

Devices in Inherited Cardiac Conditions- ARVC

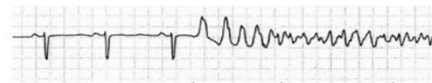
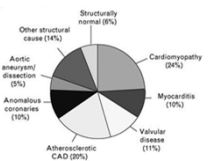
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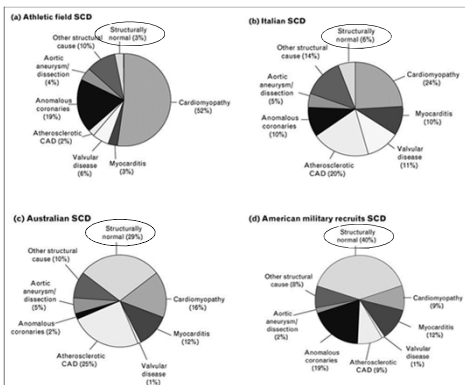
Sudden Cardiac Death

- 400,000 deaths USA/ per year
- Up to 30% have a structurally normal heart at post mortem.

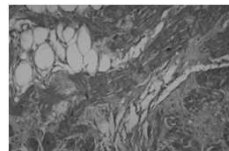


↑ VT initiation ↑ VT to VF transition ↑ VF maintenance

SAD Series

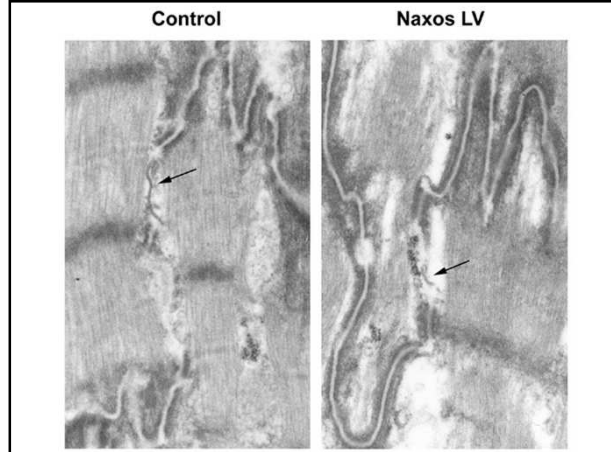
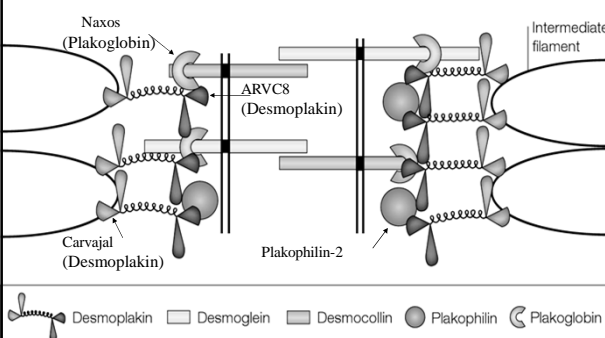


Arrhythmogenic Right Ventricular Cardiomyopathy



Dx- structural, functional and electrophysiologic abnormalities, secondary to fibrofatty replacement of RV±LV myocytes

Disease-Causing Mutations in Desmosomal Proteins



Natural History of ARVC

- Phase I: Silent phase
 - Sporadic ventricular ectopic beats
 - Subtle ECG/morphological abnormalities
 - Sudden death can occur
- Phase II: Self-evident phase
 - Clinical symptoms, sustained VT
 - Diffuse RV/LV structural abnormalities
- Phase III / IV: Advanced disease
 - ↑ dilatation, ↓ contractility of RV, LV

Introduction

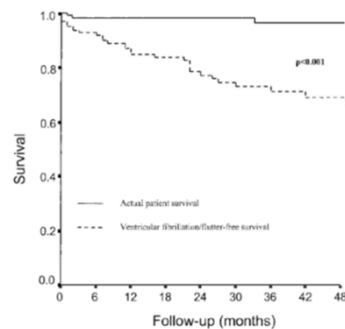
- Diagnosis
- Risk Stratification
- Indications for ICD
- Complications ICD
- Conclusions

Diagnostic Criteria

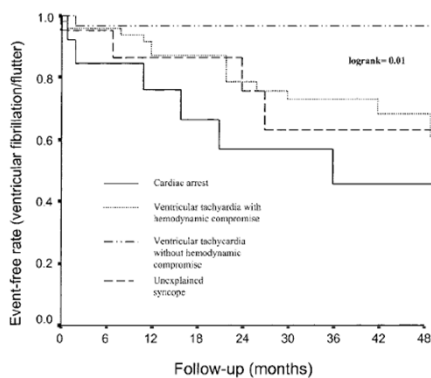
Criteria for Clinical Diagnosis of ARVC/D

	Major	Minor
Family history	Familial disease confirmed at necropsy or surgery	Family history of premature sudden death (age <35 y) due to suspected ARVC/D; family history (clinical diagnosis based on present criteria)
ECG depolarization/conduction abnormalities	Epsilon waves or localized prolongation (>110 ms) of QRS complex in right precordial leads (V ₁ to V ₃)	Late potentials on signal-averaged ECG
ECG repolarization abnormalities		Inverted T waves in right precordial leads (V ₁ and V ₂) in people aged >12 y and in absence of right bundle branch block
Arrhythmias		Sustained or nonsustained left bundle branch block-type ventricular tachycardia documented on ECG or Holter monitoring or during exercise testing; frequent ventricular extrasystoles (>1000/24 h on Holter monitoring)
Global or regional dysfunction and structural alterations	Severe dilatation and reduction of RV ejection fraction with no or mild LV involvement; localized RV aneurysms (akinetic or dyskinesic areas with diastolic bulging); severe segmental dilatation of RV	Mild global RV dilatation or ejection fraction reduction with normal LV; mild segmental dilatation of RV; regional RV hypokinesia
Tissue characteristics of walls	Fibrofatty replacement of myocardium on endomyocardial biopsy	

Protective Effect of the ICD



Corrado et al, *Circulation*. 2003;108:3084-3091



Corrado et al, *Circulation*. 2003;108:3084-3091

Independent Predictors of VF

	P	OR	95% CI
Age/5 y*	0.007	0.77	0.57-0.96
Left ventricular ejection fraction	0.037	0.94	0.89-0.95
Cardiac arrest	<0.001	79	6.8-90.6
Ventricular tachycardia with hemodynamic compromise	0.015	14	1.7-21.1
Unexplained syncope	0.07	7.5	0.84-1.81

*OR per 5-year interval.

Corrado et al, *Circulation*. 2003;108:3084-3091

Arrhythmia/Electrophysiology

Prophylactic Implantable Defibrillator in Patients With Arrhythmogenic Right Ventricular Cardiomyopathy/Dysplasia and No Prior Ventricular Fibrillation or Sustained Ventricular Tachycardia

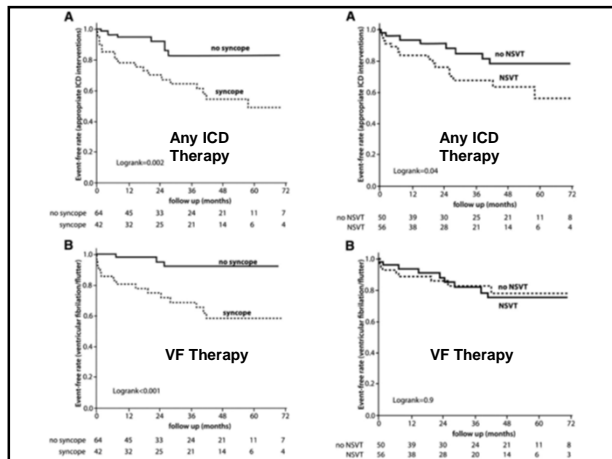
Domenico Corrado, MD, PhD; Hugh Calkins, MD; Mark S. Link, MD; Leira Leoni, MD, PhD; Stefano Favale, MD; Michela Bevilacqua, MD; Cristina Basso, MD, PhD; Deirdre Ward, MD; Giuseppe Boriani, MD; Renato Ricci, MD; Jonathan P. Piccini, MD; Dushan Dalal, MD, MPH; Massimo Santini, MD; Gianfranco Bujja, MD; Sabino Iliceto, MD; N.A. Mark Estes III, MD; Thomas Wichter, MD; William J. McKenna, MD; Gaetano Thiene, MD; Frank I. Marcus, MD

Background—The role of implantable cardioverter-defibrillator (ICD) in patients with arrhythmogenic right ventricular cardiomyopathy/dysplasia and no prior ventricular fibrillation (VF) or sustained ventricular tachycardia is an unresolved issue.

Methods and Results—We studied 106 consecutive patients (62 men and 44 women; age, 35.6±18 years) with arrhythmogenic right ventricular cardiomyopathy/dysplasia who received an ICD based on 1 or more arrhythmic risk factors such as syncope, nonsustained ventricular tachycardia, familial sudden death, and inducibility at programmed ventricular stimulation. During follow-up of 58±35 months, 25 patients (24%) had appropriate ICD interventions and 17 (16%) had shocks for life-threatening VF or ventricular flutter. At 48 months, the actual survival rate was 100% compared with the VF/ventricular flutter-free survival rate of 77% (log-rank $P=0.01$). Syncope significantly predicted any appropriate ICD interventions (hazard ratio, 2.94; 95% confidence interval, 1.83 to 4.67; $P=0.01$) and shocks for VF/ventricular flutter (hazard ratio, 3.16; 95% confidence interval, 1.39 to 5.63; $P=0.005$). The positive predictive value of programmed ventricular stimulation was 33% for any appropriate ICD intervention and 20% for shocks for VF/ventricular flutter, with a negative predictive value of 70% and 74%. None of the 27 asymptomatic patients with isolated familial sudden death had appropriate ICD therapy. Twenty patients (19%) had inappropriate ICD interventions, and 18 (17%) had device-related complications.

Conclusions—One fourth of patients with arrhythmogenic right ventricular cardiomyopathy/dysplasia and no prior sustained ventricular tachycardia or VF had appropriate ICD interventions. Syncope was an important predictor of life-saving ICD intervention and is an indication for ICD. Prophylactic ICD may not be indicated in asymptomatic patients because of their low arrhythmic risk regardless of familial sudden death and programmed ventricular stimulation findings. Programmed ventricular stimulation had a low predictive accuracy for ICD therapy. (Circulation. 2009;120:1144-1152.)

Key Words: cardiomyopathy ■ death, sudden ■ electrophysiology ■ implantable cardioverter-defibrillators ■ tachyarrhythmias



Predictors of SCD

Variable	Univariable Analysis			Multivariable Analysis		
	HR	95% CI	P	HR	95% CI	P
Syncope	3.82	2.15-5.72	0.008	2.94	1.83-4.67	0.013
NSVT	1.74	1.35-3.19	0.03	1.62	0.96-4.82	0.068
Age ≤35 y	1.36	0.91-3.13	0.07	1.22	0.72-2.56	0.47
LV dysfunction (EF <55%)	1.21	0.87-4.73	0.10	1.13	0.64-3.46	0.59
Family history of SD	1.43	0.76-4.12	0.14	0.90	0.35-5.90	0.82
Male gender	1.37	0.65-3.94	0.24	...	...	...
Right precordial T-wave inversion	1.20	0.42-2.13	0.33	...	...	...
Inducibility at PMS	1.03	0.23-3.61	0.98	...	...	...
Diffuse RV involvement	1.07	0.52-3.19	0.35	...	...	...
Late potentials on SAECG	0.82	0.37-3.48	0.23	...	...	...
Antiarrhythmic drug therapy	0.59	0.24-2.43	0.51	...	...	...

Abbreviations as in Table 1.

Implantable Cardioverter/Defibrillator Therapy in Arrhythmogenic Right Ventricular Cardiomyopathy

Single-Center Experience of Long-Term Follow-Up and Complications in 60 Patients

Thomas Wichter, MD, FESC; Matthias Paul, MD; Christian Wollmann, MD; Tayfun Acil, MD; Petra Gerdes, RN; Obaidullah Ashraf, MD; Tony D.T. Tjan, MD; Rajsid Soeparwata, MD; Michael Block, MD; Martin Borggreffe, MD, FESC; Hans H. Scheld, MD, FESC, FETS; Günter Breithardt, MD, FESC; Dirk Böcker, MD

Background—Arrhythmogenic right ventricular cardiomyopathy (ARVC) is a major cause of ventricular tachycardia (VT) and cardiac arrest in young patients. We hypothesized that treatment with implantable cardioverter/defibrillators (ICDs) is safe and improves the long-term prognosis of ARVC patients at high risk of sudden death.

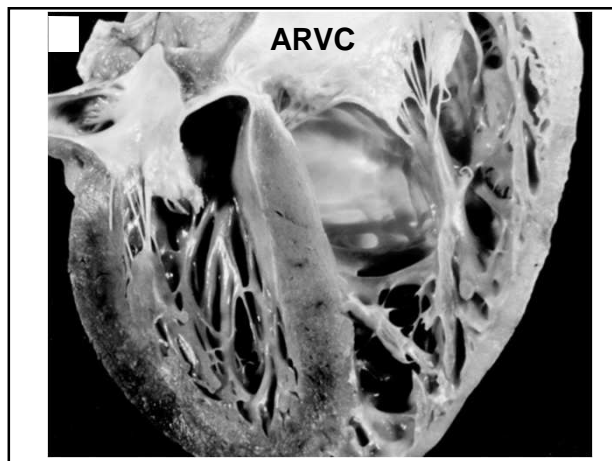
Methods and Results—Sixty patients with ARVC (aged 43±16 years) were treated with transvenous ICD systems. Despite a higher number of right ventricular sites tested for adequate lead positions ($P<0.05$), lower R-wave amplitudes ($P<0.001$) were achieved in ARVC patients compared with other entities. During follow-up of 80±43 months (306 patient-years), event-free survival was 40%, 30%, 26%, and 26% for appropriate ICD therapies and 79%, 64%, 59%, and 56% for potentially fatal VT (>240 bpm) after 1, 3, 5, and 7 years, respectively. Multivariate analysis identified extensive right ventricular dysfunction as an independent predictor of appropriate ICD discharge. Fifty-three adverse events occurred in 37 patients during the perioperative ($n=10$) or follow-up ($n=43$) period, mainly related to the leads ($n=31$ in 21 patients). No lead perforation was observed. Freedom from adverse events was 90%, 78%, 56%, and 42% and freedom from lead-related complications was 95%, 85%, 74%, and 63% after 1, 3, 5, and 7 years, respectively.

Conclusions—These results strongly suggest an improvement in long-term prognosis by ICD therapy in high-risk patients with ARVC. However, meticulous placement and long-term observation of transvenous lead performance with focus on sensing function are required for the prevention and/or early recognition of disease progression and lead-related morbidity during long-term follow-up of ICD therapy in ARVC. (Circulation. 2004;109:1503-1508.)

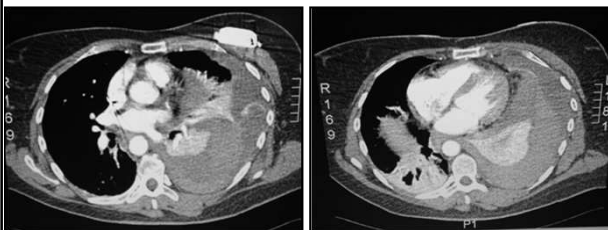
Key Words: cardiomyopathy ■ heart arrest ■ tachyarrhythmias ■ defibrillators, implantable ■ arrhythmogenic right ventricular dysplasia

Voltage mapping in ARVC

Corrado, et al Circulation, June 2005



ARVC – ICD complications



- Lead perforation
- Lead displacement
- Threshold rises
- Undersensing

Events and Complications ICD Therapy

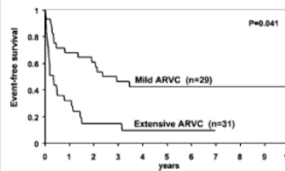


Figure 2. Multivariate Cox regression analysis identified extensive RV dysfunction as an independent predictor (P=0.041) of appropriate ICD therapies for VT/VF during long-term follow-up (60±43 months) in ARVC.

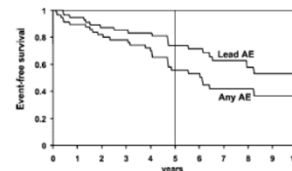


Figure 3. Complications during follow-up (80±43 months) after ICD implantation in ARVC. Kaplan-Meier curves depict survival free of all adverse events (any AE) and lead-related complications (lead AE).

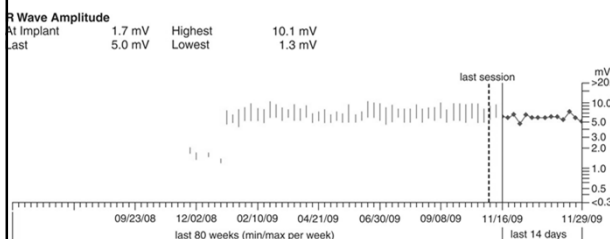
Wichter et al, Circulation 2004

	Patients, n (%)	Events (Severe)
Adverse events (total)	37 (62)	53
Severe adverse events	25 (42)	38
Perioperative period (30 days)	10 (17)	10 (2)
Bleeding or hematoma/seroma	4 (7)	4 (1)
Lead dislodgment	1 (2)	1 (1)
VT cluster	5 (8)	5 (0)
Follow-up period (80±43 months)*	27 (45)	43 (35)
Device infection	3 (5)	4 (3)
Device malfunction	3 (5)	3 (3)
Device dislodgment (pocket perforation)	2 (3)	2 (2)
Frequent inappropriate ICD discharges	3 (5)	3 (0)
Psychiatric problems (fear of ICD shocks)	1 (2)	1 (1)
Lead-related complications	21 (35)	31 (26)
Insulation failure/oversensing	10 (17)	13 (11)
Undersensing	8 (13)	8 (7)
Lead fracture	5 (8)	5 (4)
Lead dislodgment	2 (3)	2 (2)
Lead thrombosis	2 (3)	2 (1)
Subcutaneous lead fracture	1 (2)	1 (1)

*Some patients had >1 event.

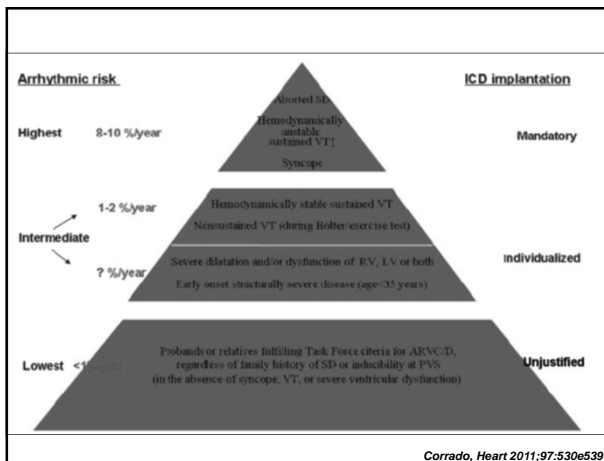
CS Pace-Sense Lead

Evolution of R wave amplitude after implantation.



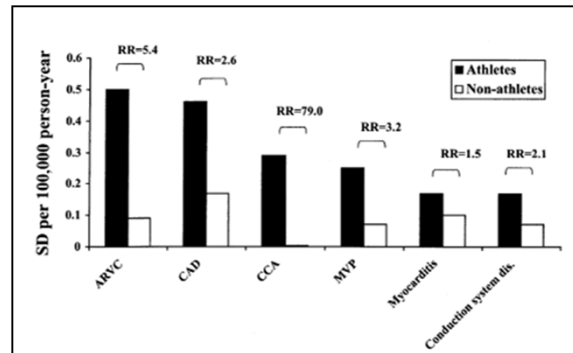
Lochy S et al. Europace 2010;12:1195-1196

Risk Stratification



Corrado, Heart 2011;97:530e539.

Lifestyle & Prevention SCD in High Risk Groups



Corrado et al, J Am Coll Cardiol 2003; 42:1959-63

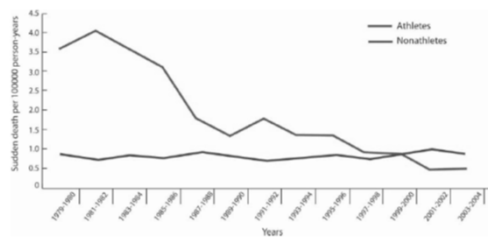


Figure 3 Annual Incidence Rates of Sudden Cardiac Death Among Screened Competitive Athletes and Unscreened Nonathletes in the Veneto Region of Italy From 1979 to 2004

Corrado et al, J Am Coll Cardiol 2008;52:1981-9