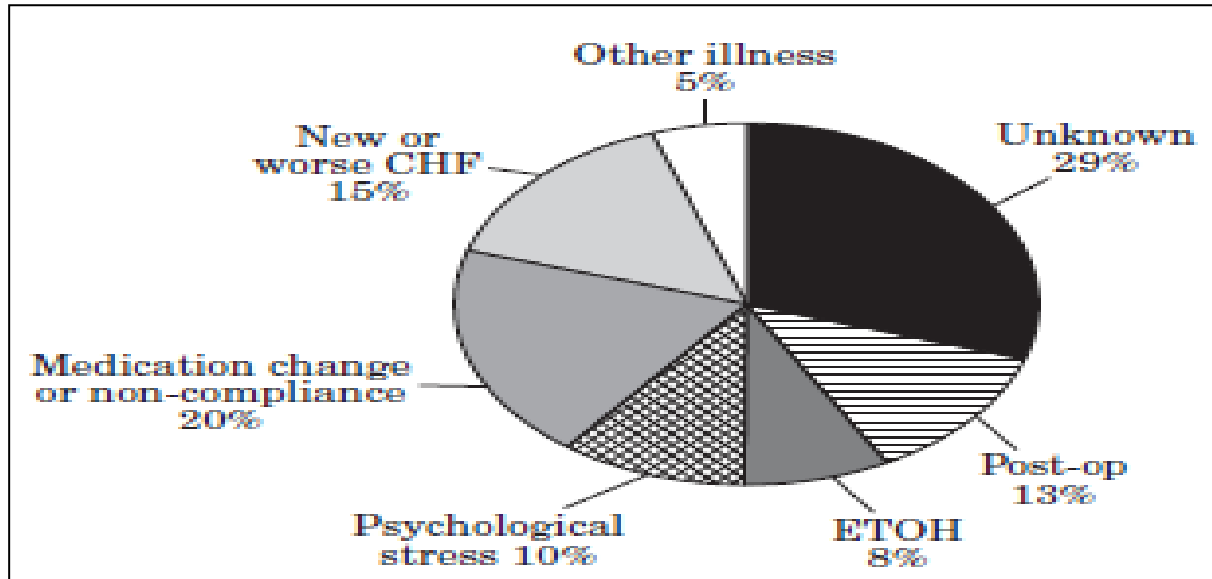


Orage rythmique réfractaire à l'ablation conventionnelle

P Maury, CHU Toulouse

L'orage rythmique



• Greene Europace 2000

Table 1 Reversible causes of electrical storm < 10%

Acute myocardial ischemia
Electrolyte imbalances
Decompensated heart failure
Hyperthyroidism
Infections, fever
Pro-arrhythmic drug Effects
Early postoperative period

Muser D, et al. 2017

Predictive factors

VT ^{1,2} or VF ⁴ indication for ICD

LVEF < 25% ^{2,3}

Chronic renal failure ²

QRS \geq 120 msec ³

Lack of beta-blocker ³

Digoxin use

Ischemic heart disease ⁴

1. Exner et al. Circ 2001
2. Brigadeau et al. EHJ 2005
3. Arya et al. AJC 2006
4. Verma et al. JCE 2004

Choix stratégiques orage rythmique



trigger

AA drugs

standard reanimation
sedation

Pacing ?

Ablation

Hemodynamical support
(ECMO)

Sympathetic blockade ?

Renal denervation ?

Transplantation ???

Management of electrical storm

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

I

C

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

I

B

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

I

B

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

IIa

C

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}

IIa

C

Quinidine may be considered in patients with CAD and electrical storm due to recurrent PVT when other AAD therapy fails.^{323,324}

IIb

C

2022 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death

Autonomic modulation may be considered in patients with electrical storm refractory to drug treatment and in whom catheter ablation is ineffective or not possible.^{326,328,340}

IIb

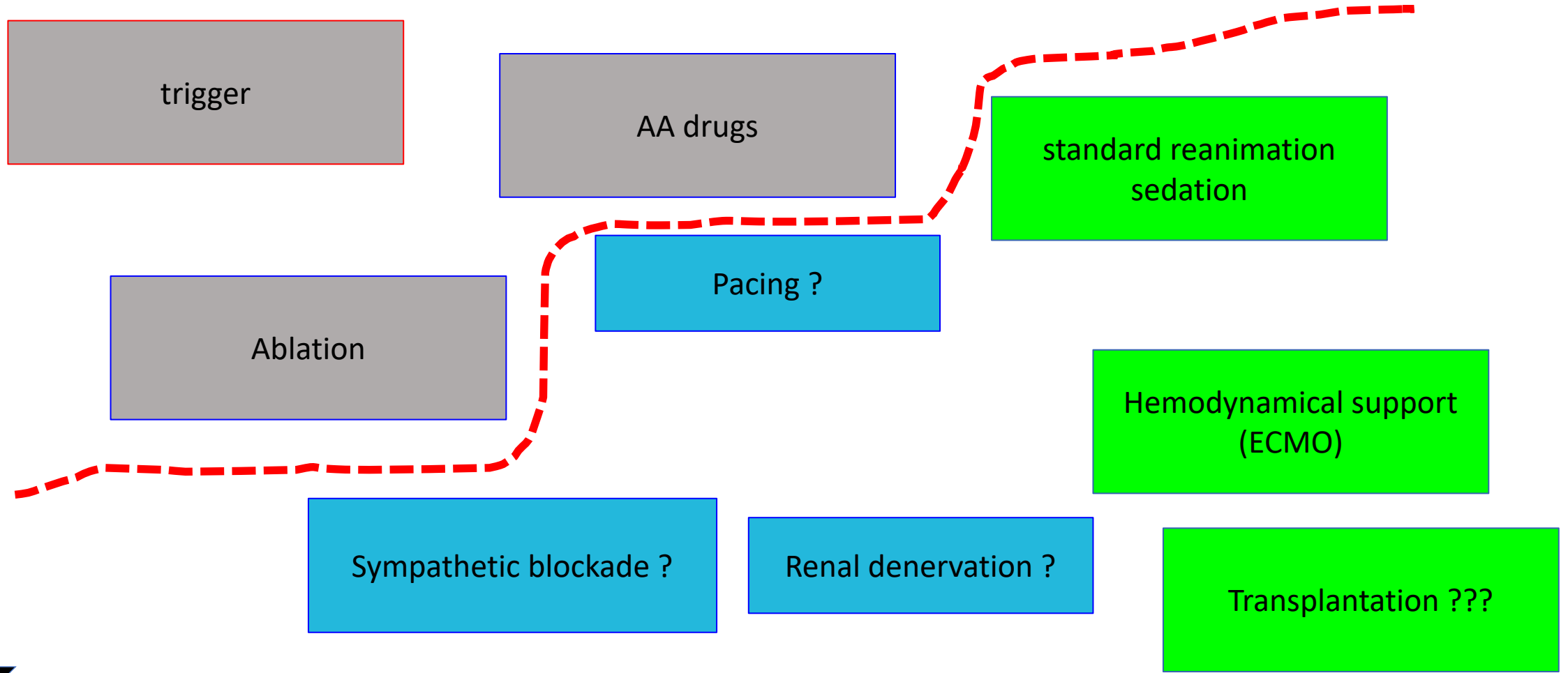
C

Institution of mechanical circulatory support may be considered in the management of drug-refractory electrical storm and cardiogenic shock.³³⁵

IIb

C

Choix stratégiques orage rythmique



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

R Martins, et al. Circulation. 2020;142:1599-1601.

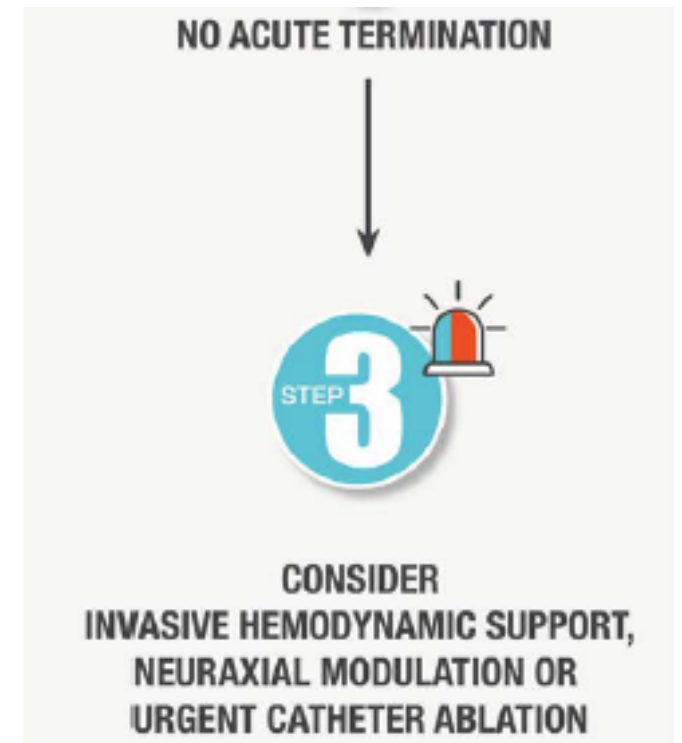
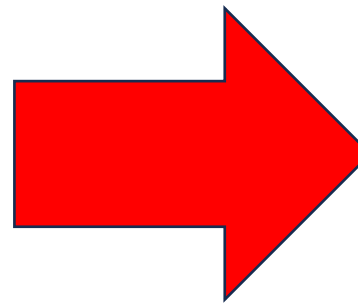
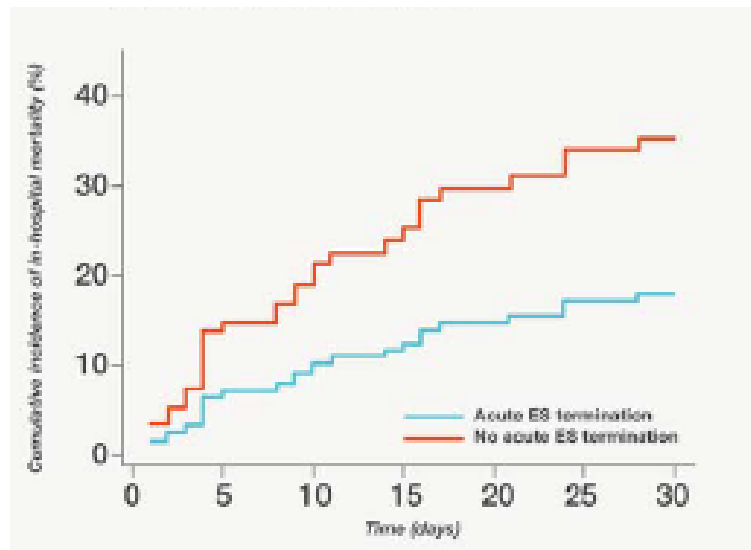
116 patients (74% ischemic cardiomyopathy)

LVEF 25%

8 (4 -14) chocs dans les dernières heures

Median 2 antiarrhythmic drugs administered after ES onset (amiodarone 82%; lidocaine 44%, BB 41%)

47%: *arret orage en 15 minutes apres intubation-sedation profonde*



51 patients with post-MI arrhythmic storm
Arrhythmic storm 8 days after MI diagnosis.

Pacing rate ~40% above baseline rate, and gradually increased until PVC/VA disappearance.

Mean overdrive pacing rate was 94.5 ± 9.3 bpm maintained for 5.0 [3-8] days



Number of shocks after overdrive pacing onset was significantly reduced, (7 [4; 15] vs. 0 [0; 1]; $P < .0001$).
Overdrive pacing effectively suppressed recurrent arrhythmias, with no on-treatment recurrence in 47 patients (92%).

Twenty-one patients (41%) had VA recurrence during pacing weaning attempts (14 ablations)

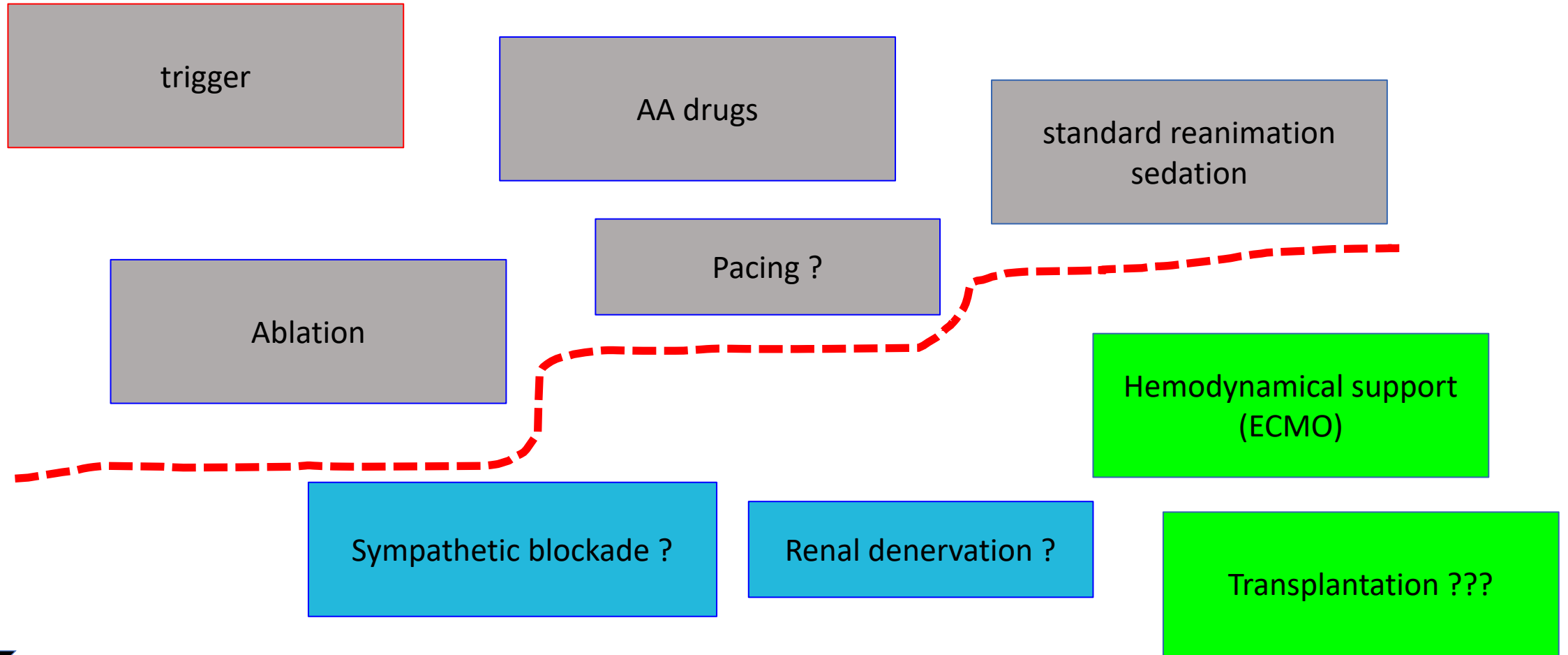
**Solution d'attente
parfois/souvent orage régressif**

Overdrive pacing for ventricular fibrillation storm after myocardial infarction

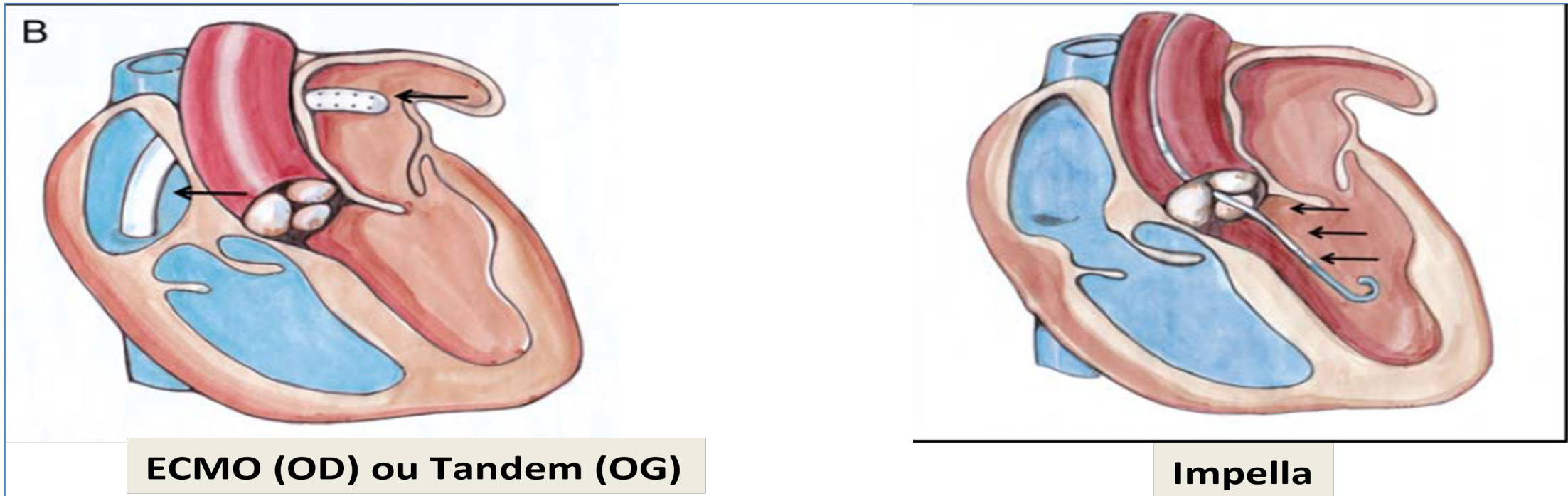
Jan Charton ^{1,2,*}, Xavier Bouteiller ^{1,2}, Estelle Gandjakhch ³,
Xavier Waintraub ³, Cedric Klein⁴, Philippe Maury ⁵, Pierre Baudinaud ⁶,
Eloi Marijon ⁶, Romain Tixier ^{1,2}, Thomas Baudinet ^{1,2}, Frederic Sacher ^{1,2},
Mélèze Hocini ^{1,2}, Michel Haïssaguerre ^{1,2}, and Josselin Duchateau ^{1,2}

European Heart Journal (2024) 45, 4968–4970

Choix stratégiques orage rythmique



Need for mechanical assistance ?



A few study, a few patients, no randomisation

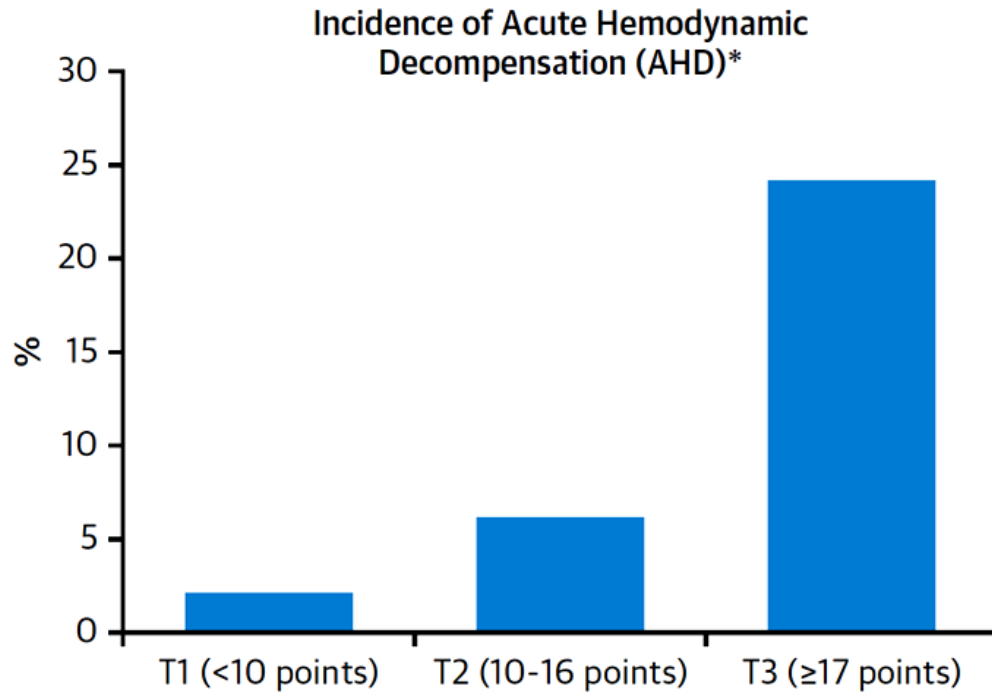
- No more complications
- Allows mapping during VT et RF more complete
- Mortality and recurrences high and unchanged (intractable heart failure)
but more diseased patients

Poor pronosis as a rescue, better if planned

Impella 2.5 less efficient
Risk of magnet interaction

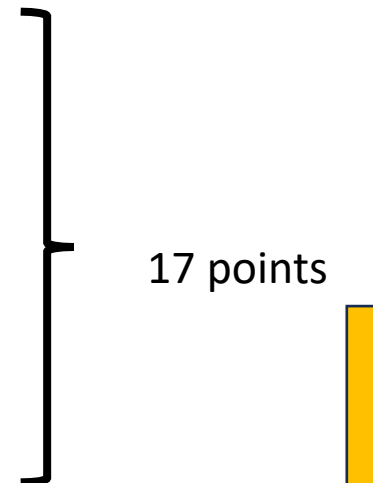
FIGURE 2 Risk Score to Predict Periprocedural AHD

Predictors of AHD - PAINESD Score
N = 193 patients w/ scar-related VT



*Sustained hypotension (SBP <80-90 mm Hg) despite increasing doses of vasopressors and requiring mechanical hemodynamic support or procedure discontinuation.

PAINESD RISK SCORE	
VARIABLE	SCORE
Pulmonary disease [chronic obstructive] - COPD	5
Age >60 years	3
Anesthesia [general]	4
Ischemic cardiomyopathy	6
NYHA class III or IV	6
Ejection fraction <25%	3
Storm [VT]	5
Diabetes mellitus	3



PAINESD risk score		Risk Category	
Variable	Score		
Pulmonary disease (chronic obstructive)	5	Low risk	≤ 8
Age > 60 yr	3		
Ischemic cardiomyopathy	6	Intermediate risk	9-14
NYHA class III or IV	6		
Ejection fraction < 25%	3		
Storm (VT)	5	High risk	≥ 15
Diabetes mellitus	3		

Méta-analyses les plus récentes

year	patients	LVAD	Acute success	VA recurrence	Short term mortality	Transplantation LVAD	complications
Mariani 2021	5 études / 400 pts	Impella/Tandem	NS	NS	p=0.07	–	bleeding
Luni 2019	9 études / 2573pts	Impella/Tandem/ ECMO	NS	NS	NS	NS	more
Turagam 2019	5 études/2026 pts	????	p=0.07	NS	NS	–	more

Mariani S. *Artif Organs*. 2021;45:987-997

Luni FK. *J Cardiovasc Electrophysiol*. 2019;30:886-895.

Turagam MK. *J Interv Card Electrophysiol*. 2019;55:197-205

The STORM-ECMO Study (unpublished)

multicenter cohort of 318 patients supported with V-A ECMO for ES-related refractory cardiogenic shock,

ablation associated with a significantly higher probability of successful ECMO weaning
magnitude of benefit was greatest when ablation was performed early (\leq Day 4 after cannulation)

Choix stratégiques orage rythmique

trigger

AA drugs

standard reanimation
sedation

Ablation

Pacing ?

Hemodynamical support
(ECMO)

Sympathetic blockade ?

Renal denervation ?

Transplantation ???



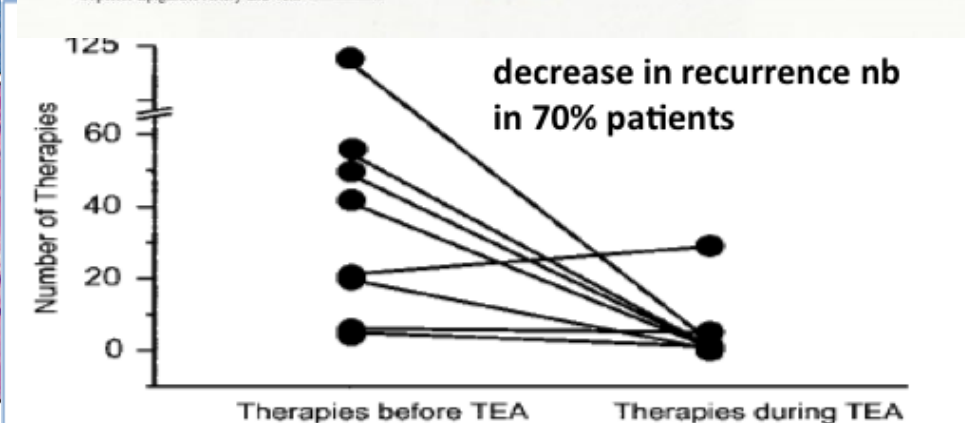
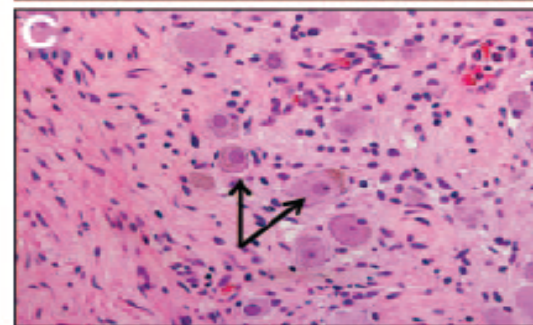
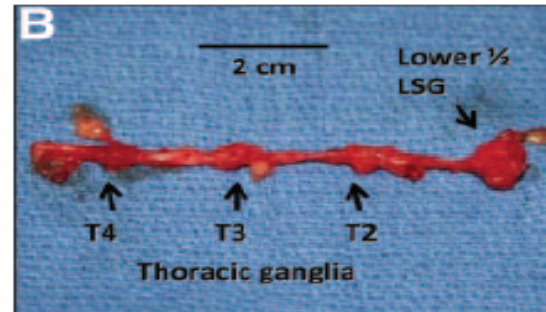
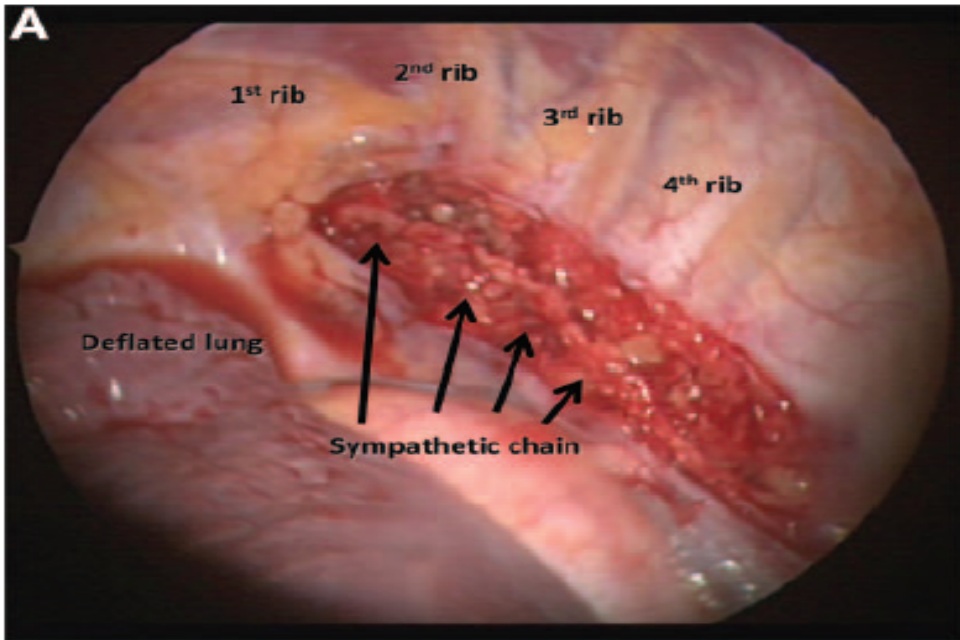
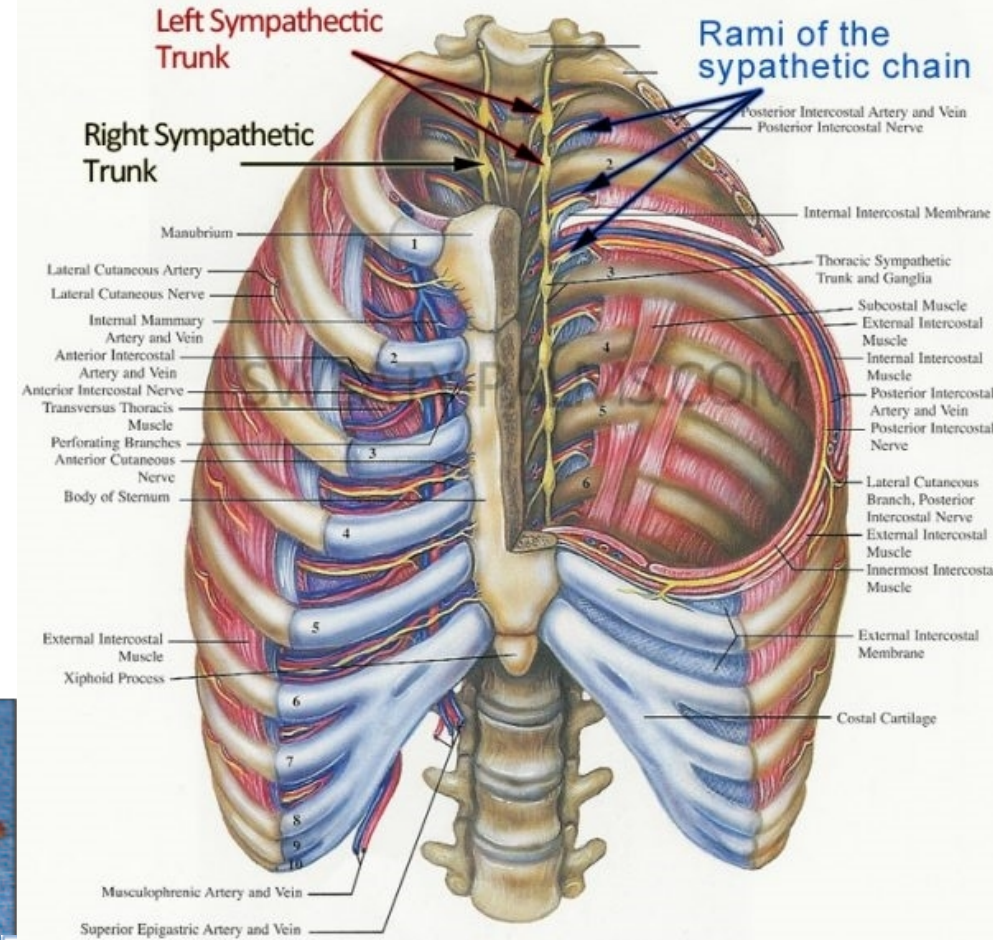
Sympathetic denervation

Neuraxial Modulation for Refractory Ventricular Arrhythmias

Value of Thoracic Epidural Anesthesia and Surgical Left Cardiac Sympathetic Denervation

Tara Bourke, MD; Marmar Vaseghi, MD; Yoav Michowitz, MD; Vineet Sankhla, MD; Mandar Shah, MD; Nalla Swapna, MD; Noel G. Boyle, MD, PhD; Aman Mahajan, MD, PhD; Calambur Narasimhan, MD, DM; Yash Lokhandwala, MD, DM; Kalyanam Shivkumar, MD, PhD

(Circulation. 2010;121:2255-2262.)



Sympathetic denervation

Cardiac sympathetic denervation in patients with refractory ventricular arrhythmias or electrical storm: Intermediate and long-term follow-up

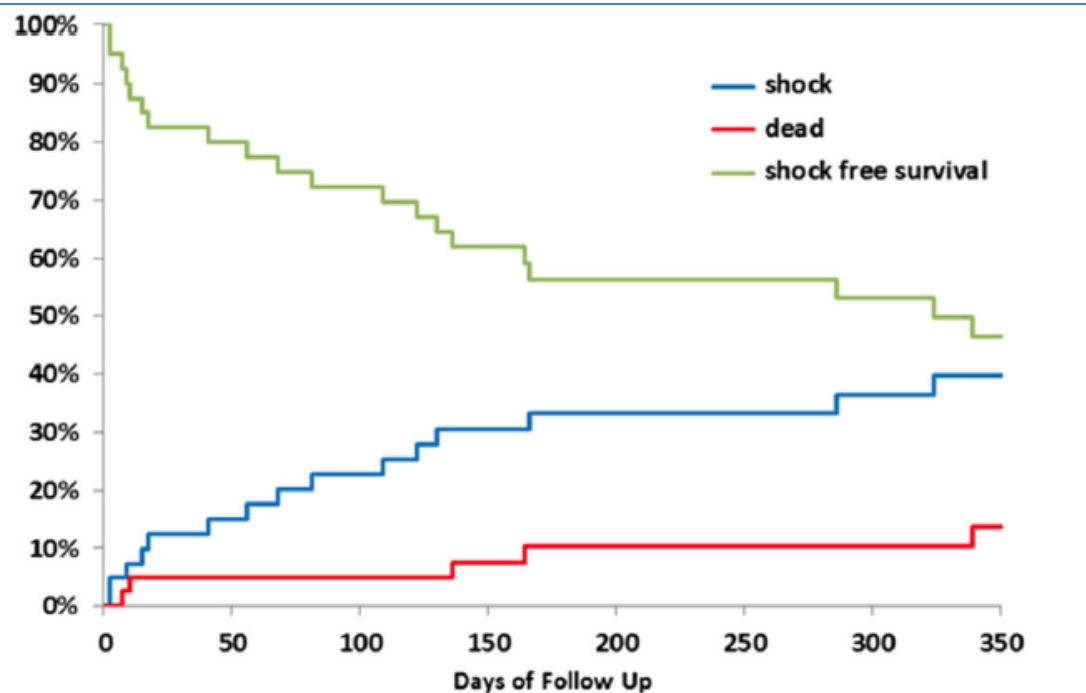
Marmar Vaseghi, MD, MS^{*}, Jean Gima, RN, MSN, NP^{*}, Christopher Kanaan, BS^{*}, Olujimi A. Ajijola, MD, PhD[†], Alexander Marmureanu, MD^{†,‡}, Aman Mahajan, MD, PhD^{†,‡}, and Kalyanam Shivkumar, MD, PhD, FHRS^{*}

Heart Rhythm. 2014 March ; 11(3): 360–366.

41 pts ES/recurring VT
+ structural heart disease
+ after ablation failure

stelloctomy inf + T2-T4

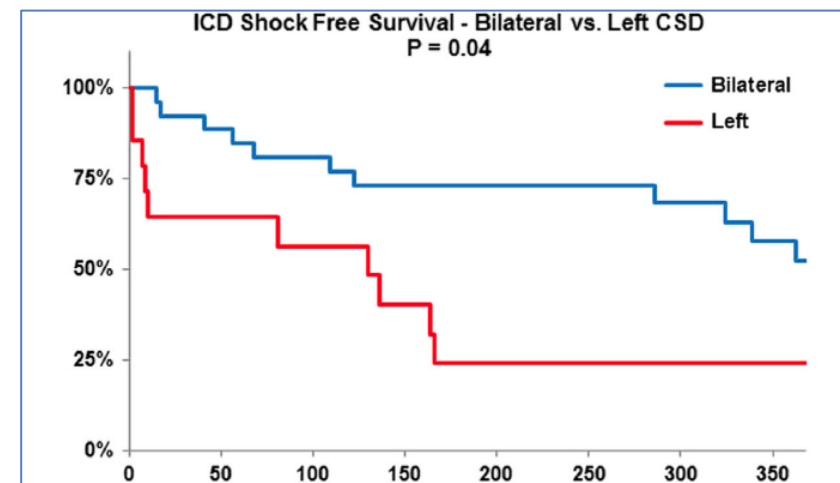
Surgical experience +++
(Claude Bernard Horner syndrome)



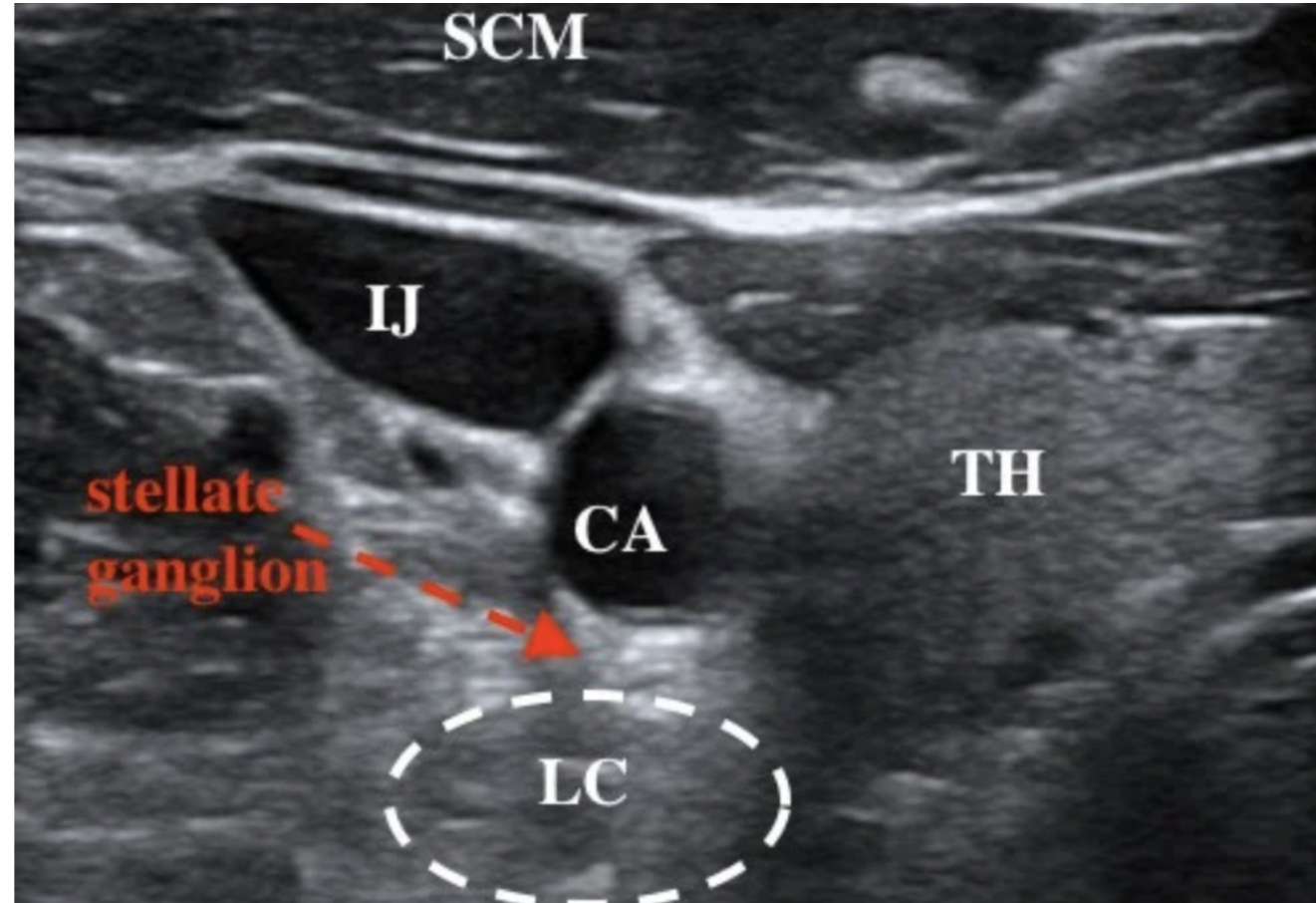
50% arrhythmia recurrence-free

41% mortality

90% ICD shock reduction in 90% patients



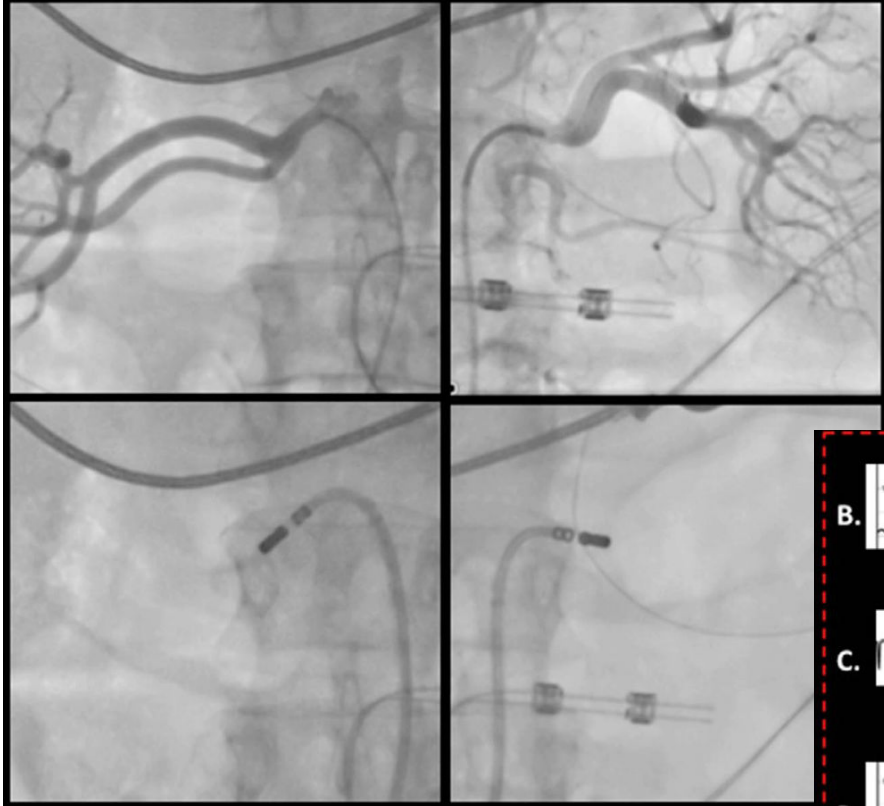
blochage percutané ganglion stellaire (G)



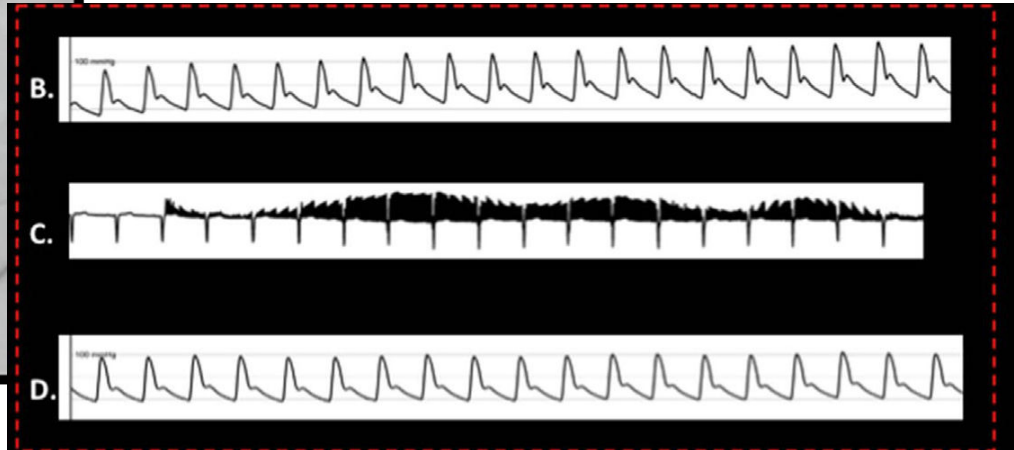
Plus adapté a l'urgence, CI si anticoagulation, peut prévoir l'efficacité de la sympathctomie

Pas forcément efficace !

Renal denervation



13 pts with SHD and refractory VT
85% success at 3 months
Ukena C. Clin Res Cardiol. 2016;105:873-9.



Renal denervation for refractory ventricular arrhythmias

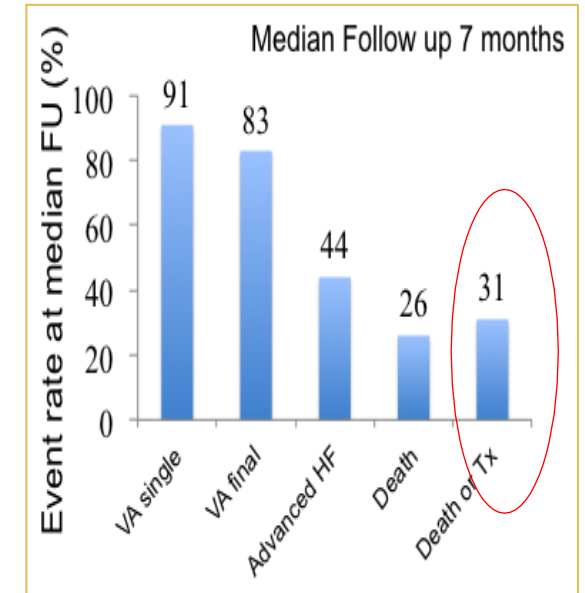
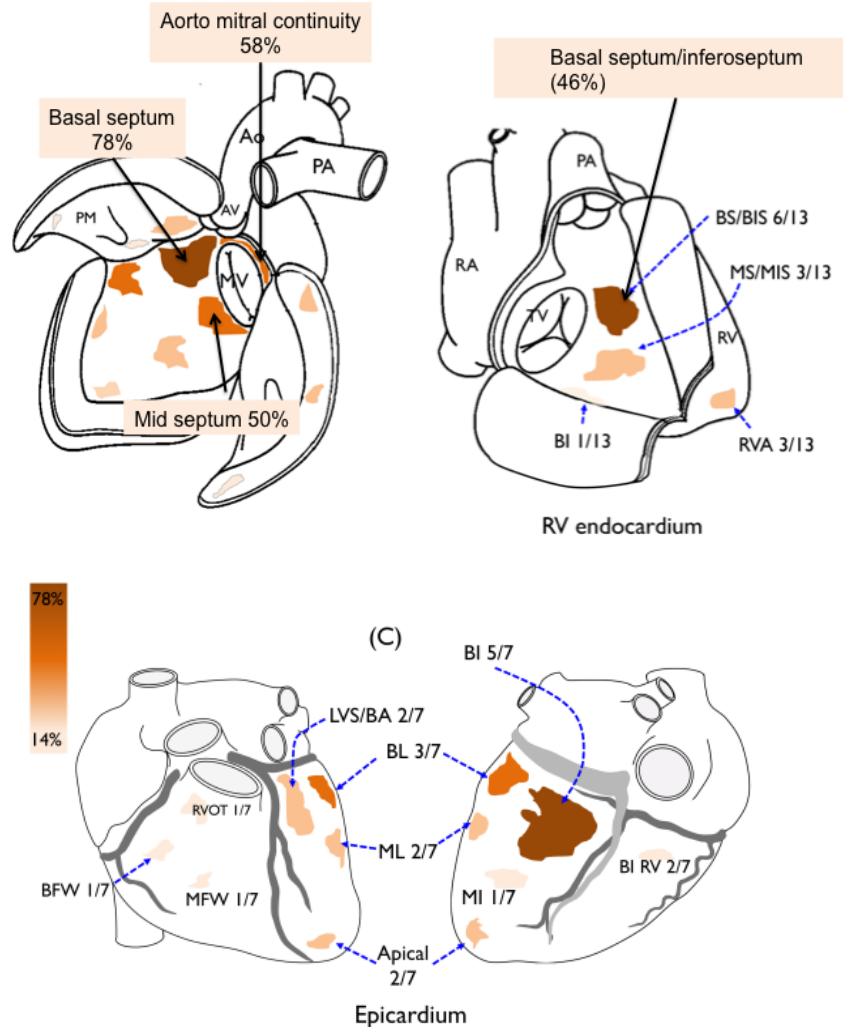
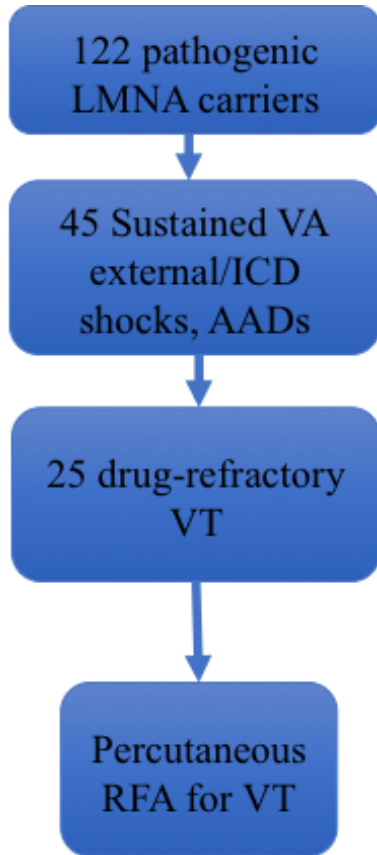
Trends Cardiovasc Med. 2014 July ; 24(5): 206–213.

Jason S. Bradfield, Marmar Vaseghi, and Kalyanam Shivkumar*

Need for urgent transplantation ?

*No !!!! Wait acute results please ...
Maybe except for LMNA mutations ?*

Mean LVEF $34 \pm 12\%$
VT storm in 36%
47 procedures (1-4)



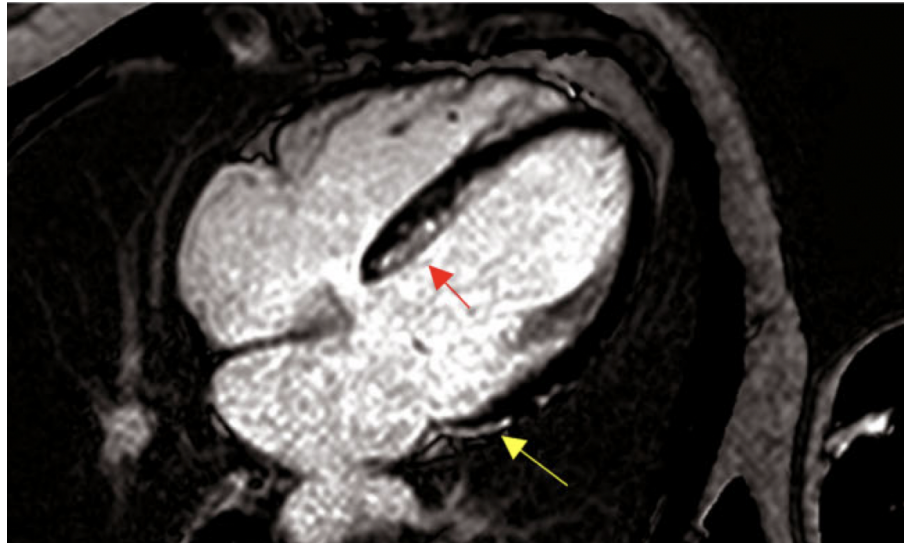
**Harbinger of end stage HF
Consider early transplant**

Phospholamban ?

RBM20 ?

Filamin C

Eur Heart J Case Rep 2021 22;5:ytab422



Un seul cas rapporté ablation endo/epi

Qq uns dans notre experience, a priori OK

ICD implantation should be considered in DCM/ HNDCM patients with a LVEF <50% and ≥ 2 risk factors (syncope, LGE on CMR, inducible SMVT at PES, pathogenic mutations in *LMNA*,^d *PLN*, *FLNC*, and *RBM20* genes).

IIa

C

titine

15 patients over 6 years

FEVG 30%

4 pst BAV, 1/2 tr cond intra V

LGE 85% (mid myoc, intra-septal)

40% atrial arrhythmias

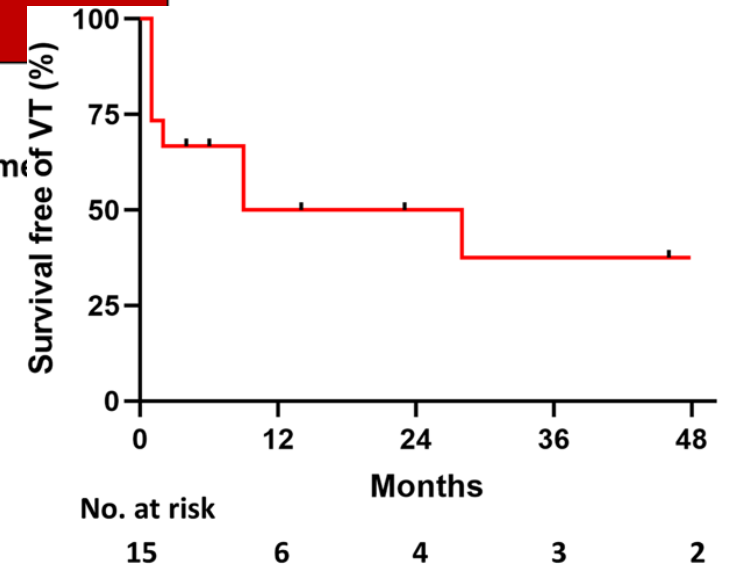
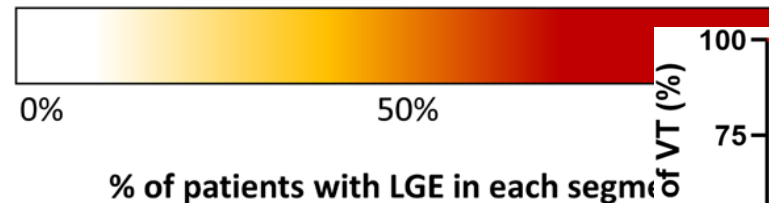
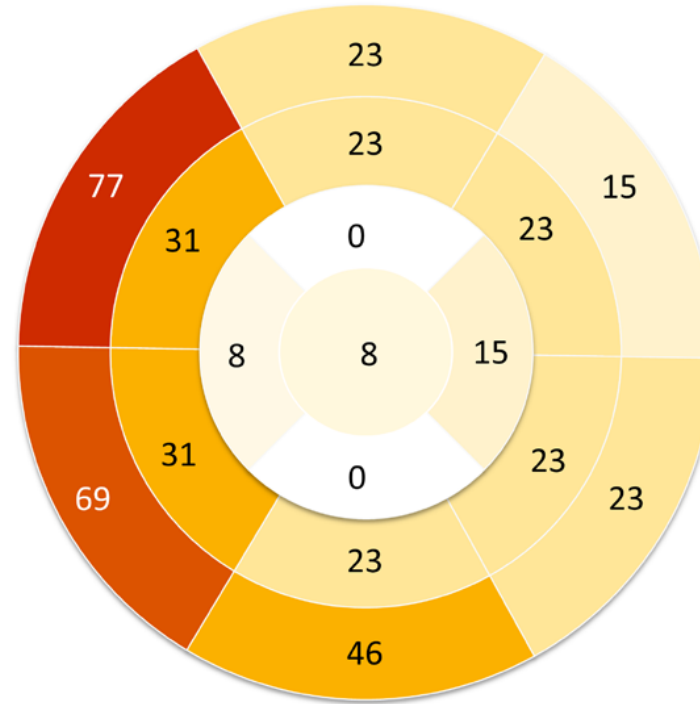
Substrate: peri-aortic and basal septal
VTs septal outflow tract region

FU 26.5±23.0 months

53% VT recurrence

20% transplanted or mechanical circulatory support

Enriquez, et al. Circ Arrhythm



(Heart Rhythm 2025;22:701–702)

 Check for updates

What happens to patients awaiting urgent transplantation for refractory electrical storm when they are not transplanted?

Miloud Cherbi, MD,¹ Léa Benabou, MD,² Maxime Faure, MD,² Matteo Pozzi, MD,³
Estelle Gandjbakhch, MD, PhD,⁴ Shaïda Varnous, MD,⁴ Karim Benali, MD,^{2,5} Redwane Rakza, MD,⁶
Raphael P. Martins, MD, PhD,⁶ Clément Delmas, MD, PhD,¹ Philippe Maury, MD¹

Urgent heart transplantation (HTx) may be considered when all previous strategies fail ...
but substantial post-operative mortality

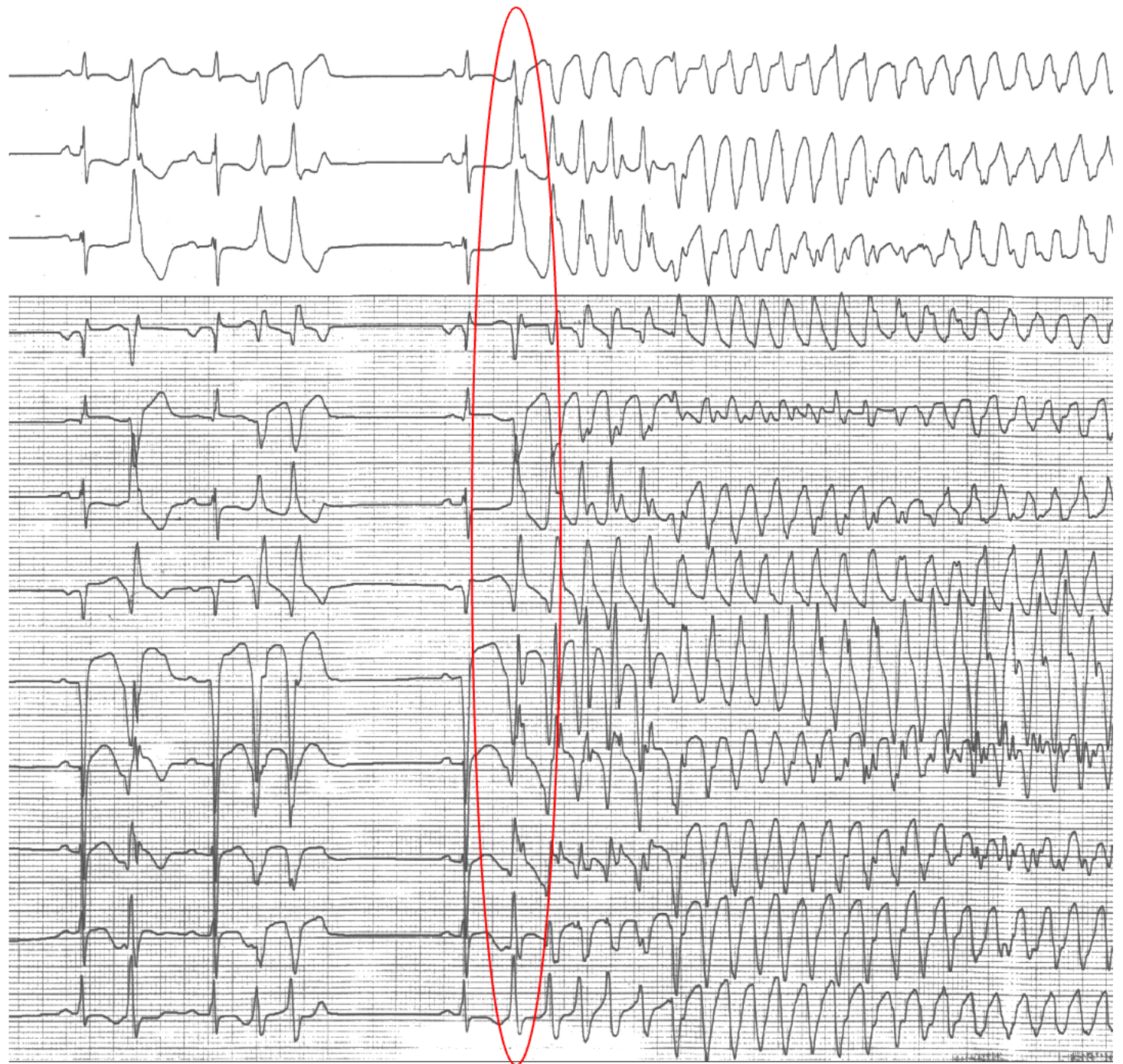
39 patients inscrits sur liste en urgence pour orage incoercible (7 seulement post AMI)
TT maximal 59% avec ablation (multiple chez 9 patients)

26 patients **(66%)** ont quitté le service vivants et non transplantés ...
Mortalité aigue 13 patients **(33%)** (cause non rythmique majorité)

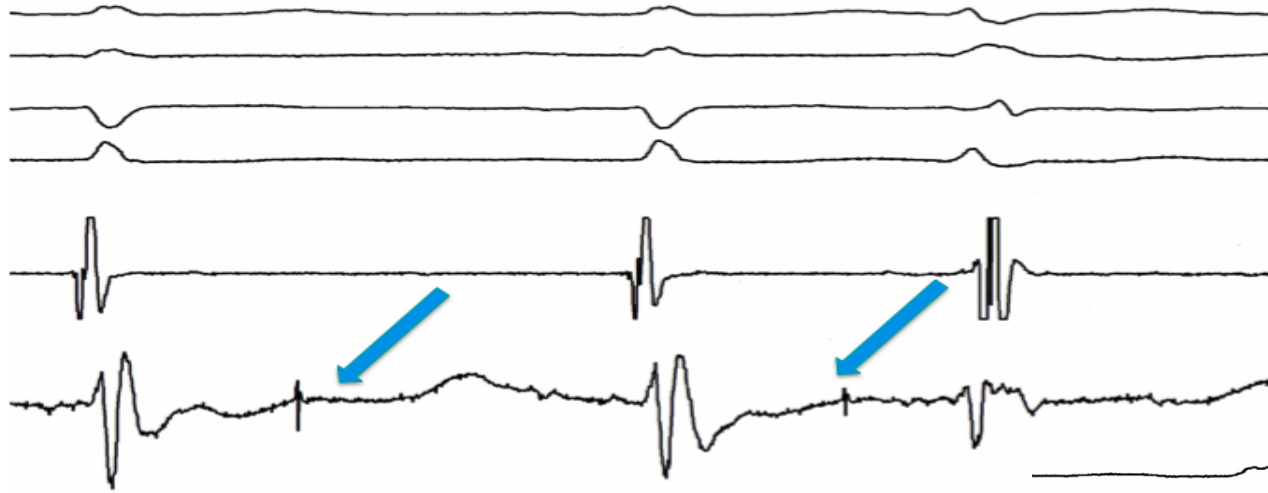
Mortalité aigue transplantés pour orage ? 29%Martins, Eur Heart J Acute Cardiovasc Care 2023

**Ne pas trop se
presser parfois ?**

« post-ischemic ES »



Purkinje ablation



« concealed » premature V beats

Onset VF



Catheter Ablation of Refractory Ventricular Fibrillation Storm After Myocardial Infarction: A Multicenter Study

110 patients Refractory VF in IHD Emergency Purkinje ablation

Control group: 143 patients with VF responsive to medical tt

Age, y	65 ± 11
Male	92 (84%)
Type of MI at the time of VF occurrence	
Acute MI	43 (39%)
Subacute MI	48 (44%)
Remote MI	19 (17%)
Extent of Coronary Artery Disease	
1 vessel disease	41 (37%)
2 vessel disease	31 (28%)
3 vessel disease	38 (35%)
MI site	
Anterior	81 (74%)
Inferior	22 (20%)
Multiple	7 (6%)
LV ejection fraction, %	31 ± 10
Total number of defibrillation before ablation	median 15

ESV

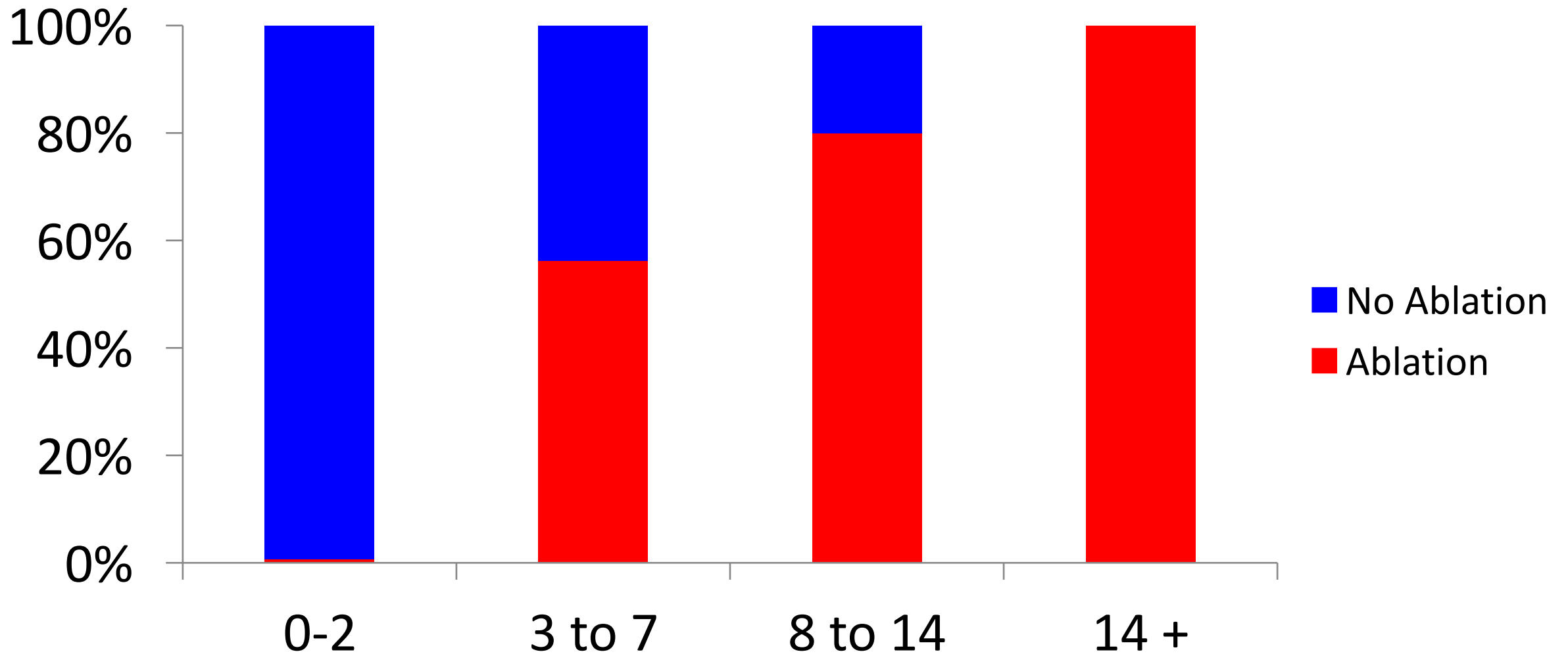
spontanées	86%
scar/territoire infarctus	100%
septum	86%
Purkinje	90%

LIFESAVING PURKINJE ABLATION OF INCESSANT VENTRICULAR FIBRILLATION IN ISCHEMIC HEART DISEASE: A MULTICENTER CASE-CONTROL STUDY

Meleze Hocini, MD, Ashok Shah, MD, Lukasz Szumowski, MD, Philippe Maury, MD, Patrizio Pascale, MD, Rathika Parkash, MD, Luigi Di Biase, MD, Yong Mei, MD, Josef Kautzner, MD, Akihiko Nogami, MD, Lena Rivard, MD, Andrea Natale, MD, Paul Khairy, MD, Petr Peichl, MD and Michel Haissaguerre, MD. Hôpital Cardiologique du Haut Lévêque, Bordeaux-Mérignac, France

Circulation. 2019 May 14;139(20):2315-2325

DELAI IDM ET NECESSITE ABLATION



Conclusions

SÉDATION, AA et ABLATION (répétées) doivent rester la pierre angulaire du tt des orages

Parfois **savoir attendre** (sédation, pacing)

Les étapes ensuite (**SYMPATHECTOMIE/LYSE, assistance**) sont plus hasardeuses mais parfois efficaces

La **greffe doit rester la toute dernière solution** après échec de TOUT (sauf certaines CM mutées)
car **orage incoercible n'est pas synonyme de fin de vie** (du tout du tout)