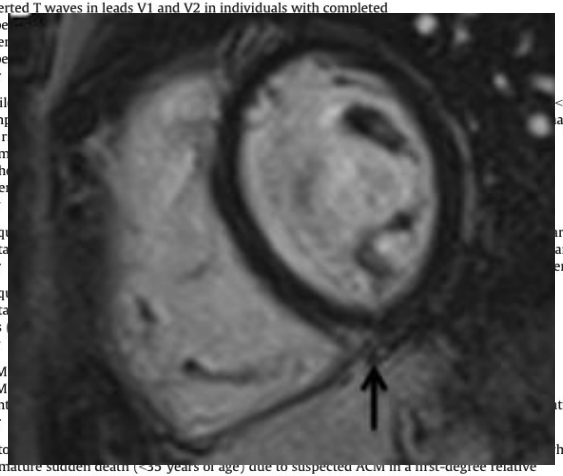
By EMB (limited indications):Major

- Fibrous replacement of the myocardium in ≥1 sample, with or without fatty tissue

By CE-CMR:Major

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

IV. Depolarization abnormalities	*Minor* • Inverted T waves in leads V1 and V2 in individuals with completed pube • Inver pube	
	Minor • Epsil comp the r • Term of th abse	<0.5 mV peak to peak) in limb leads (in the absence of a, or pericardial effusion)
V. Ventricular arrhythmias	*Major* • Frequ susta	ar extrasystoles (>500 per 24 h), non-sustained or ar tachycardia with a RBBB morphology (excluding ern")
	Minor • Frequ susta axis	
VI. Family history/genetics	*Major* • ACM • ACM • Ident *Minor* • Histo	ation hether the family member meets diagnostic criteria
	• Premature sudden death (<35 years of age) due to suspected ACM in a first-degree relative • ACM confirmed pathologically or by diagnostic criteria in a second-degree relative	



Corrado D, Diagnosis of arrhythmogenic cardiomyopathy: The Padua criteria.
Int J Cardiol. 2020

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Category	Right ventricle (upgraded 2010 ITF diagnostic criteria)	Left ventricle (new diagnostic criteria)
I. Morpho-functional ventricular abnormalities	*By echocardiography, CMR or angiography:* *Major* • Regional RV akinesia, dyskinesia, or bulging *plus* one of the following: - global RV dilatation (increase of RV EDV according to the imaging test specific nomograms) - global RV systolic dysfunction (reduction of RV EF according to the imaging test specific nomograms) *Minor* • Regional RV akinesia, dyskinesia or aneurysm of RV free wall	*By echocardiography, CMR or angiography:Minor* • Global LV systolic dysfunction (depression of LV EF or reduction of echocardiographic global longitudinal strain), with or without LV dilatation (increase of LV EDV according to the imaging test specific nomograms for age, sex, and BSA) *Minor* • Regional LV hypokinesia or akinesia of LV free wall, septum, or both
II. Structural myocardial abnormalities	*By CE-CMR:Major* • Transmural LGE (stria pattern) of ≥1 RV region(s) (inlet, outlet, and apex in 2 orthogonal views)	*By CE-CMR:Major* • LV LGE (stria pattern) of ≥1 Bull's Eye segment(s) (in 2 orthogonal views) of the free wall (subepicardial or midmyocardial), septum, or both
III. Repolarization abnormalities	*Minor* • Inverted T waves in left precordial leads (V_4-V_6) (in the absence of complete LBBB) pubertal development (in the absence of complete RBBB) • Inverted T waves in V1,V2,V3 and V4 in individuals with completed pubertal development in the presence of complete RBBB.	f com-
IV. Depolarization abnormalities	*Minor* • Epsilon wave (reproducible low-amplitude signalsbetween end of QRS complex to onset of the T wave) in the right precordial leads (V1 to V3) • Terminal activation duration of QRS ≥55 ms measured from the nadir of the S wave to the end of the QRS, including R', in V1, V2, or V3 (in the absence of complete RBBB)	*Minor* • Low QRS voltages (<0.5 mV peak to peak) in limb leads (in the absence of obesity, emphysema, or pericardial effusion)
V. Ventricular arrhythmias	*Major* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia of LBBB morphology *Minor* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia of LBBB morphology with inferior axis ("RVOT pattern")	*Minor* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia with a RBBB morphology (excluding the "fascicular pattern")
VI. Family history/genetics	*Major* • ACM confirmed in a first-degree relative who meets diagnostic criteria • ACM confirmed pathologically at autopsy or surgery in a first degree relative • Identification of a pathogenic or likely pathogenetic ACM mutation in the patient under evaluation *Minor* • History of ACM in a first-degree relative in whom it is not possible or practical to determine whether the family member meets diagnostic criteria • Premature sudden death (<35 years of age) due to suspected ACM in a first-degree relative • ACM confirmed pathologically or by diagnostic criteria in a second-degree relative	

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Category	Right ventricle (upgraded 2010 ITF diagnostic criteria)	Left ventricle (new diagnostic criteria)
I. Morpho-functional ventricular abnormalities	*By echocardiography, CMR or angiography:* *Major* • Regional RV akinesia, dyskinesia, or bulging *plus* one of the following: - global RV dilatation (increase of RV EDV according to the imaging test specific nomograms) - global RV systolic dysfunction (reduction of RV EF according to the imaging test specific nomograms) *Minor* • Regional RV akinesia, dyskinesia or aneurysm of RV free wall	*By echocardiography, CMR or angiography:Minor* • Global LV systolic dysfunction (depression of LV EF or reduction of echocardiographic global longitudinal strain), with or without LV dilatation (increase of LV EDV according to the imaging test specific nomograms for age, sex, and BSA) *Minor* • Regional LV hypokinesia or akinesia of LV free wall, septum, or both
II. Structural myocardial abnormalities	*By CE-CMR:Major* • Transmural LGE (stria pattern) of ≥1 RV region(s) (inlet, outlet, and apex in 2 orthogonal views) *By EMB (limited indications):Major* • Fibrous replacement of the myocardium in ≥1 sample, with or without fatty tissue	*By CE-CMR:Major* • LV LGE (stria pattern) of ≥1 Bull's Eye segment(s) (in 2 orthogonal views) of the free wall (subepicardial or midmyocardial), septum, or both (excluding septal junctional LGE)
III. Repolarization abnormalities	*Major* • Inverted T waves in right precordial leads (V_1,V_2, and V_3) or beyond in individuals with complete pubertal development (in the absence of complete RBBB) *Minor* • Inverted T waves in leads V1 and V2 in individuals with completed pub • Inve pub	*Minor* • Inverted T waves in left precordial leads (V_4-V_6) (in the absence of complete LBBB)
IV. Depolarization abnormalities	*Minor* • Epsi con the • Terr of tl abs	*Minor* • Low QRS voltages (<0.5 mV peak to peak) in limb leads (in the absence of obesity, emphysema, or pericardial effusion) n the absence of
V. Ventricular arrhythmias	*Major* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia of LBBB morphology *Minor* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia of LBBB morphology with inferior axis ("RVOT pattern")	*Minor* • Frequent ventricular extrasystoles (>500 per 24 h), non-sustained or sustained ventricular tachycardia with a RBBB morphology (excluding the "fascicular pattern")
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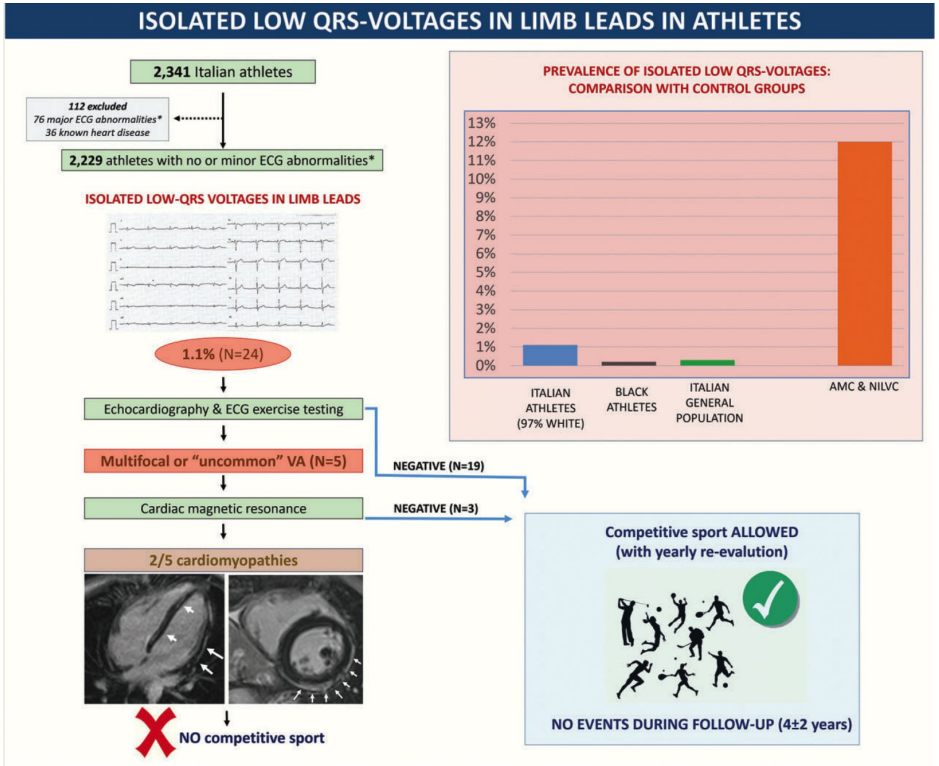
VENTRICOLO SINISTRO

ESC European Society of Cardiology
Europace (2022) 00, 1–12
https://doi.org/10.1093/europace/euab330

CLINICAL RESEARCH

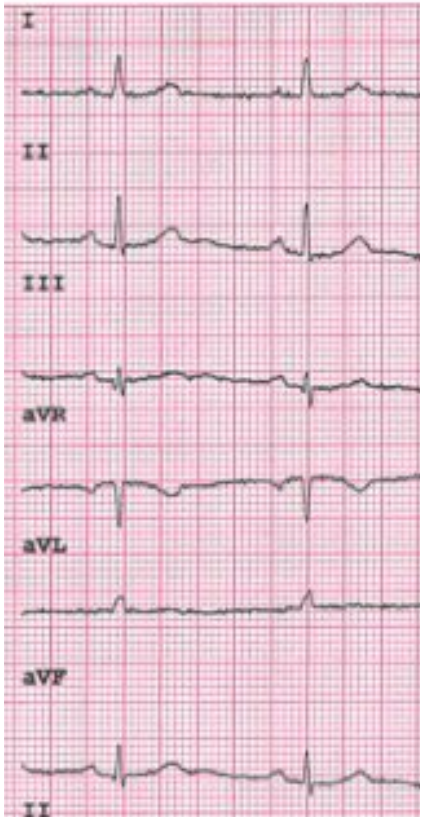
Prevalence and clinical significance of isolated low QRS voltages in young athletes

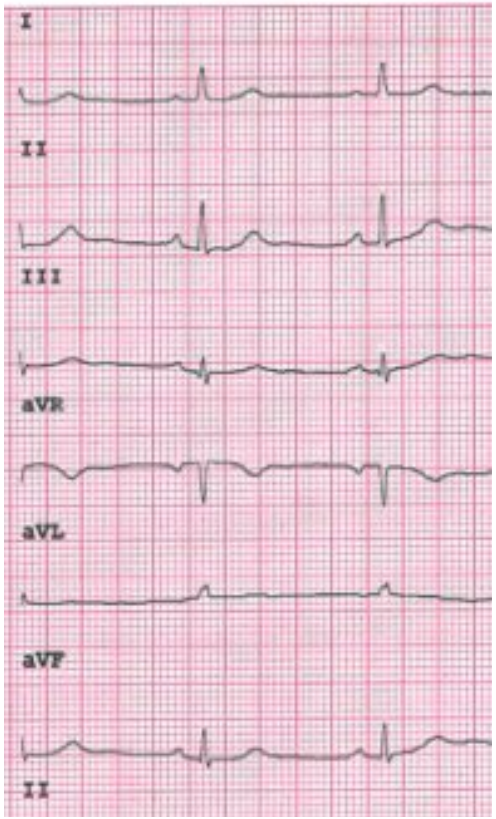
Alessandro Zorzi [1], Natascia Bettella [1], Mario Tatangelo [2], Alvise Del Monte [1], Teresina Vessella[3], Barbara Poscolieri[3], Cinzia Crescenzi[4], Davide Pegorin[1], Flavio D'Ascenzi [5], Valentina Pescatore[6], Franco Giada [6], Patrizio Sarto[3], Leonardo Calò [4], Maurizio Schiavon [7], Dario Gregori[1], David M. Hadley [8], Jonathan A. Drezner [9], Antonio Pelliccia [2†], and Domenico Corrado [1*†]



Conclusions Unlike cardiomyopathy patients, the ECG pattern of isolated LQRSV was rarely observed in athletes. This ECG sign should prompt clinical work-up for exclusion of an underlying cardiomyopathy.

0,05-150 Hz





0,05-40 Hz

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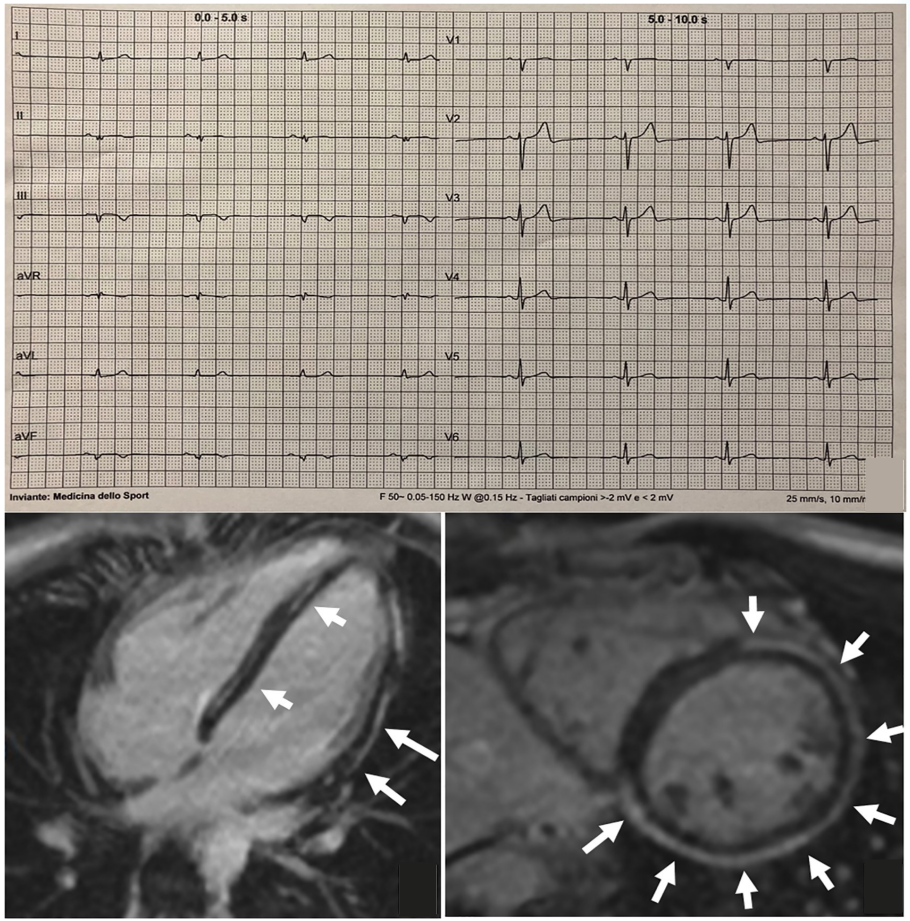
Atleta, M, 25 anni.
Anamnesi familiare negativa per CMP e MCI.
Non sintomi.
Test da sforzo: BEV a Bbdx/asse superiore
Ecocardiogramma: nella norma.



Zorzi et al., Prevalence and clinical significance of isolated low QRS voltages in young athletes, EP Europace, 2022.

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III. Repolarization abnormalities	*Major* • Inverted T waves in right precordial leads (V_1,V_2, and V_3) or beyond in individuals with complete pubertal development (in the absence of complete RBBB) *Minor* • Inverted T waves in leads V1 and V2 in individuals with completed pubertal development (in the absence of complete RBBB) • Inverted T waves in V1,V2,V3 and V4 in individuals with completed pubertal development in the presence of complete RBBB.	*Minor* • Inverted T waves in left precordial leads (V_4-V_6) (in the absence of complete LBBB)
IV. Depolarization abnormalities	*Minor* • Epsilon wave (reproducible low-amplitude signalsbetween end of QRS	*Minor* • Low QRS voltages (<0.5 mV peak to peak) in limb leads (in the absence of
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Corrado D, Diagnosis of arrhythmogenic cardiomyopathy: The Padua criteria.
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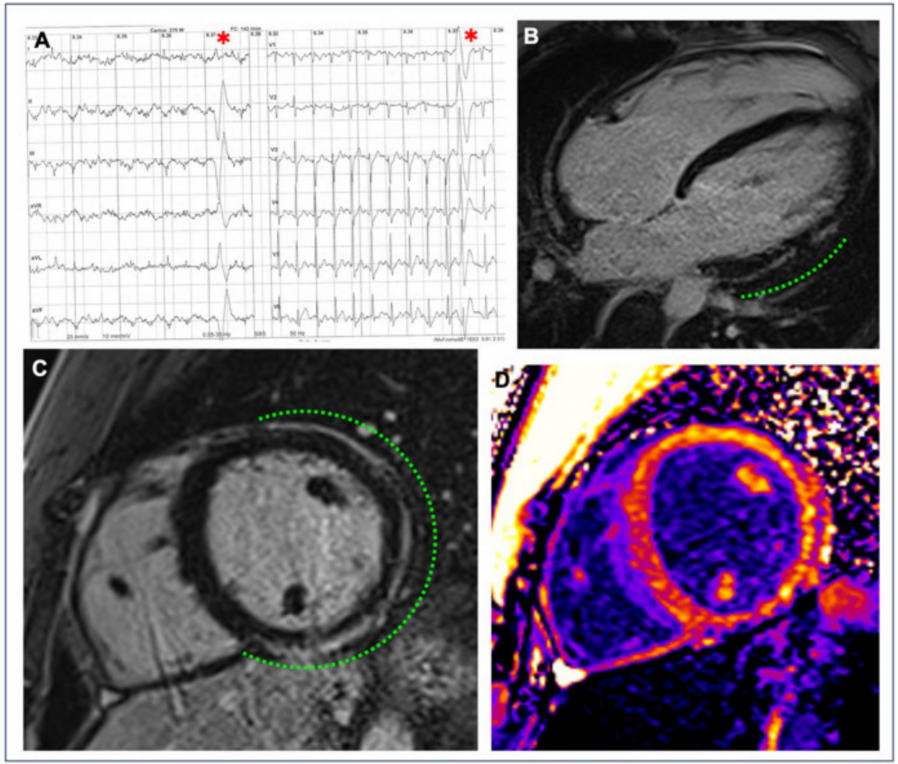
M, 26 anni.
Giocatore di hockey professionista.
Al test da sforzo: BEV tipo **BBdx/asse superiore** agli alti carichi.



Brunetti et al., Role of Cardiac Magnetic Resonance Imaging in the Evaluation of Athletes with Premature Ventricular Beats. *J Clin Med*. 2022

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IV. Depolarization abnormalities	*Minor* • Epsilon wave (reproducible low-amplitude signalsbetween end of QRS complex to onset of the T wave) in the right precordial leads (V1 to V3) • Terminal activation duration of QRS ≥55 ms measured from the nadir	*Minor* • Low QRS voltages (<0.5 mV peak to peak) in limb leads (in the absence of obesity, emphysema, or pericardial effusion)
V.		
VI. Family history/genetics	*Major* • ACM confirmed in a first-degree relative who meets diagnostic criteria • ACM confirmed pathologically at autopsy or surgery in a first degree relative • Identification of a pathogenic or likely pathogenetic ACM mutation in the patient under evaluation *Minor* • History of ACM in a first-degree relative in whom it is not possible or practical to determine whether the family member meets diagnostic criteria • Premature sudden death (<35 years of age) due to suspected ACM in a first-degree relative • ACM confirmed pathologically or by diagnostic criteria in a second-degree relative	
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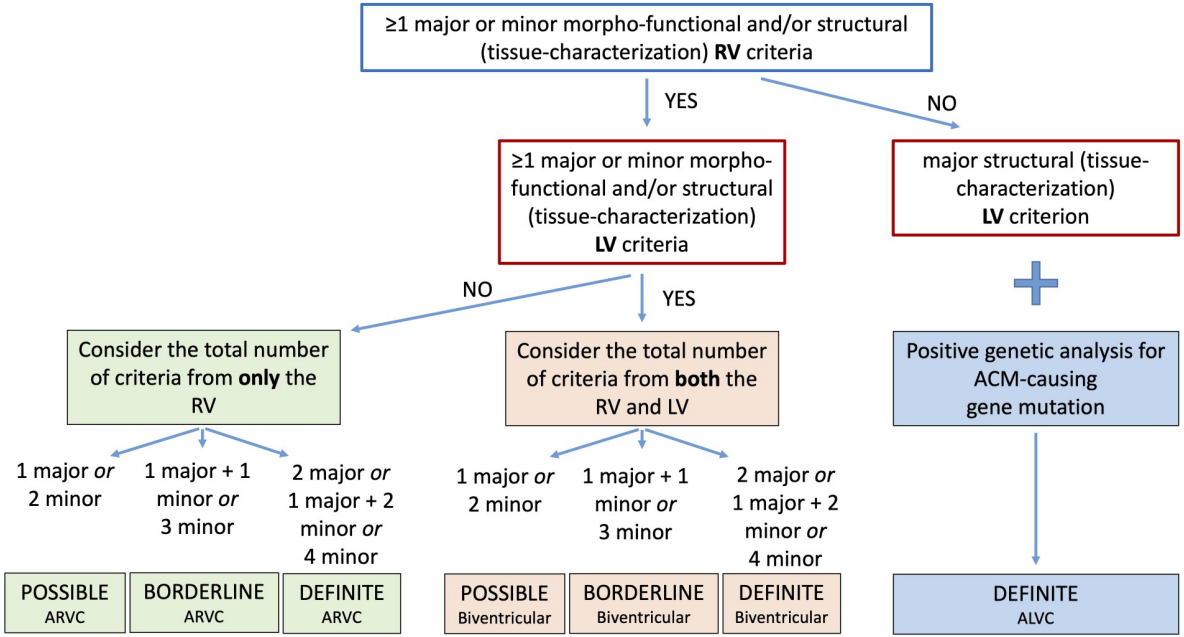

Adapted from Corrado D et al. Evolving Diagnostic Criteria for Arrhythmogenic Cardiomyopathy. J Am Heart Assoc. 2021.

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PLATFORM OF LABORATORIES FOR ADVANCES IN CARDIAC EXPERIENCE

ROMA
Centro Congressi
di Confindustria
Auditorium
della Tecnica

9ª Edizione

30 Settembre
1 Ottobre
2022

Grazie per l'attenzione