Recurrent Implantable Defibrillator Discharges (ICD) Discharges – ICD Storm

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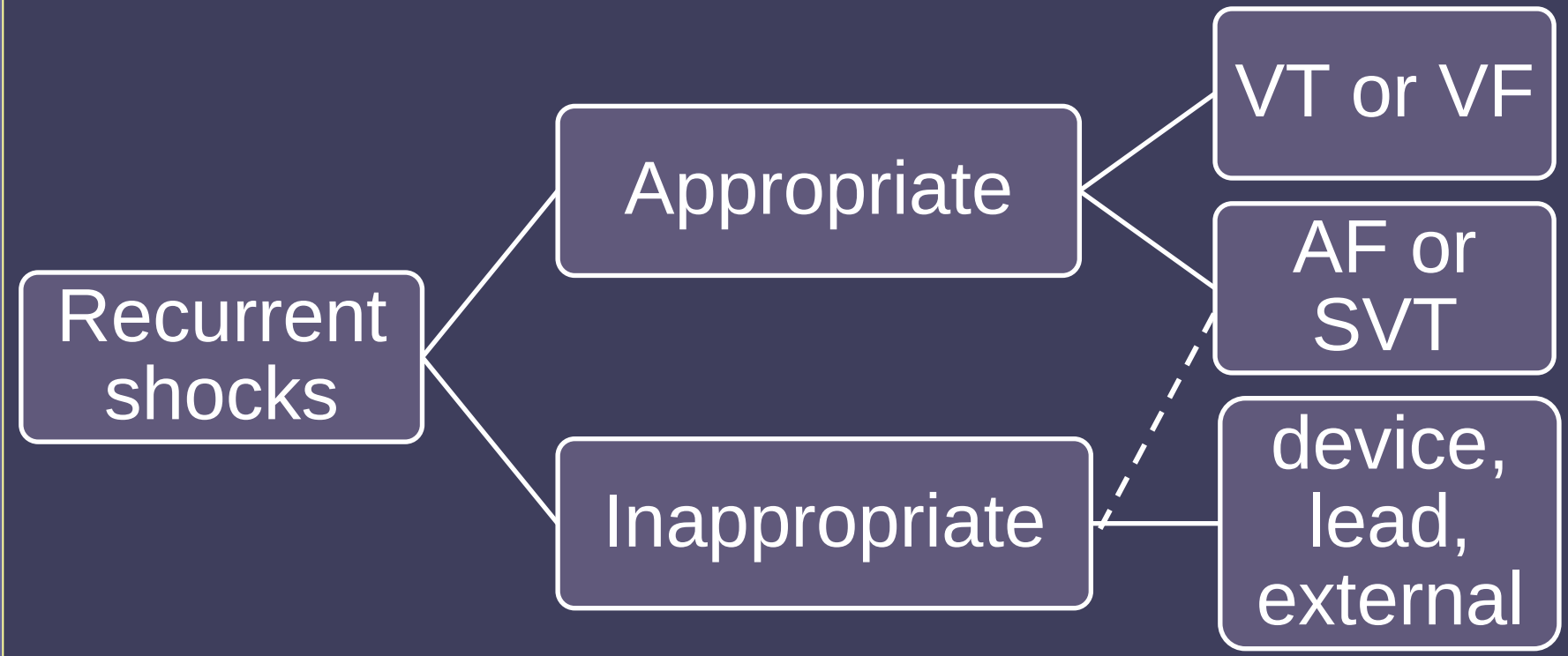
Disclosures

- Consultant: Biosense Webster, Medtronic
- Honoraria: Medtronic

A Case

- A 70 y.o. man is admitted to the CCU d/t 3 ICD shocks over the last 2 hours
- h/o MI – 10 years ago
- LVEF= 30%
- No angina, no heart failure

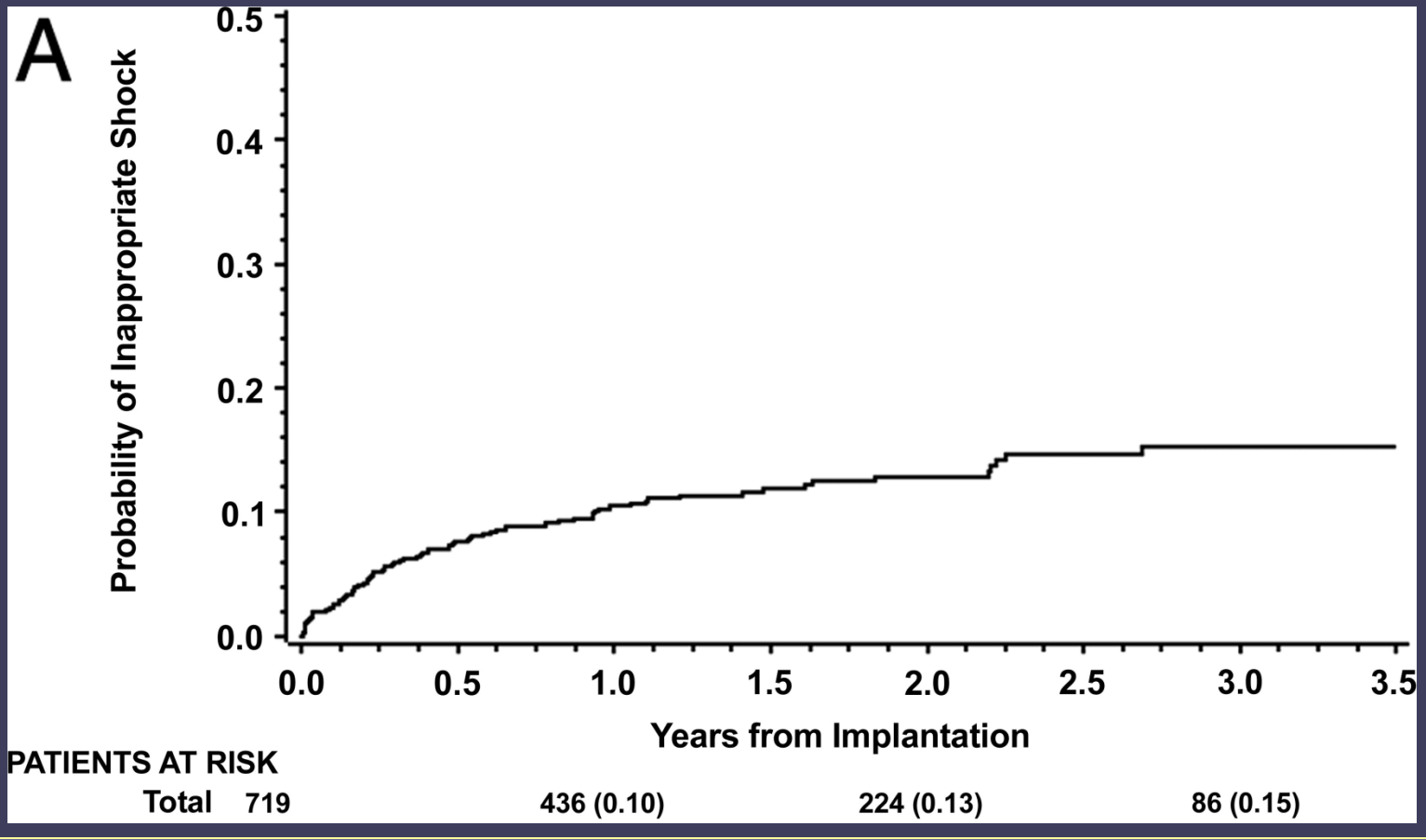
What do we Need to Know?



Inappropriate shocks

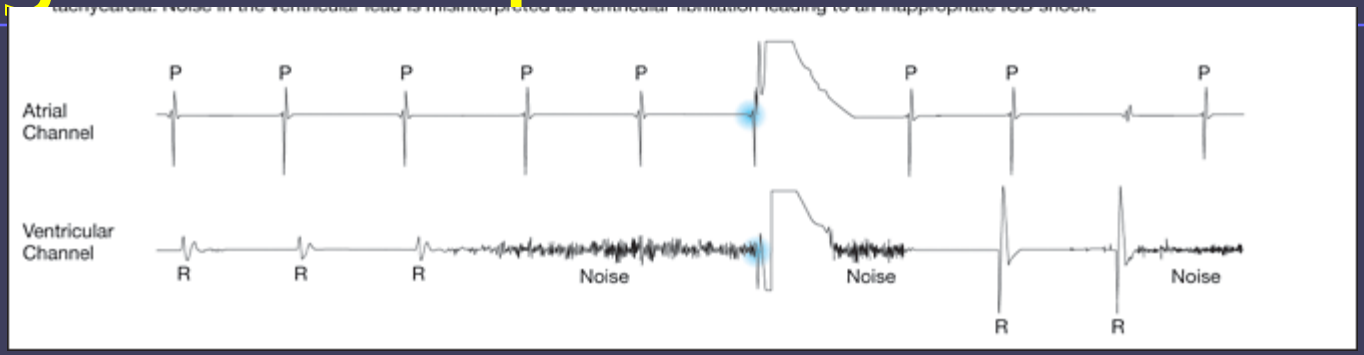
- A shock for a non-ventricular arrhythmia is appropriate but therapy/ programming is not
- True inappropriate shocks are caused by inappropriate signal interpretation:
  - Oversensing of T waves
  - Double counting of QRS complex
  - Oversensing due to lead failure or insulation break
  - Oversensing of diaphragmatic myopotentials
  - Electromagnetic interference

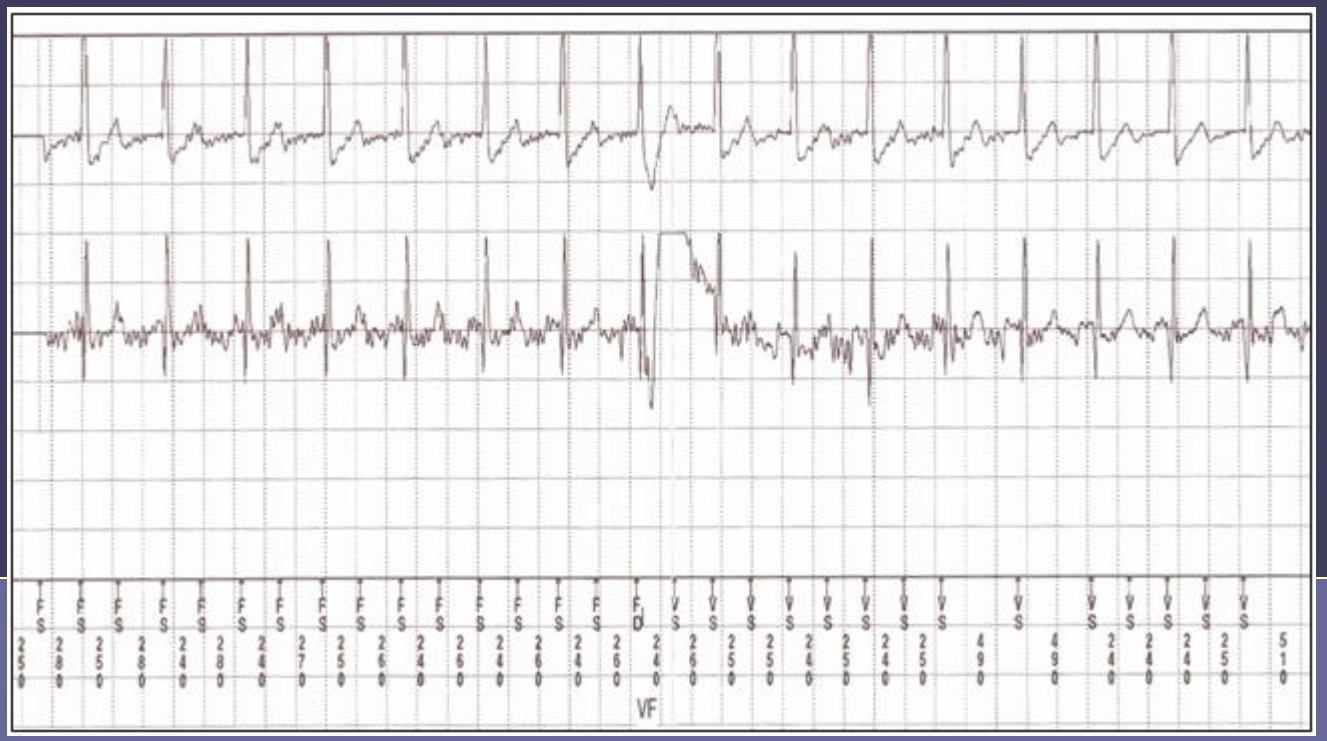
Incidence of Inappropriate Shocks



Daubert JP, et al J Am Coll Cardiol 2008

ICD Shocks d/t Inappropriate Signal Interpretation





Inappropriate Therapy/ Programing

- Shock therapy given for
  - Sinus tachycardia
  - Atrial flutter
  - Atrial fibrillation
  - Other SVT
  - PVCs

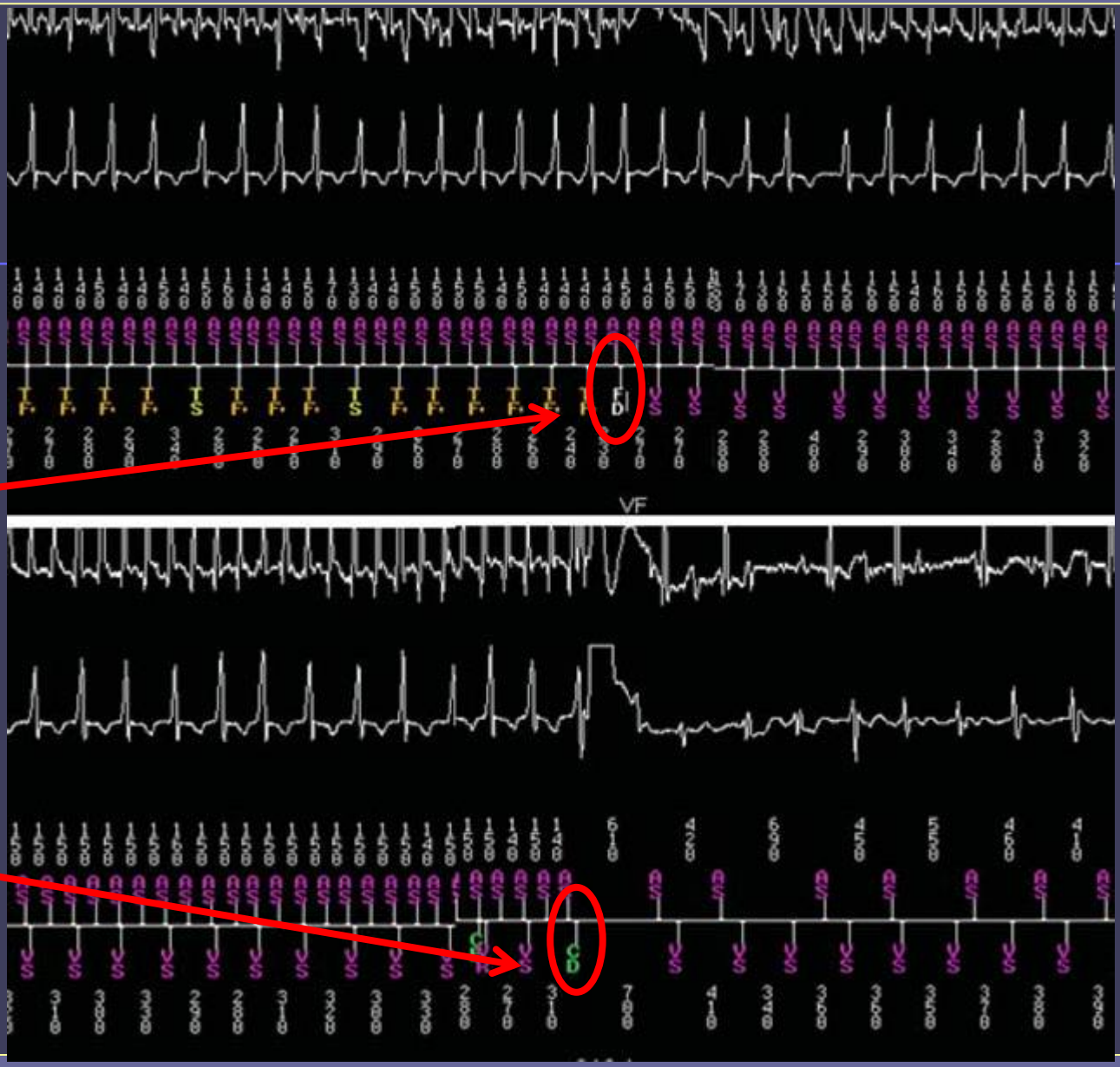
atrial

Ventricular

Marker

VF detected

Shock delivered



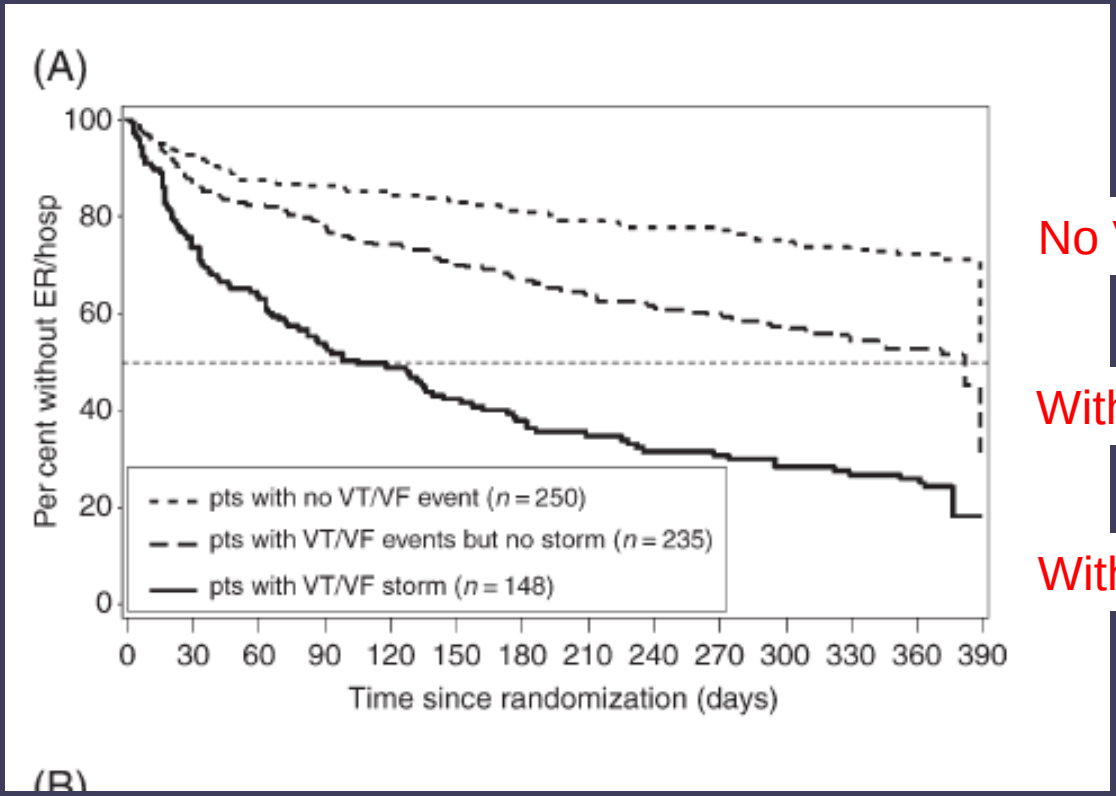
Management of Inappropriate Therapy/ Programing

- Device reprogramming
  - Change detection zones
  - Add arrhythmia discrimination features
  - Add an atrial lead
- Treat non ventricular arrhythmia
  - Drugs
  - Ablation

Recurrent Appropriate ICD Shocks- Electrical Storm

- >2 in a 24-hour period
- Incidence rate: 10-40%.
- Occurs in
  - Structural heart disease- post MI scar
  - Primary electrical abnormality (e.g. Brugada syn.)
- Associated with higher risk for recurrent storms.
- Mandates immediate diagnostic and therapeutic measures
- Bad prognosis

Recurrence of VT/VF



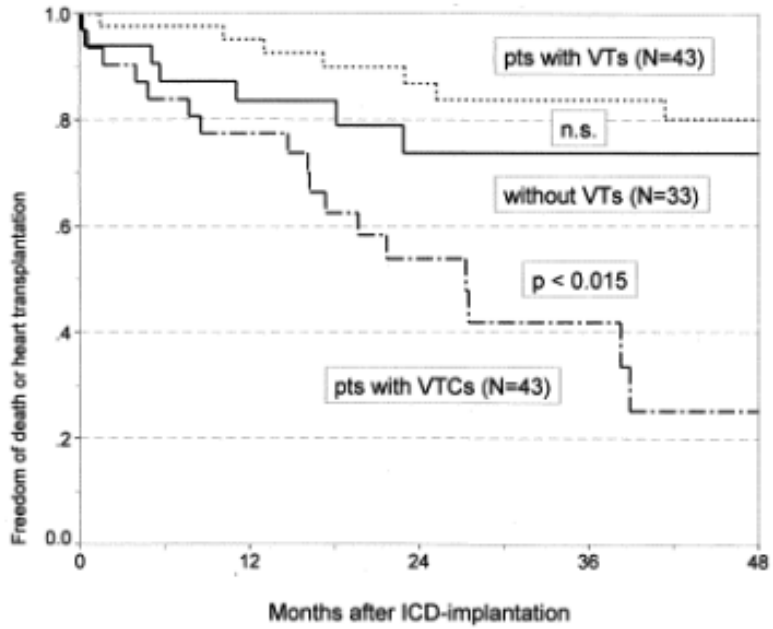
No VT

With VT

With storm

Hohnloser et al, E Heart J 2006

Death/ Transplant Free Survival



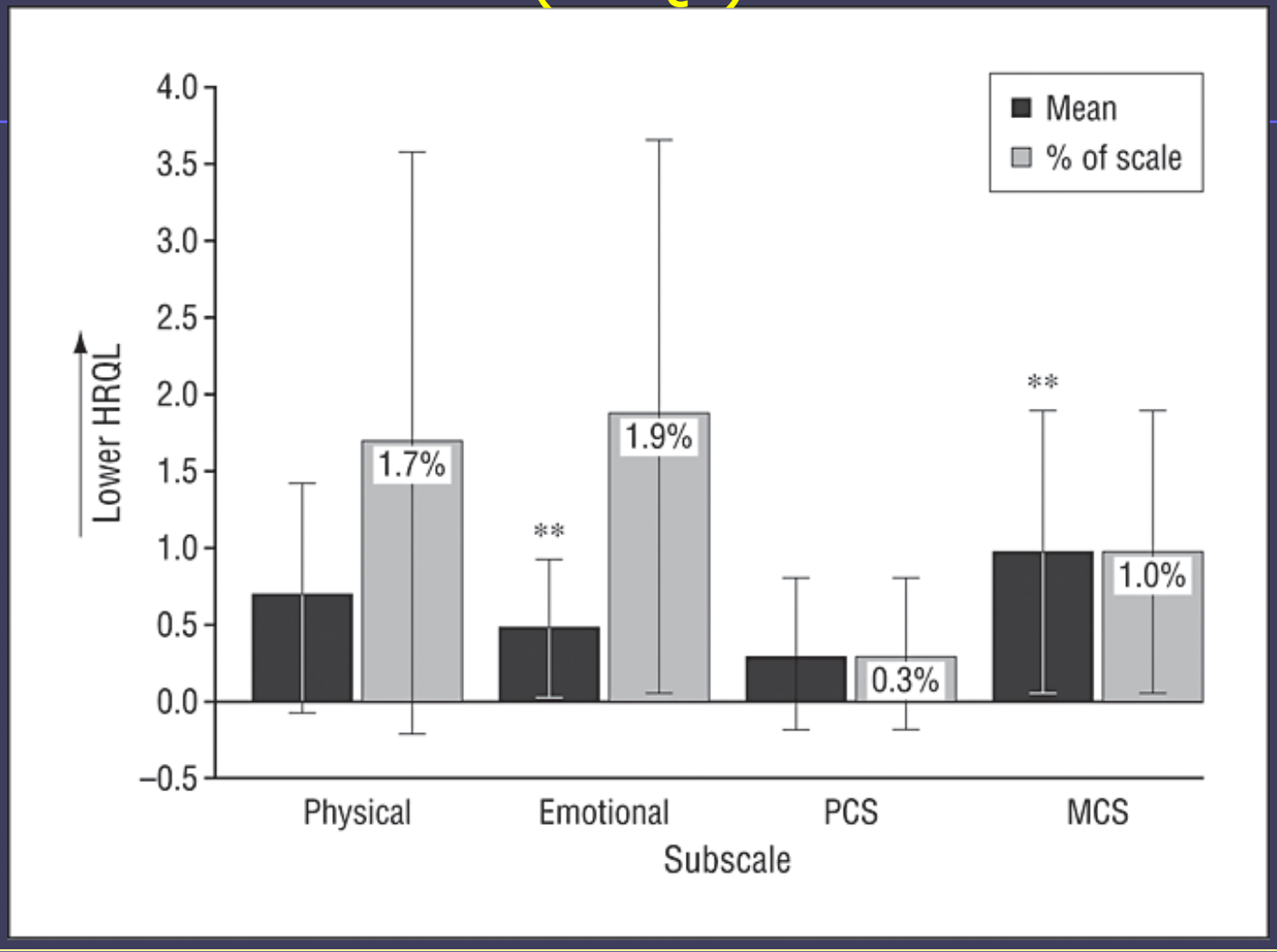
← Post Storm

Figure 3. Survival free of heart transplantation in patients with single or no VTs and VTCs after implantation. VT = ventricular tachycardias; VTC = ventricular tachycardia cluster.

Figure options

Bansch D et al. JACC 2000

Impact of Shocks on Health-related Quality-of-life (HRQL)



Passman, R. et al. Arch Intern Med 2007.

ARCHIVES OF INTERNAL MEDICINE

Potential Causes of ICD Storms

- **Unknown**
- Non-compliance with drug therapy
- Worsening of heart failure
- Early postoperative period
- Alcohol excess
- Electrolyte abnormalities
- Myocardial ischemia

Management of Electrical Storms

- Drugs
  - B blockade
  - Amiodarone
  - Class I – Quinidine?
- Pacing
  - For bradycardia and long-short TdP
- Sedation
- Ablation

Arrhythmia/Electrophysiology

Catheter Ablation for the Treatment of Electrical Storm in Patients With Implantable Cardioverter-Defibrillators

Short- and Long-Term Outcomes in a Prospective Single-Center Study

TT1

TABLE 1. Baseline Clinical and Demographic Characteristics of the Study Population

Age (mean±SD), y	64±13
Gender, M/F	85/10
LV ejection fraction (mean±SD), %	36±11
NYHA class (mean±SD)	2.9±1.1
Underlying heart disease, %	
CAD	72 (76)
IDCM	10 (11)
ARVD	13 (14)
Medications, %	
Amiodarone	89 (94)
β-Blockers	92 (97)
ACE inhibitors or ARBs	81 (85)
Sotalol	5 (5)

t times showing different VT bundle-branch-block patterns in V_1 or

Carbucicchio c et al. Circulation 2008

VT Ablation Following Electrical Storm

Table 3. Long-Term Outcome According to Acute Results of CA

	ES Recurrence	VT Recurrence	SCD	CD
Complete success (class A) (n=68), n (%)	0/68	11/68 (16)	0/68	6/68 (9)
Partial success (class B) (n=17), n (%)	0/17	11/17 (65)	0/17	1/17 (6)
Failure (class C) (n=10), n (%)	8/10 (80)	10/10 (100)	4/10 (40)	4/10 (40)

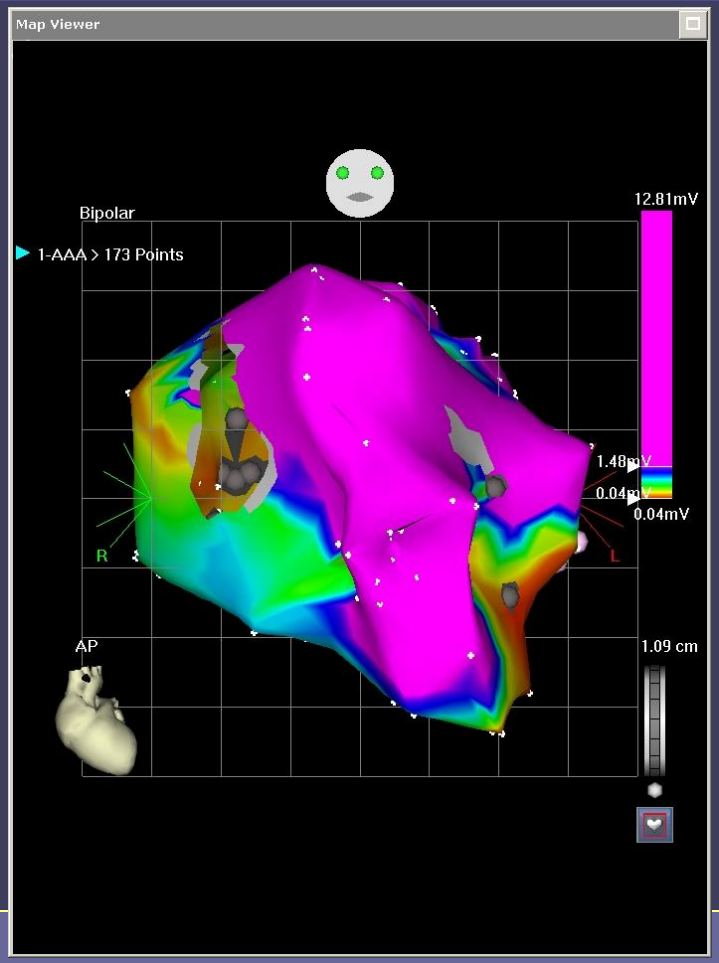
Median FU = 22 months

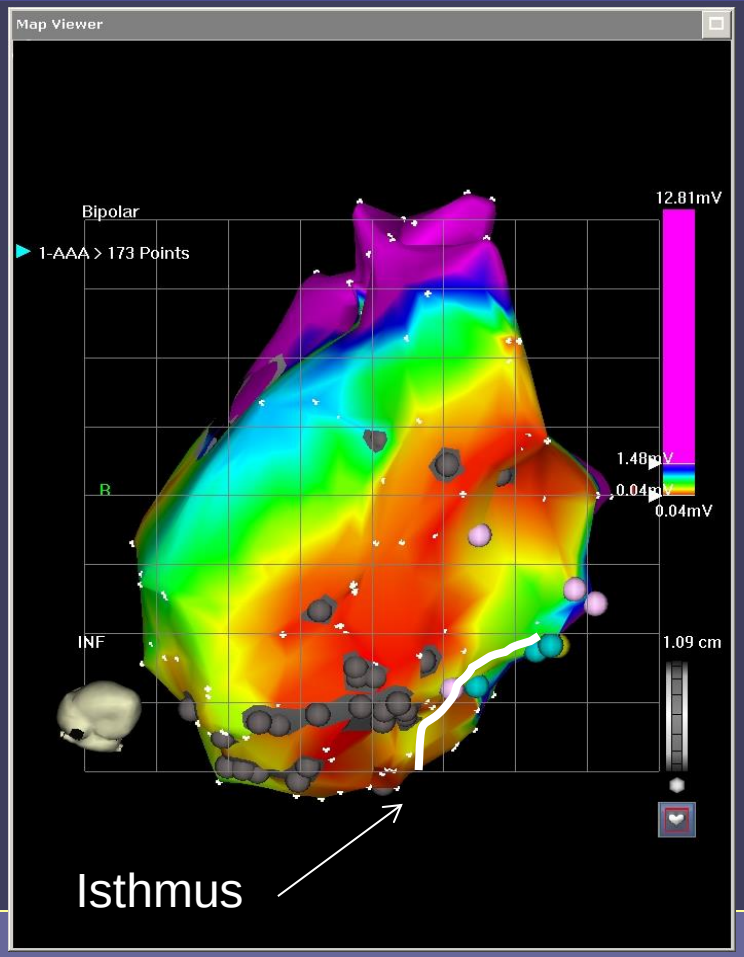
Table 4. Multivariate Cox Regression Model for Cardiac Mortality

Variables	*P*	HR	95% CI
Gender (male vs female)	0.124	7.28	0.58–91.14
Age (for each 1-y increase)	0.004	1.15	1.04–1.25
IDCM vs non-IDCM	0.003	13.69	2.47–75.64
LV ejection fraction (for 10% unit increment)	0.05	0.40	0.15–0.99
NYHA class (for 1-step increment)	0.77	0.86	0.31–2.37
Nontolerated vs tolerated VT	0.11	6.75	0.66–69.60
Pleomorphic vs monomorphic VT	0.58	0.55	0.06–4.64
Acute failure of CA (class C vs A or B)	0.008	15.23	2.05–112.83

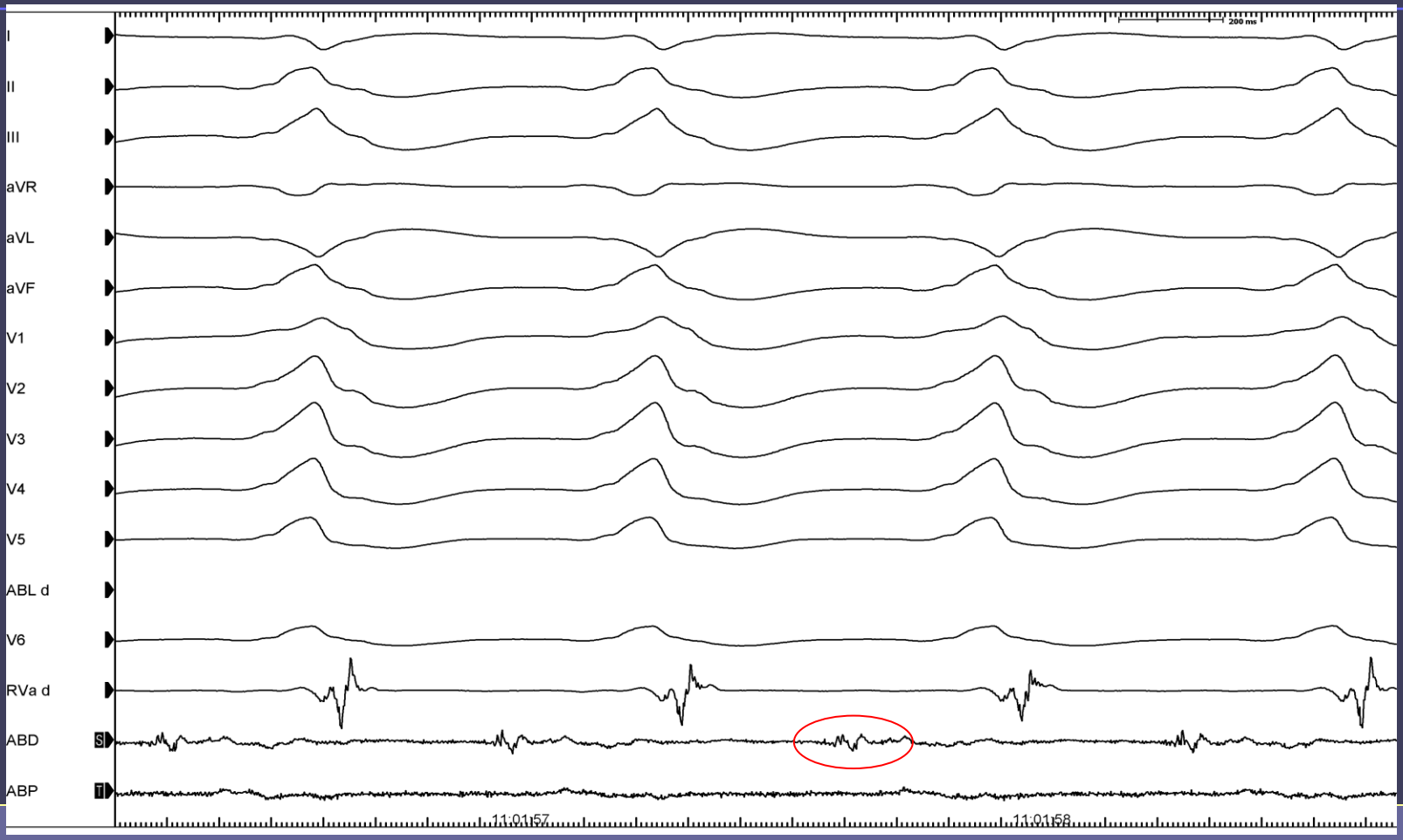
Carbucicchio C, et al. Circulation 2008

A 70 y.o. Man, 10 years post MI, with VT Storm, Failed Amiodarone

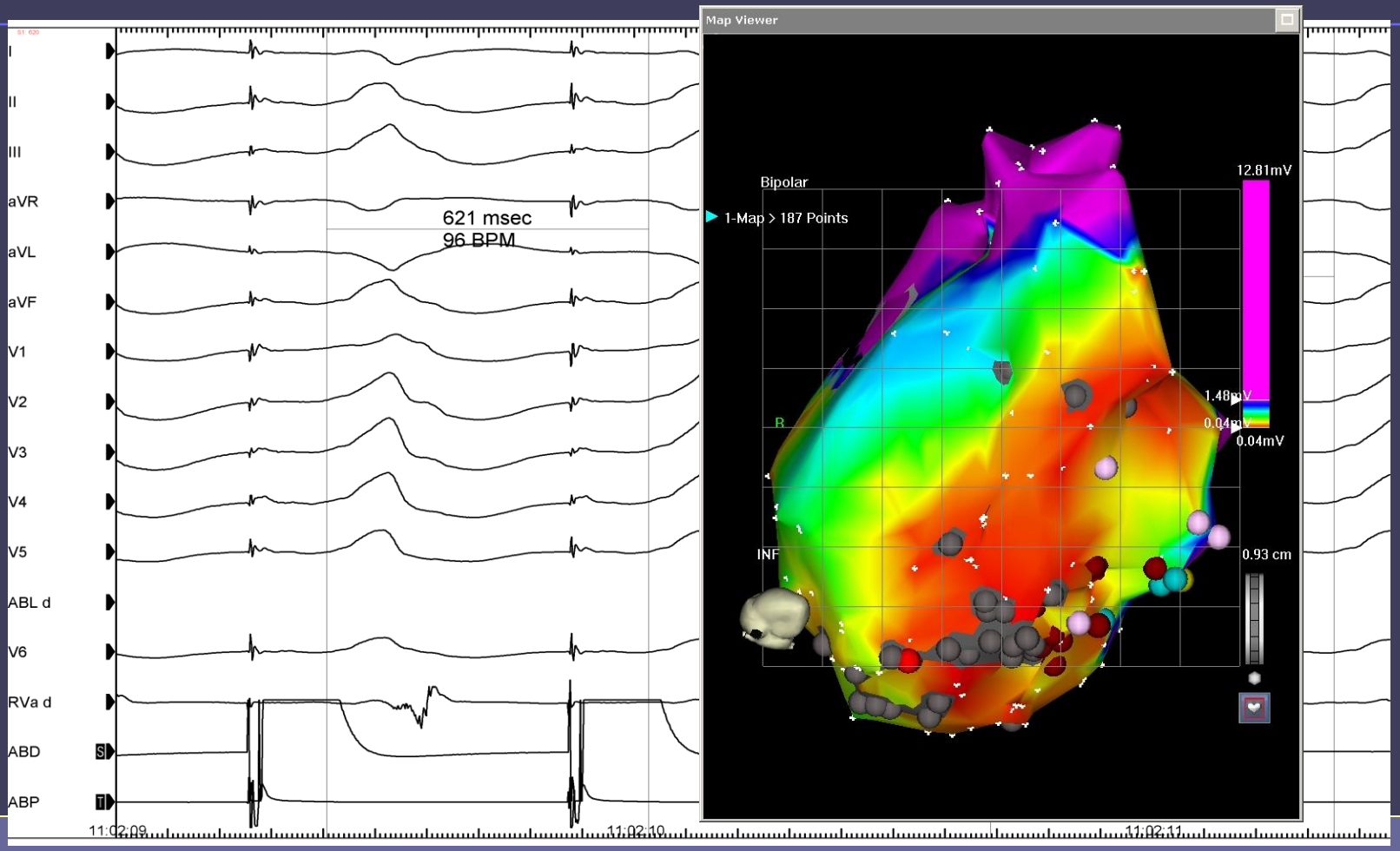




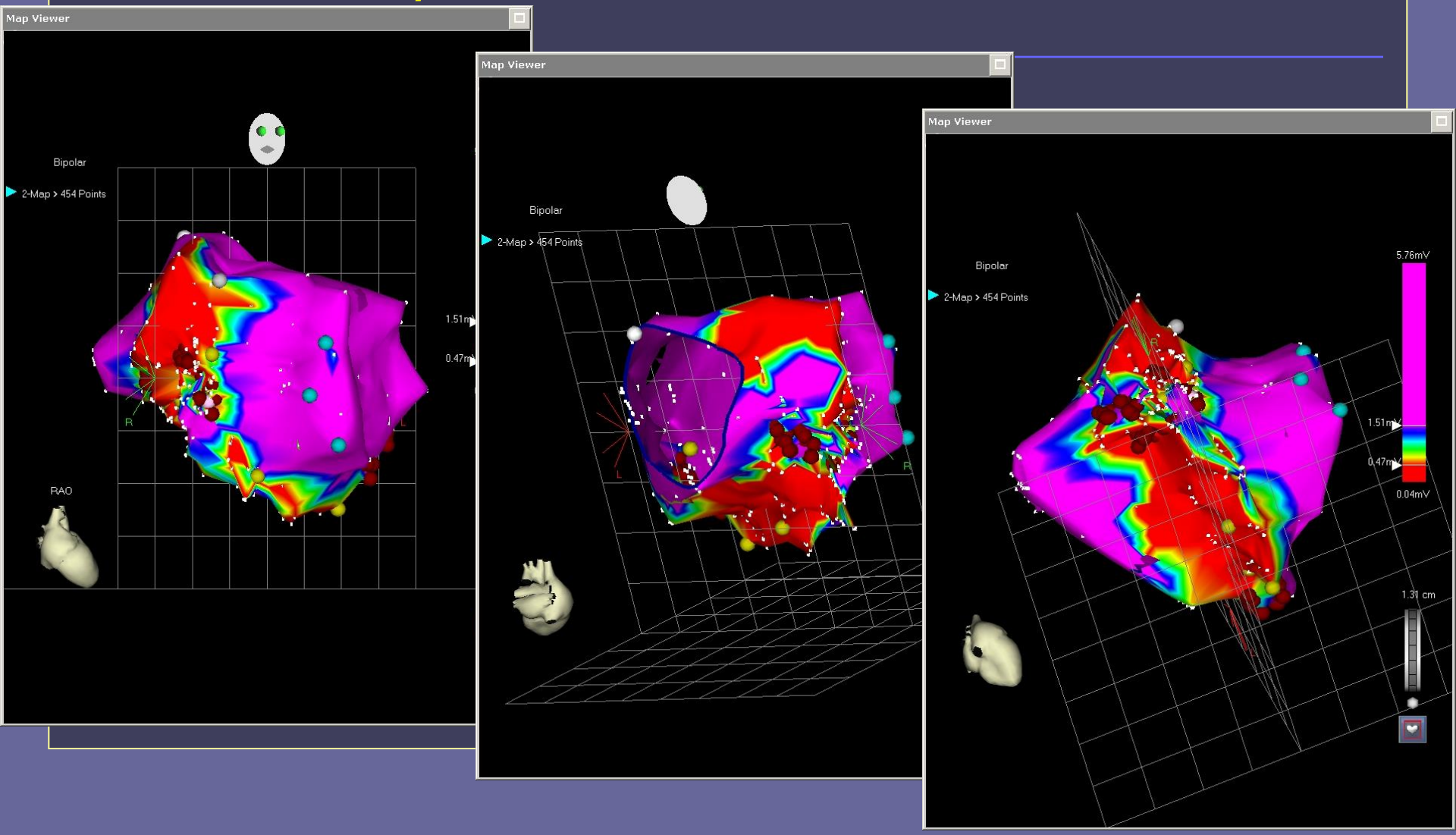
Diastolic Potentials on the Ablation Catheter



Pace Map and Concealed Entrainment from Isthmus



A 65 y.o, ICD for Primary Prevention, Severe AS, Recurrent VTs



Arrhythmia/Electrophysiology

Irrigated Radiofrequency Catheter Ablation Guided by Electroanatomic Mapping for Recurrent Ventricular Tachycardia After Myocardial Infarction

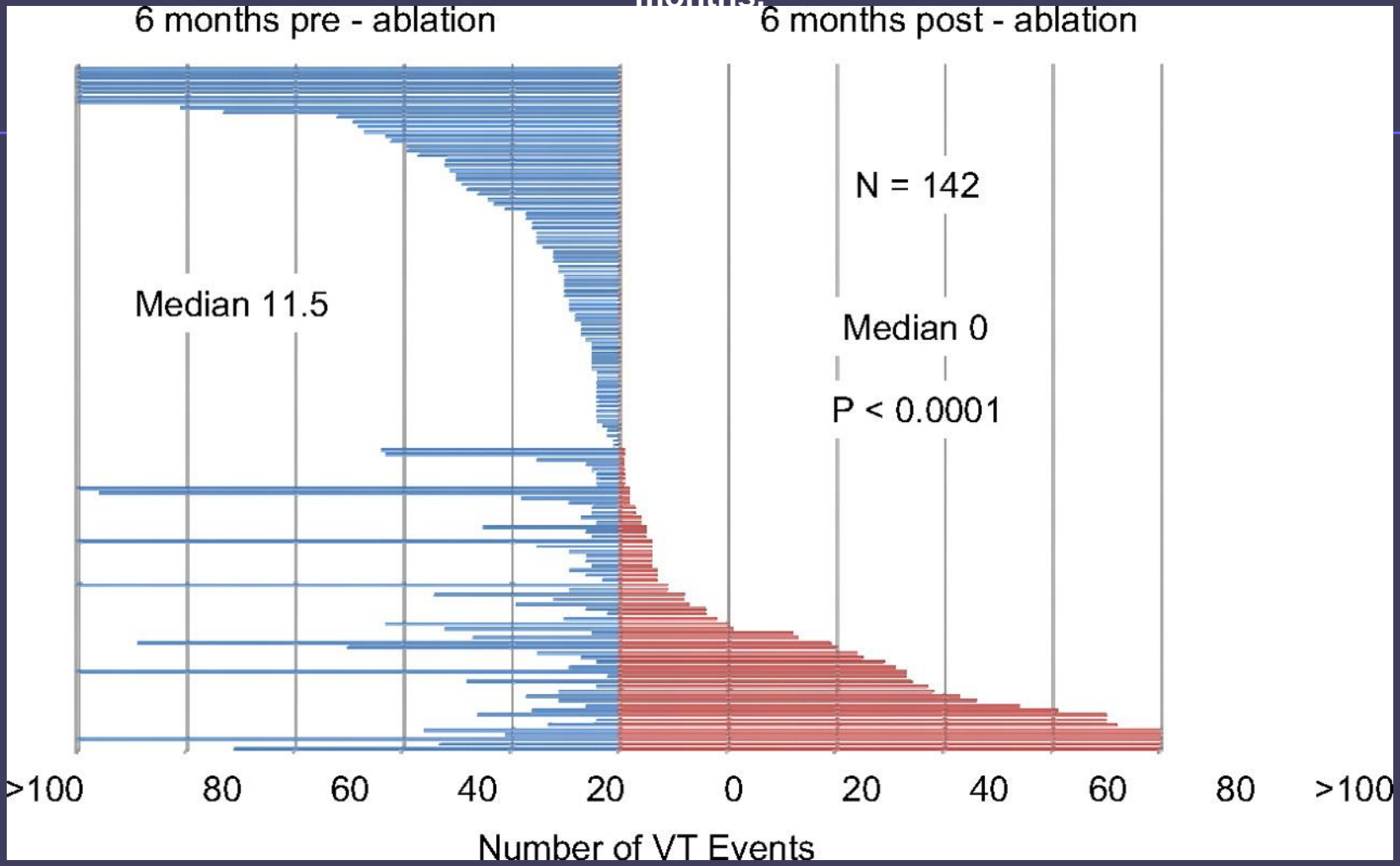
The Multicenter Thermocool Ventricular Tachycardia Ablation Trial

- 230 post AMI patients with recurrent episodes of monomorphic VT (median, 11 in the preceding 6 months).
- All inducible monomorphic VTs with a rate approximating or slower than any spontaneous VTs were targeted. The primary end point of freedom from recurrent incessant VT or intermittent VT after 6 months of follow-up was achieved for 123 patients (53%)

Stevenson WG et al. Circulation 2008

Circulation

Figure 1. Plot showing the frequency of VT during the 6 months before (blue lines) and after (red lines) ablation for 142 patients with ICDs before and after ablation who survived 6 months.



Stevenson WG et al. Circulation 2008

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ORIGINAL ARTICLE

Prophylactic Catheter Ablation for the Prevention of Defibrillator Therapy

Vivek Y. Reddy, M.D., Matthew R. Reynolds, M.D., Petr Neuzil, M.D., Ph.D., Allison W. Richardson, M.D., Milos Taborsky, M.D., Ph.D., Krit Jongnarangsin, M.D., Stepan Kralovec, Lucie Sediva, M.D., Jeremy N. Ruskin, M.D., and Mark E. Josephson, M.D.

N Engl J Med 2007; 357:2657-2665 | December 27, 2007

126 patients not using class I or III antiarrhythmic drugs, prior MI, and either VF arrest, unstable VT, or prior ICD and single appropriate shock

Randomized.

13% female, mean age 66 years, mean follow-up 2 years

71% NYHA Class II, 18% NYHA Class III, Mean EF 31.7%

18% had VF arrest, 52% had unstable VT, 21% had syncope and inducible VT and 9% had prior ICD and single appropriate shock, 96% received beta-blockers and 91% received ACE-inhibitors, index MI was anterior in 41% of patients and 67% had prior revascularization

ICD implantation with substrate-based catheter ablation n=62

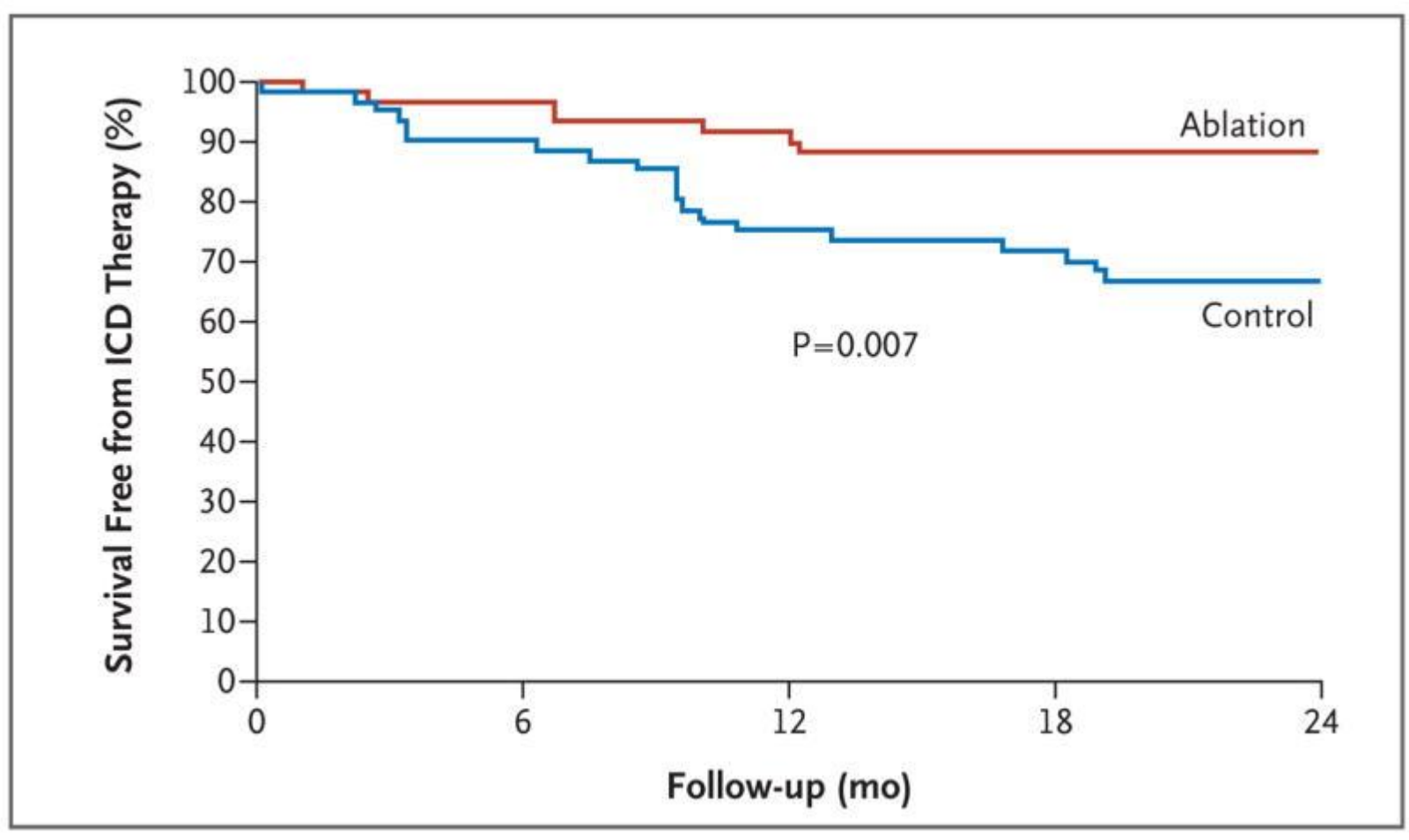
ICD alone n=64

SMASH-VT: Clinical End Points

End point	Ablation group (n=64), n (%)	Control group (n=64), n (%)	Hazard ratio (95% CI)
ICD events	8 (12)	21 (33)	0.35 (0.15–0.78)
ICD shocks	6 (9)	20 (31)	0.27 (0.11–0.67)
ICD storm	4 (6)	12 (19)	0.30 (0.09–1.00)
Death	6 (9)	11 (17)	0.59 (0.22–1.59)

Reddy V et al. *N Engl J Med* 2007; 357:2657-2665.

SMASH-VT: Clinical end points

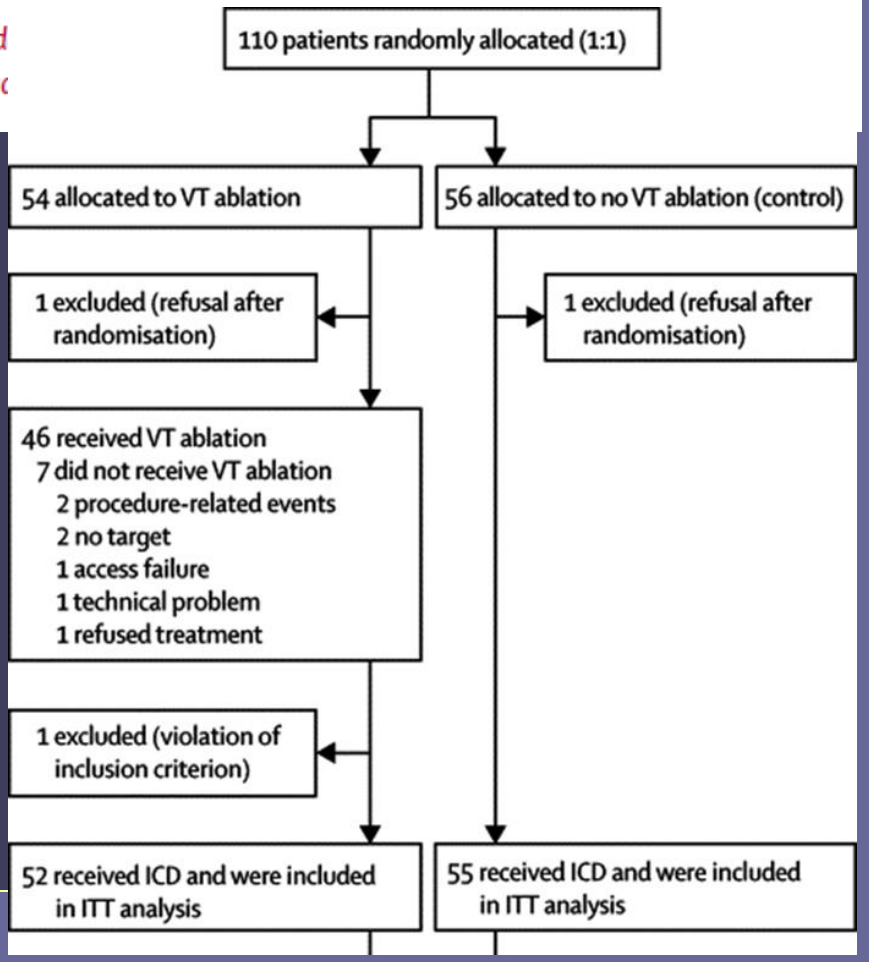


Reddy V et al. *N Engl J Med* 2007; 357:2657-2665.

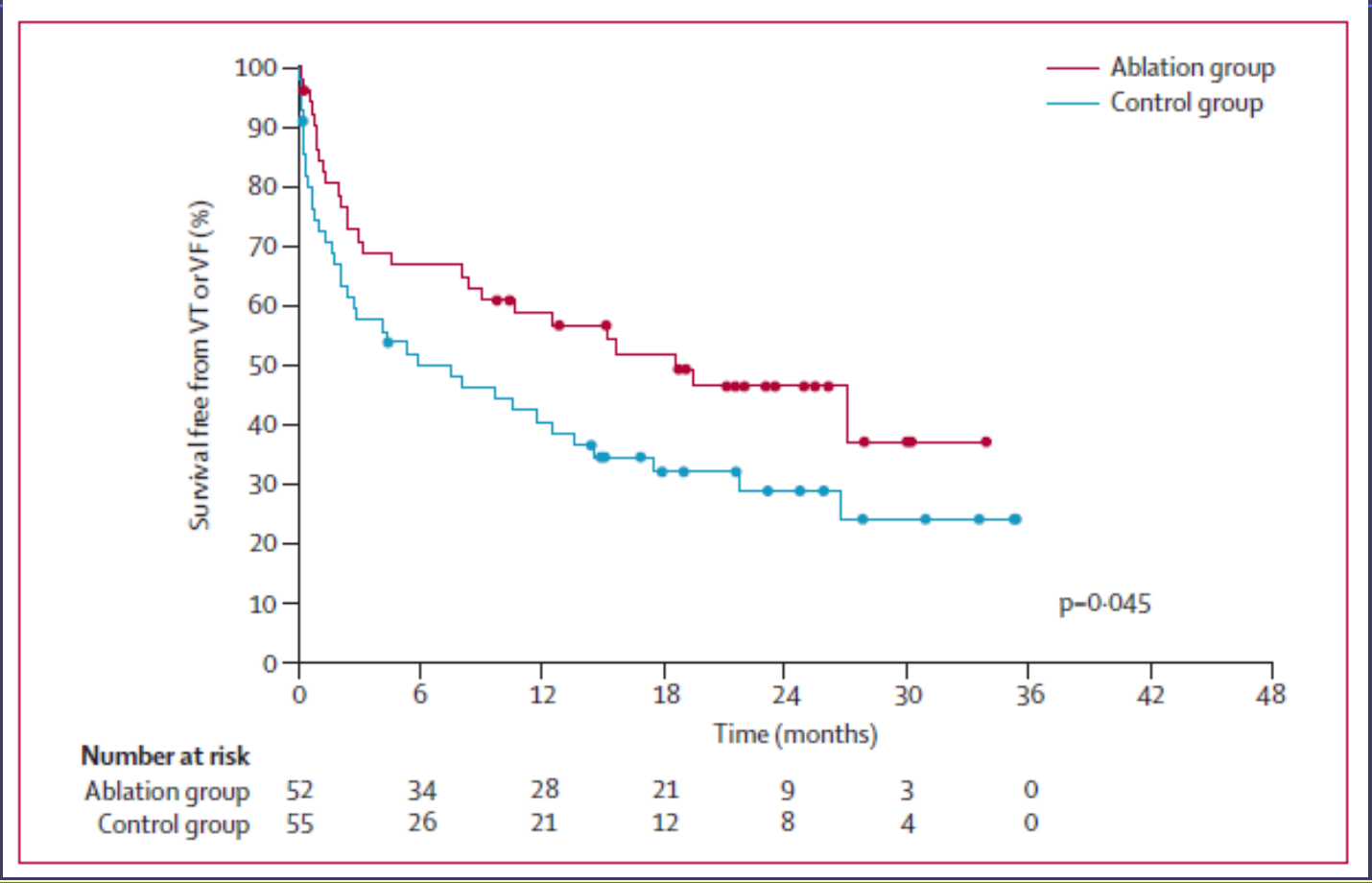
Catheter ablation of stable ventricular tachycardia before defibrillator implantation in patients with coronary heart disease (VTACH): a multicentre randomised controlled trial

Karl-Heinz Kuck, Anselm Schaumann, Lars Eckardt, Stephan Willems, Rod
Josef Kautzner, Burghard Schumacher, Peter S Hansen, for the VTACH stu

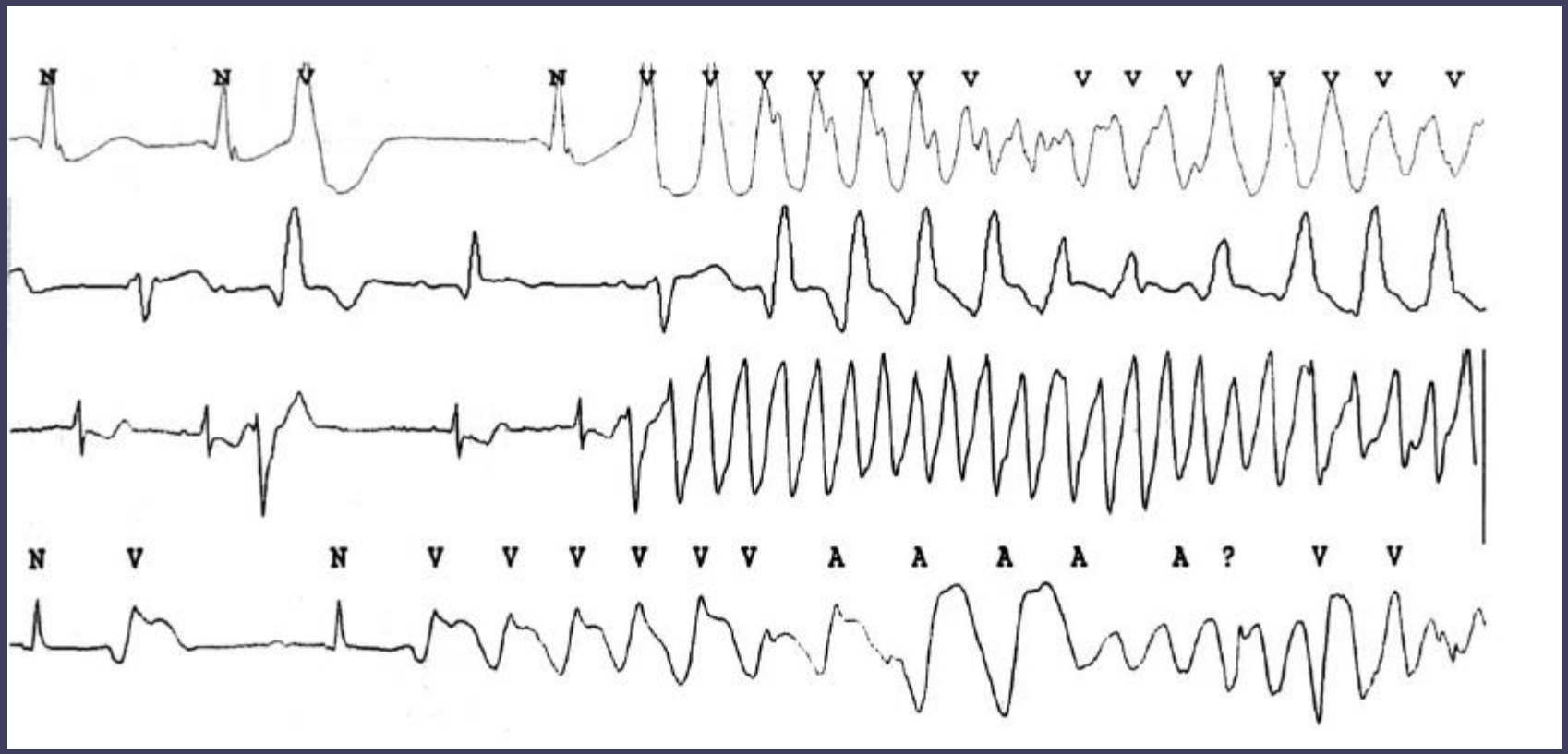
- 16 European centers
- 110 patients
- Post AMI w/ stable VT
- LVEF < 50%



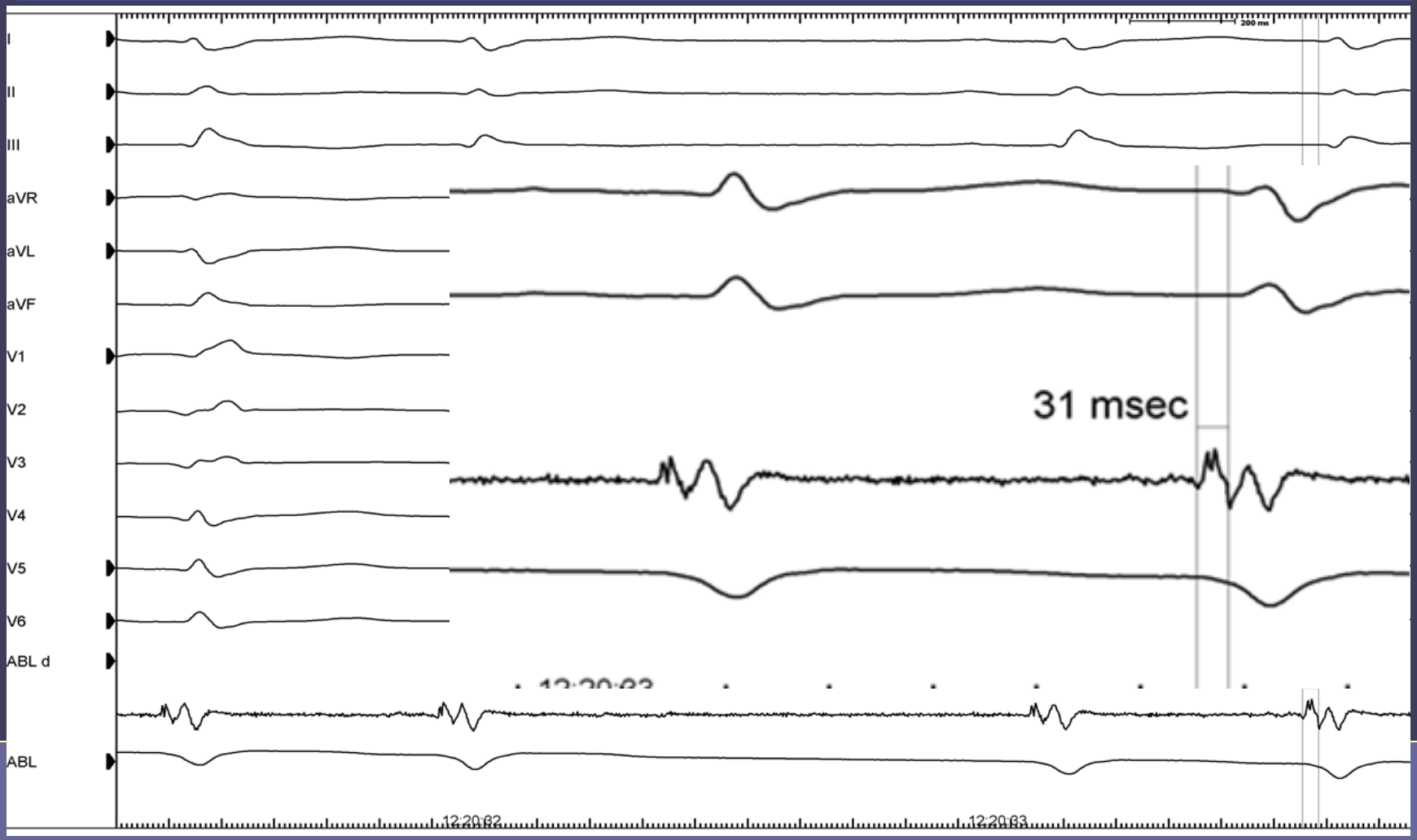
VTACH Study Results



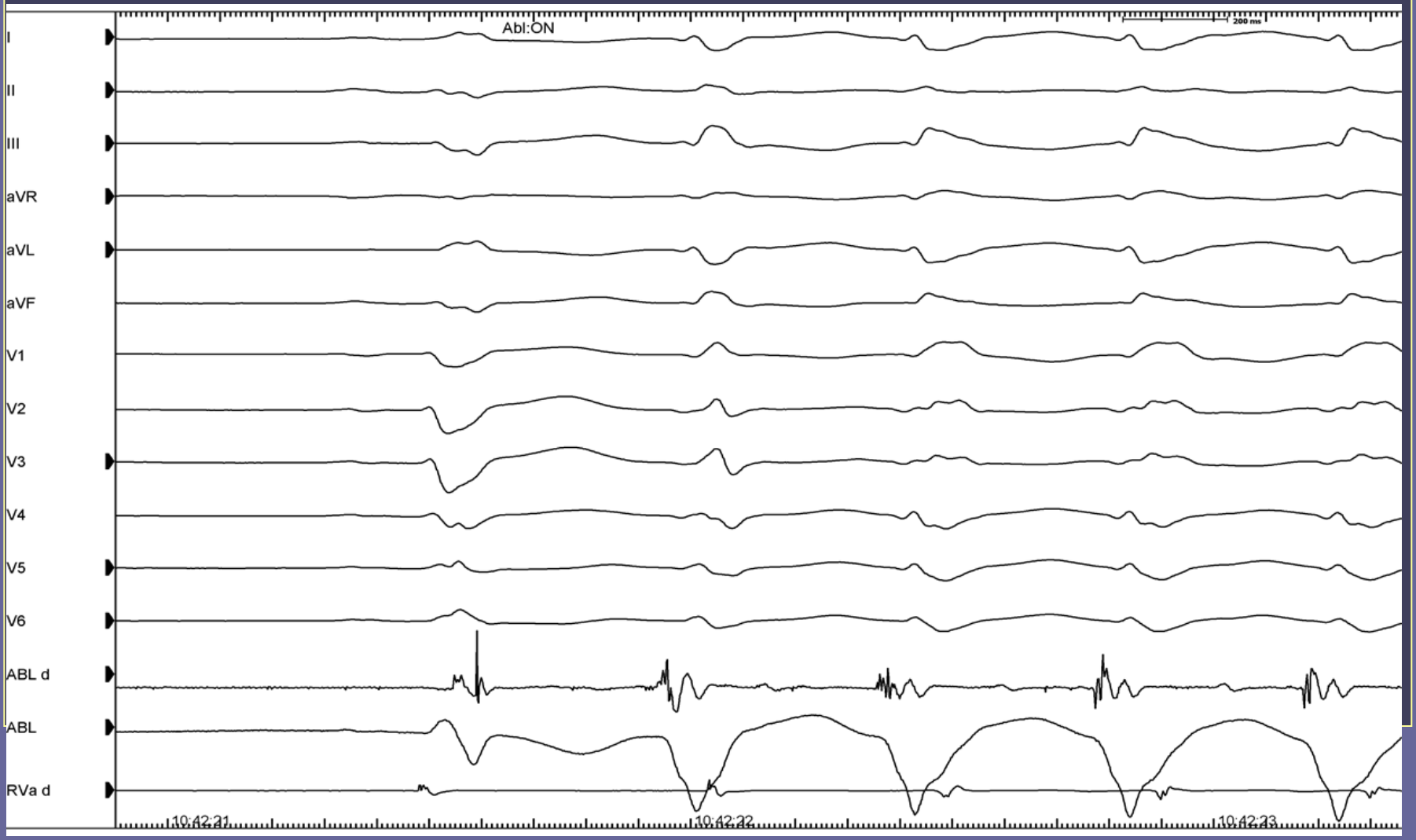
A 60 y.o Admitted for Recurrent Shocks for Polymorphic VTs



Patient Taken to the EP Lab



Purkinje Automaticity during RFA

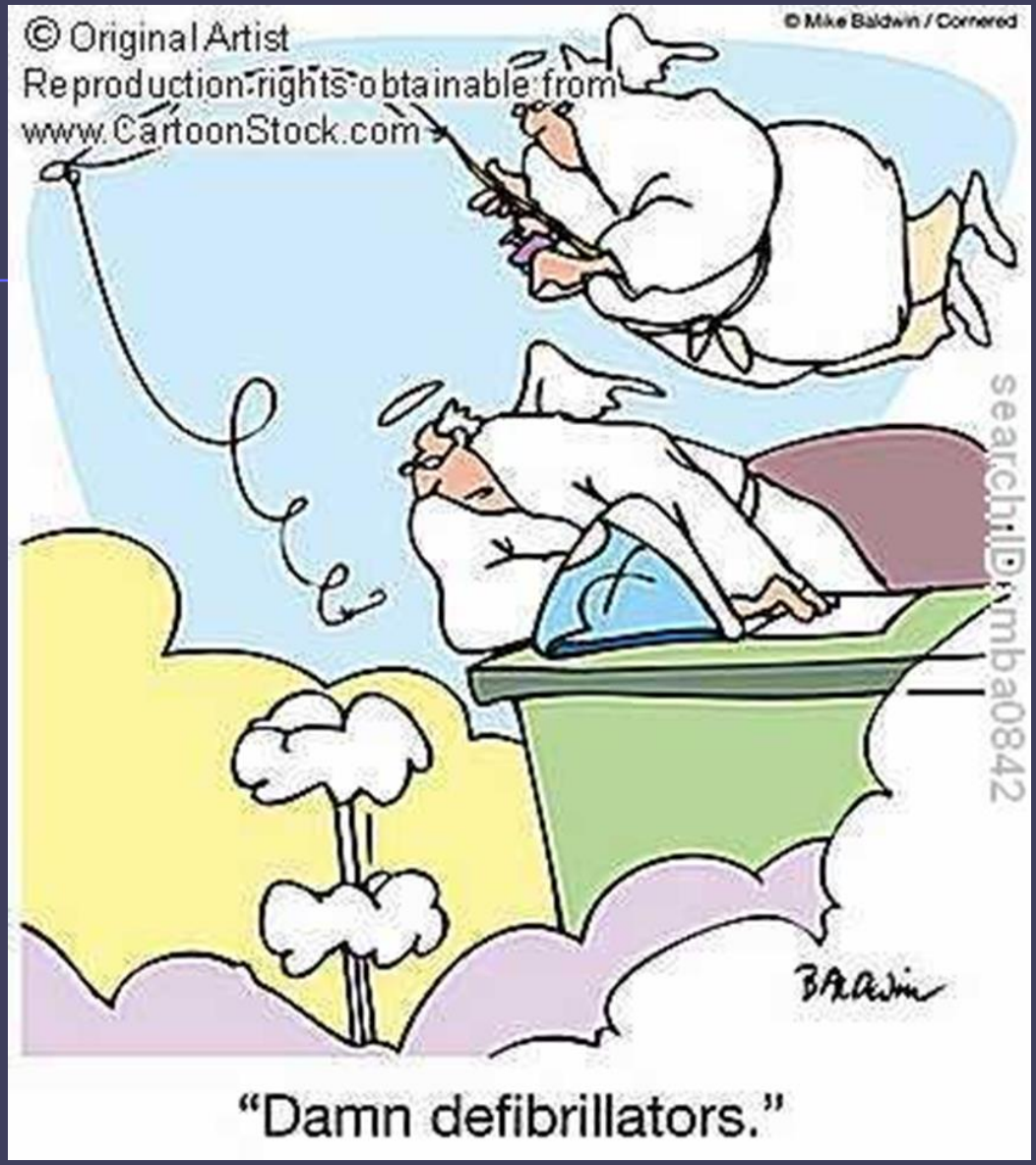


Catheter Ablation of VT is Recommended

1. for symptomatic sustained monomorphic VT (SMVT), including VT terminated by an ICD, that recurs despite antiarrhythmic drug therapy or when antiarrhythmic drugs are not tolerated or not desired;
2. for control of incessant SMVT or VT storm that is not due to a transient reversible cause;
3. for patients with frequent PVCs, NSVTs, or VT that is presumed to cause ventricular dysfunction;
4. for bundle branch reentrant or interfascicular VTs;
5. for recurrent sustained polymorphic VT and VF that is refractory to antiarrhythmic therapy when there is a suspected trigger that can be targeted for ablation.

EHRA/HRS Expert Consensus on Catheter Ablation of Ventricular Arrhythmias
Heart Rhythm / Europace 2009

Thank you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searchIDnmba0842
"Damn defibrillators."

Main VT Ablation Studies

	Number of patients	Treatment	Mean follow-up (months)	Long-term mortality (%	Acute success (n [%])	Long-term success (freedom from VT; %)
Catheter ablation after multiple events/ICD interventions						
Calkins et al (2000)[12]	146 (21% without ICD)	VT ablation (non-randomised)	8	25%*	59 (41%)	44%*
Stevenson et al (2008)[13]	231 (6% without ICD)	VT ablation (non-randomised)	6	18%†	113 (49%)	53%
Tanner et al (2009)[28]	63 (33% without ICD)	VT ablation (non-randomised)	12	8%	51 (81%)	NR‡
Catheter ablation in patients with ICDs with electrical storm						
Carbucicchio et al (2008)[29]	95	VT ablation (non-randomised)	22	16%	85 (89%)§	66%
Catheter ablation before ICD interventions						
Reddy et al (2007)[14]	128	VT ablation vs no VT ablation (randomised)	22·5	9% vs 17%	NR	88% vs 67%¶

VT=ventricular tachycardia. ICD=implantable cardioverter defibrillator. NR=not reported. *1-year Kaplan-Meier estimate. †After 12 months. ‡Recurrence of VT is reported in 31 (49%) patients. §After 1–3 procedures. ¶Freedom from ICD treatment.

Strategies to Reduce Appropriate Shocks for Ventricular Tachycardia / Fibrillation

- Re-programming of ICD
- Drug therapy
  - Limited options
  - Side effects including pro-arrhythmia
- **Catheter Ablation**

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Heart Rhythm Disorders

Strategic Programming of Detection and Therapy Parameters in Implantable Cardioverter-Defibrillators Reduces Shocks in Primary Prevention Patients

Results From the PREPARE (Primary Prevention Parameters Evaluation) Study

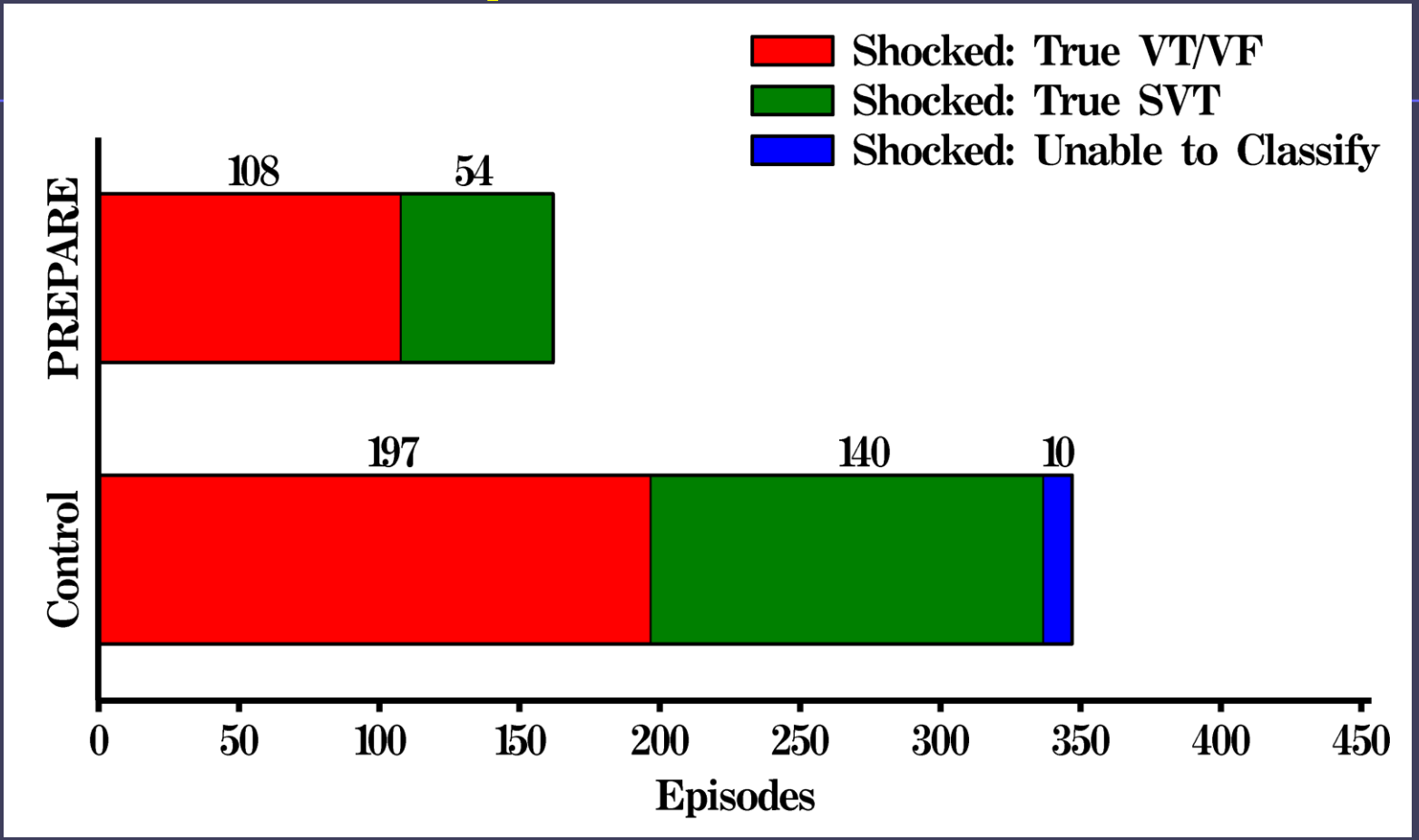
Bruce L. Wilkoff, MD, FACC,* Brian D. Williamson, MD, FACC,† Richard S. Stern, MD, FACC,‡ Stephen L. Moore, DO, FACC,§ Fei Lu, MD, FACC,‖ Sung W. Lee, MD, FACC,¶ Ulrika M. Birgersdotter-Green, MD,# Mark S. Wathen, MD,** Isabelle C. Van Gelder, MD,†† Brooke M. Heubner, MS,‡‡ Mark L. Brown, PHD,‡‡ Keith K. Holloman, BA,‡‡ for the PREPARE Study Investigators

PREPARE Strategies to Reduce Shocks[1]

- Avoid detecting slower tachycardia
- Avoid detecting non-sustained tachycardia
- Avoid detecting SVT as VT/VF
- ATP therapy for fast VT
- High output 1st shock

[1] Wilkoff BL, Stern R, Williamson B, et al. Design of the Primary Prevention Parameters Evaluation (PREPARE) trial of implantable cardioverter defibrillators to reduce patient morbidity. Trials 2006; 7:18.

Shocked Episodes[1]



Incidence rate (events/pt-yr): 0.26 PREPARE vs. 0.69 Control

Incidence rate ratio: PREPARE / Control = 0.37 (63% relative reduction), p=0.003

Ratio adjusted for baseline characteristics = 0.42 (58% relative reduction), p=0.001

[1] Peterson B and Rogers T. Medtronic data on file. August 2008.

MADIT-RIT

Variable	Conventional Therapy (N = 514)	High-Rate Therapy (N = 500)	Delayed Therapy (N = 486)	P Value for High-Rate Therapy vs. Conventional Therapy	P Value for Delayed Therapy vs. Conventional Therapy
First occurrence of therapy — no. of patients (%)					
Appropriate therapy	114 (22)	45 (9)	27 (6)	<0.001	<0.001
Shock	20 (4)	22 (4)	17 (3)	0.68	0.74
Antitachycardia pacing	94 (18)	23 (5)	10 (2)	<0.001	<0.001
Inappropriate therapy	105 (20)	21 (4)	26 (5)	<0.001	<0.001
Shock	20 (4)	11 (2)	13 (3)	0.12	0.28
Antitachycardia pacing	85 (17)	10 (2)	13 (3)	<0.001	<0.001
Total occurrences of therapy — no. of occurrences					
Appropriate therapy	517	185	196	<0.001	<0.001
Shock	71	72	53	0.35	0.15
Antitachycardia pacing	446	113	143	<0.001	<0.001
Inappropriate therapy	998	75	264	<0.001	<0.001
Shock	105	25	49	0.001	0.16
Antitachycardia pacing	893	50	215	<0.001	<0.001

Moss AJ, et al. N Engl J Med 2012

Strategies to Reduce Appropriate Therapies- Device Programming

Variable	Conventional Therapy (N=514)	High-Rate Therapy (N=500)	Delayed Therapy (N=486)	P Value for High-Rate Therapy vs. Conventional Therapy	P Value for Delayed Therapy vs. Conventional Therapy
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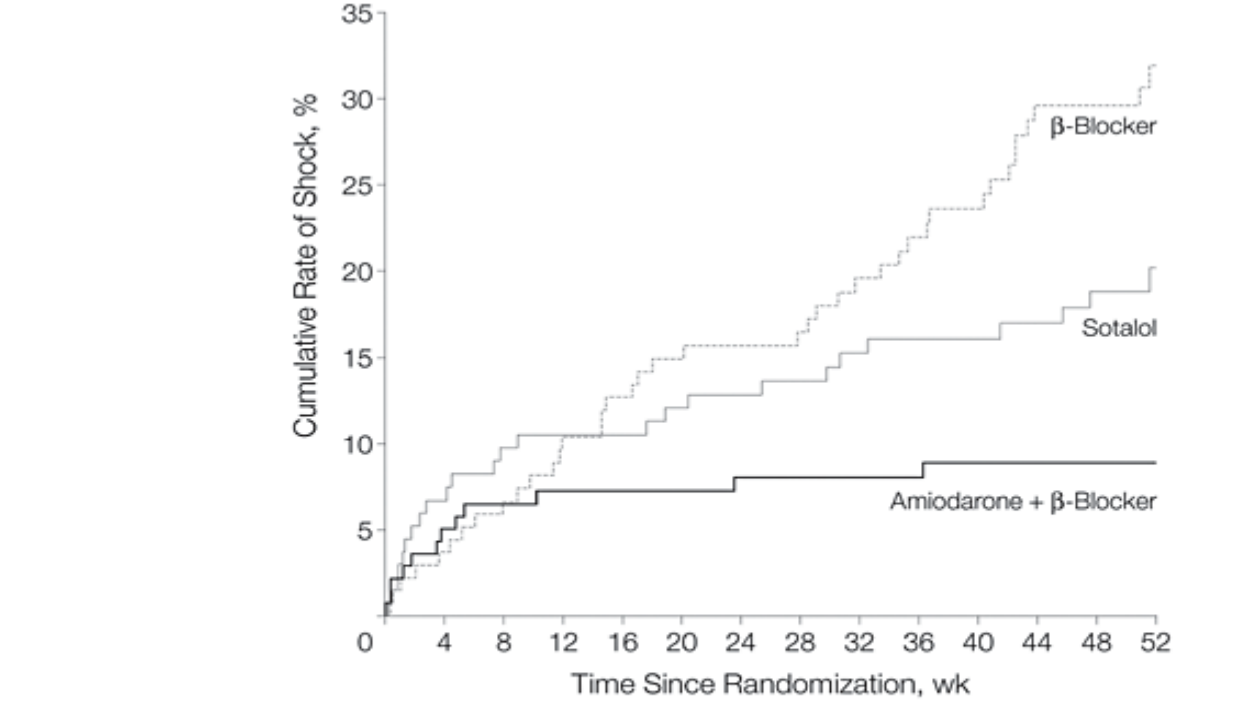
Moss AJ, et al. N Engl J Med 2012

Medical Rx to Decrease ICD Shocks



No. at Risk					
β-Blocker	138	119	109	91	42
Sotalol	134	118	108	94	35
Amiodarone + β-Blocker	140	124	115	106	56

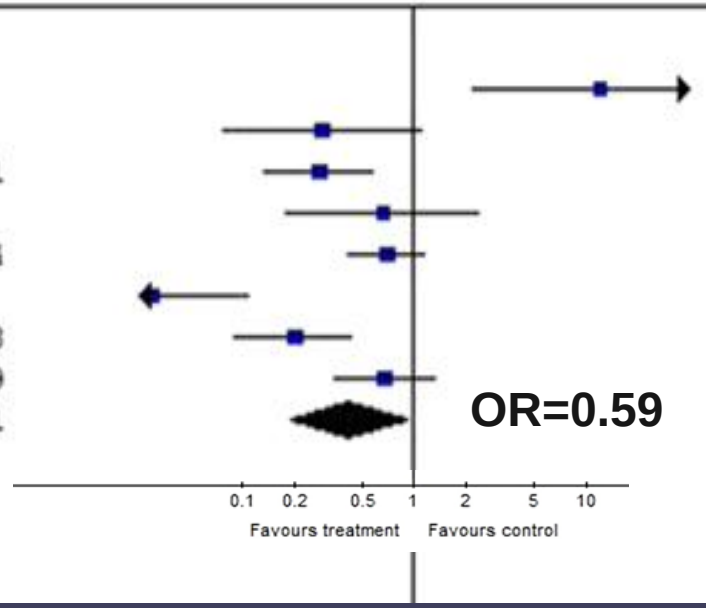
Connolly S, et al. JAMA 2006

Medical Rx to Decrease ICD Shocks

Review: ICD Shock Prevention Trials
Comparison: 01 Mortality
Outcome: 02 Shock Reduction

Study or sub-category	Treatment n/N	Control n/N
01 Anti-Arrhythmic Medication Trials		
Seidl	19/35	7/35
Kuhlkamp	15/46	24/47
Pacifico	45/151	73/151
Kettering	16/50	19/50
SHIELD	197/419	113/214
Singer	31/135	27/37
OPTIC	38/274	42/138
ALPHEE	137/377	46/109
Subtotal (95% CI)	1487	781

Total events: 498 (Treatment), 351 (Control)
Test for heterogeneity: $Chi^2 = 40.51$, df = 7 ($P < 0.00001$), $I^2 = 82.7\%$
Test for overall effect: Z = 2.14 (P = 0.03)



Ha AH, et al. Heart Rhythm 2012

VTACH Study Results

	Ablation (n=52)	Control (n=55)	Hazard ratio (95% CI)	p value
Time to first VT or VF (months, mean [SD]; median [IQR])	15·9 (1·7); 18·6 (2·4*)	11·3 (1·5); 5·9 (0·8–26·7)	0·61 (0·37–0·99)	0·045†
24-month event-free survival estimates (%)‡				
VT recurrence (category 1)	46·6%	28·8%	0·61 (0·37–0·99)	0·045†
VT recurrence (all categories)	46·4%	28·8%	0·61 (0·38–1·01)	0·051†
Hospital admission for cardiac reasons	67·4%	45·4%	0·55 (0·30–0·99)	0·044†
VT storm	75·0%	69·7%	0·73 (0·36–1·50)	0·395†
Syncope	96·2%	85·4%	0·36 (0·07–1·81)	0·197†
Death	91·5%	91·4%	1·32 (0·35–4·94)	0·677†
Appropriate ICD intervention (n [%])	26 (50·0%)	38 (69·1%)	..	0·051§
ICD shock (n [%])	17 (32·7%)	29 (52·7%)	..	0·051§
Appropriate ICD shock (n [%])	14 (26·9%)	26 (47·3%)	..	0·045§
Inappropriate ICD shock (n [%])	4 (7·7%)	6 (10·9%)	..	0·743§
≥2 shocks per year (n [%])	6 (11·5%)	15 (27·3%)	..	0·021§
≥2 appropriate shocks per year (n [%])	4 (7·7%)	12 (21·8%)	..	0·018§
Number of appropriate ICD interventions per patient per year¶ (mean [SD]; median [range])	7·1 (16·3); 0·2 (0–91)	58·3 (263·5); 3·0 (0–1940)	..	0·013‖
Number of appropriate ICD shocks per patient per year§ (mean [SD]; median [range])	0·6 (2·1); 0 (0–14·2)	3·4 (9·2); 0 (0–48·4)	..	0·018‖