

BIELLA CUORE
12-13 SETTEMBRE 2025



Lo storm aritmico:
come orientarsi nella tempesta tra vecchie e nuove armi

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Electrical storm (ES) is defined as three or more discrete episodes of ventricular arrhythmia within 24 hours, or incessant ventricular arrhythmia for more than 12 hours.

Incidence



Primary prev ICD
4–7%

Secondary prev ICD
10–30%

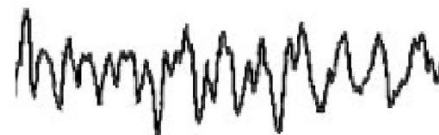


ICM = NICM
5.8–6.9%/50.9 mo

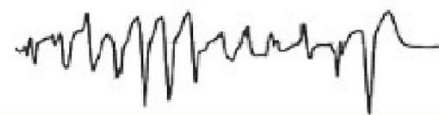
Presenting arrhythmia



SMVT 86–97%



VF 1–21%



**SMVT
+VF** 3–14%

PVT 2–8%

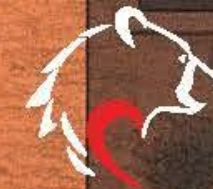
Outcomes



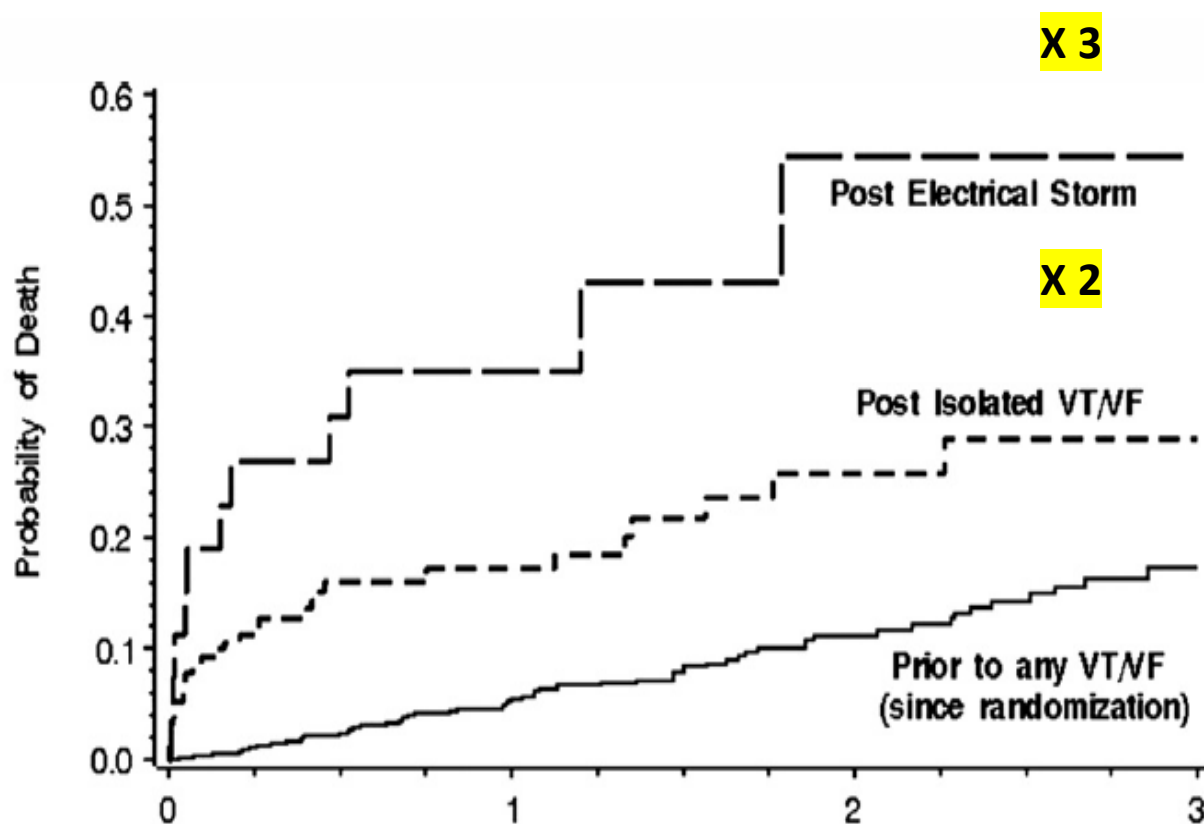
Mortality
3.3 x ↑



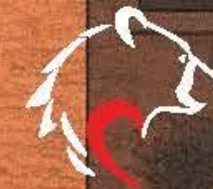
Re-hospitalization
4.8 x ↑



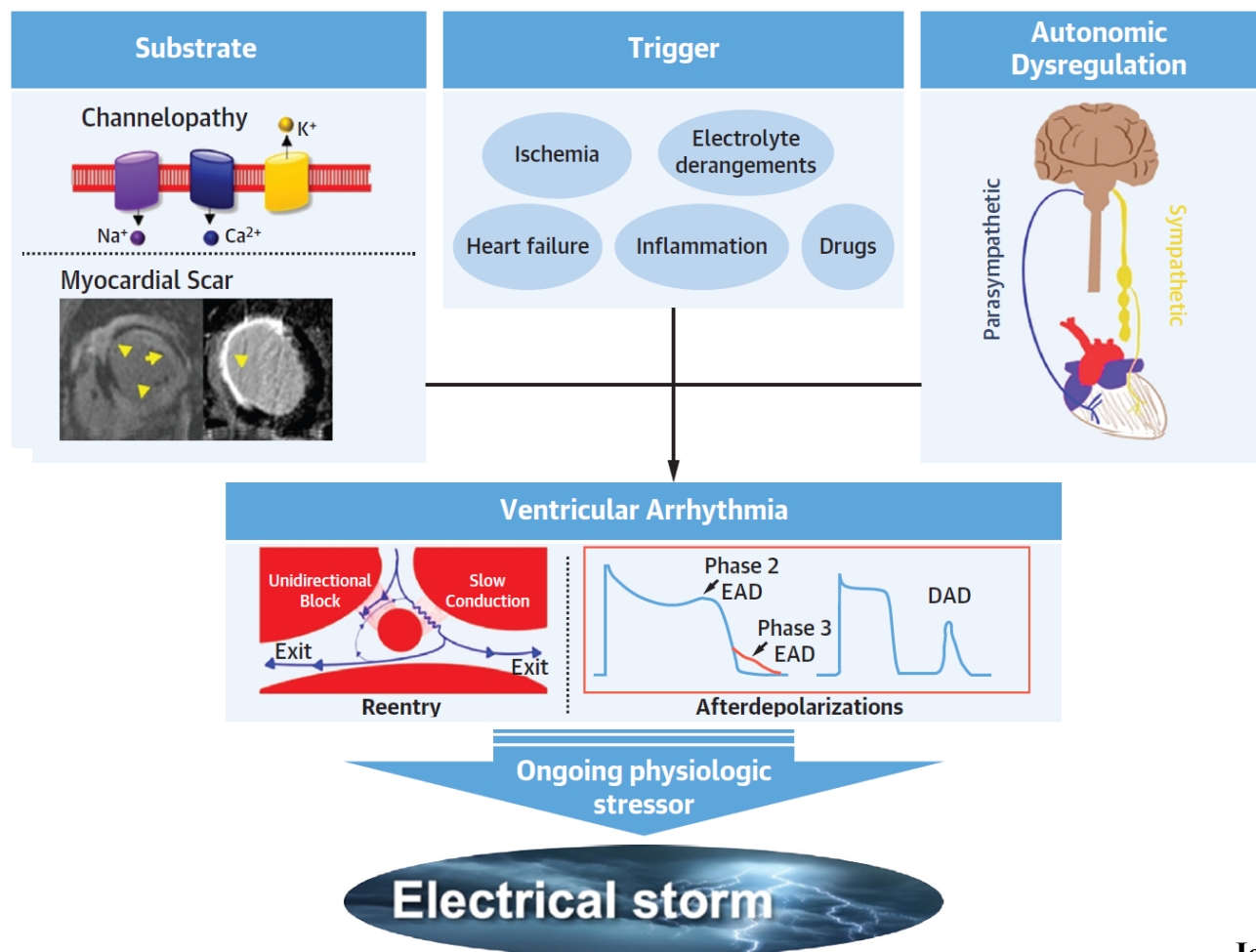
ES: mortality multiplier

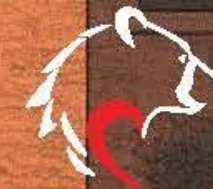


A meta-analysis of electrical storm studies showed a **2.5-fold increase in mortality** in patients with **electrical storm** compared with patients with **unclustered ventricular arrhythmia**.

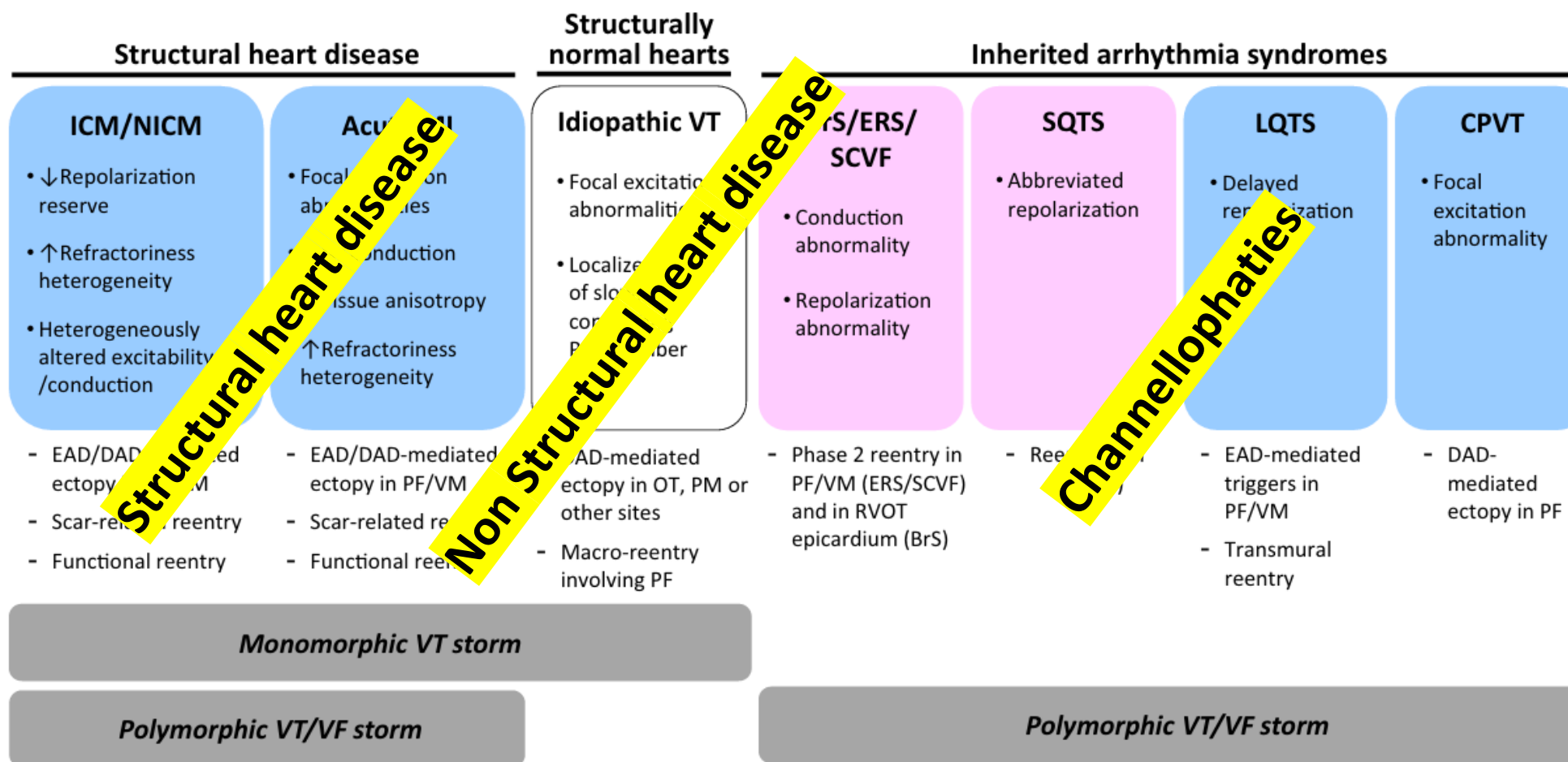


Mechanisms of Arrhythmogenesis in ES





Substrates for electrical storm





Triggering events for electrical storm

- **Unknown ($\approx 66\%$)**
 - **Decompensated heart failure**
 - **Acute ischemia**
 - **Metabolic disturbances (T4, Ca, Mg, K)**
- } ($\approx 33\%$)
- Drug pro-arrhythmia
 - Drug overdose
 - Fever and sepsis (DCM, Brugada)
 - Post cardiac surgery
 - ICD induced (CRT pacing, inappropriate therapies)



Initial evaluation of patients with ES

DC cardioversion is recommended as the first-line treatment for patients with haemodynamically not-tolerated SMVT.^{303,339}

I

B

Investigation for reversible causes (e.g. electrolyte imbalances, ischaemia, hypoxaemia, fever)^c is recommended in patients with VA.^{292,298}

I

C

Electrical storm
≥3 sustained VT episodes in 24 hours

ICD interrogation

Place external defibrillator pads

Hemodynamic
assessment

Identify triggers
Laboratory analysis

Cardiac assessment
Echocardiography

Ischemic evaluation
Coronary angiogram

Optimize ICD settings

Optimization of ICD programming is indicated to avoid inappropriate and unnecessary therapies and to reduce mortality.³⁷³⁻³⁷⁵

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In electrically unstable patients after SCA, with suspicion of ongoing myocardial ischaemia, a coronary angiogram is indicated.

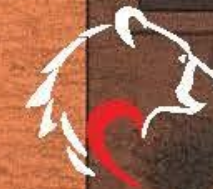
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In patients with newly documented VA (frequent PVCs, NSVT, SMVT), a baseline 12-lead ECG, recording of the VA on 12-lead ECG, whenever possible, and an echocardiogram are recommended as first-line evaluation.

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Ischemic or Coronary Evaluations in Patients With Monomorphic VT Electrical Storm Undergoing VT Ablation

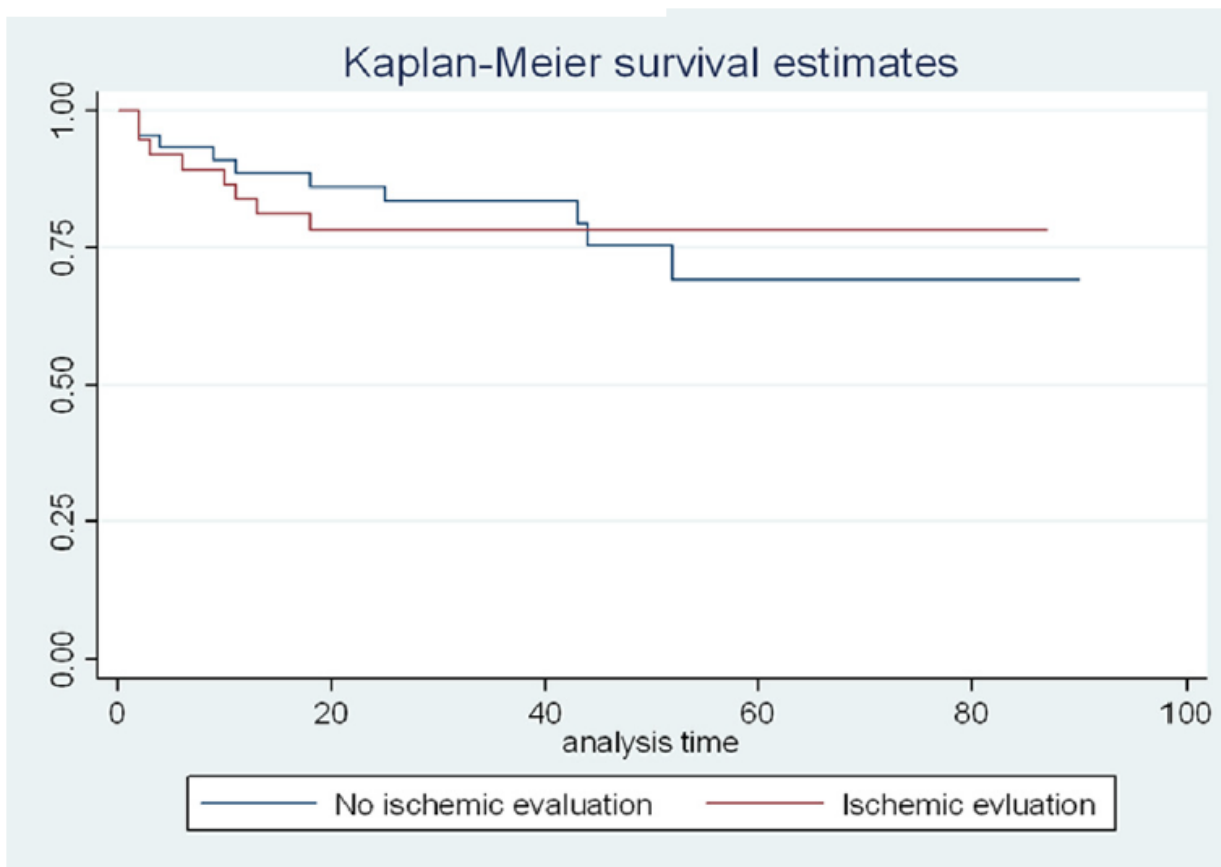
97 patients with VT storm in the absence of ACS underwent VT ablations.

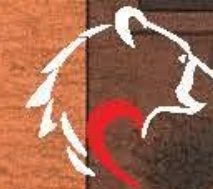
Mean LVEF 30%, mean NYHA class II.

45% underwent coronary evaluations

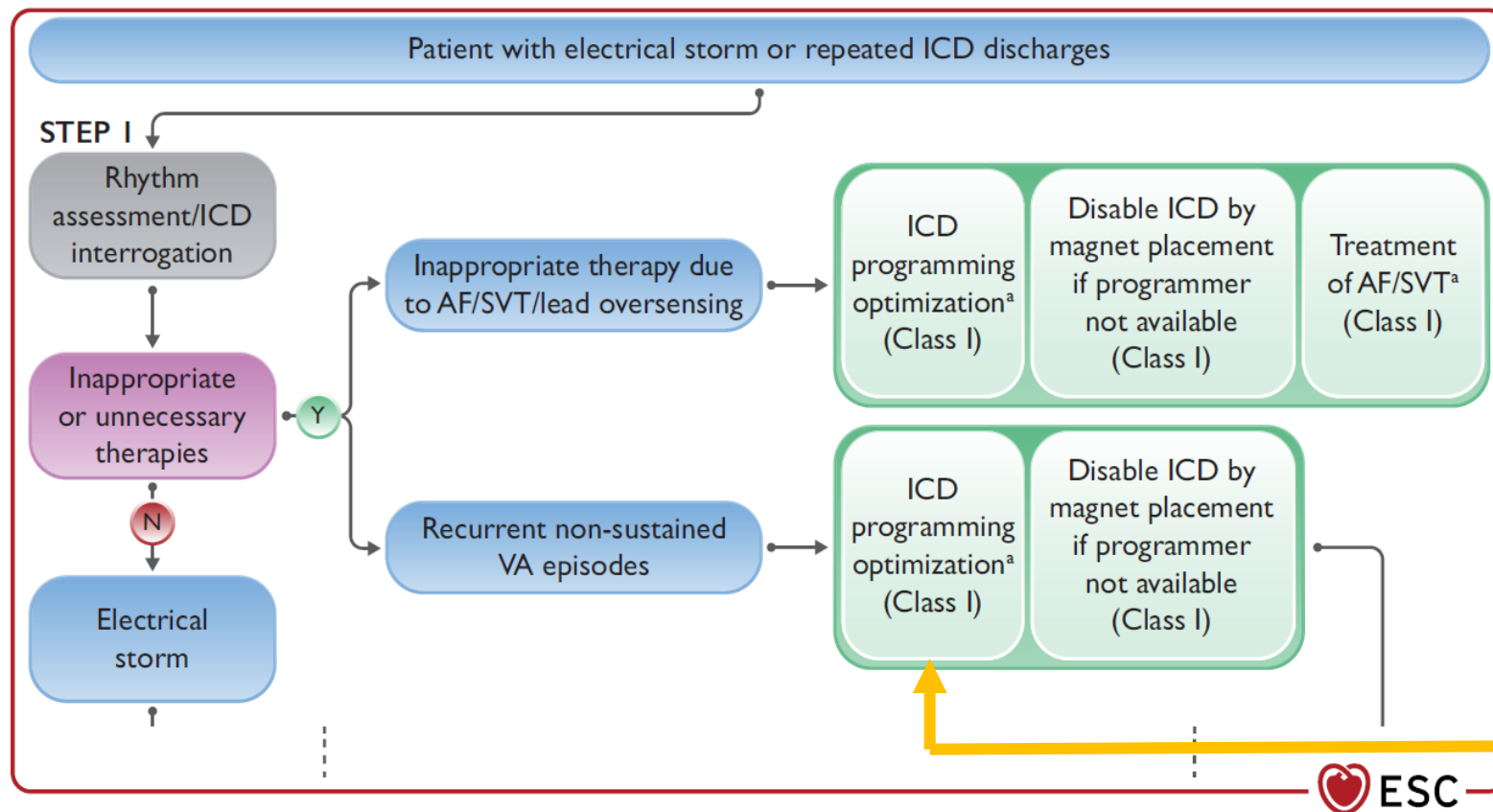
The yield of these evaluations was low:

- No acute coronary occlusions were identified (4% had revascularization, in all VT reoccurred).
- There was **no association between ischemic evaluation and acute ablation outcomes or mortality during follow-up.**





Beware of “pseudo-electrical storm”



Catheter ablation is recommended for ICD patients with recurrent SVT resulting in inappropriate ICD therapies. ^{401,402}	I	C
Pharmacological treatment or catheter ablation is recommended in patients with AF-related inappropriate ICD therapies despite optimal ICD programming. ^{401,405,407}	I	C

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Electrical storm
≥3 sustained VT episodes in 24 hours

ICD interrogation

Hemodynamic assessment	Identify triggers Laboratory analysis
Cardiac assessment Echocardiography	Ischemic evaluation Coronary angiogram

Optimize ICD settings

Antiarrhythmic therapy	Antiadrenergic therapy
Sedation and anxiolysis	Hemodynamic support

Mild to moderate sedation is recommended in patients with electrical storm to alleviate psychological distress and reduce sympathetic tone.

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Antiarrhythmic therapy with beta-blockers (non-selective preferred) in combination with intravenous amiodarone is recommended in patients with SHD and electrical storm unless contraindicated.^{317,318}

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Intravenous magnesium with supplementation of potassium is recommended in patients with TdP.²⁹⁵

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Isoproterenol or transvenous pacing to increase heart rate is recommended in patients with acquired LQT syndrome and recurrent TdP despite correction of precipitating conditions and magnesium.

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Deep sedation/intubation should be considered in patients with an intractable electrical storm refractory to drug treatment.³²⁵

IIa

C



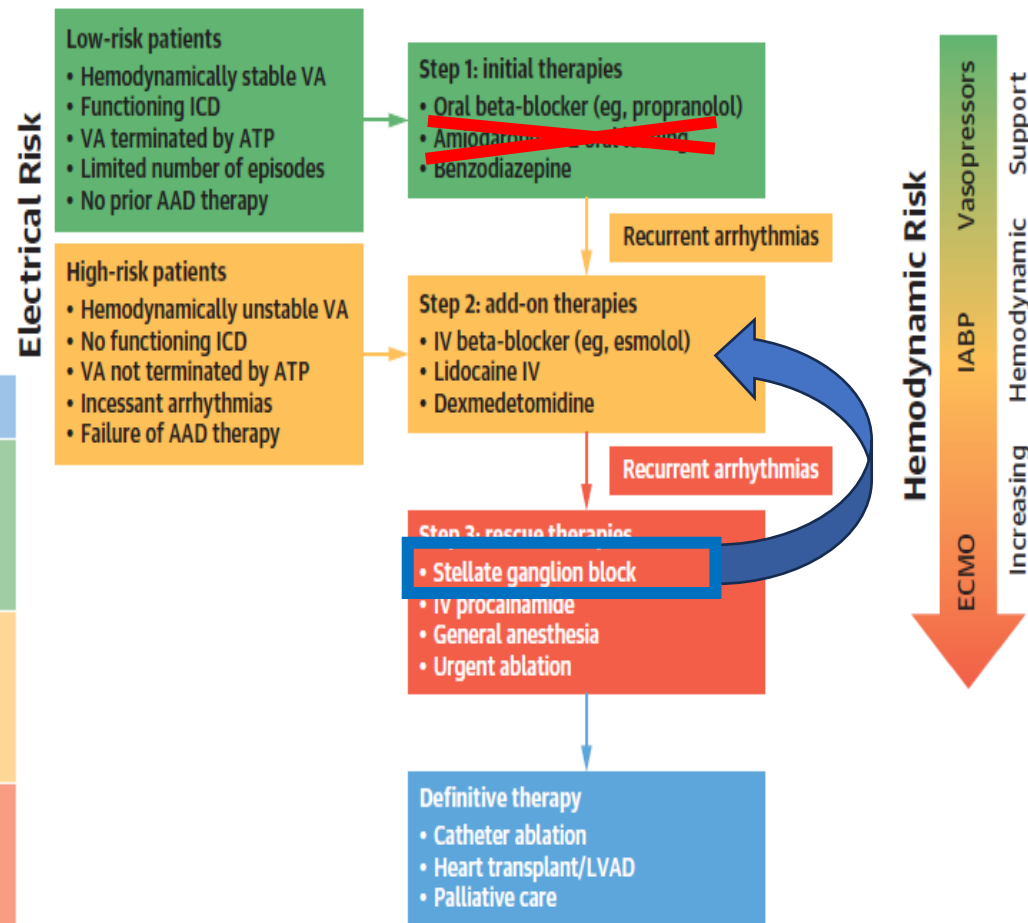
Clinical management of ES: the four pillars

Antiarrhythmic therapy

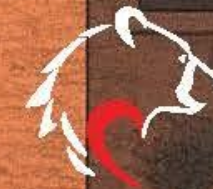
Antiadrenergic therapy

Sedation and anxiolysis

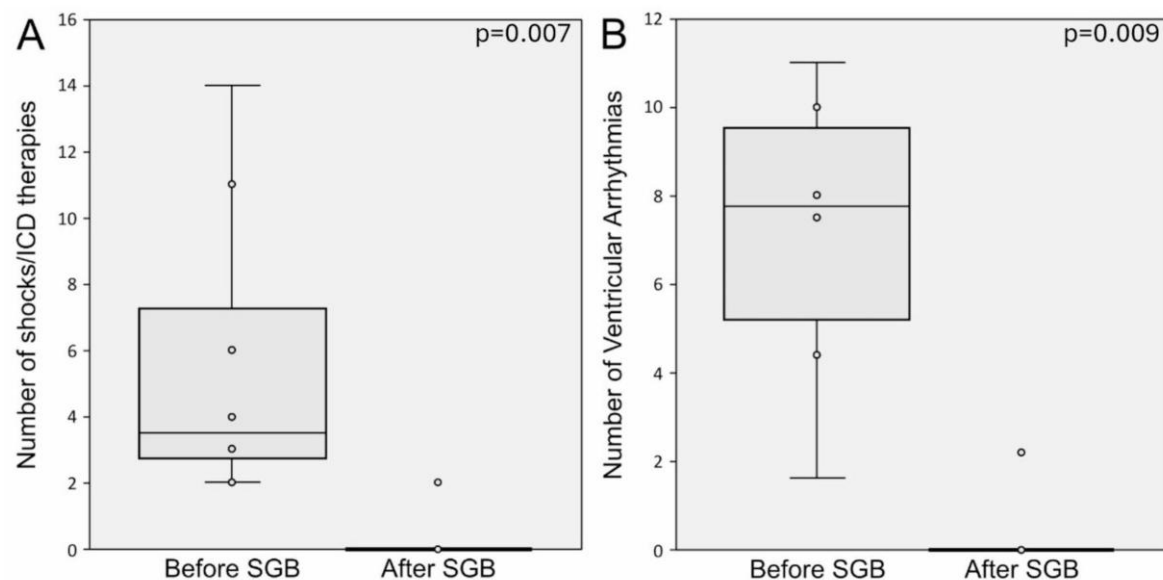
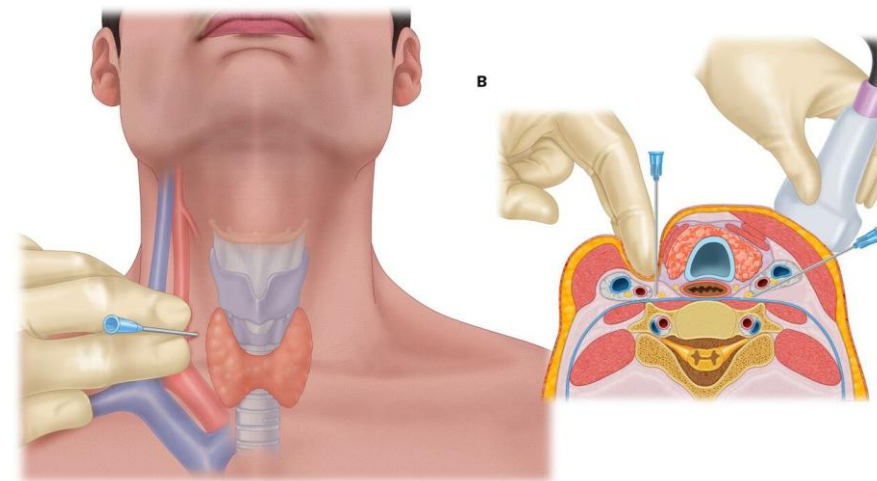
Hemodynamic support



Intensity	Antiarrhythmic Drugs	Adrenergic Blockade	Sedation/Anxiolysis	Hemodynamic Support
Step 1	Amiodarone IV* • Bolus 5-10 mg (max 5 mg/kg) over 20 min • Repeat 150 mg bolus over 10 min for recurrent VA • Infusion 1 mg/min until free from VA ≥ 6 hrs (may continue for longer) • Continue 0.5 mg/min until ES resolves	Oral beta-blocker • Propranolol 20-40 mg Q6h (preferred) • Metoprolol tartrate 25-50 mg Q6h (may be less effective) • May instead increase GDMT beta-blocker (eg, bisoprolol, carvedilol, metoprolol succinate) for selected low-risk patients	Benzodiazepine • Lorazepam 1 mg Q4-6h PRN • Diazepam 5 mg Q4-6h PRN • Midazolam 2 mg Q1-2h PRN	Vasopressors • Phenylephrine 0.1-2.0 µg/kg/min • Vasopressin 0.01-0.04 U/min • Norepinephrine 0.02-0.2 µg/kg/min
Step 2	Lidocaine IV† • Bolus 1-1.5 mg/kg (max 100-120 mg) • May repeat 0.5-0.75 mg/kg Q5-10 min x1-2 doses (max 300 mg or 3 mg/kg) • Infusion 1-2 mg/min (max 4 mg/min) • Goal serum procainamide concentration: 1.5-5 µg/mL	IV beta-blocker • Esmolol • Bolus 0.5 mg/kg (may repeat Q5 min x2) • Infusion 50-300 µg/kg/min • Propranolol 1-3 mg Q5 min (max 5 mg) • Metoprolol 2.5-5 mg Q5 min (max 15 mg)	Dexmedetomidine • Bolus (optional) 0.5-1 µg/kg over 10 min (typically not recommended due to risk of hypotension) • Infusion 0.2-0.7 µg/kg/h (maximum 1.0-1.5 µg/kg/h)	Intra-aortic balloon pump • Contraindicated with aortic aneurysm/dissection, severe aortic insufficiency, or peripheral vascular disease • Less effective with tachycardia or atrial fibrillation
Step 3	Procainamide IV‡ • Bolus 10-15 mg/kg (max 17-20 mg/kg, usually 1 g total) over 30-60 min • Infusion 1-2 mg/min (max 4 mg/min) • Goal serum procainamide concentration: 4-8 µg/mL (up to 10 µg/mL)	Stellate ganglion blockade • Left stellate ganglion blockade • 20 mL of 0.25% bupivacaine without epinephrine • Bilateral blocks if intubated	General anesthesia • Endotracheal intubation • Propofol infusion often used, titrated to RAAS goal of -3 • Opioid typically added (eg, fentanyl infusion)	Advanced MCS • ECMO preferred • Percutaneous LVAD can be considered for selected patients • Contraindicated with severe aortic insufficiency or peripheral vascular disease



Efficacy of stellate ganglion block in treatment of electrical storm: a systematic review and meta-analysis

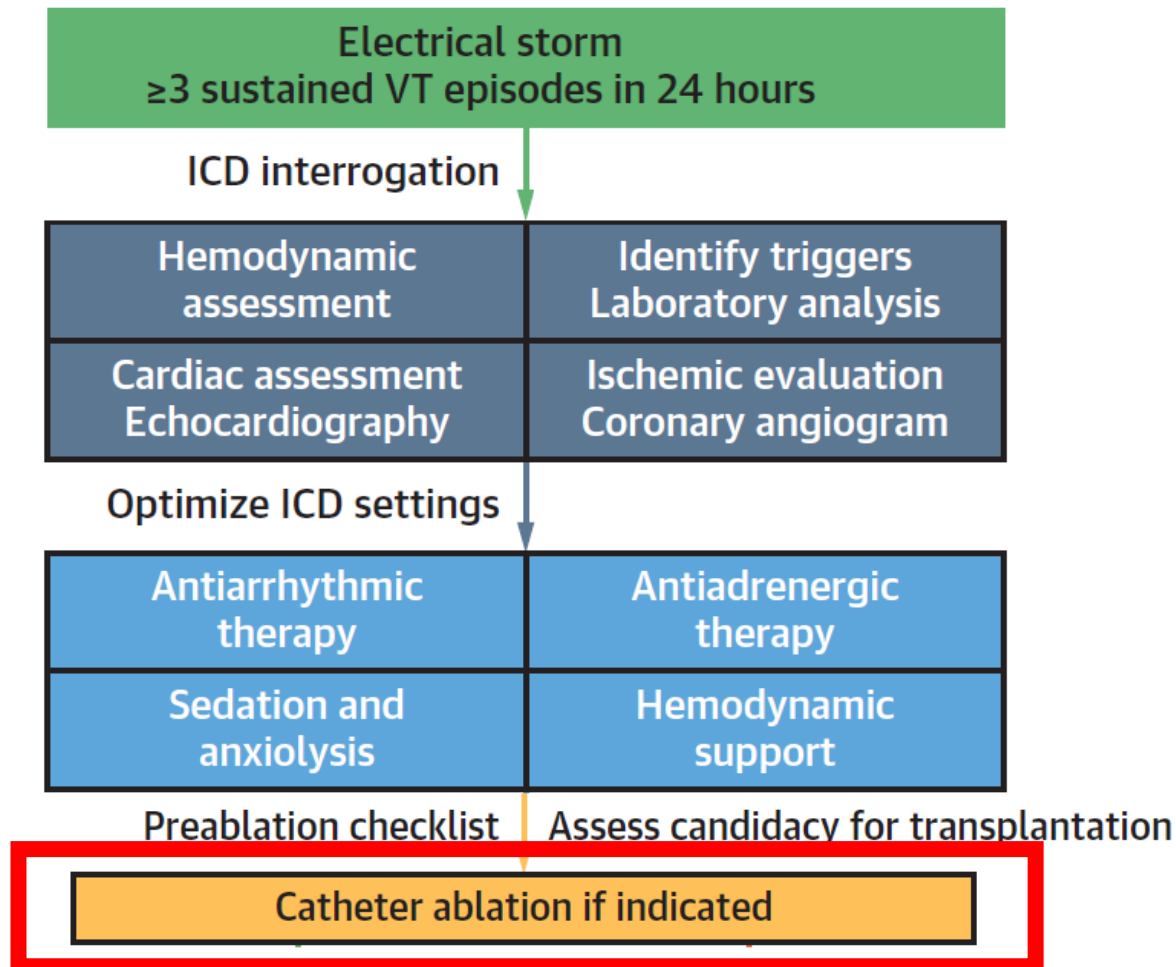


A total of 553 ES episodes in 542 patients from 15 observational studies were included.

- **VAs requiring shock decrease from 3.5 (IQR 2.25–7.25) to 0 (IQR 0–0), $p = 0.007$.**
- **Complete resolution after SGB occurred in 64.6%.**
- **In-hospital/30-day mortality remained high (22%).**

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Catheter ablation is recommended in patients presenting with incessant VT or electrical storm due to SMVT refractory to AADs.^{330,331}

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Catheter ablation should be considered in patients with recurrent episodes of PVT/VF triggered by a similar PVC, non-responsive to medical treatment or coronary revascularization.^{221,332,333}

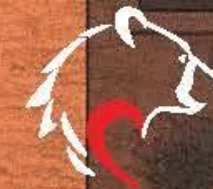
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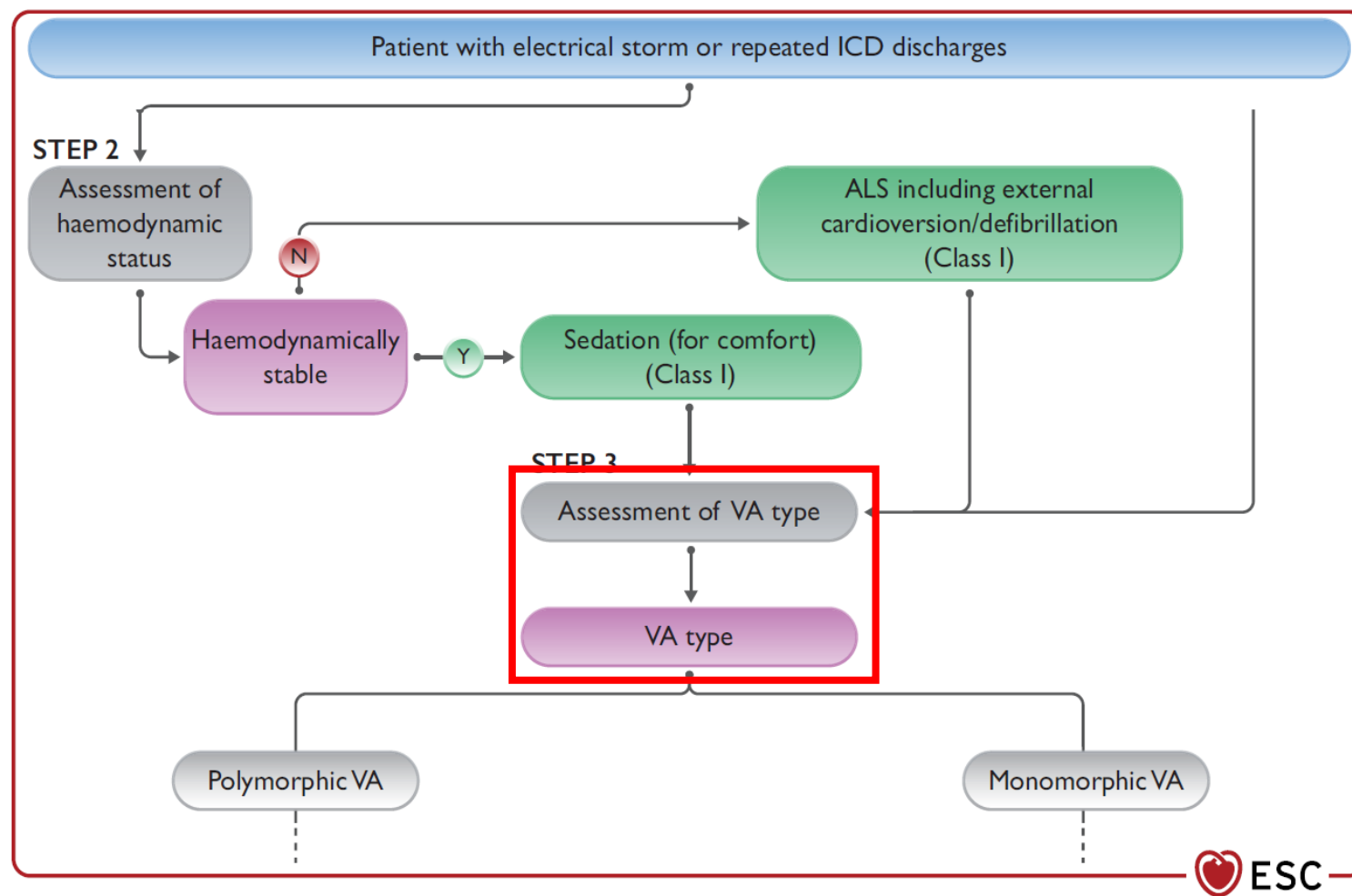
In patients with CAD and recurrent, symptomatic SMVT, or ICD shocks for SMVT despite chronic amiodarone therapy, catheter ablation is recommended in preference to escalating AAD therapy.⁴⁷¹

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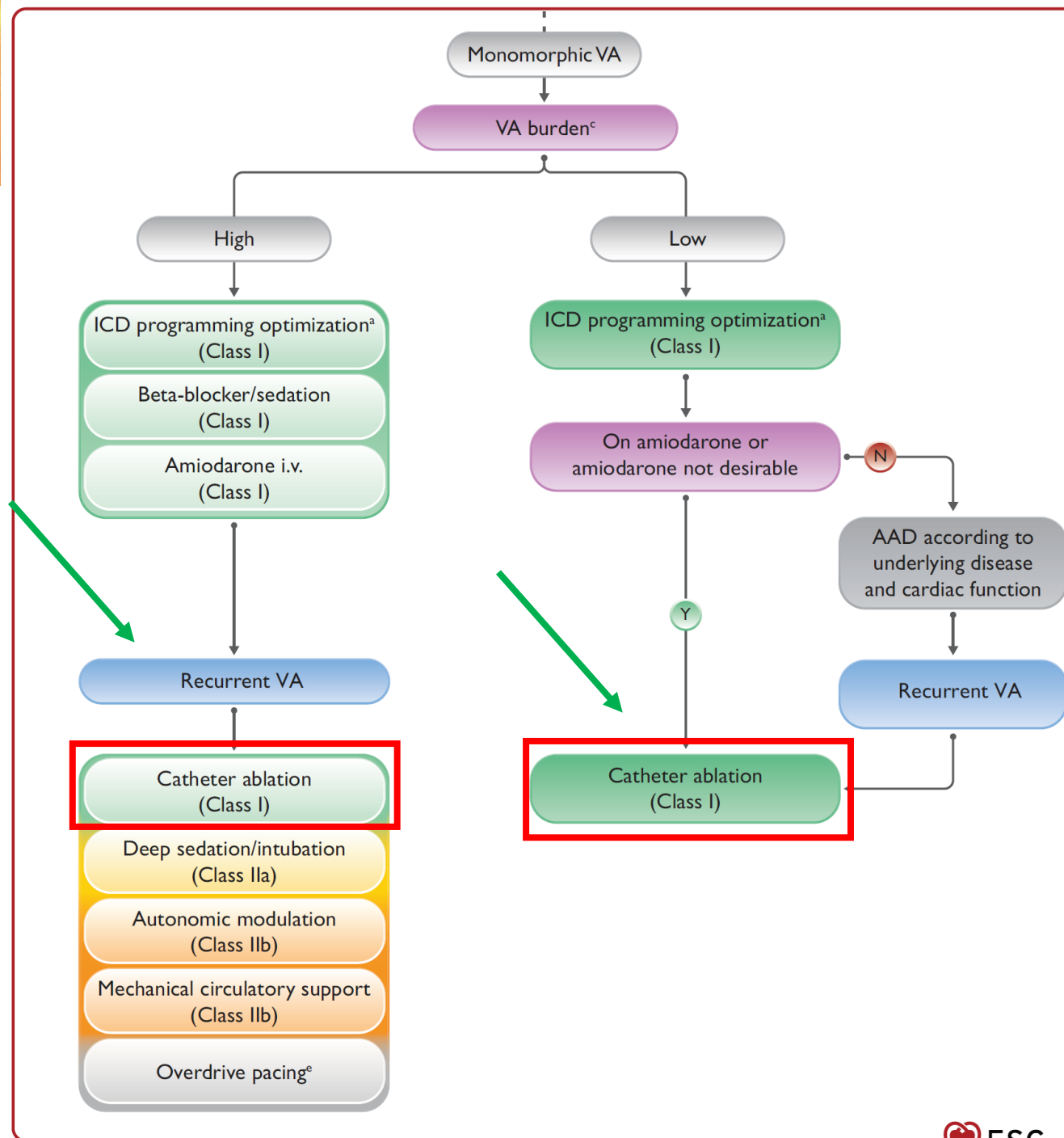
B



Catheter ablation of ES according to VA type



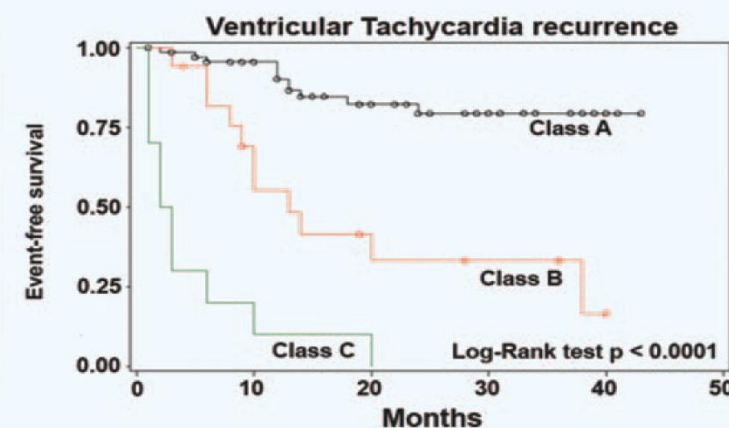
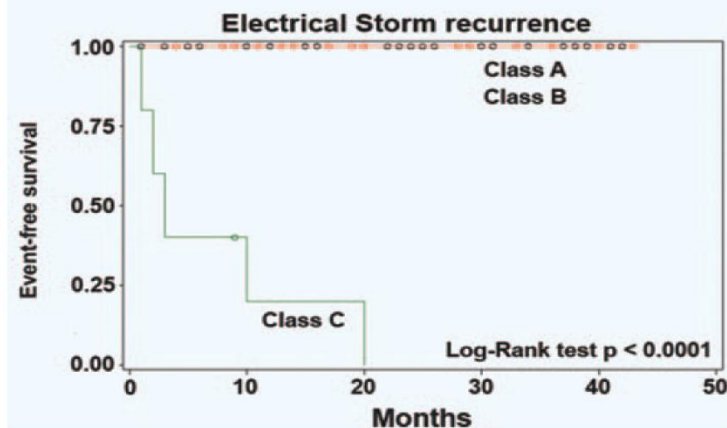
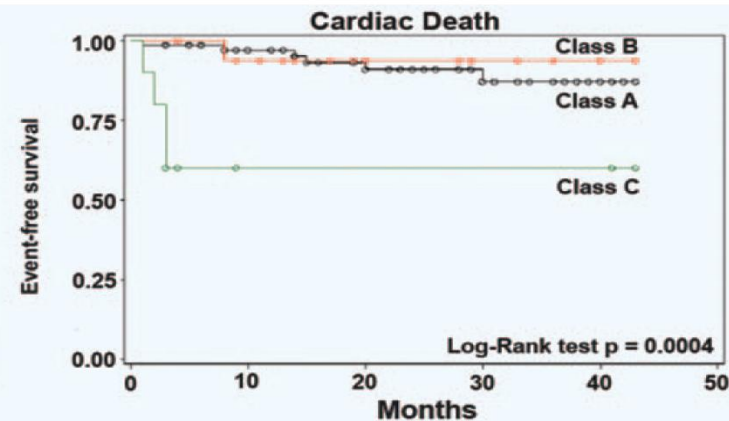
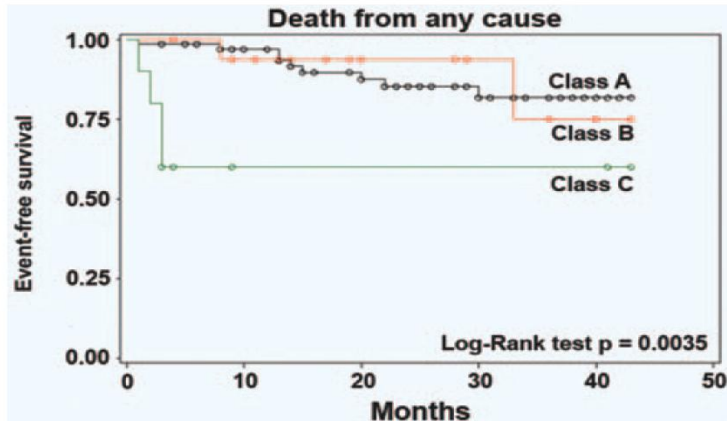
Monomorphic VT





VT ablation in monomorphic VT storm

Class A: CA success Class B: CA partial success Class C: CA failure

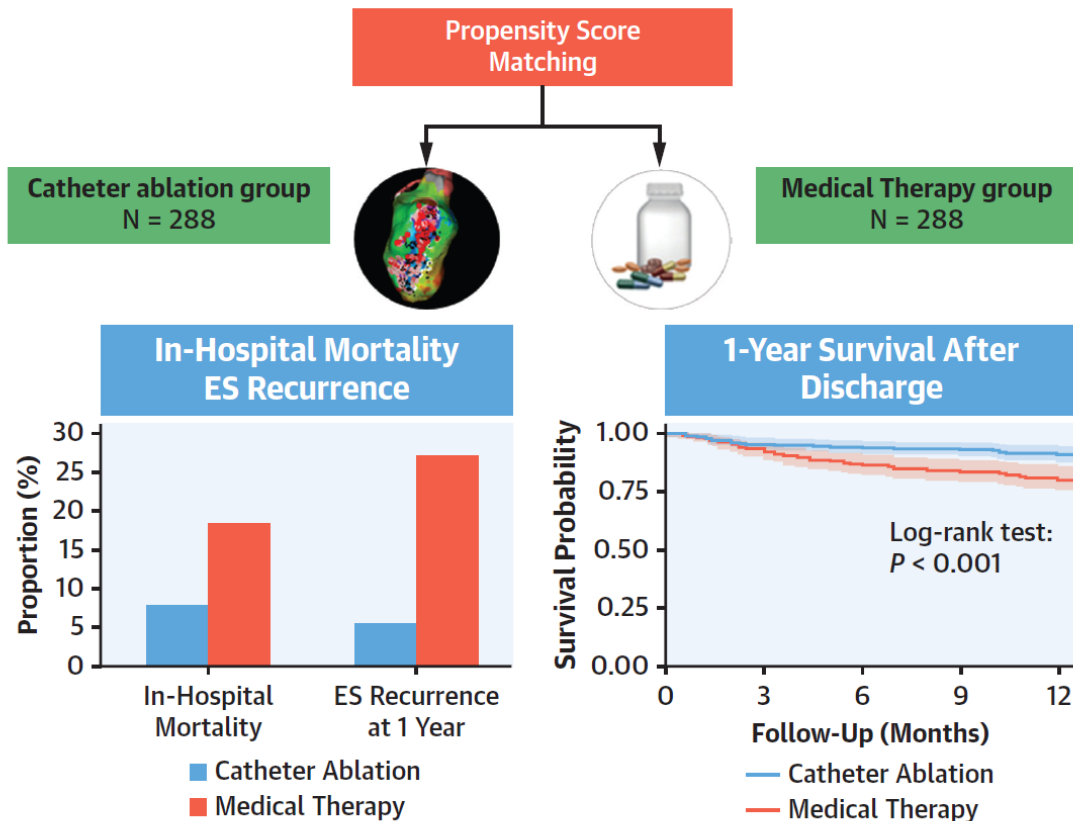


In patients with SHD and drug-refractory VT storm, **catheter ablation is effective in reducing the risk of VT relapse, ICD shocks, ES recurrences**, and could also reduce cardiac mortality and HF hospitalization.

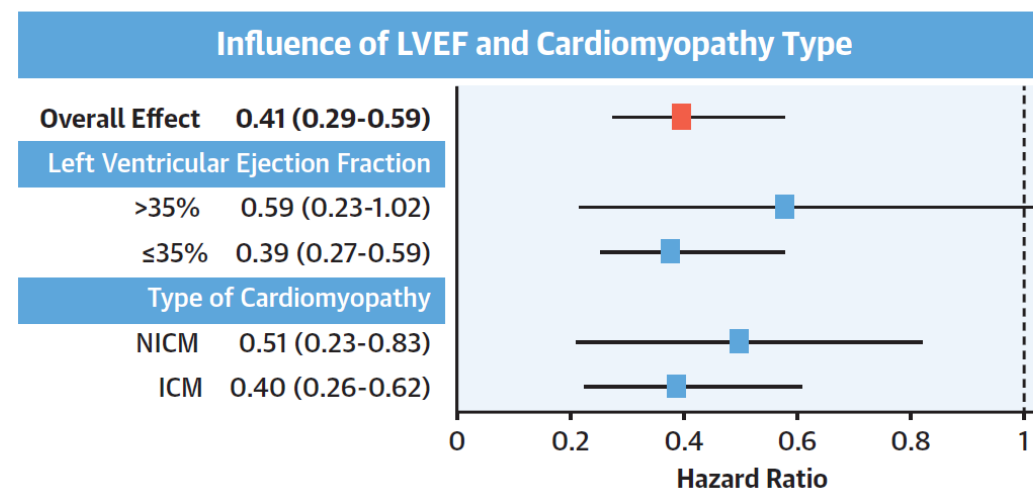


Impact of Catheter Ablation of Electrical Storm on Survival: A Propensity Score-Matched Analysis

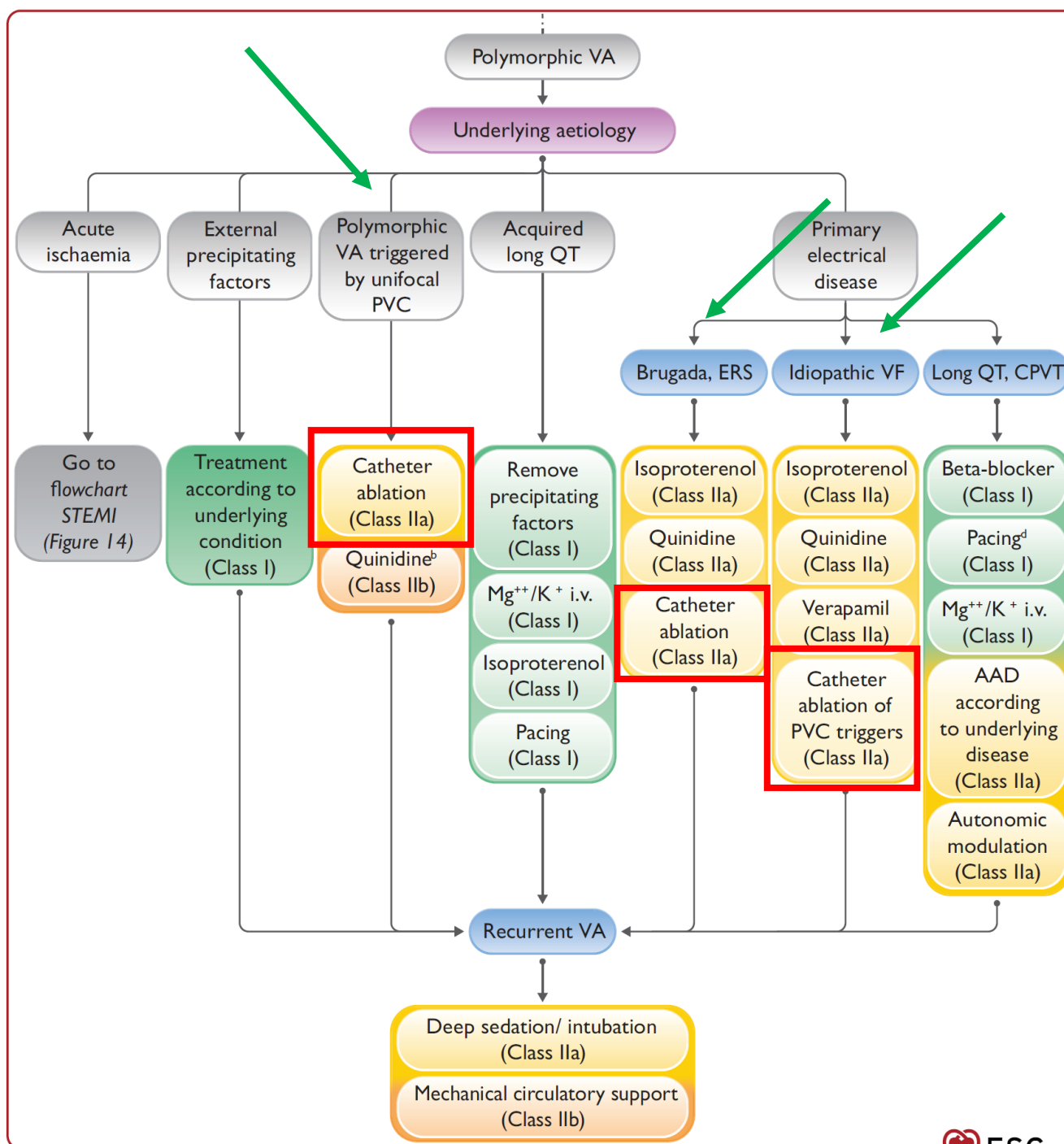
780 patients admitted for ES in the context of SHD in 4 tertiary centers
492 patients treated using medical therapy / 288 patients underwent catheter ablation

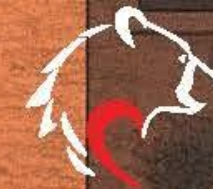


- Catheter ablation was associated with a **59% reduction of death at 1 year.**
- ES recurrence was as an independent predictor of death (HR 2.39, 95% CI 1.51-3.79, $p < 0.001$).



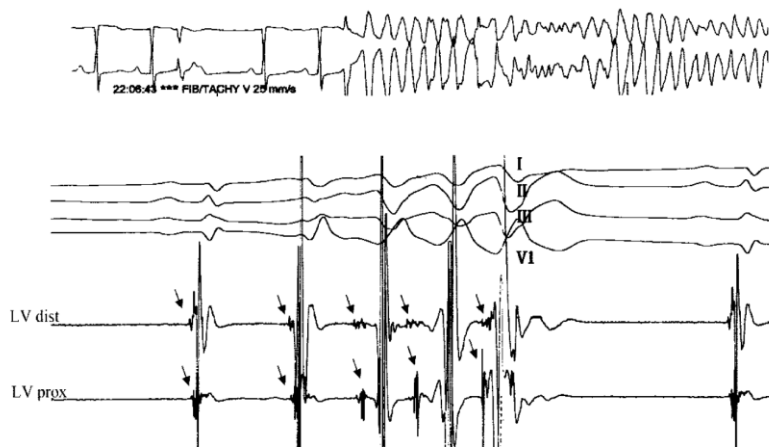
Polymorphic VT





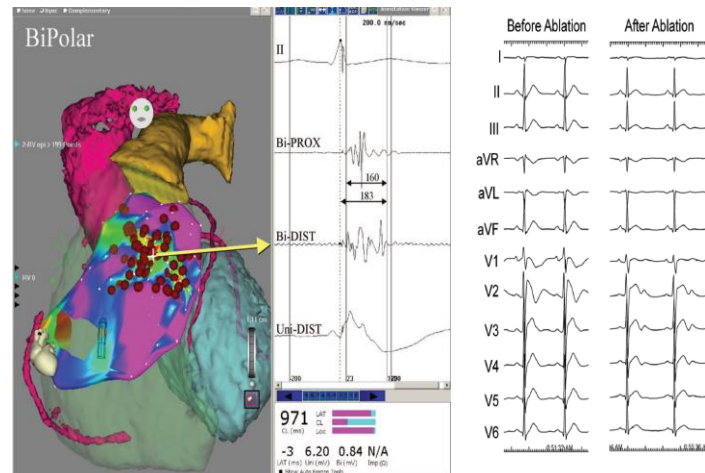
VT ablation in Polymorphic VT storm

Recurrent PVT/VF with similar PVC



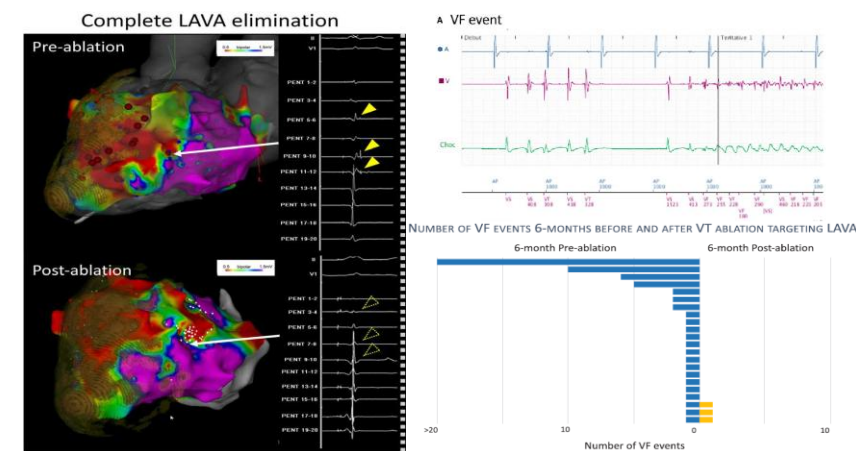
Idiopathic VF is characterized by dominant triggers from the distal Purkinje system. These sources can be eliminated by focal ablation.

BRUGADA syndrome



Ablation over the epicardial RVOT results in normalization of the Brugada ECG pattern and prevents VF recurrency (spontaneously or during EPS).

Structural heart disease

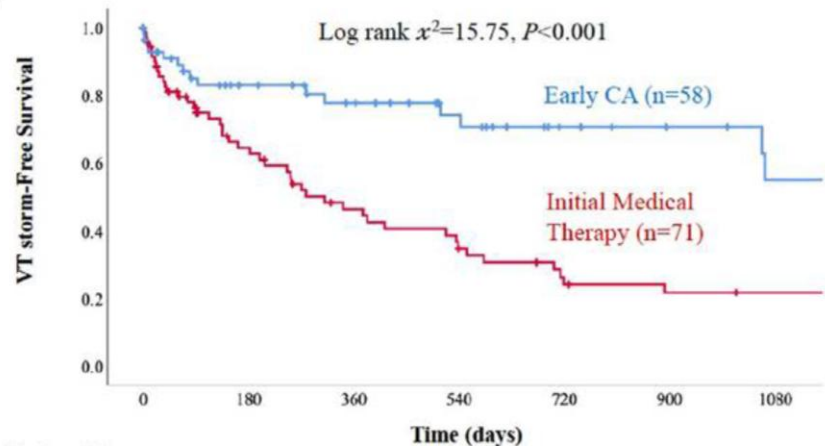
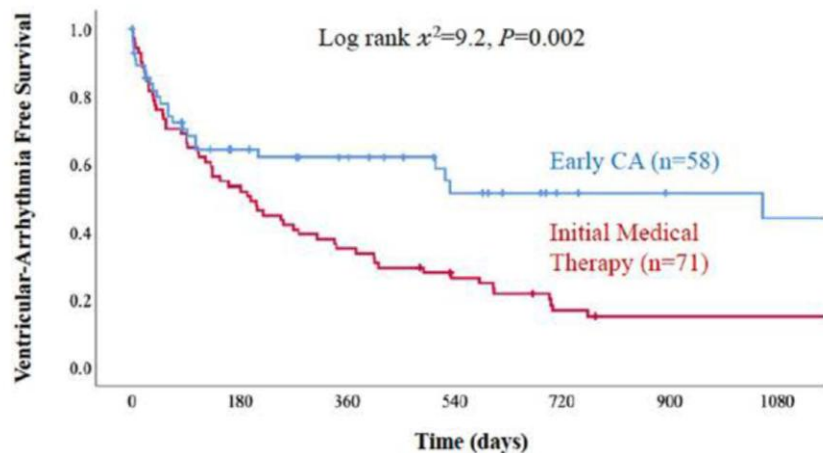


Substrate-guided VT ablation is associated with a highly significant reduction in VF recurrences ($P < 0.0001$), suggesting overlapping arrhythmogenic substrates between VT and VF in SHD patients.

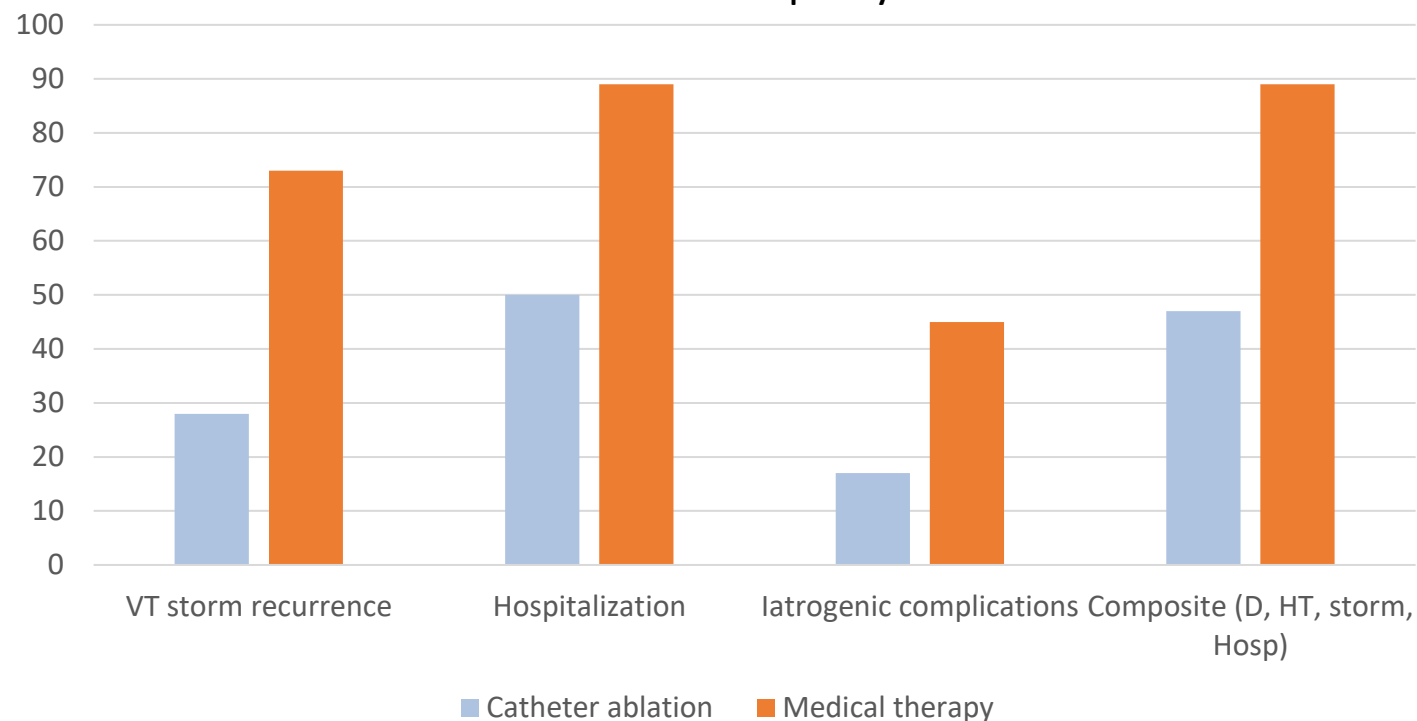


Early catheter ablation vs. initial medical therapy for ES

Early: CA was performed during the index hospitalization with ES storm.

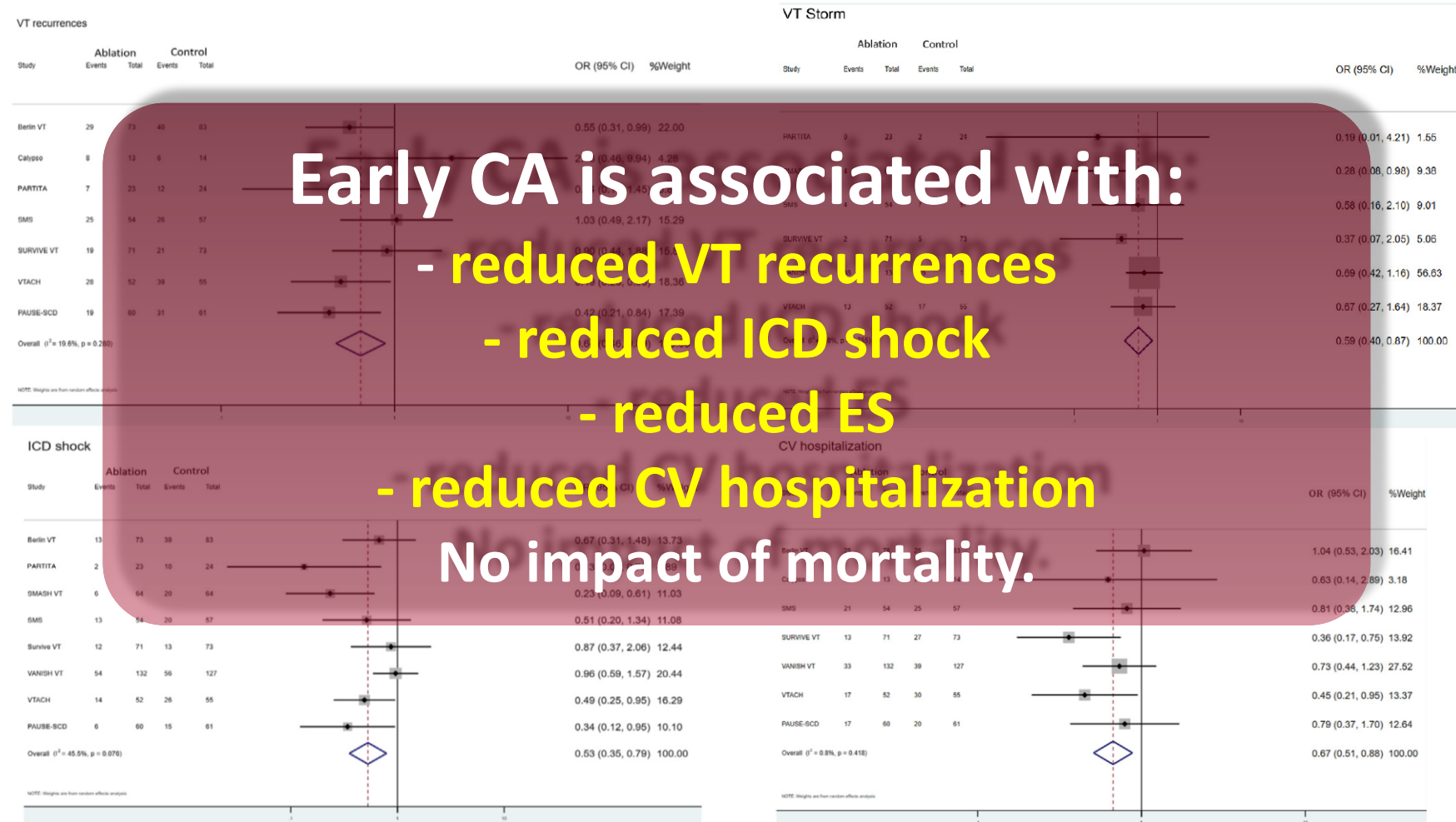


Median follow-up: 2 years





Early VT ablation: a systematic review and meta-analysis of RCTs

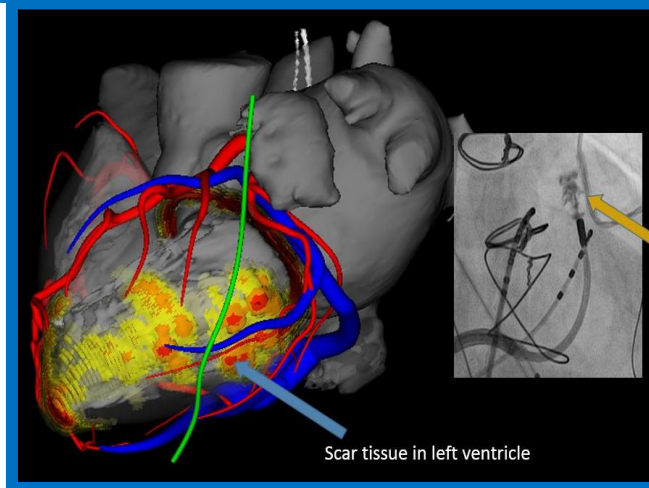




VT ablation vs. Escalation of AADs: The VANISH Trial

- Multicentre, randomized, controlled trial.
- Enrolment: January 2012 – January 2015
- 259 patients, IHD, ICD, at least an episode of VT during AAD therapy, randomly assigned in a 1:1 ratio to:

Catheter ablation (CA + ongoing AAD):
132 patients



Escalated-therapy (increased
amiodarone and mexiletine): 127 pts

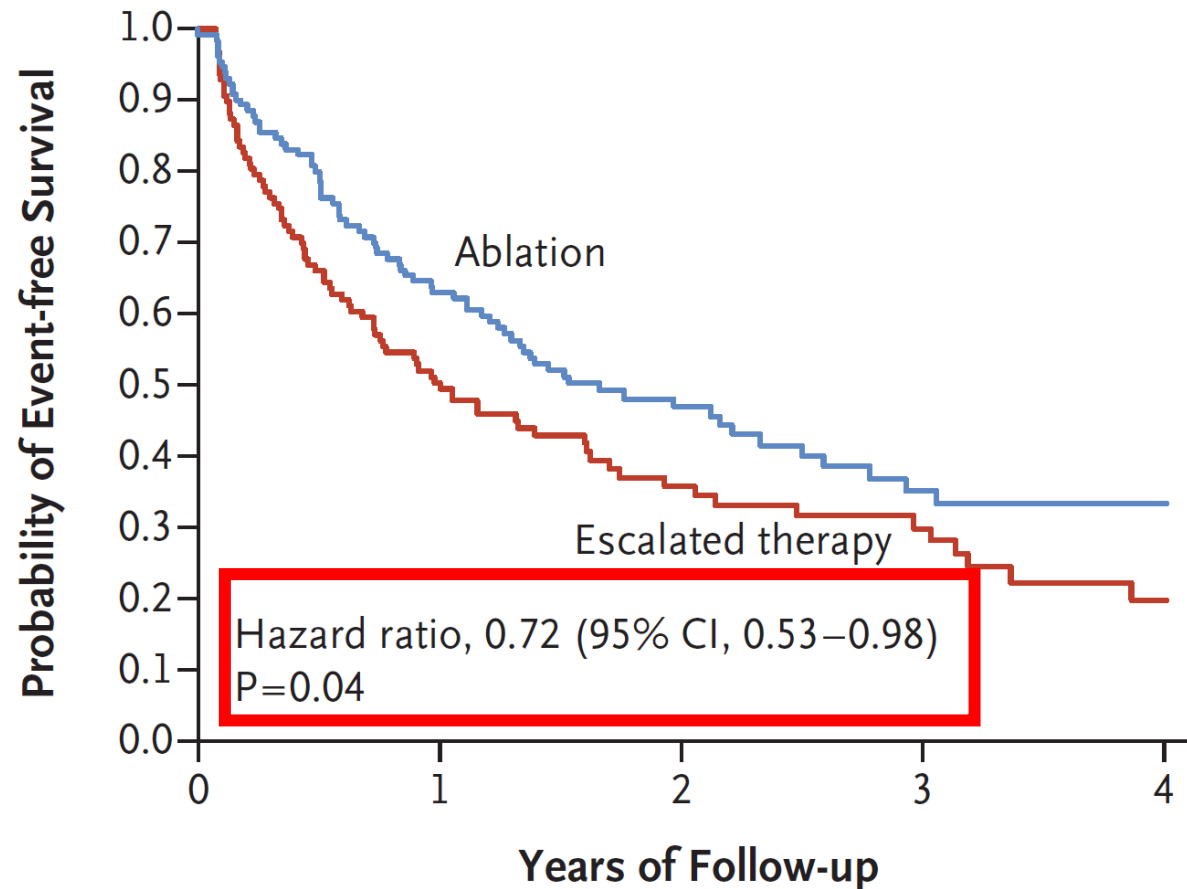


Mean f-up: 28 months

Primary efficacy endpoint:
composite death,
ES, or appropriate
ICD shock.



VT ablation vs. Escalation of AADs: The VANISH Trial



In patients with VT despite AADs, catheter ablation is more effective than AAD escalation in reducing the composite endpoint of death, ES, or appropriate ICD shock.



Conclusions

- ❖ Because CA is not always available, AADs and adrenergic blockade are needed to stabilize the patients during the early phase of ES.
- ❖ In ES and, especially, in incessant drug-refractory VT, CA is a life-saving procedure.
- ❖ Considering that ICD does not prevent VTs and the limited efficacy and tolerability of AADs, the long-term control of ES and VTs is primary driven by CA.
- ❖ Early CA is more effective than AAD in reducing VA burden, ICD therapies, CV hospitalization, ES recurrence, and mortality.