


Storm aritmico: medicina personalizzata

Prof. Federico Guerra
Cardiology and Arrhythmology Clinic
Ancona, Italy

Definition of electrical storm

- **3** or more VT/VF episodes within 24 hours
 - Long-standing VT lasting ≥ 12 hours
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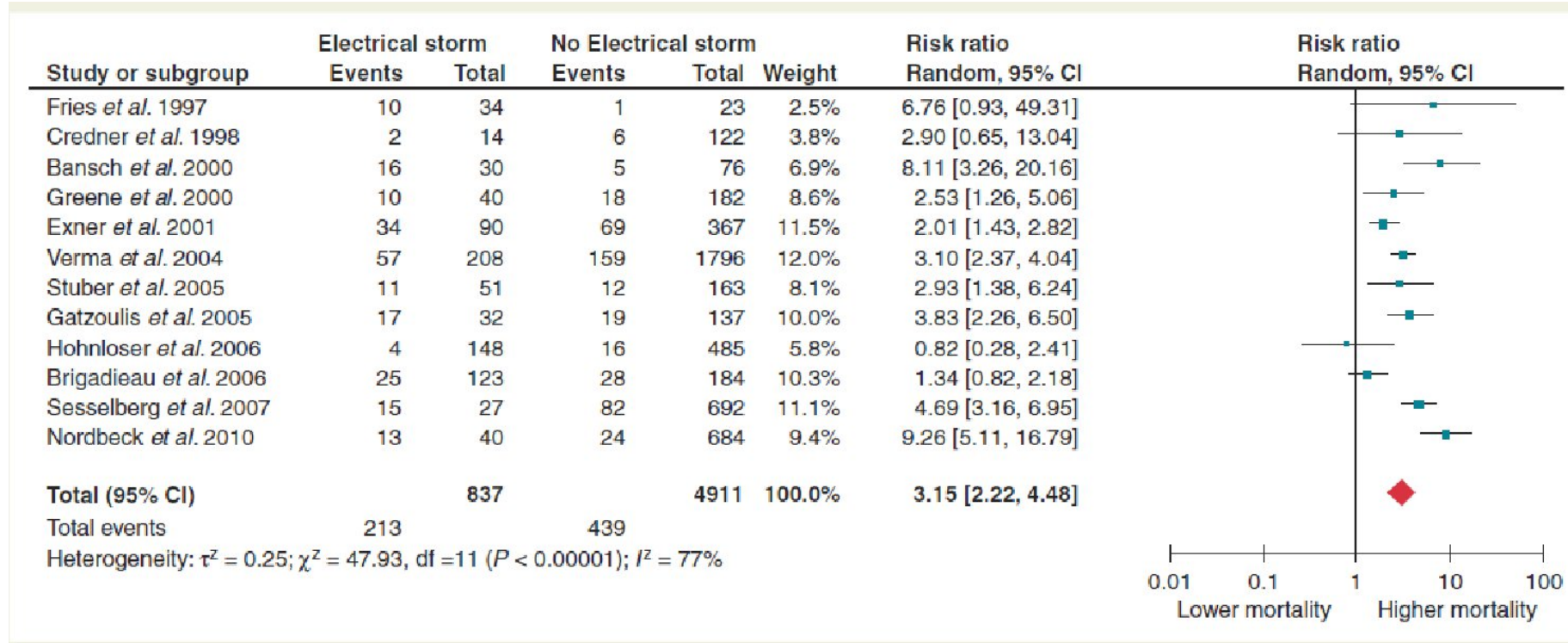
Rule of **5** : episodes within 5 min count as one

Epidemiology

- Prevalence: 10-20% in ICD patients but otherwise unknown
- 10-60% secondary prevention
- 4-7% primary prevention
- Incidence raising due to:
 - More awareness by the clinician
 - More ICD implants
- In ACS:
 - ~5% in STEMI patients
 - ~1-2% in STEMI patients

Author	Year	Definition	Population	%
Wood	1995	≥ 3 VT/VF ≤ 24 h	ICD (secondary prevention)	10
Kowey	1996	≥ 2 VT/VF ≤ 24 h	All ES patients	-
Villacastin	1996	≥ 2 shocks for VT	ICD (secondary prevention)	20
Fries	1997	> 2 VT ≤ 1 h	ICD (secondary prevention)	60
Credner	1998	≥ 3 VT/VF ≤ 24 h	ICD (secondary prevention)	10
Nademanee	2000	≥ 20 VT/VF ≤ 24 h ≥ 4 VT/VF ≤ 1 h	All ES patients	-
Greene	2000	≥ 3 VT/VF ≤ 24 h	ICD (secondary prevention)	18
Bansch	2000	≥ 3 VT/VF ≤ 24 h	ICD (secondary prevention)	28
Exner	2001	≥ 3 VT/VF ≤ 24 h	ICD (secondary prevention)	20
Verma	2004	≥ 2 VT/VF ≤ 24 h	ICD (secondary prevention)	10
Arya	2005	≥ 3 VT/VF ≤ 24 h	ICD (30% primary prevention)	13
Brigadeau	2006	≥ 2 VT/VF ≤ 24 h	ICD (secondary prevention)	58
Honhloser	2006	≥ 3 VT/VF ≤ 24 h	ICD (secondary prevention)	23
Sesselberg	2007	≥ 3 VT/VF ≤ 24 h	ICD (primary prevention)	4
Nordbeck	2010	≥ 3 VT/VF ≤ 24 h	ICD (55% primary prevention)	7
Streinert	2011	≥ 3 VT/VF ≤ 24 h	ICD (81% primary prevention)	7

Electrical storm and death



- Independent risk factor for mortality
 - OR 2.4 -7.4 from RCTs
 - OR 3.15 from MAs
- Non-sudden cardiac death much more prevalent than sudden cardiac death

Clinical presentation

Heart failure

- The most frequent ES by far. Patients with ICD or CRT-D. The ES precedes the clinical deterioration due to HF worsening

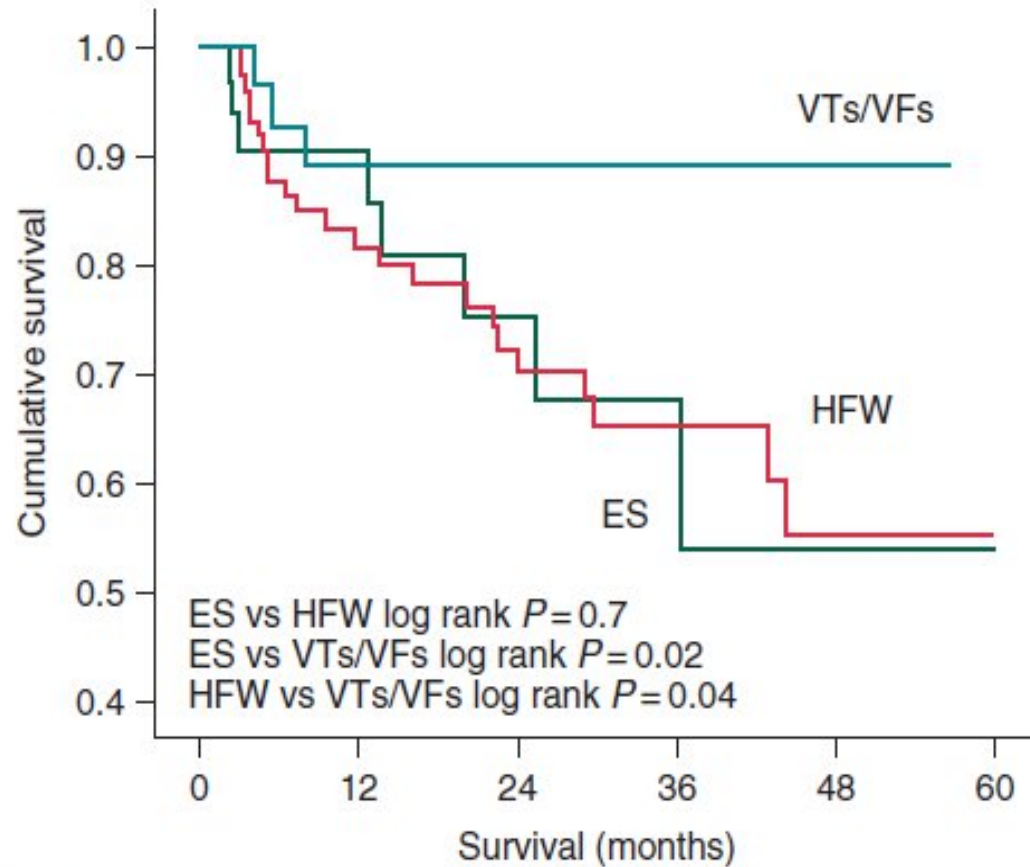
Channelopathies

- «Out of the sky» events, no preceding symptoms. These include Brugada and long QT syndrome, non compaction cardiomyopathy, and ARVD

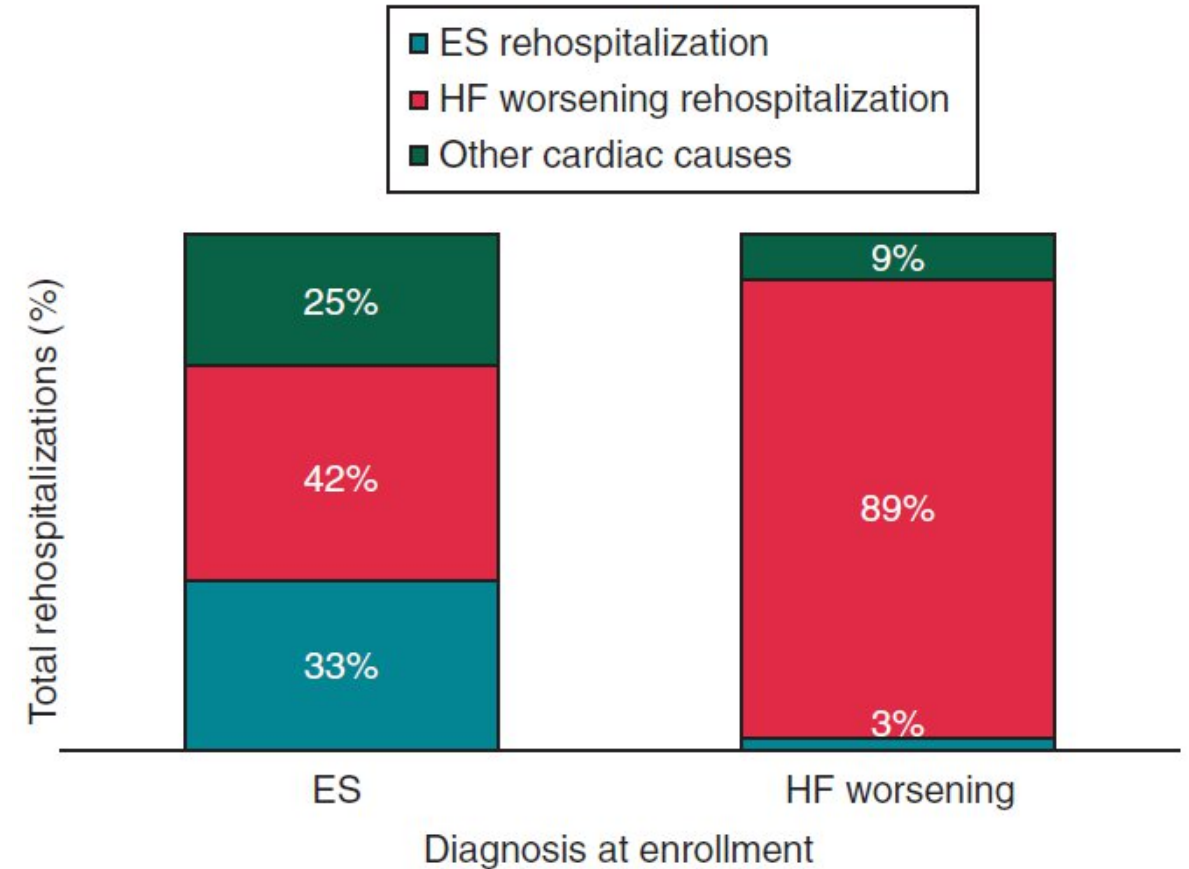
Acute coronary syndromes

- Before or right after reperfusion. They are usually patients without an ICD experiencing many VT episodes while in the cath lab.

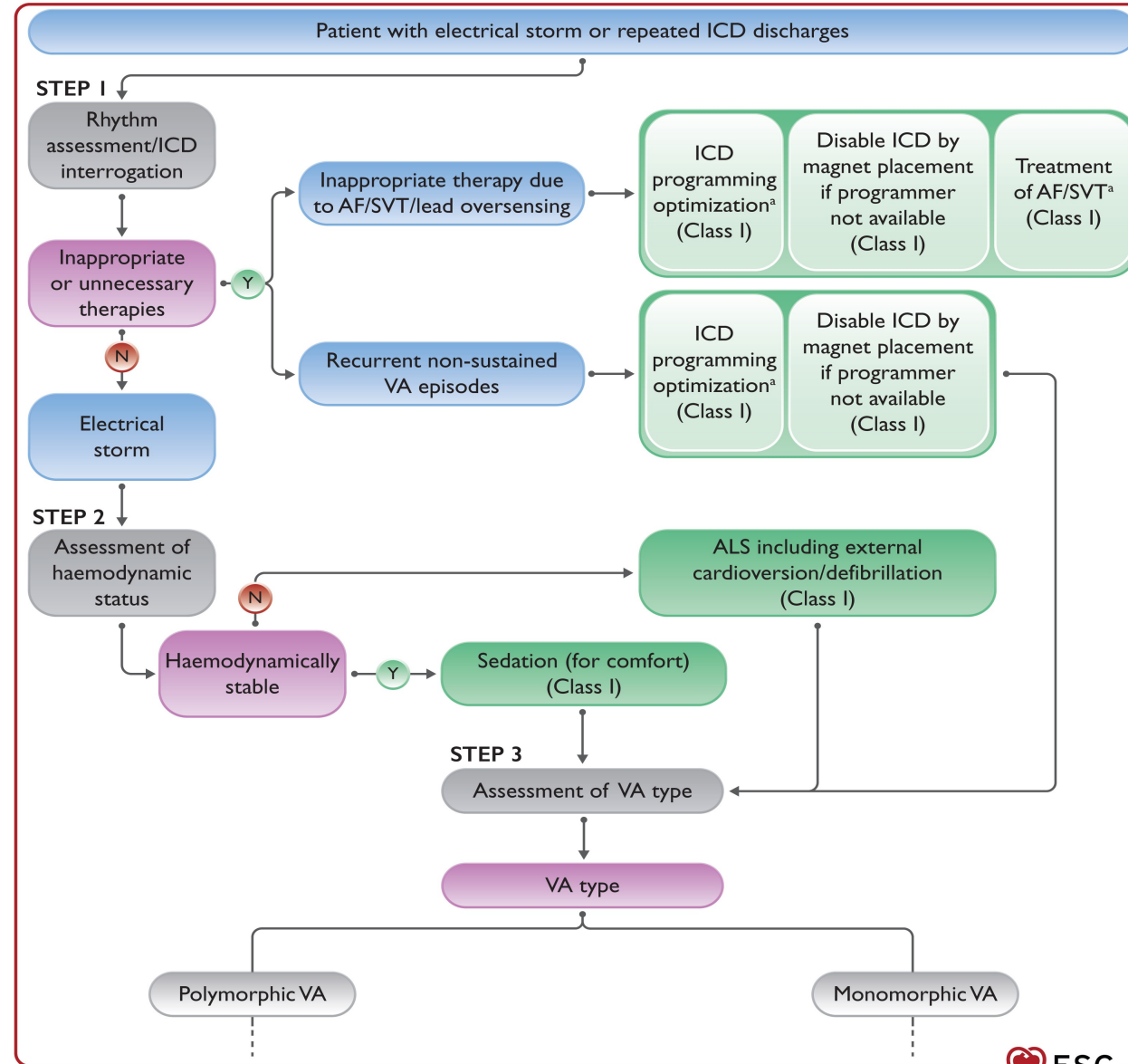
Electrical storm and HF



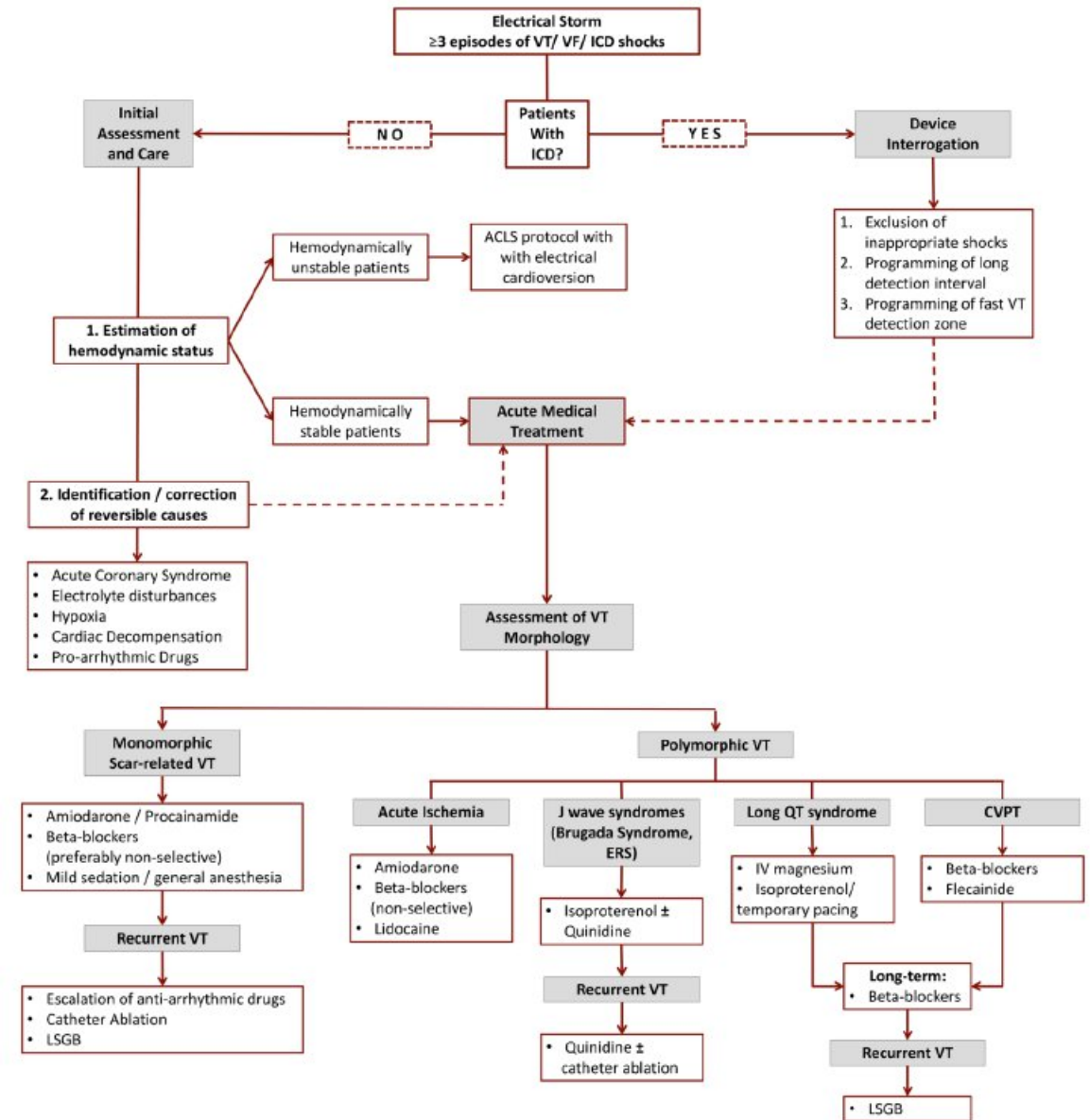
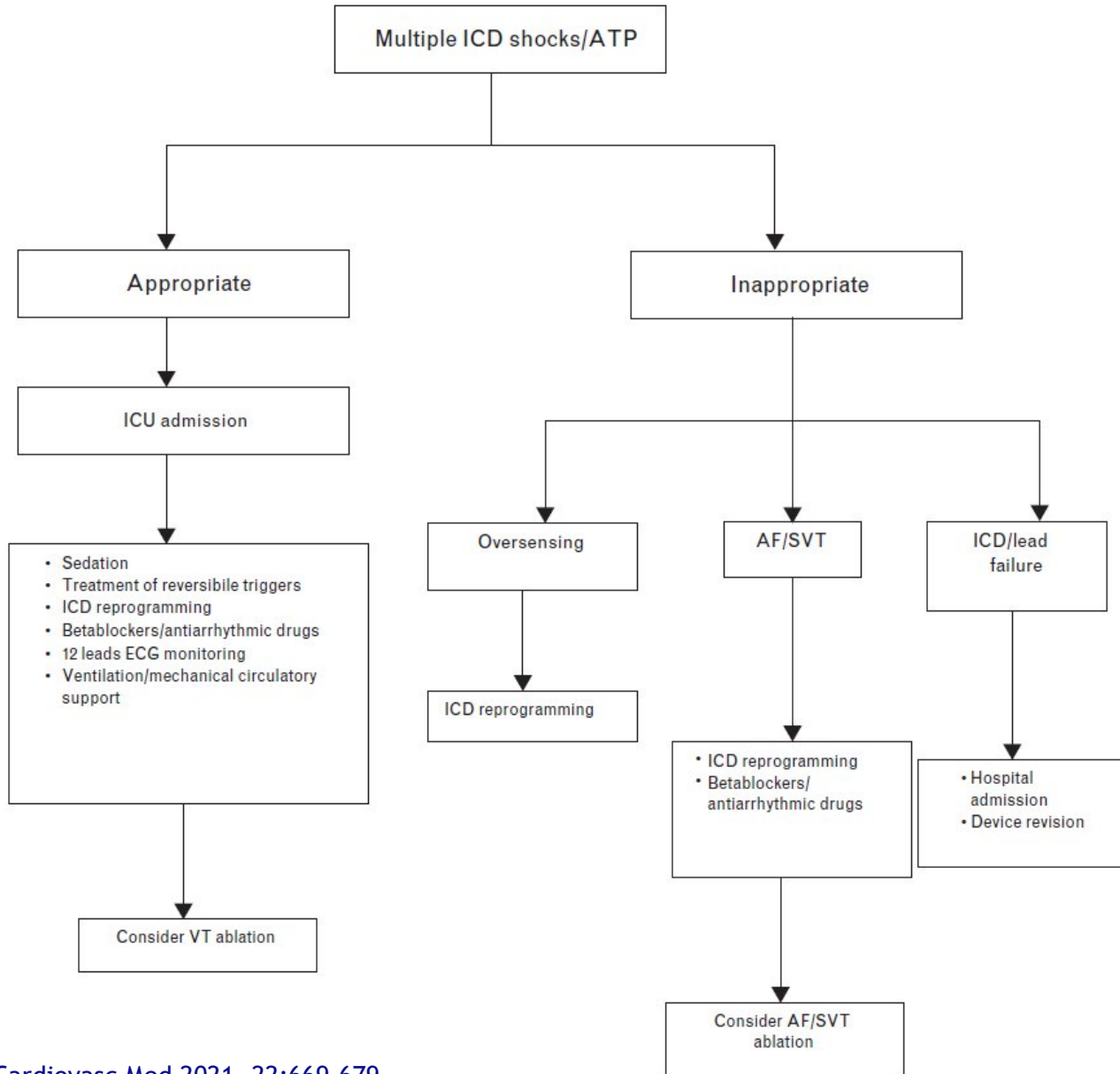
No. at risk						
ES	34	20 (0.91)	10 (0.75)	5 (0.67)	2 (0.54)	1 (0.54)
WHF	82	50 (0.81)	34 (0.72)	18 (0.65)	8 (0.55)	2 (0.55)
VTs/VFs	30	24 (0.89)	16 (0.89)	8 (0.89)	2 (0.89)	-



Treatment



Treatment



Acute termination vs. recurrence prevention

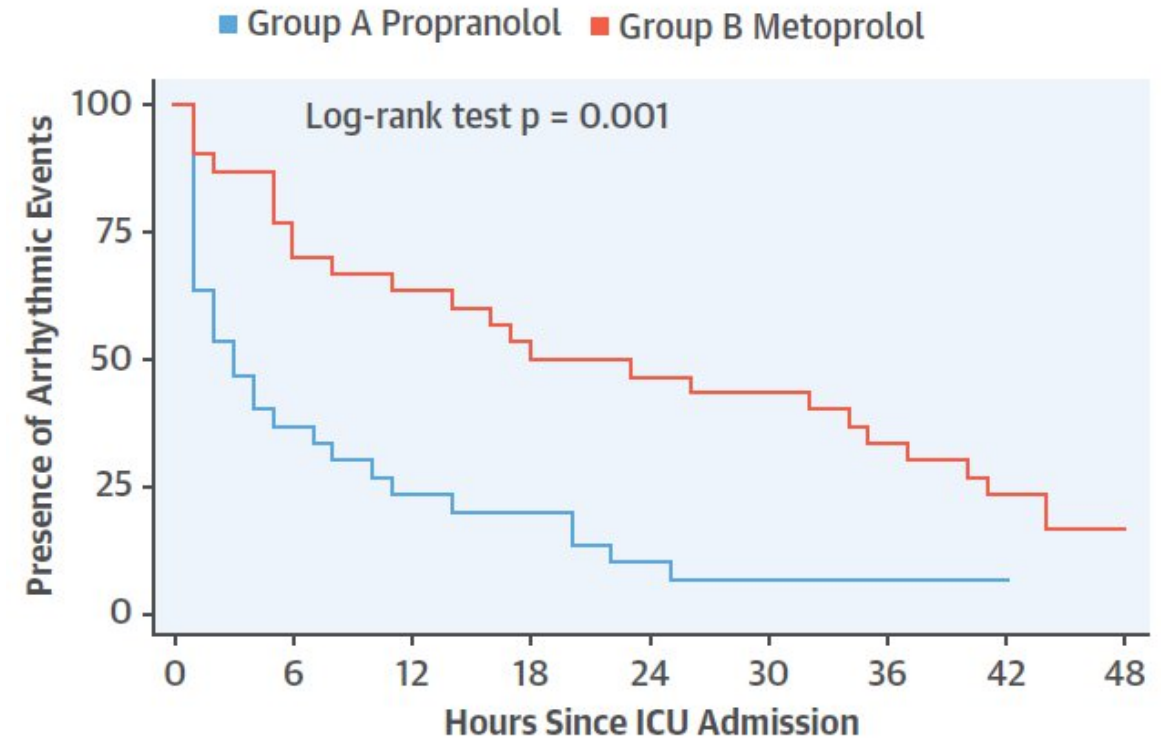
Treatment	Acute	Chronic
Anti-arrhythmic drugs	?	+
HF drugs		+
Sedation	+	
CRT upgrade		+
Ganglia ablation	+	
ECMO/LVAD	+	?
Sympathetic denervation	+	+
VT ablation	+	+

Propranolol Versus Metoprolol for Treatment of Electrical Storm in Patients With Implantable Cardioverter-Defibrillator

- Propranolol blocks β_2 receptors too, which are not down regulated in failing heart

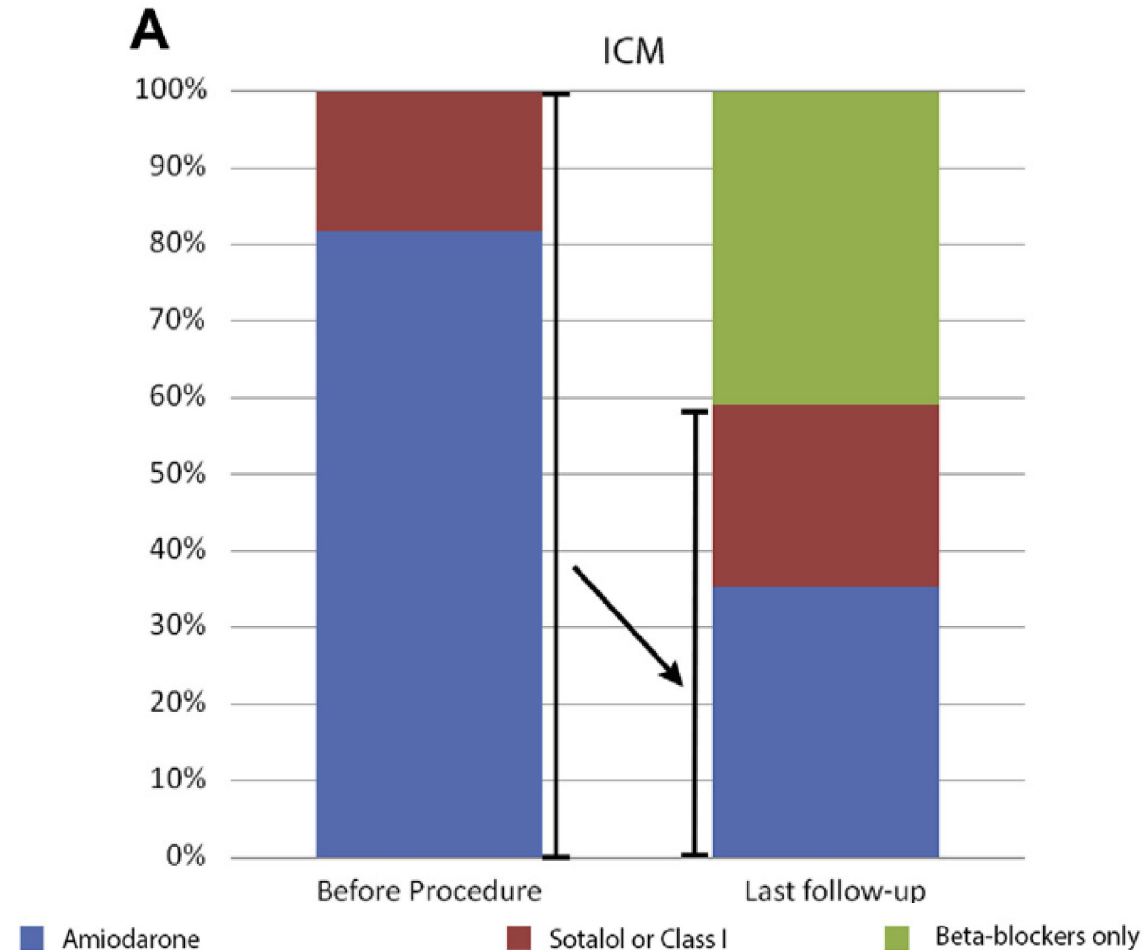
TABLE 2 The Effect of Treatment on Number of Events and ICD Discharges, Detected in Each Time Period After ICU Admission, in 2 Groups of Interest (Group A [Propranolol] Versus Group B [Metoprolol])

Time period after the initiation of treatment	Events			ICD Discharges		
	Group A (n = 30)	Group B (n = 30)	p Value*	Group A (n = 30)	Group B (n = 30)	p Value*
	Propranolol	Metoprolol		Propranolol	Metoprolol	
0-6 h	62	59	0.632	40	41	0.585
7-12 h	21	50	0.001	13	34	0.004
13-18 h	9	36	0.001	6	23	0.003
19-24 h	9	33	0.002	5	19	0.01
25-30 h	9	31	0.002	5	16	0.01
31-36 h	7	25	0.002	5	12	0.036
37-42 h	4	18	0.01	2	7	0.107
43-48 h	0	9	†	0	4	†
Total	121	261		76	156	
Overall IRR (95% CI)‡	0.375 (0.186-0.764)		0.001	0.428 (0.227-0.892)		0.004

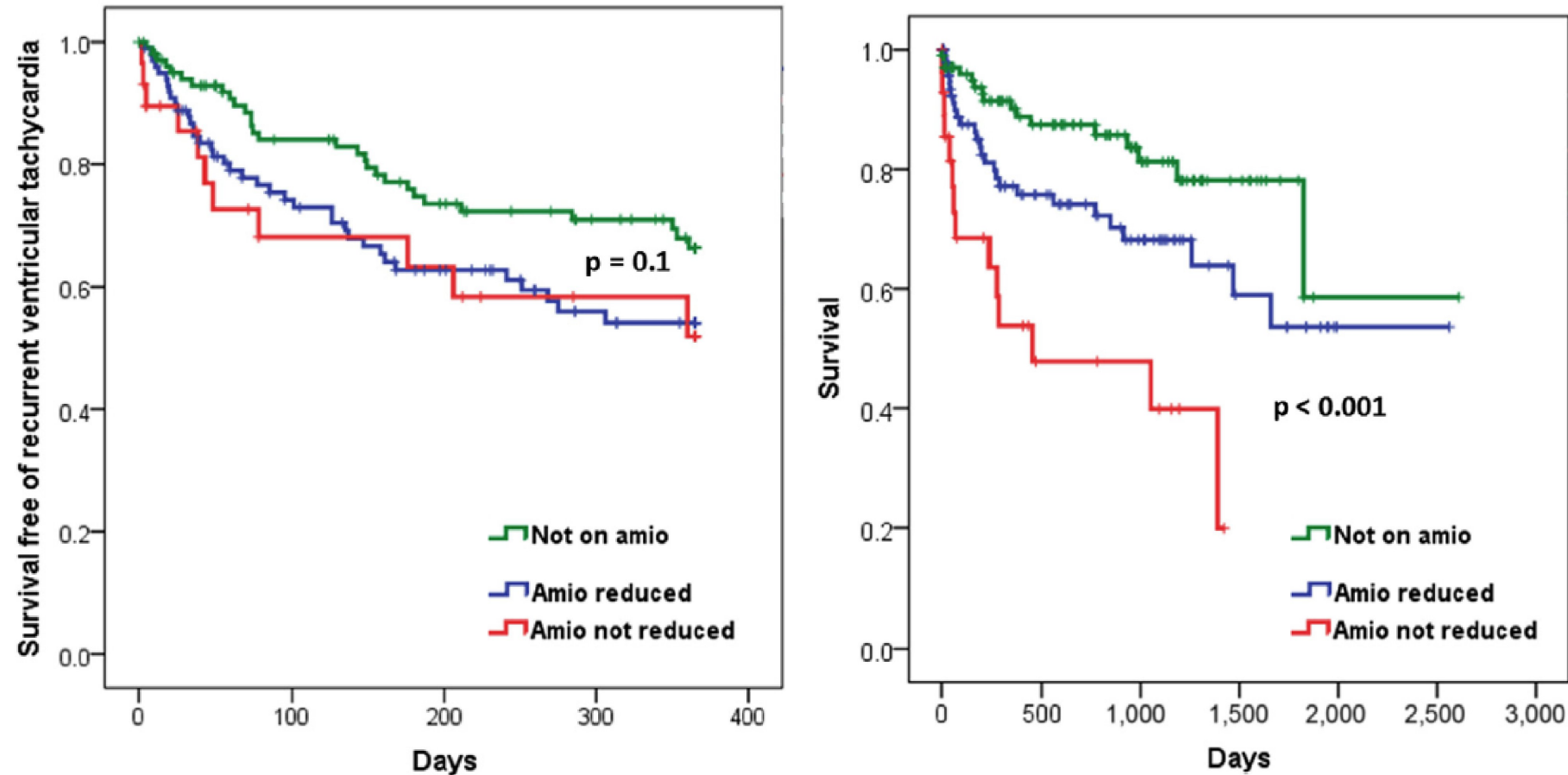


- Propranolol is associated with decreased norepinephrine spillover
- Propranolol is lipid soluble, therefore able to act on CNS

Long-Term Outcomes of Catheter Ablation of Electrical Storm in Nonischemic Dilated Cardiomyopathy Compared With Ischemic Cardiomyopathy

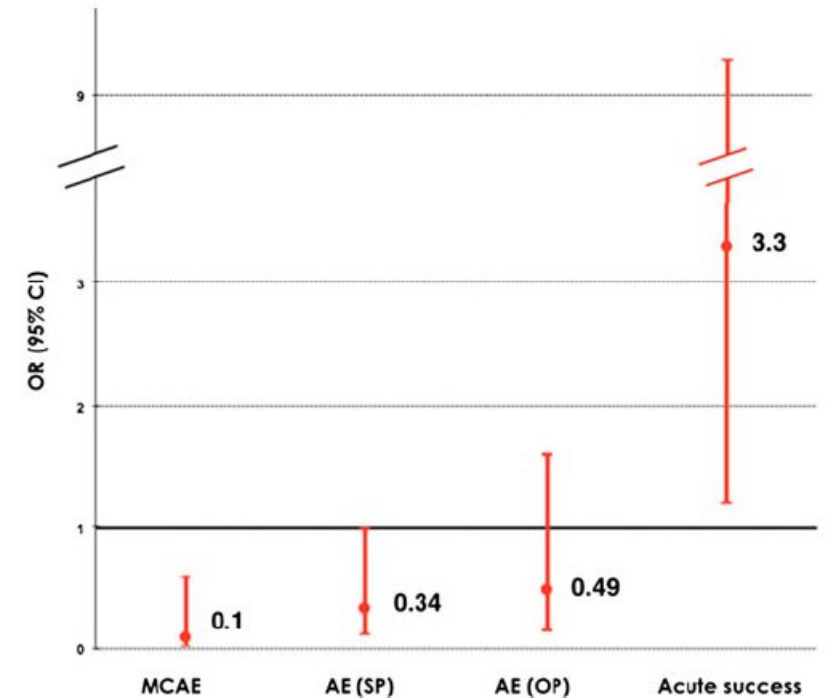
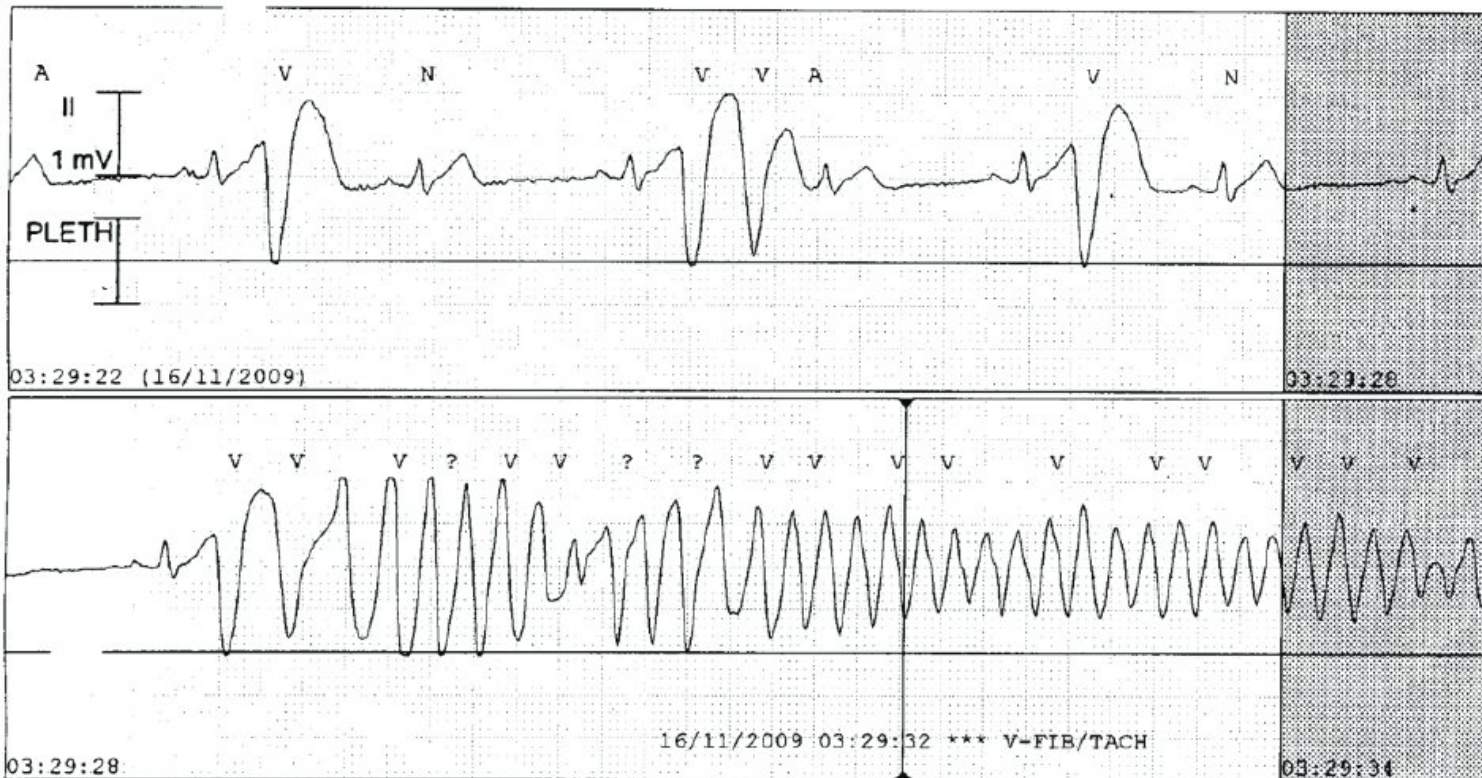


Amiodarone Discontinuation or Dose Reduction Following Catheter Ablation for Ventricular Tachycardia in Structural Heart Disease



Randomized comparison of intravenous procainamide vs. intravenous amiodarone for the acute treatment of tolerated wide QRS tachycardia: the PROCAMIO study

Isoprenaline and quinidine to calm Brugada VF storm



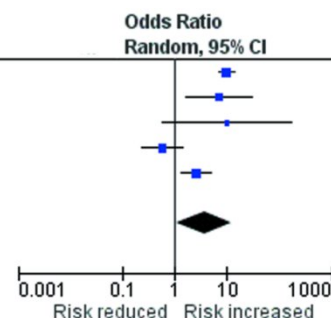
Role of electrical storm as a mortality and morbidity risk factor and its clinical predictors: a meta-analysis

Federico Guerra*, Matilda Shkoza, Lorena Scappini, Marco Flori, and Alessandro Capucci

• Secondary prevention

Study or Subgroup	Electrical Storm		No Electrical Storm		Weight	Odds Ratio Random, 95% CI
Events	Total	Events	Total			
Verma et al. 2004	158	208	430	1796	25.0%	10.04 [7.17, 14.05]
Stuber et al. 2005	49	51	126	163	18.6%	7.19 [1.67, 31.00]
Gatzoulis et al. 2005	32	32	119	137	10.6%	10.06 [0.59, 171.48]
Arya et al. 2006	13	22	100	140	22.2%	0.58 [0.23, 1.46]
Nordbeck et al. 2010	25	40	273	689	23.7%	2.54 [1.32, 4.90]
Total (95% CI)		353		2925	100.0%	3.62 [1.08, 12.14]
Total events	277		1048			

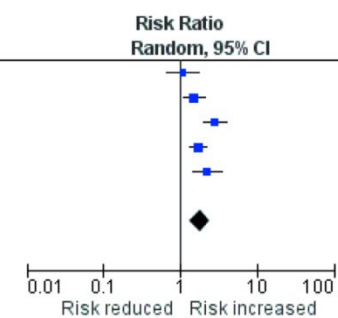
Heterogeneity: $\tau^2 = 1.50$; $\chi^2 = 40.34$, $df = 4$ ($P < 0.00001$); $I^2 = 90\%$



• mVT as triggering arrhythmia

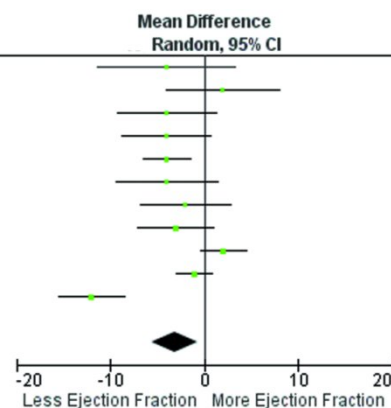
Study or Subgroup	Electrical Storm		No Electrical Storm		Weight	Risk Ratio Random, 95% CI
Events	Total	Events	Total			
Credner et al. 1998	8	14	64	122	16.1%	1.09 [0.67, 1.77]
Bansch et al. 2000	21	30	49	106	22.0%	1.51 [1.11, 2.07]
Greene et al. 2000	26	40	42	182	20.6%	2.82 [1.99, 3.99]
Stuber et al. 2005	34	51	64	163	23.5%	1.70 [1.29, 2.23]
Brigadieu et al. 2006	40	123	27	184	17.8%	2.22 [1.44, 3.41]
Total (95% CI)		258		757	100.0%	1.79 [1.35, 2.39]
Total events	129		246			

Heterogeneity: $\tau^2 = 0.07$; $\chi^2 = 12.83$, $df = 4$ ($P = 0.01$); $I^2 = 69\%$



• Ejection fraction

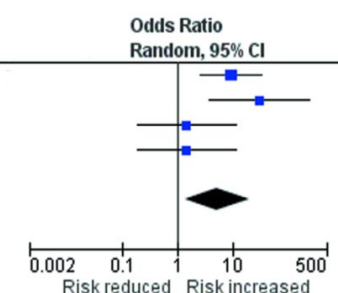
Study or Subgroup	Electrical Storm			No Electrical Storm			Weight	Mean Difference Random, 95% CI
	Mean	SD	Total	Mean	SD	Total		
Fries et al. 1997	35	12	34	39	15	23	6.0%	-4.00 [-11.34, 3.34]
Credner et al. 1998	37	11	14	35	11	122	7.1%	2.00 [-4.08, 8.08]
Bansch et al. 2000	32	13	30	36	13	106	8.0%	-4.00 [-9.27, 1.27]
Greene et al. 2000	34	13	40	38	17	182	8.6%	-4.00 [-8.73, 0.73]
Exner et al. 2001	29	10	90	33	14	367	11.2%	-4.00 [-6.51, -1.49]
Gatzoulis et al. 2005	31	14	32	35	14	137	7.9%	-4.00 [-9.39, 1.39]
Stuber et al. 2005	39	15	51	41	16	163	8.6%	-2.00 [-6.79, 2.79]
Arya et al. 2006	21	9	22	24	9	140	9.5%	-3.00 [-7.05, 1.05]
Hohnloser et al. 2006	37	13	148	35	14	485	11.3%	2.00 [-0.44, 4.44]
Sesselberg et al. 2007	22	5	27	23	4	692	11.8%	-1.00 [-2.91, 0.91]
Nordbeck et al. 2010	25	11	40	37	14	689	10.0%	-12.00 [-15.57, -8.43]
Total (95% CI)			528			3106	100.0%	-3.08 [-5.53, -0.62]
Heterogeneity: Tau ² = 12.32; Chi ² = 47.43, df = 10 (P < 0.00001); I ² = 79%								



• Class I AAD therapy

Study or Subgroup	Electrical Storm		No Electrical Storm		Weight	Odds Ratio Random, 95% CI
Events	Total	Events	Total			
Bansch et al. 2000	8	30	4	106	33.1%	9.27 [2.56, 33.54]
Stuber et al. 2005	8	51	1	163	21.9%	30.14 [3.67, 247.57]
Sesselberg et al. 2007	1	27	18	692	22.6%	1.44 [0.19, 11.20]
Nordbeck et al. 2010	1	40	12	689	22.4%	1.45 [0.18, 11.41]
Total (95% CI)		148		1650	100.0%	5.20 [1.35, 20.01]
Total events	18		35			

Heterogeneity: $\tau^2 = 1.00$; $\chi^2 = 6.44$, $df = 3$ ($P = 0.09$); $I^2 = 53\%$



Sedation in cardiac arrhythmias management

Paper	n	Sedation strategy	Level of sedation
Koovor et al.	1324	Induction: midazolam 2.5-10 mg + fentanyl 10-40 µg	Moderate or deep
		Maintenance: midazolam 3-10 mg/h + fentanyl 15-50 µg/h	
Lai et al.	150	Induction: propofol 200 µg/kg/min	Moderate or deep
		Maintenance: propofol 100 µg/kg/min	
Kezerashvili et al.	5479	Induction and maintenance: midazolam 1 mg + morphine 1 mg + fentanyl 25-50 µg, repeatable	Variable
Wutzler et al.	31	Induction: propofol 0.5-1 mg/kg + midazolam 0.03 mg/kg	Deep
		Maintenance: propofol 0.5 mg/kg every 3 min	
Wutzler et al.	120	Induction midazolam 0.03 mg/kg	Minimal (#1)
		Maintenance: none	Deep (#2)
Servatius et al.	205	Induction: propofol 0.8-1.2 mg/kg	Deep
		Maintenance: propofol 3.5-4 mg/kg/h	

Propofol, while the first choice in many EP procedures, can be difficult to handle in ES due to the risk of airway obstruction, potential proarrhythmic effects, and the absence of a reversal agent

Midazolam is seen as a better alternative, due to the reduced vagotonic effect and the prompt reversal available with flumazenil

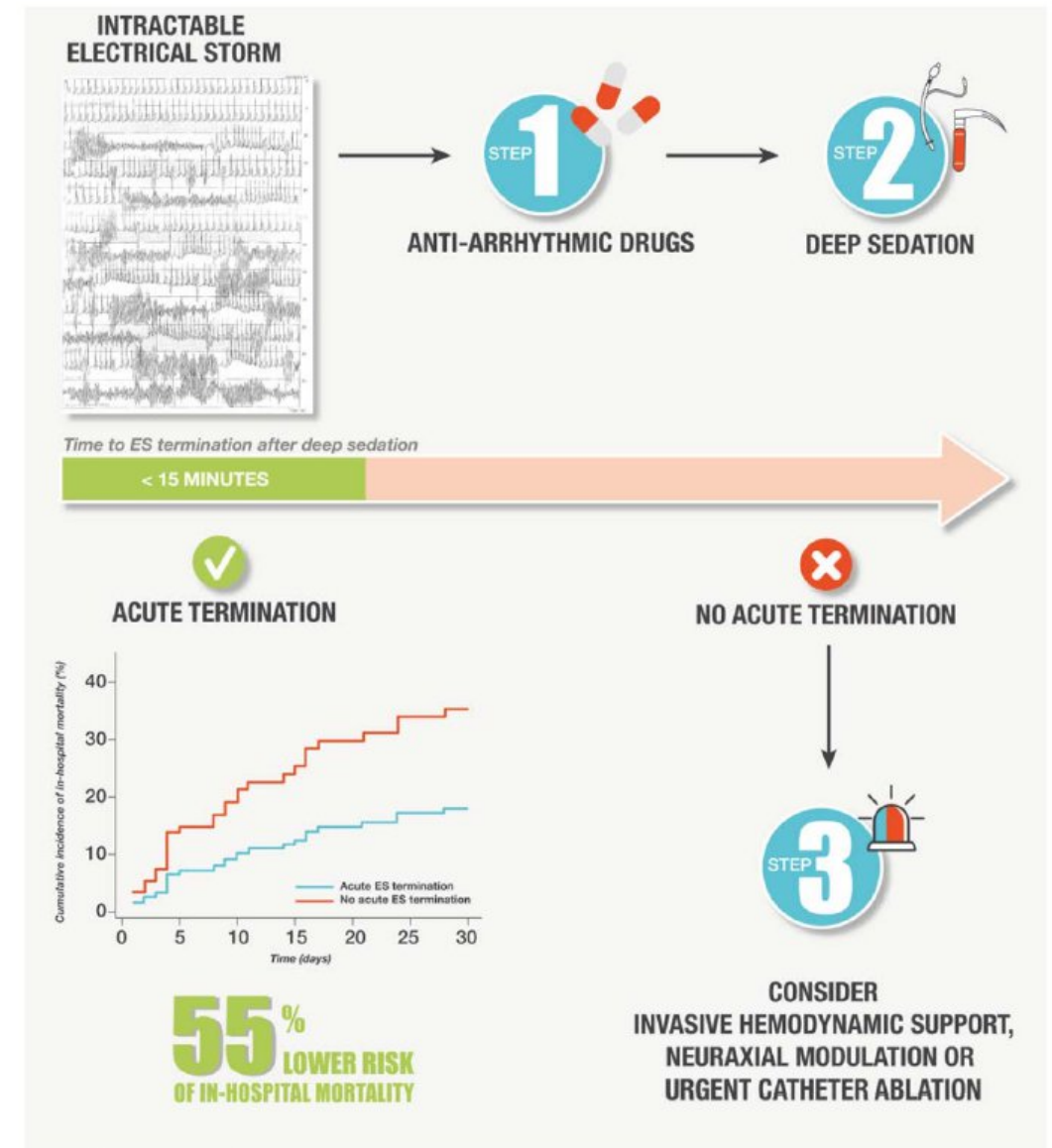
Effectiveness of Deep Sedation for Patients With Intractable Electrical Storm Refractory to Antiarrhythmic Drugs

116 patients with ischemic cardiomyopathy
LVEF 0.25

4-14 shocks in the previous 60 min

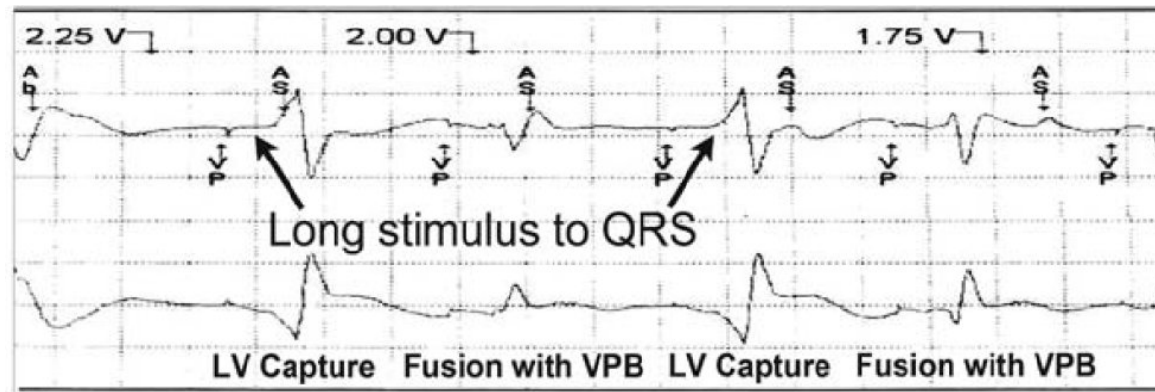
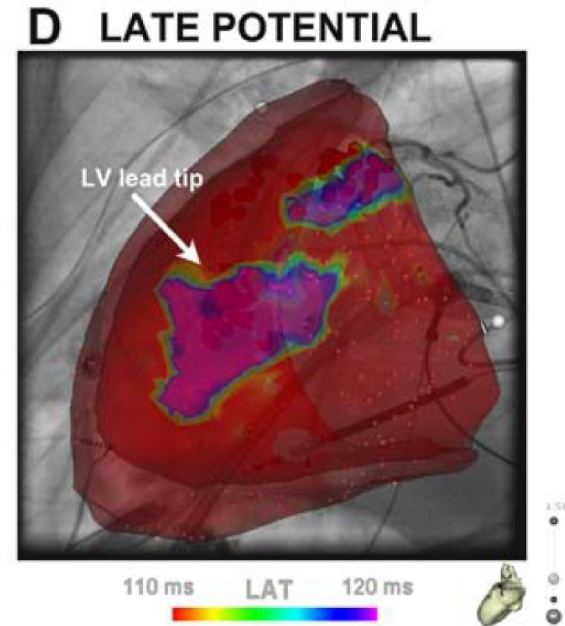
- Amiodarone 82%
- Lidocaine 44%
- Beta-blockers 41%

Acute termination: 44%



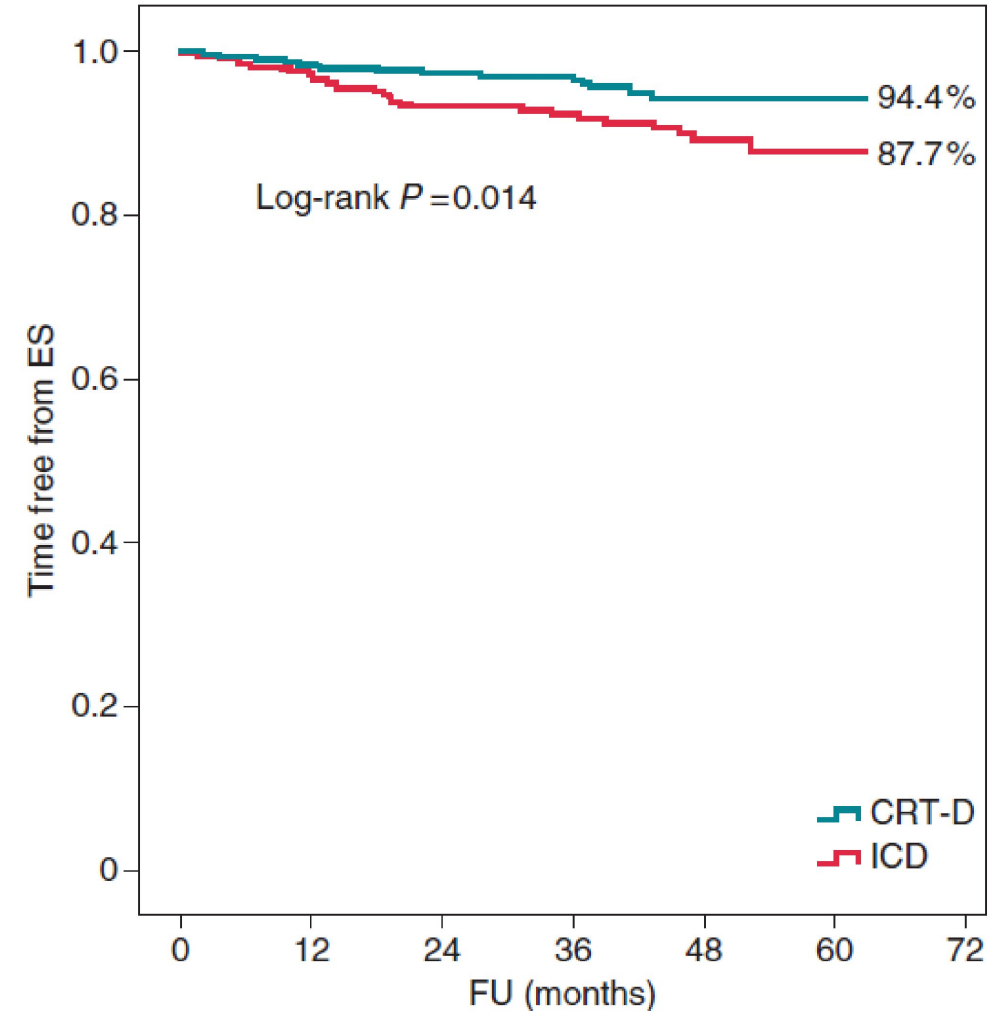
Electrical Storm Induced by Cardiac Resynchronization Therapy Is Determined by Pacing on Epicardial Scar and Can be Successfully Managed by Catheter Ablation

- Epicardial pacing at the scar border
- Re-entry mechanism
- ES starts in the 72 hours after CRT implant
- Can be solved by either repositioning or turning CRT off



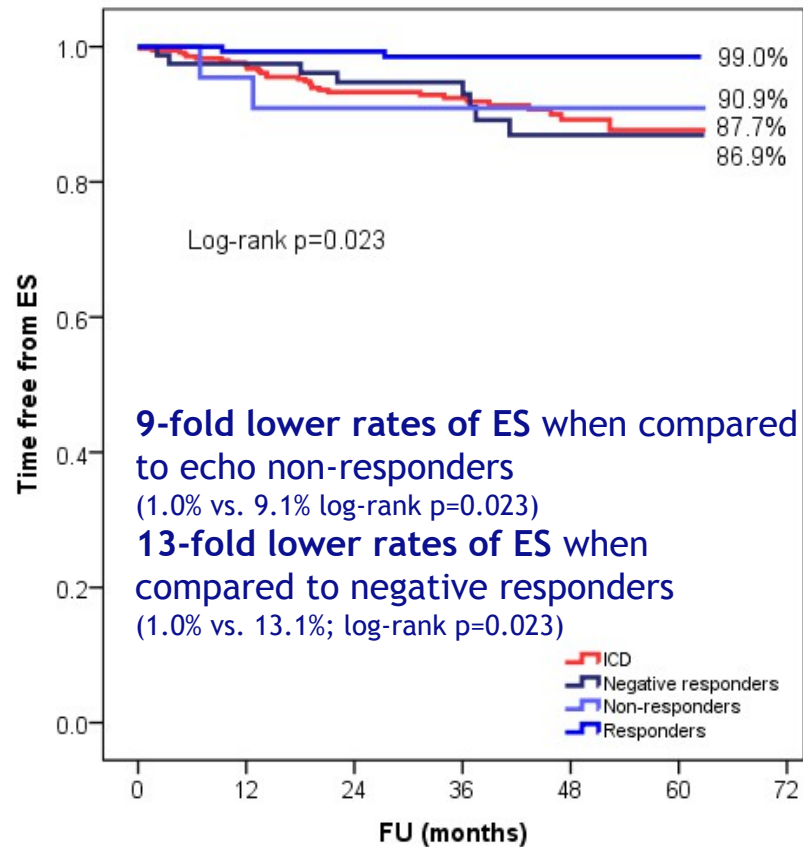
Cardiac resynchronization therapy and electrical storm: results of the OBSERVational registry on long-term outcome of ICD patients (OBSERVO-ICD)

- **1319** consecutive patients underwent ICD (n=810) or CRT-D (n=509) implantation.
- Propensity score matching was used to compare two equally sized cohorts of ICD and CRT-D pt with similar characteristics.
- Clinical response to CRT : improvement of at least one NYHA functional class at 6-month FU
- Echocardiographic response to CRT: increase in LVESV \geq 10% at 6-month
- Non-responders: all patients who did not met both the definitions for positive and negative response

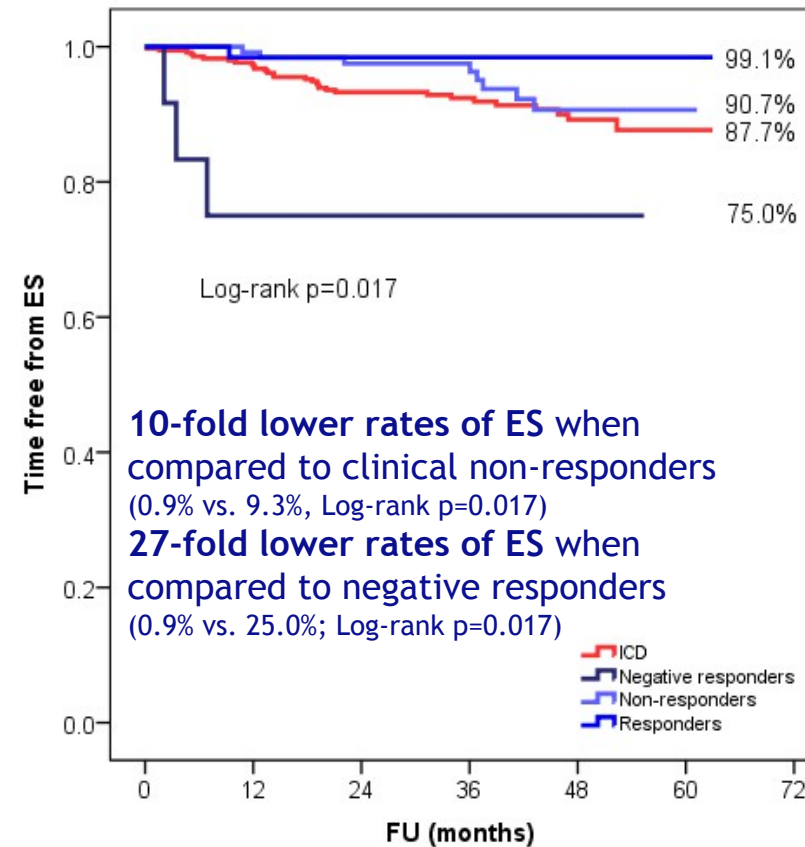


Cardiac resynchronization therapy and electrical storm: results of the OBSERVational registry on long-term outcome of ICD patients (OBSERVO-ICD)

Clinical response



Echo response



Extracorporeal Membrane Oxygenation in Patients With Electrical Storm: A Single-center Experience

Median shocks: 5 (IQR 3-23) before ablation

Median time from ECMO to ablation was 2 [IQR range, 1-4] days

Sex	Age, years	Etiology	Ventricular Arrhythmia	LVEF preimplant, %	Lactic acid preimplant, mmol/l	Venous/arterial cannula, Fr	Implantation time, min	Ablation, access	Ablation, successful	Days on ECMO	Survival at discharge
Man	68	CIHD	SMVT	30	1.0	23/15	15	Yes (RA)	Yes	1	Yes
Man	55	NIDCM	SMVT	35	5.0	21/17	20	Yes (TS)	Yes	11	Yes
Man	47	AMI	VF	10	3.0	23/15	40	Yes (TS)	Yes	5	Yes
Man	75	CIHD	SMVT	20	3.0	23/15	20	Yes (RA)	Yes	3	Yes
Man	54	AMI	VF	10	4.5	23/15	40	Yes (TS)	No	15	No
Man	64	AMI	SMVT	15	4.2	23/17	30	No	—	11	No
Man	67	AMI	VF	5	4	23/15	30	No		9	Yes

Take-home messages

- ES is a life-threatening event, and the overall management still differs from centre to centre.
- Regardless on underlying mechanisms, ES should be managed promptly, as short and long-term treatment are widely different.
- Emerging pharmacological and non pharmacological treatments could benefit patients with ES but all therapeutic options should be tailored to the specific characteristics of each single patient.



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