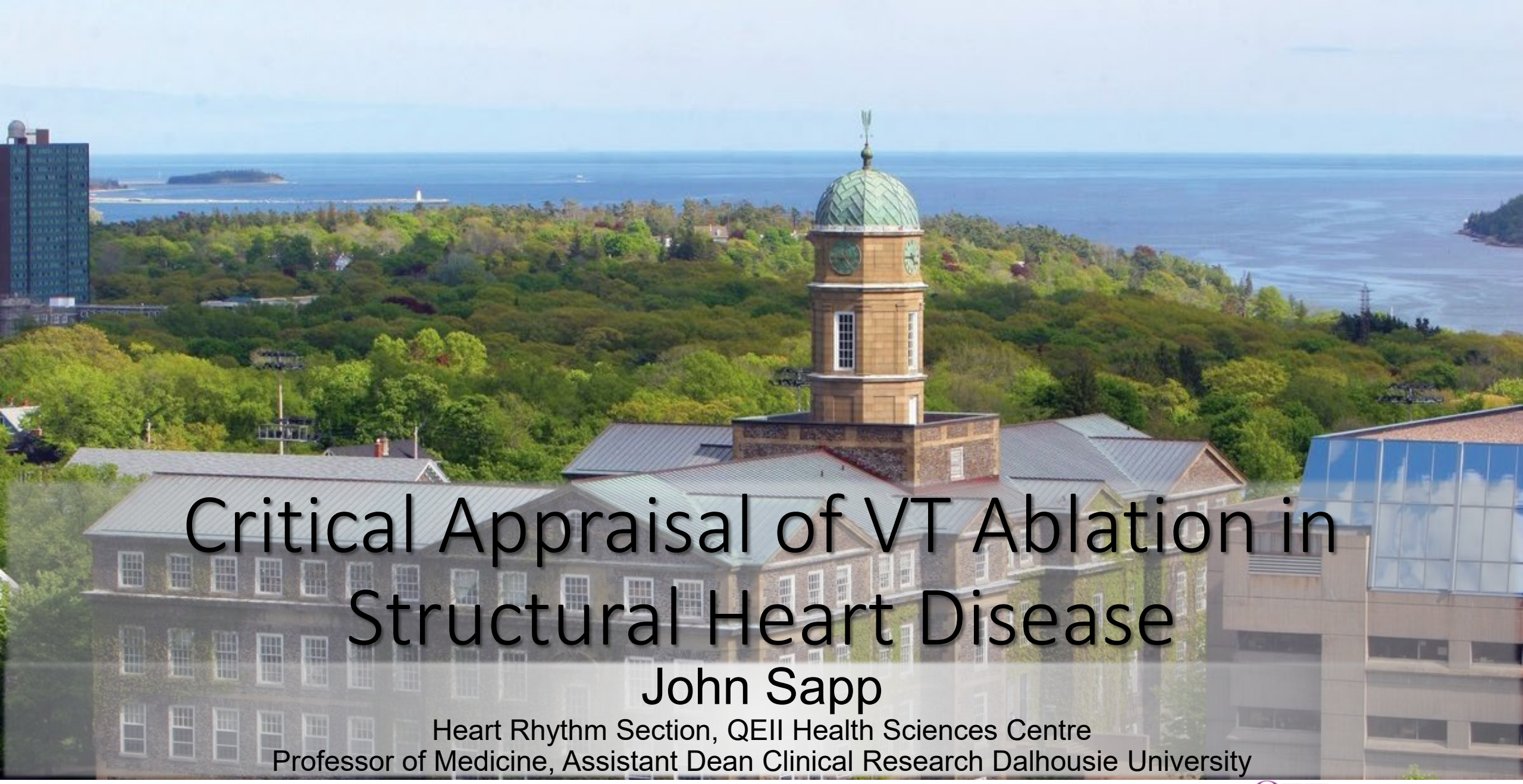


Critical Appraisal of VT Ablation in Structural Heart Disease

John Sapp
Heart Rhythm Section, QEII Health Sciences Centre
Professor of Medicine, Assistant Dean Clinical Research Dalhousie University

DALHOUSIE UNIVERSITY
Inspiring Minds

QEII HEALTH SCIENCES CENTRE FOUNDATION

Maritime Heart Centre

Disclosures

- Research Funding:
  - Johnson and Johnson
  - Abbott
- Consulting, Honoraria
  - Medtronic
  - Johnson and Johnson
  - Abbott
  - Varian

Objectives:

- Motivation for suppression of VT: drugs/ablation
- Why is ablation not the *perfect* treatment?
- Ablation outcomes and risks
- Can ablation *change mortality risk*?
- Indications
- What do we not know?

Investigating Ventricular Arrhythmias

In a huge medical victory,

we have created a new disease

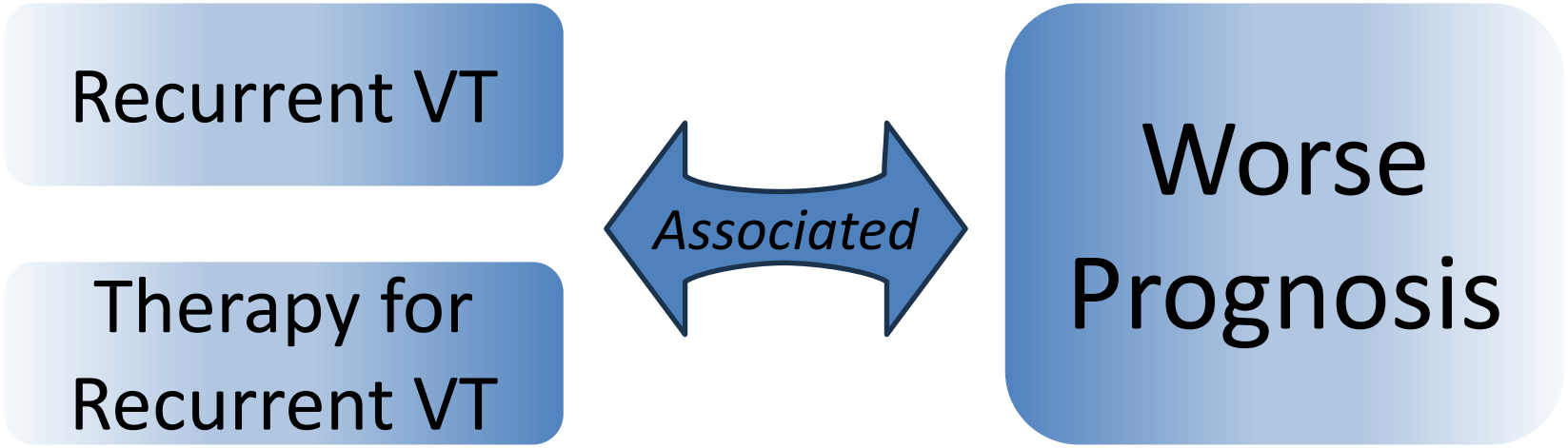
We now have a new disease

Patients are Living With VT

- Patients now survive with recurrent VT
- Can we suppress it? Should we?

Motivation

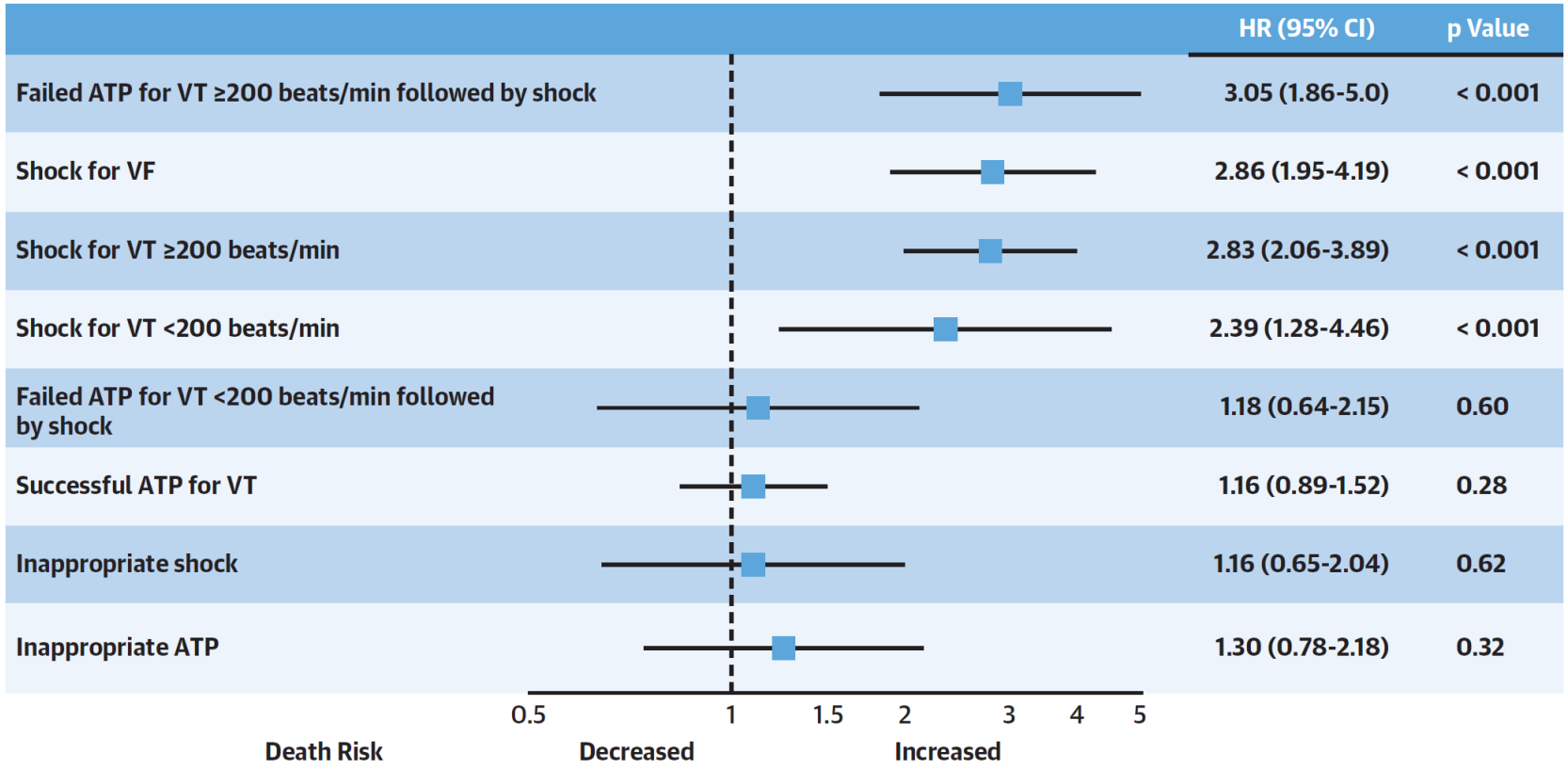
In every study…



Motivation:
Even in the ICD era, VT is associated with death

Combined MADIT Studies

CENTRAL ILLUSTRATION Combined Assessment of Therapy and Arrhythmia Type on Subsequent Mortality



Aktaş, M.K. et al. J Am Coll Cardiol. 2021;77(20):2453-62.

Unclustered episodes are not associated with as much risk…

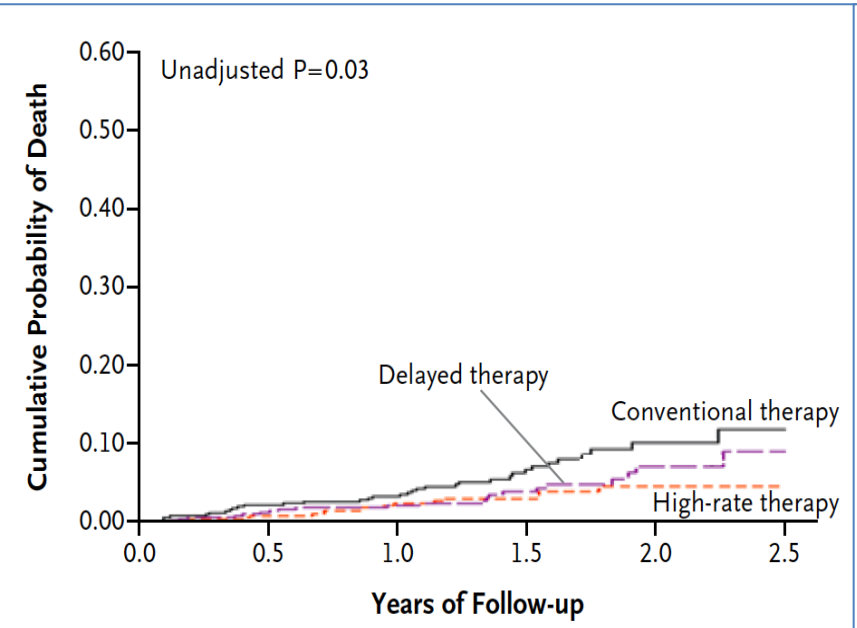
DALHOUSIE UNIVERSITY *Inspiring Minds*

Maritime Heart Centre

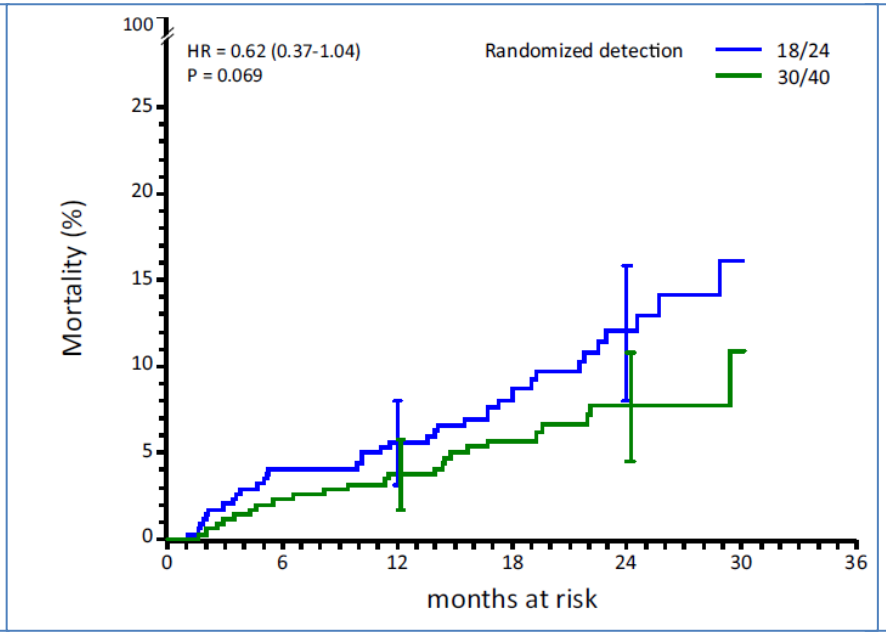
ICD shocks save lives:

But Avoiding Shocks Saves More?

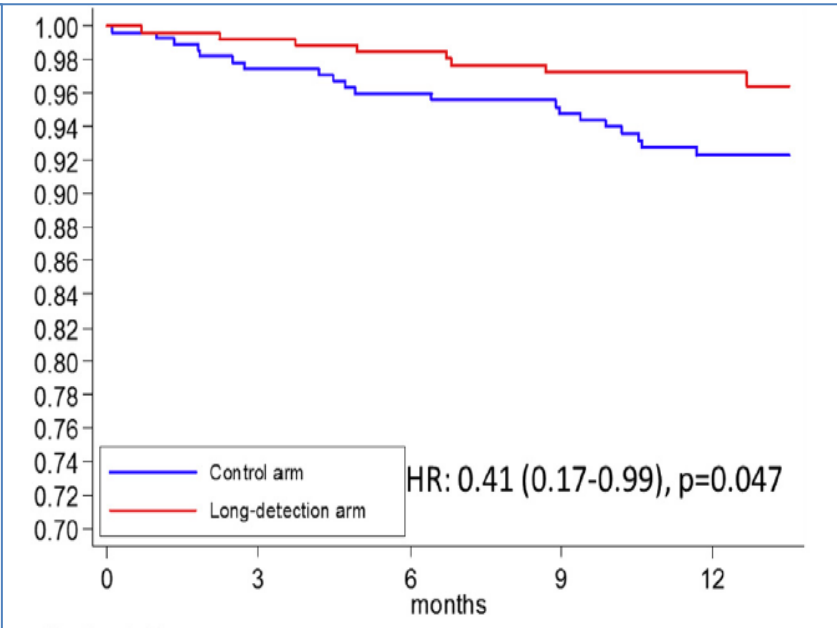
MADIT RIT Moss 2012



PAINFREE SST Sterns 2016



ADVANCE III Gasparini 2017



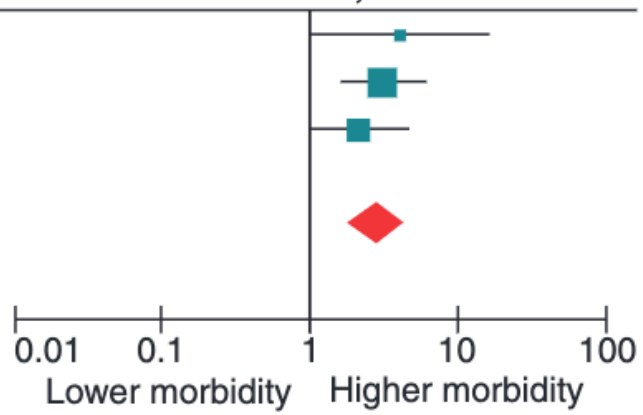
Trials of ICD programming to avoid shocks

More VT is Worse: clusters

RR 2.85 for Death/Transplant/CHF hosp/Cardiogenic shock

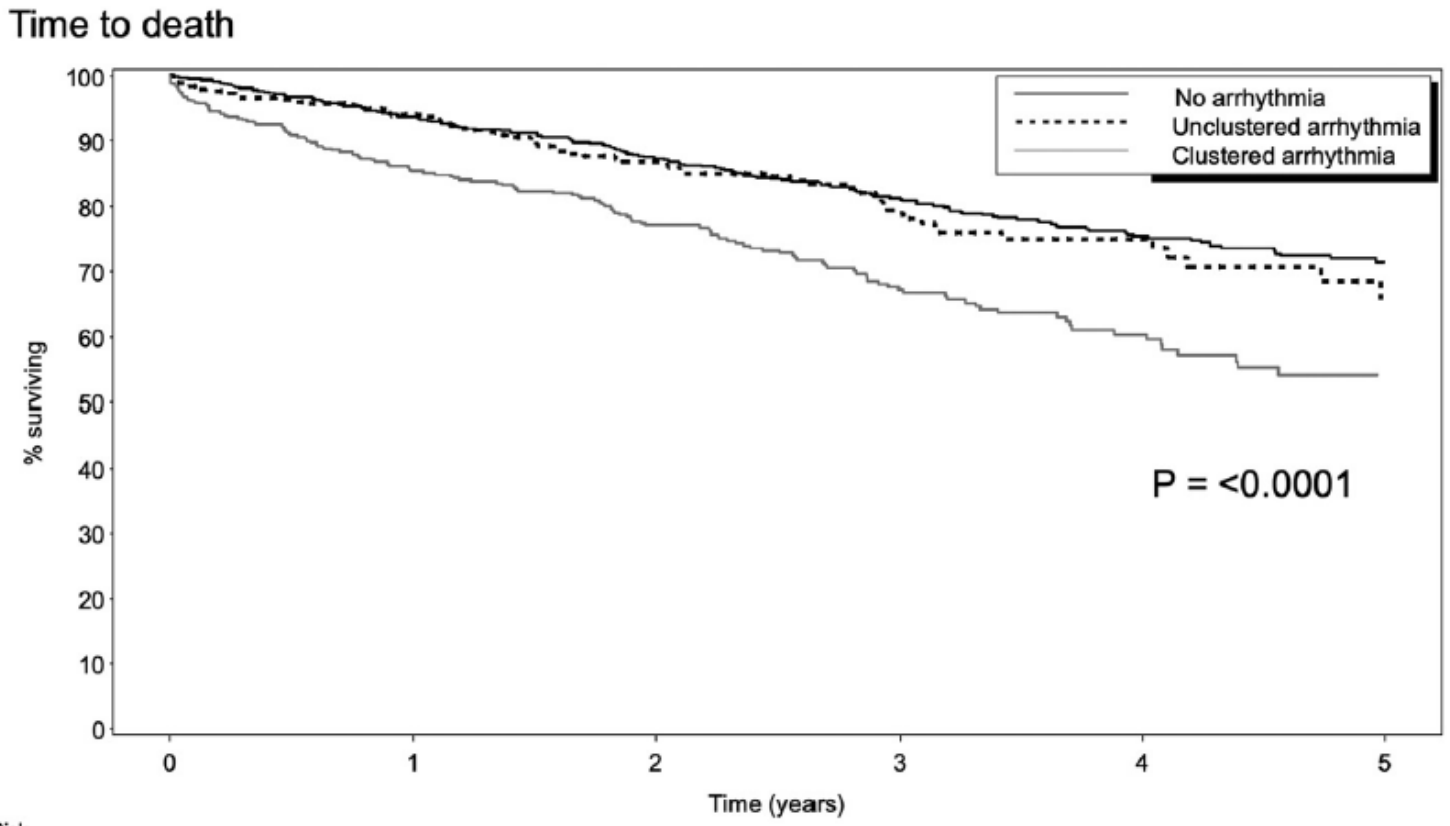
Study or subgroup	Electrical storm Events	Total	No Electrical storm Events	Total	Weight	Risk ratio Random, 95% CI
Credner *et al.* 1998	4	14	3	43	10.9%	4.10 [1.04, 16.12]
Bansch *et al.* 2000	20	30	9	43	51.0%	3.19 [1.69, 6.00]
Greene *et al.* 2000	14	40	9	57	38.1%	2.22 [1.06, 4.62]
Total (95% CI)		**84**		**143**	**100.0%**	**2.85 [1.81, 4.48]**
Total events	38		21			

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 0.84$, df = 2 ($P = 0.66$); $I^2 = 0\%$



Clustered Arrhythmias are bad

FIGURE 2 Mortality Curves for the 3 Main Groups



No. at Risk						
No arrhythmia	893	832	634	424	260	124
Unclustered arrhythmia	406	296	200	117	56	24
Clustered arrhythmia	465	342	231	152	81	30

Simon and Makuch curve taking into account the change in an individual's group status over time where individuals at risk within clustered, unclustered, with no arrhythmias are not fixed at baseline.

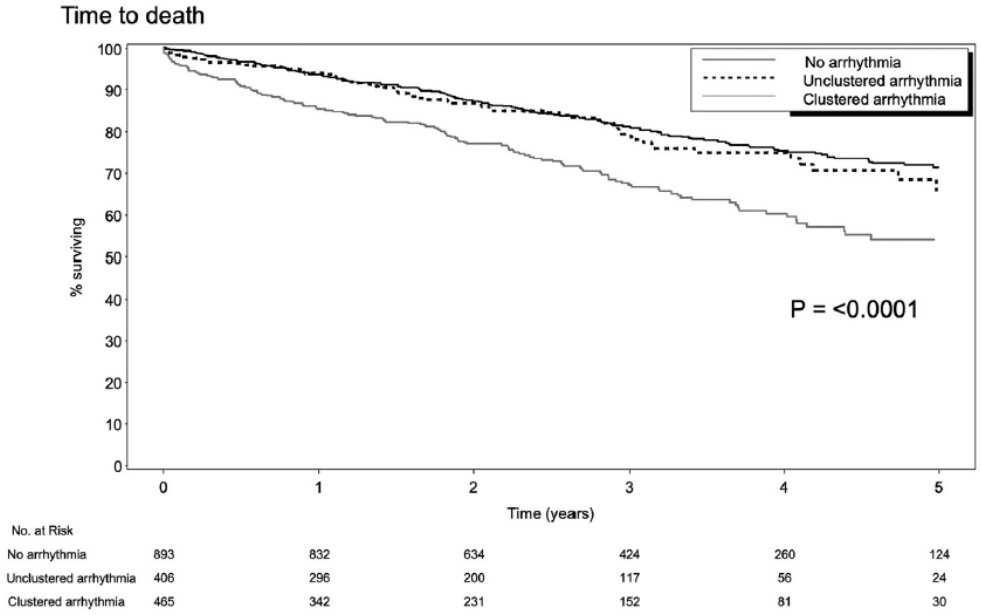
1,764 patients in RAFT

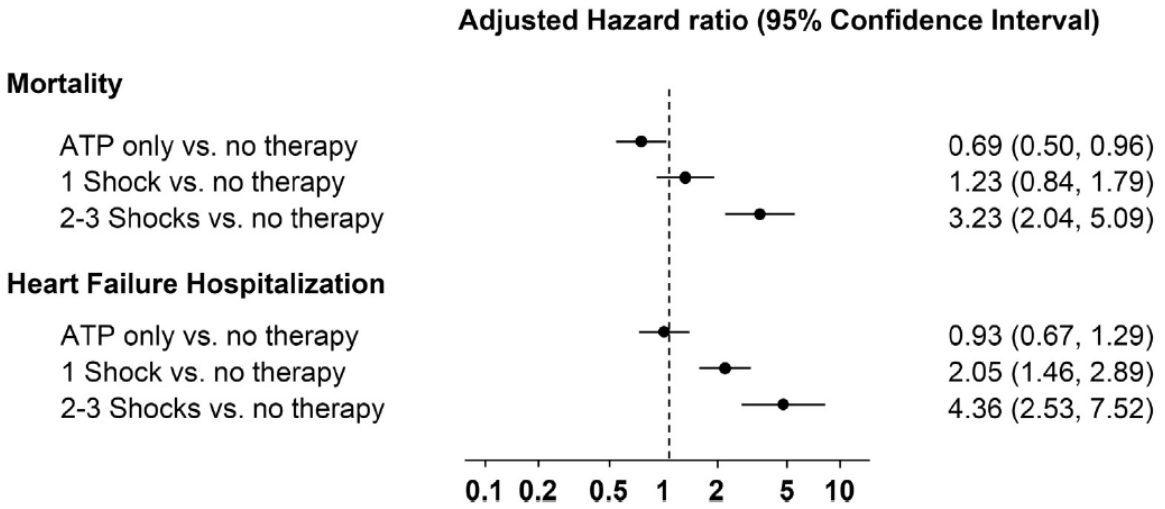
15,000 arrhythmias in
871 patients
11,278 VAs

Elsokkari…Sapp
JACC EP 2020

Clustered Arrhythmias are bad

FIGURE 2 Mortality Curves for the 3 Main Groups





Elsokkari…Sapp
JACC EP 2020

CJC Open 1 (2019) 161–167

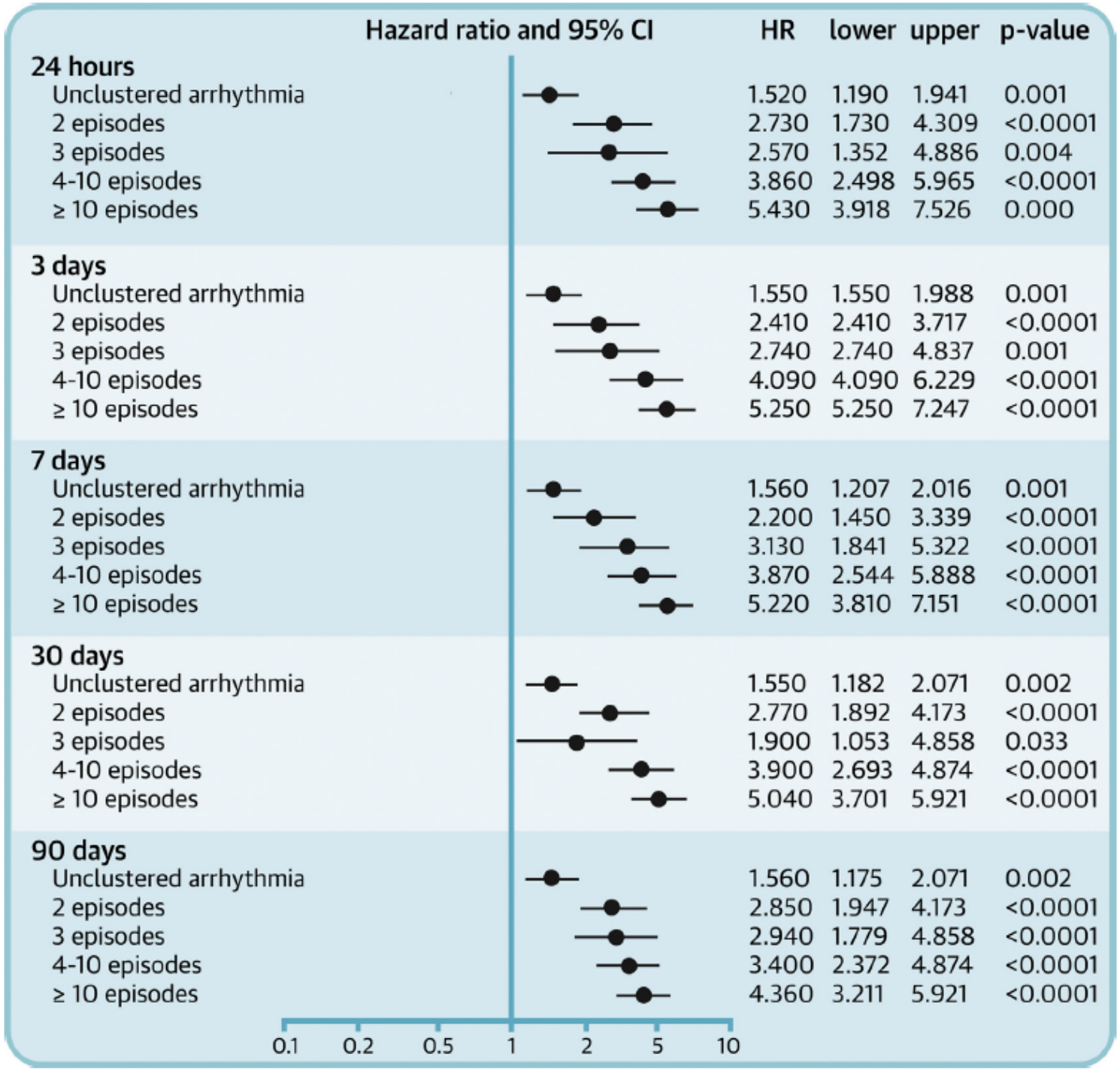
Original Article

The Effect of Shock Burden on Heart Failure and Mortality

Ciorsti J. MacIntyre, MD,[a] John L. Sapp, MD,[a] Amir Abdelwahab, MD, MSc, MBBCh,[a] Mousa Al-Harbi, MD,[a] Steve Doucette, MSc,[b] Chris Gray, MD,[a] Martin J. Gardner, MD,[a] and Ratika Parkash, MD, MS[a]

Mortality Risk According to Cluster Burden

Hazard Ratio for death compared with patients with no VT

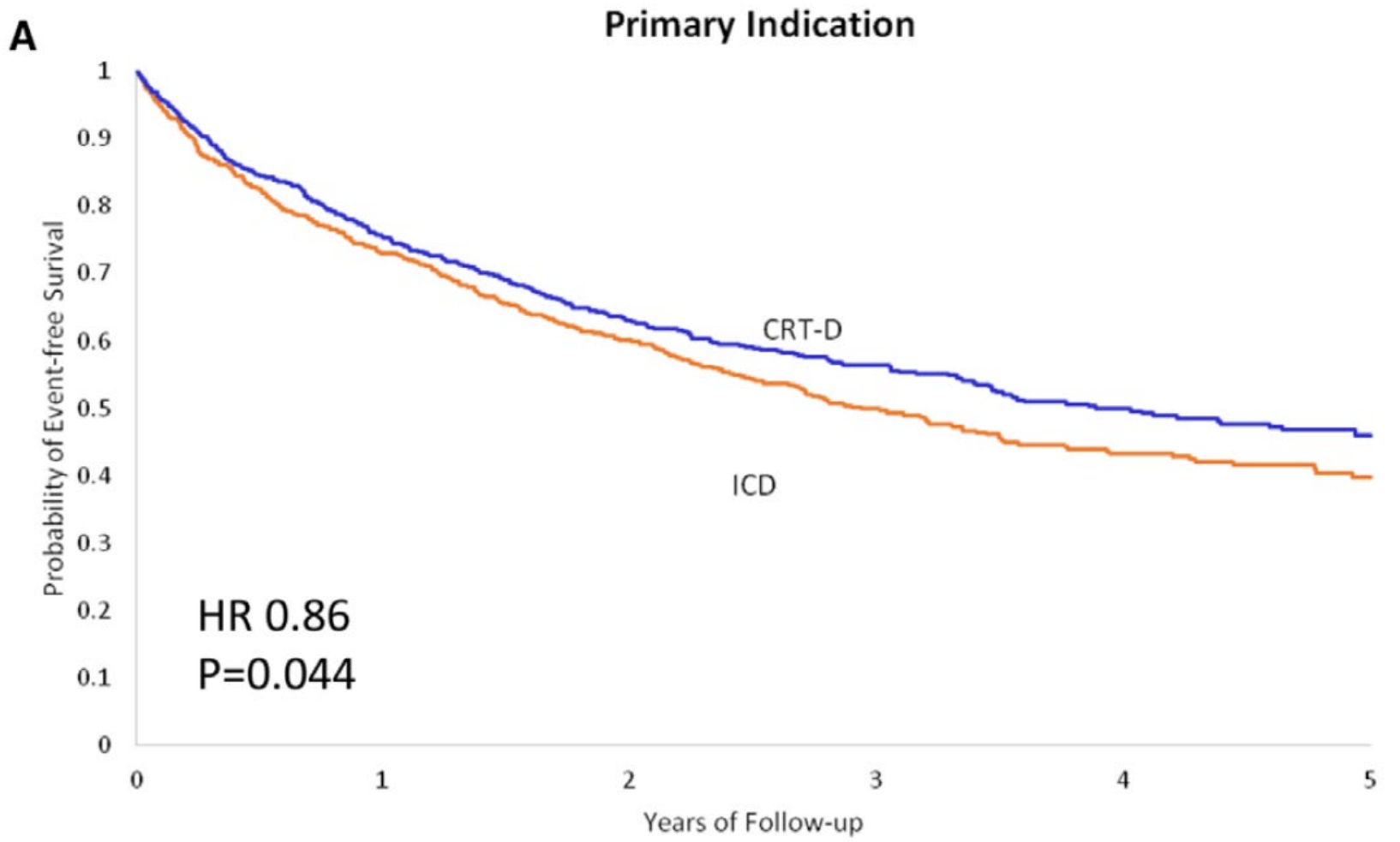


ElSokkari JACC EP 2020

Can We Modify Arrhythmia Risk?

- Potassium management (POTCAST *NEJM* 2025)
- Reducing heart failure reduces the risk of sudden cardiac death
  - ARNI: reduced SCD (HR 0.8 in PARADIGM)
  - MRA: reduced SCD (RALES)
  - Beta-blockers: reduced VA (Capricorn—carvedilol)
  - Cardiac Resynchronization

Cardiac Resynchronization and VT



ICD	770	585	365	217	121	54
CRT-D	759	555	376	232	114	64

RAFT Substudy
Circ AE 2017

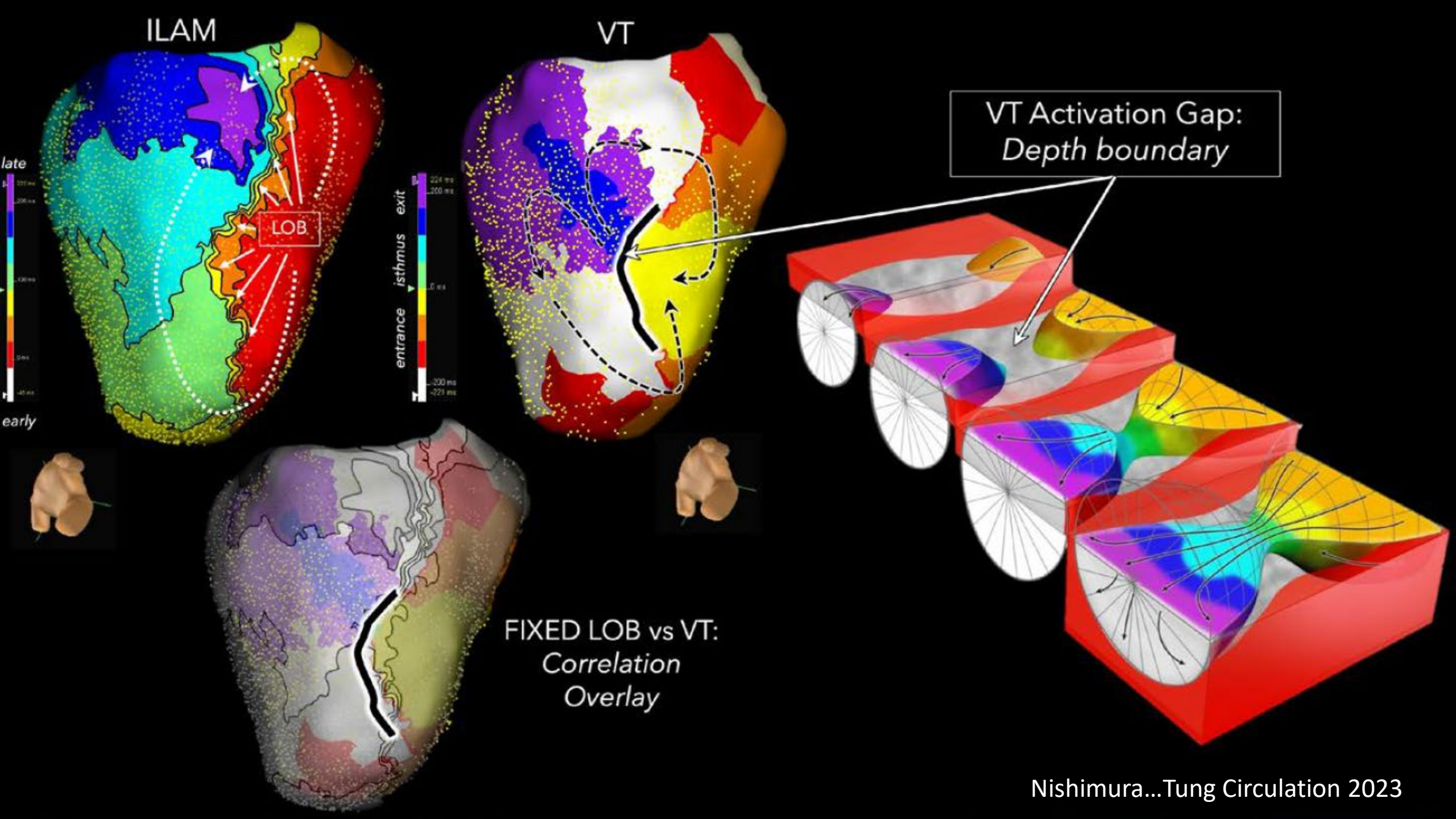
Suppression of VT

- Antiarrhythmic Drugs
- Catheter Ablation

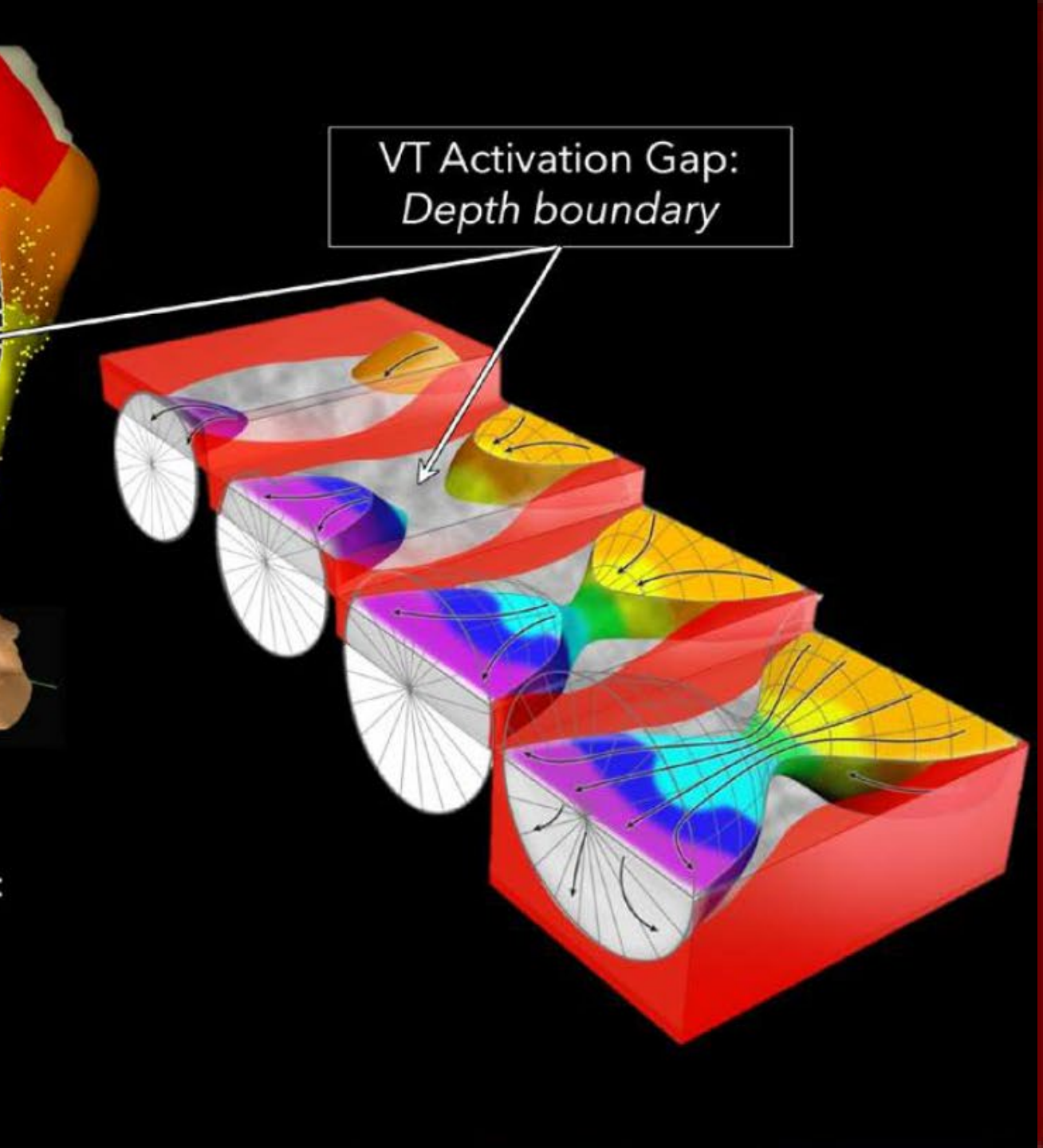
Amiodarone

…Administered systemically…

DALHOUSIE UNIVERSITY
Inspiring Minds

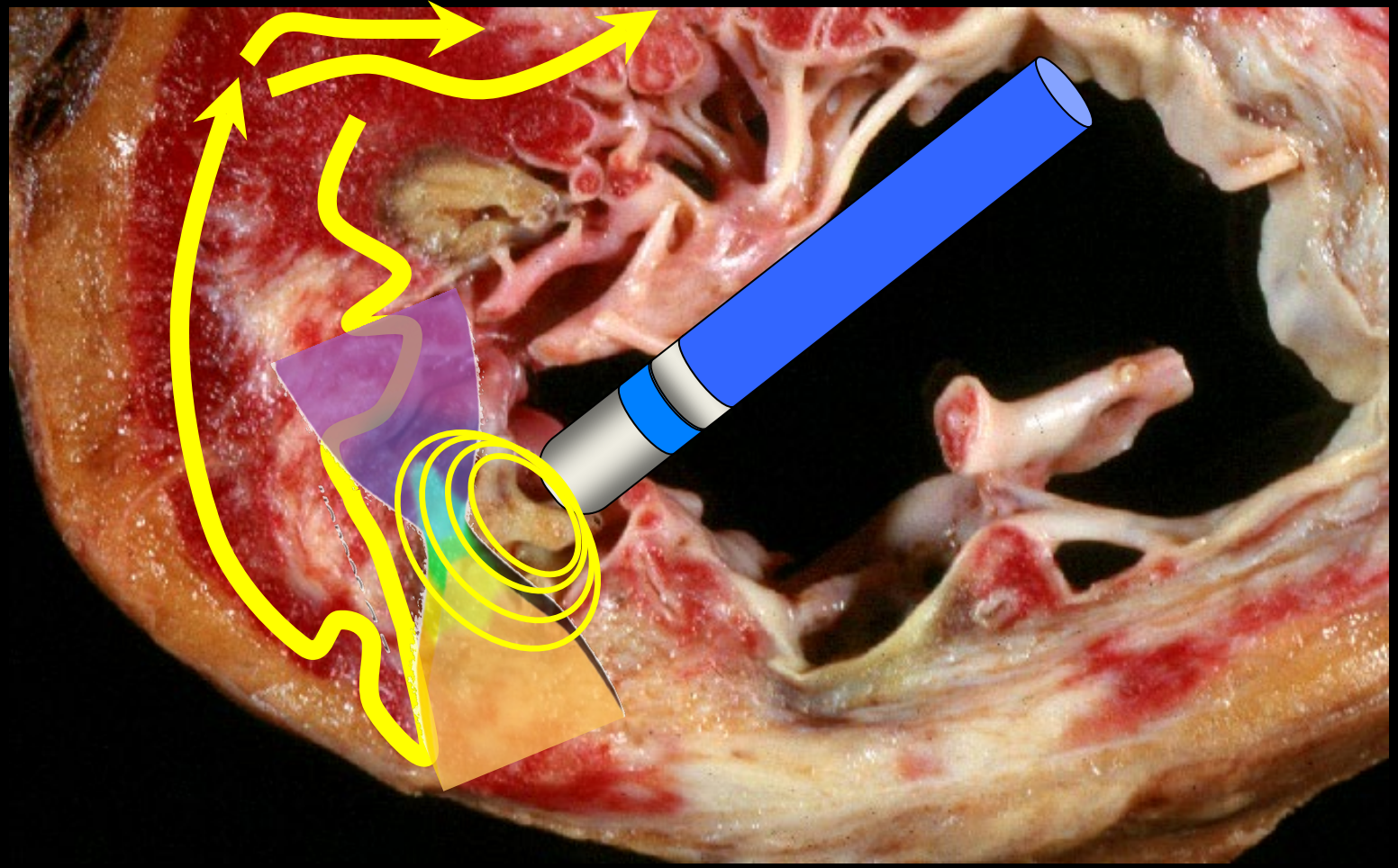


Nishimura…Tung Circulation 2023



Xu…Nazarian Circulation 2025

Local Therapy



Why do we fail?

- Noninducible VT
- Nonsustained
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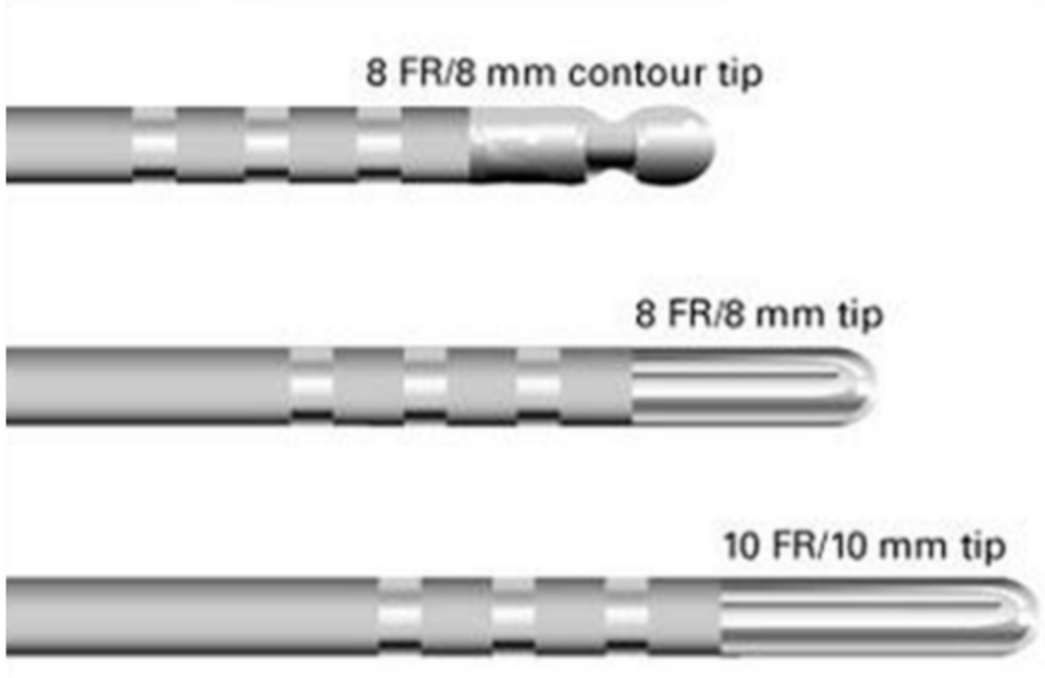
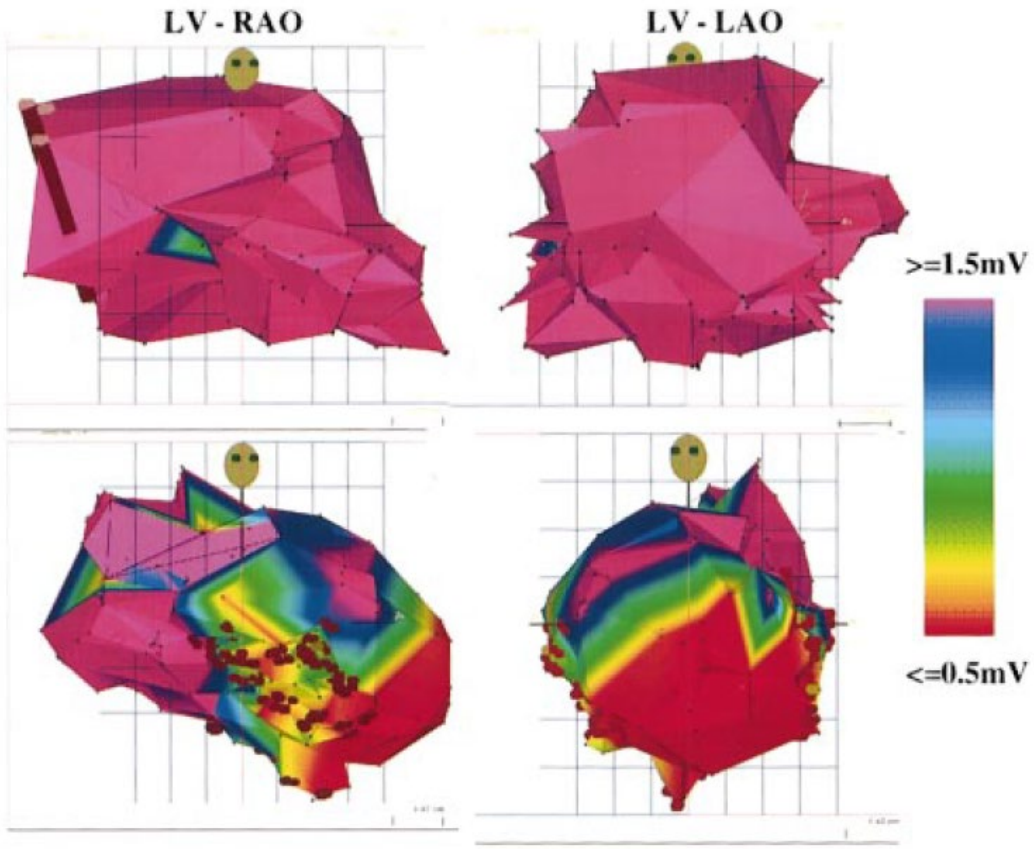
- Can’t identify substrate
- Safety
- Diffuse patchy scar
- Too deep for RF
- Insufficient contact
- Too close to critical structures

Advances in Ablation



Fallavollita 2014

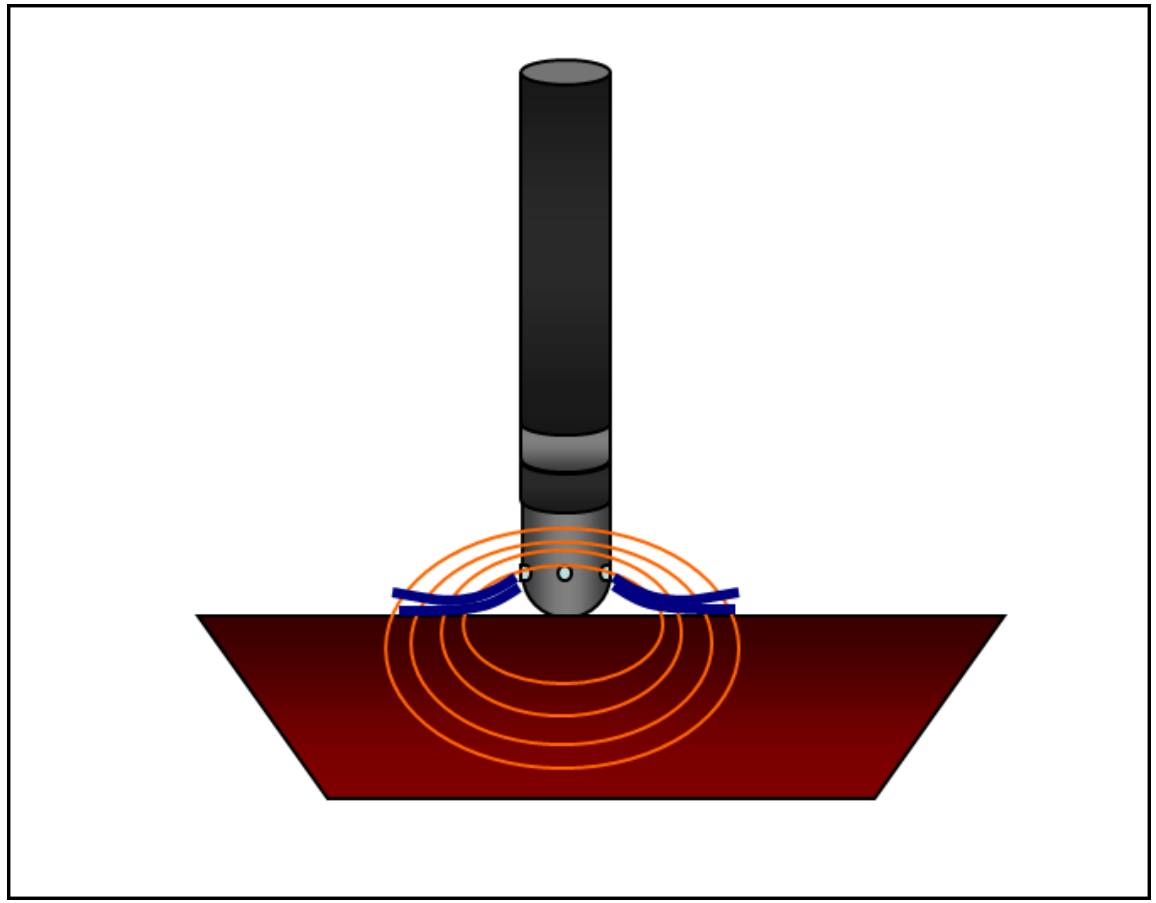
Advances in Ablation



Electroanatomic mapping

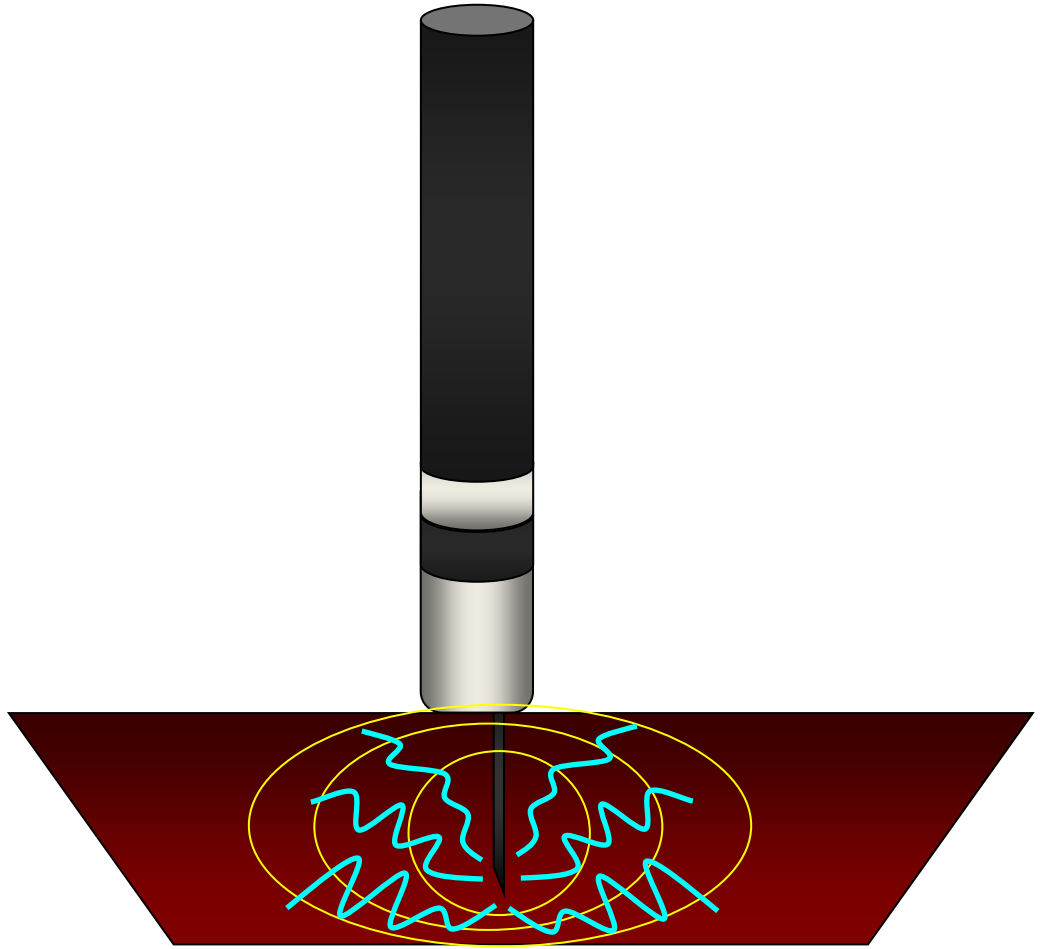
Marchlinski 2000

Advances in Ablation



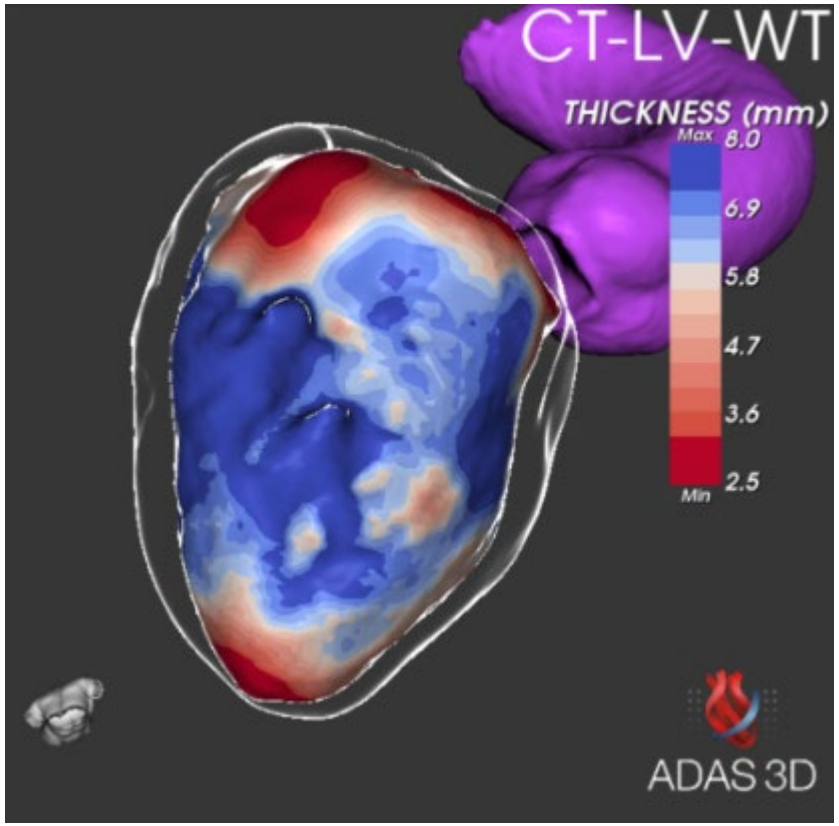
Irrigated Tip

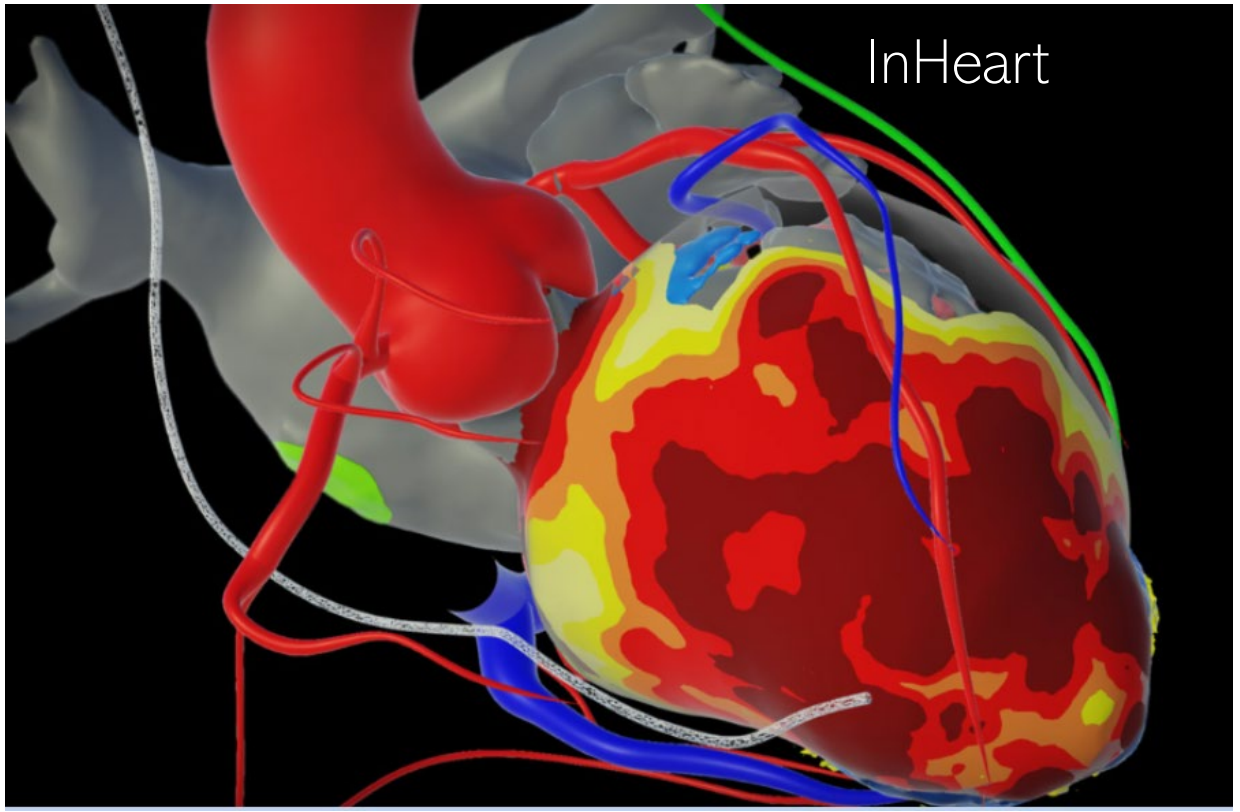
Advances in Ablation



Advances in Ablation

Advances in Ablation





Advances in Ablation

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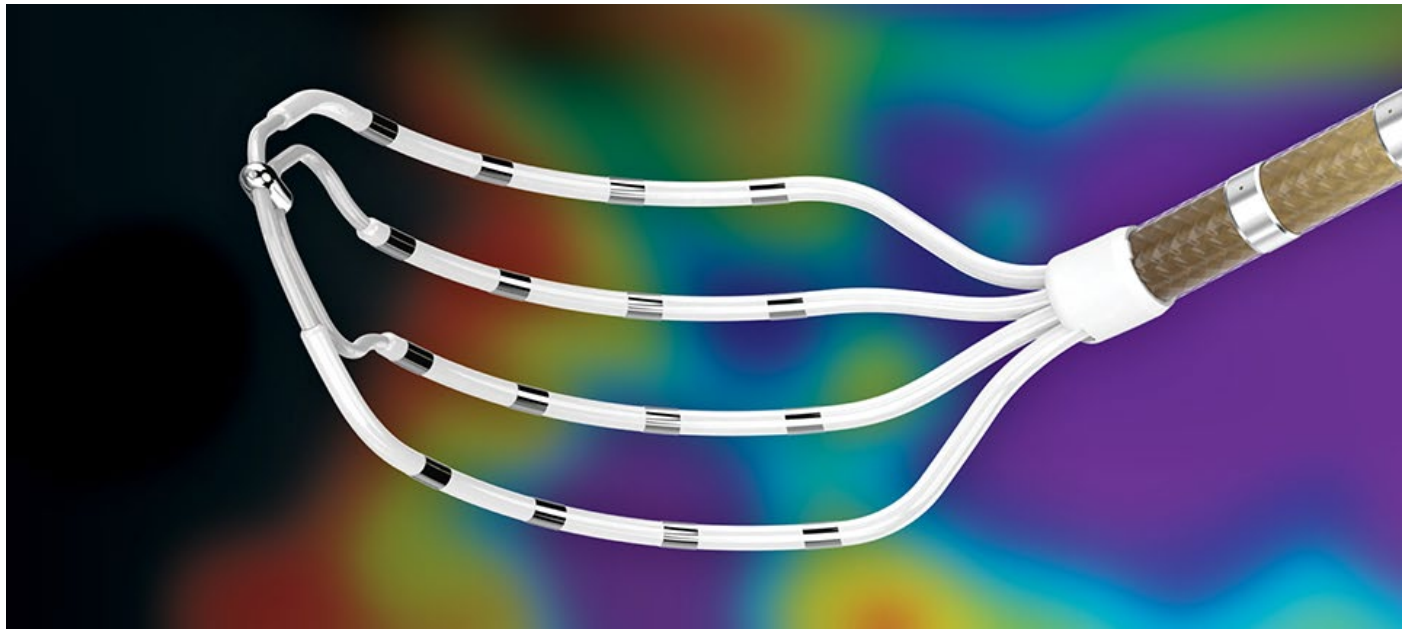

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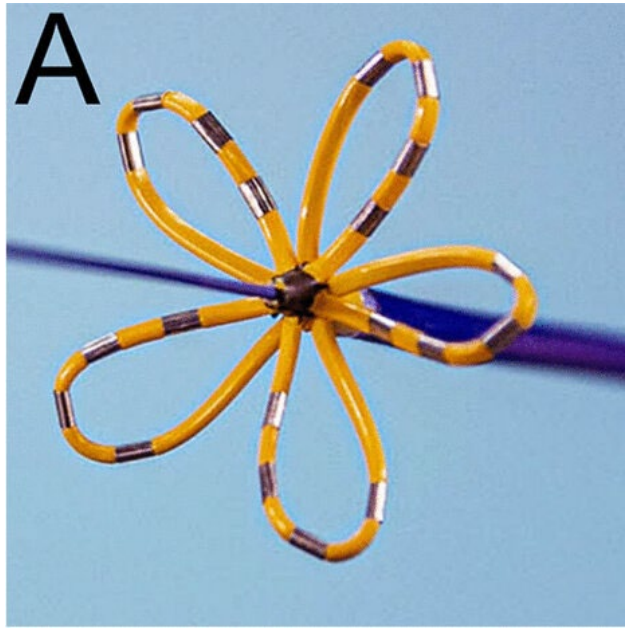

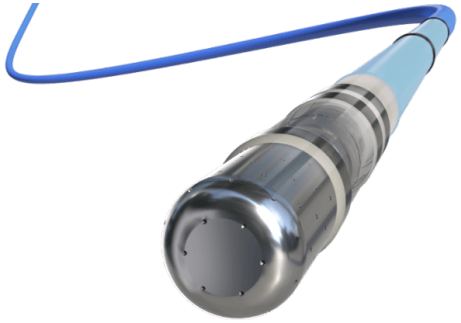

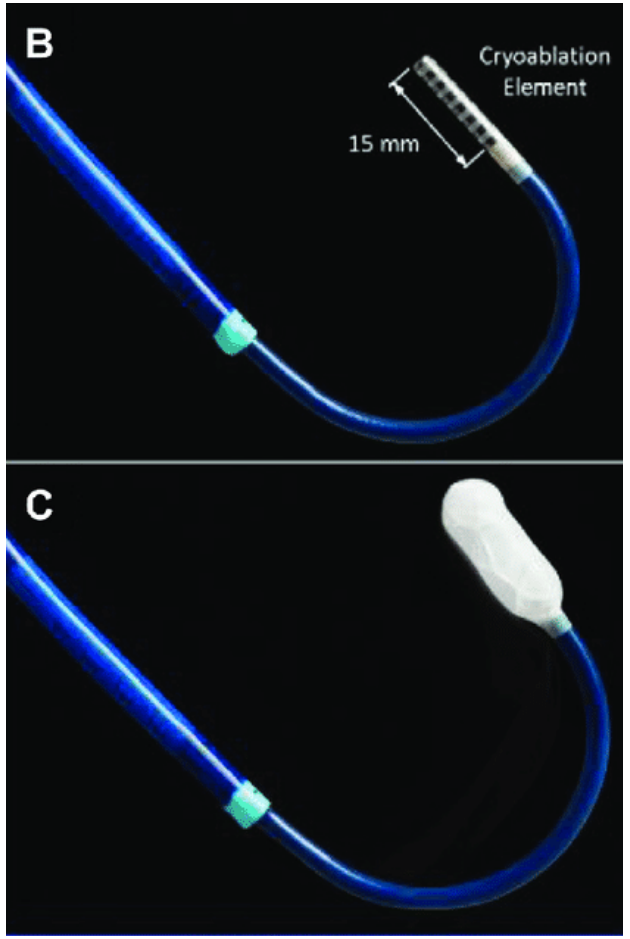

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Why do we fail?

- Noninducible VT
- Nonsustained
- Not tolerated

} Rapid mapping
Substrate Mapping

- Can't identify substrate } Advanced Imaging *helps*

Why do we fail?

- Safety
- Too close to critical structures

Intracardiac Echo

Image Integration

- Diffuse patchy scar
- Too deep for RF
- Insufficient contact

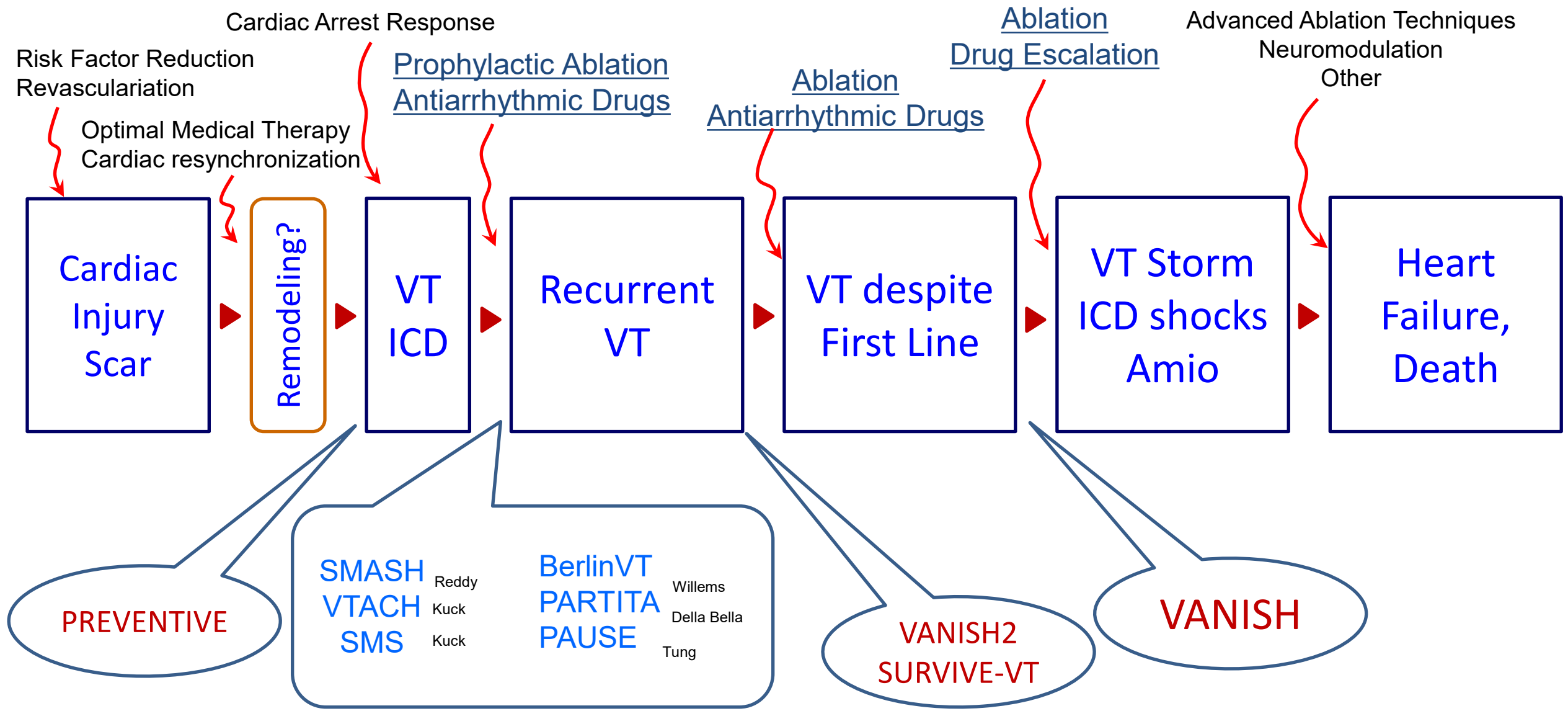
Still important issues…

Our Current Capability

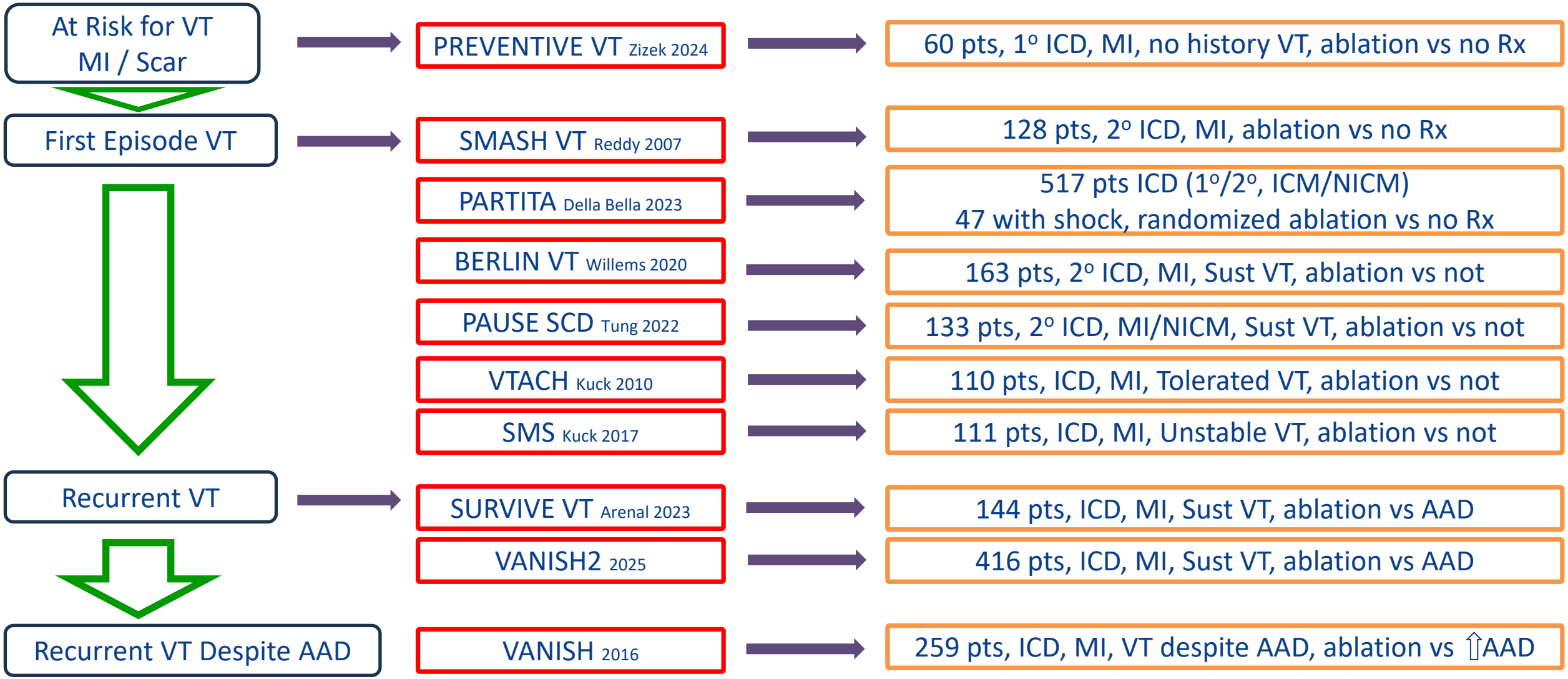
- Ablation Outcomes and Risks

Outcomes

Clinical Course of VT Patients: Opportunities for Intervention



Evidence for VT Ablation: context



Total 1571 patients

Randomized Trials of Catheter Ablation: Primary Outcomes

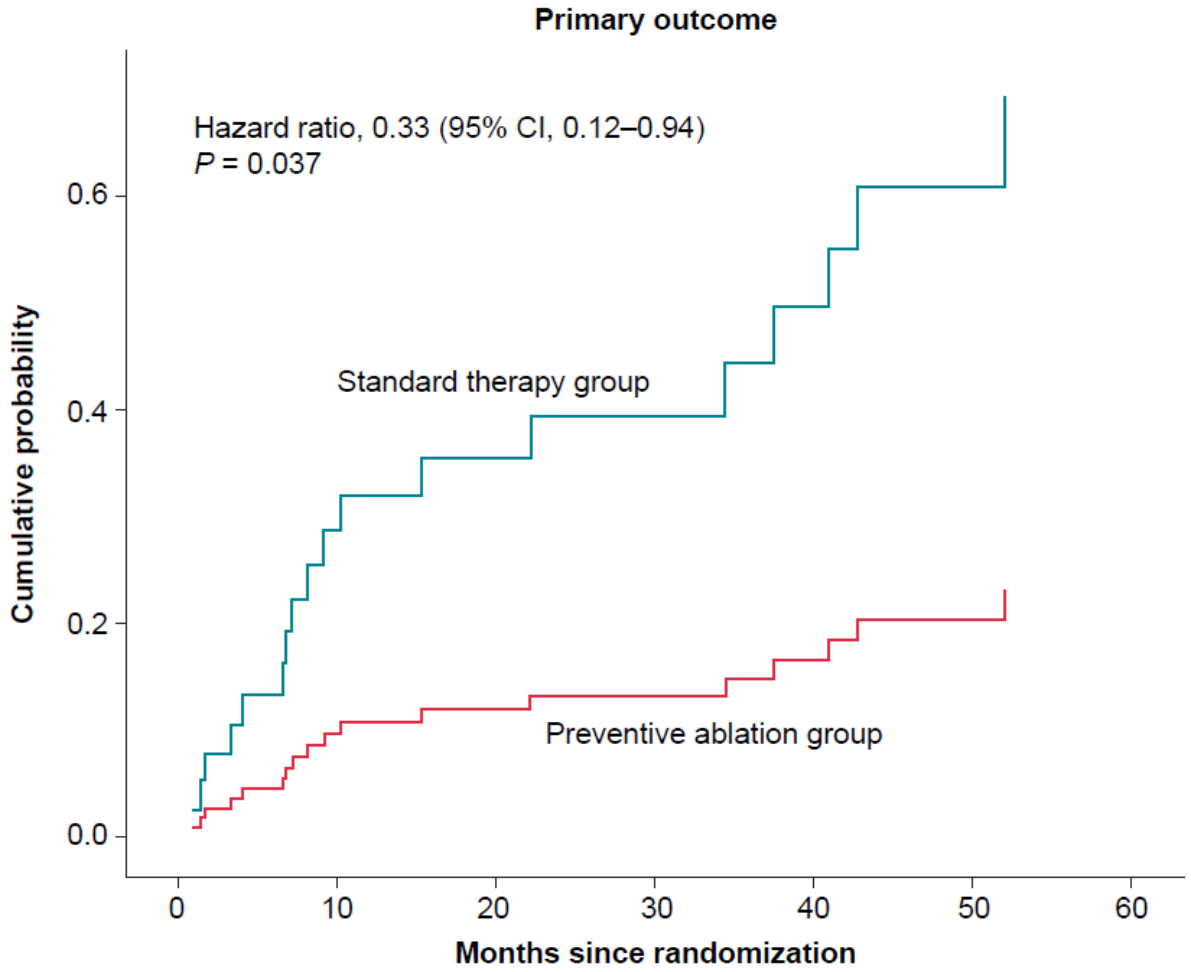
Impact of preventive substrate catheter ablation on implantable cardioverter-defibrillator interventions in patients with ischaemic cardiomyopathy and infarct-related coronary chronic total occlusion

The PREVENTIVE VT randomized multicentre trial

Zizek *Europace* 2024

60 patients with MI and Chronic Total Occlusion
Primary prophylactic ICD, no history of VA
EF≤40 (mean 36.5)

Primary endpoint: Composite of appropriate ICD therapy or unplanned admission due to symptomatic VAs



Randomized Trials Primary Outcomes

Preventive or Deferred Ablation of Ventricular Tachycardia in Patients With Ischemic Cardiomyopathy and Implantable Defibrillator (BERLIN VT)

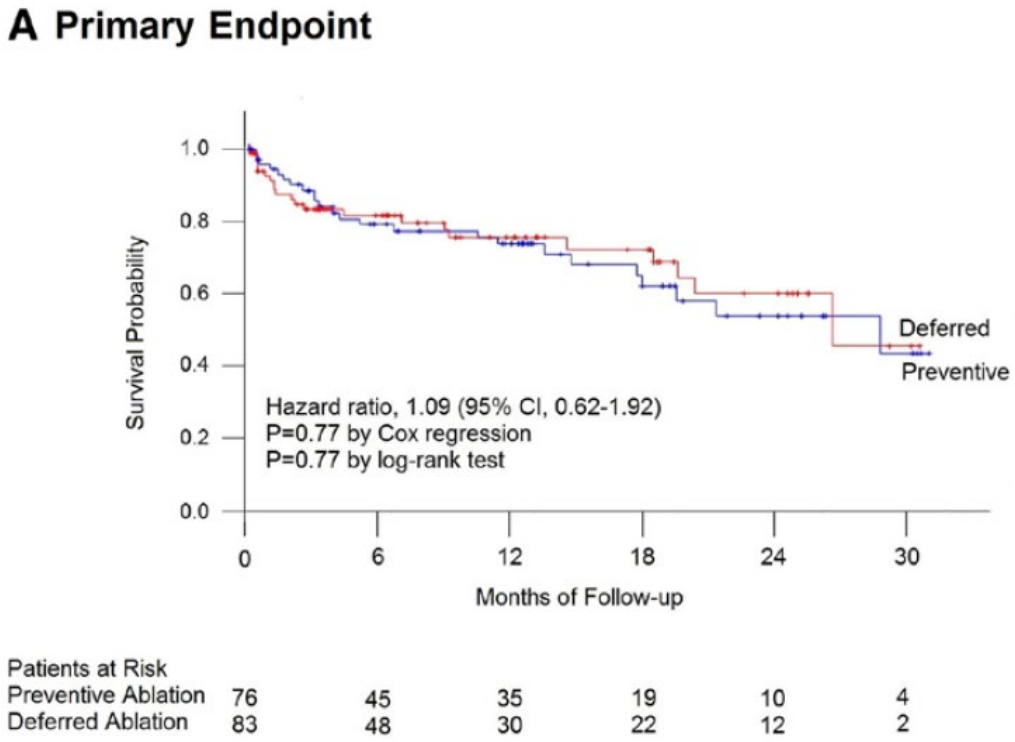
A Multicenter Randomized Trial

Willems et al *Circulation* 2020

163 patients with new onset VT, prior MI, EF 30-50
Randomized to ablation within 2 weeks vs wait for 3rd appropriate shock

Approximately 30% AAD use

Primary Endpoint: Composite of Death, Hospitalization for worsening HF, Hosp for VT/VF



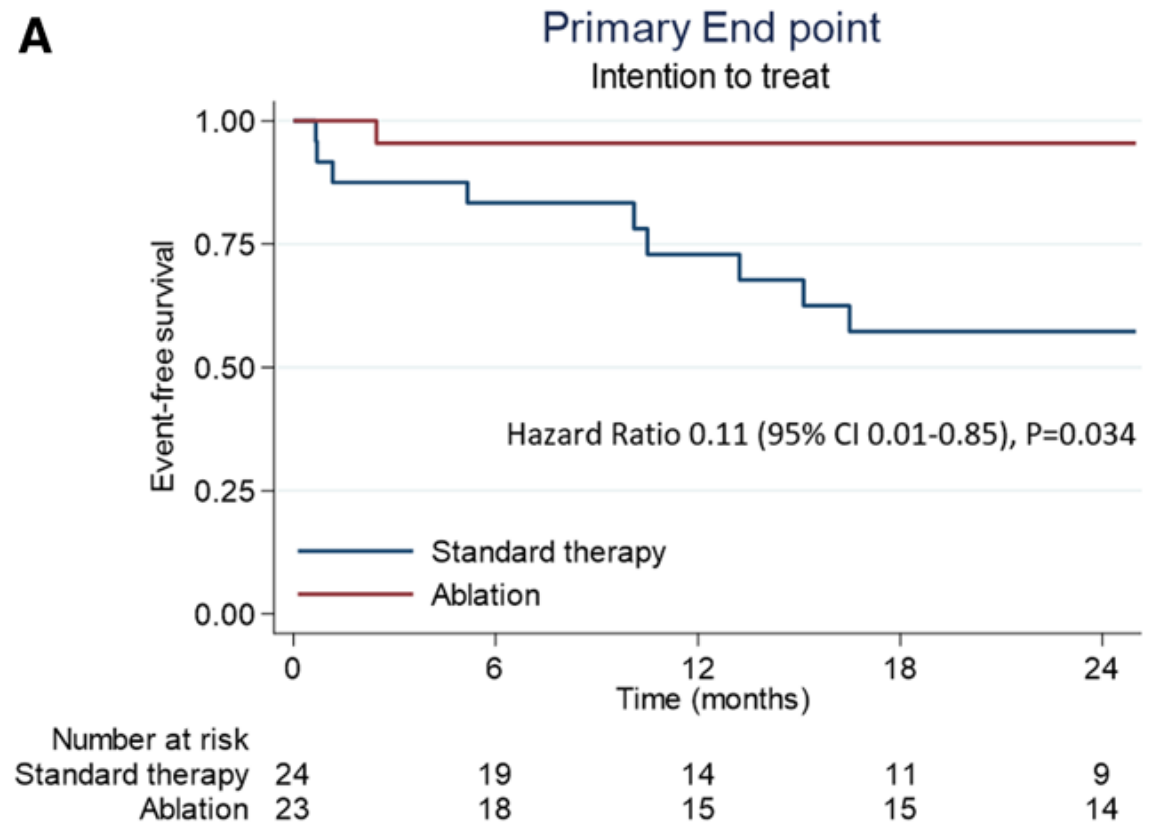
Randomized Trials Primary Outcomes

Does Timing of Ventricular Tachycardia Ablation Affect Prognosis in Patients With an Implantable Cardioverter Defibrillator? Results From the Multicenter Randomized PARTITA Trial

Della Bella *Circulation* 2022

517 pts with new ICD enrolled
47 had treated VT and were randomized
- 81% ischemic
- 74% primary pro indication

Primary endpoint composite of death or hospitalization for worsening HF



Randomized Trials Primary Outcomes

- SMASH — Any appropriate ICD therapy (ATP or Shock)
- SMS — Any appropriate ICD therapy
- VTACH — Recurrence of any sustained VT or VF
- PAUSE SCD — VT recurrence, CV hospitalization, Death

Randomized Trials Primary Outcomes

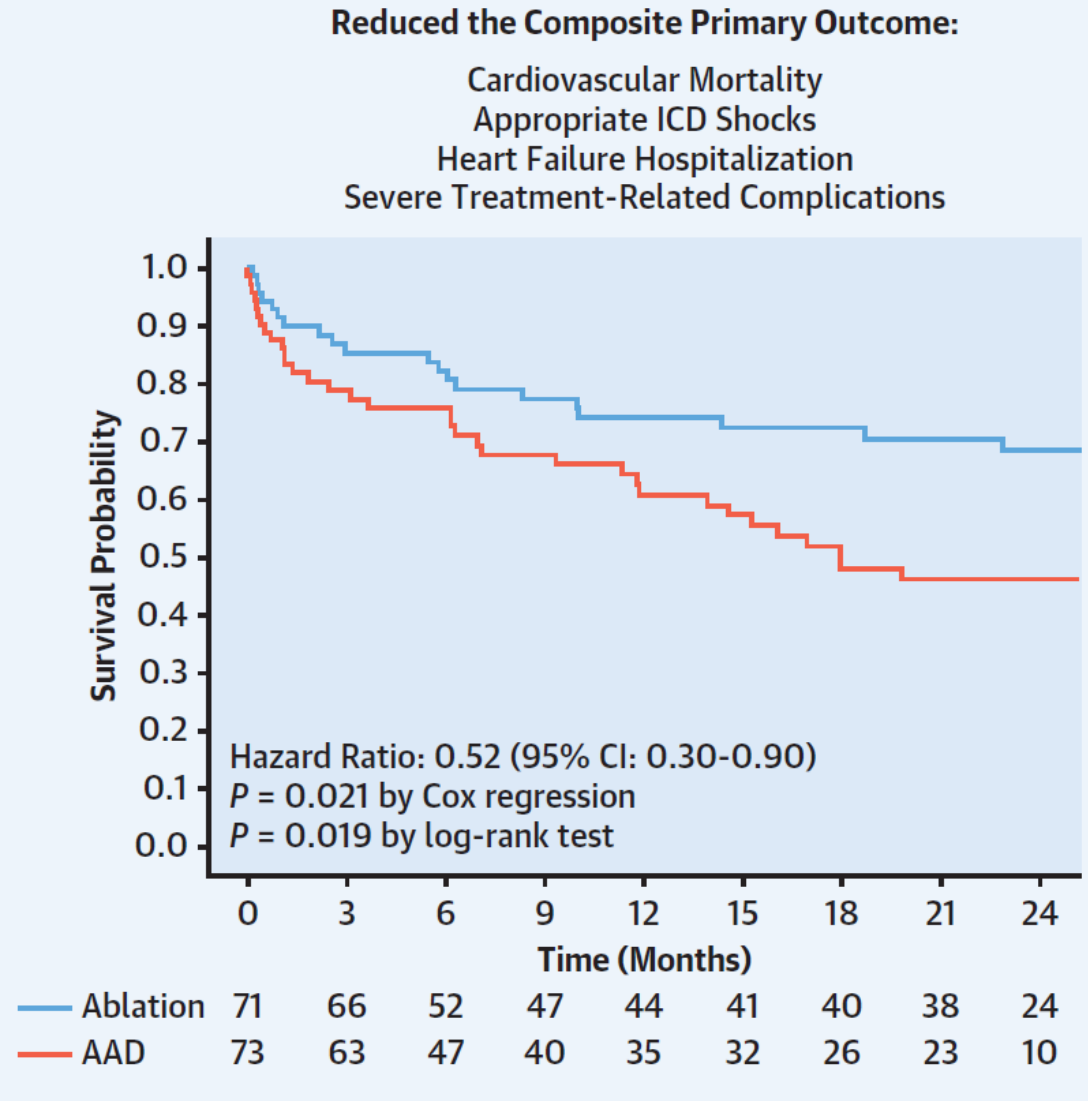
Substrate Ablation vs Antiarrhythmic Drug Therapy for Symptomatic Ventricular Tachycardia

Arenal *JACC* 2022

SURVIVE VT

145 patients with prior MI with symptomatic VT (shock, sustained VT & Syncope, new onset VT)
Randomized to ablation or AAD (amio unless contraindicated)

Primary Outcome: Composite of CV Death, appropriate shock, unplanned HF Hosp, Severe treatment-related complications



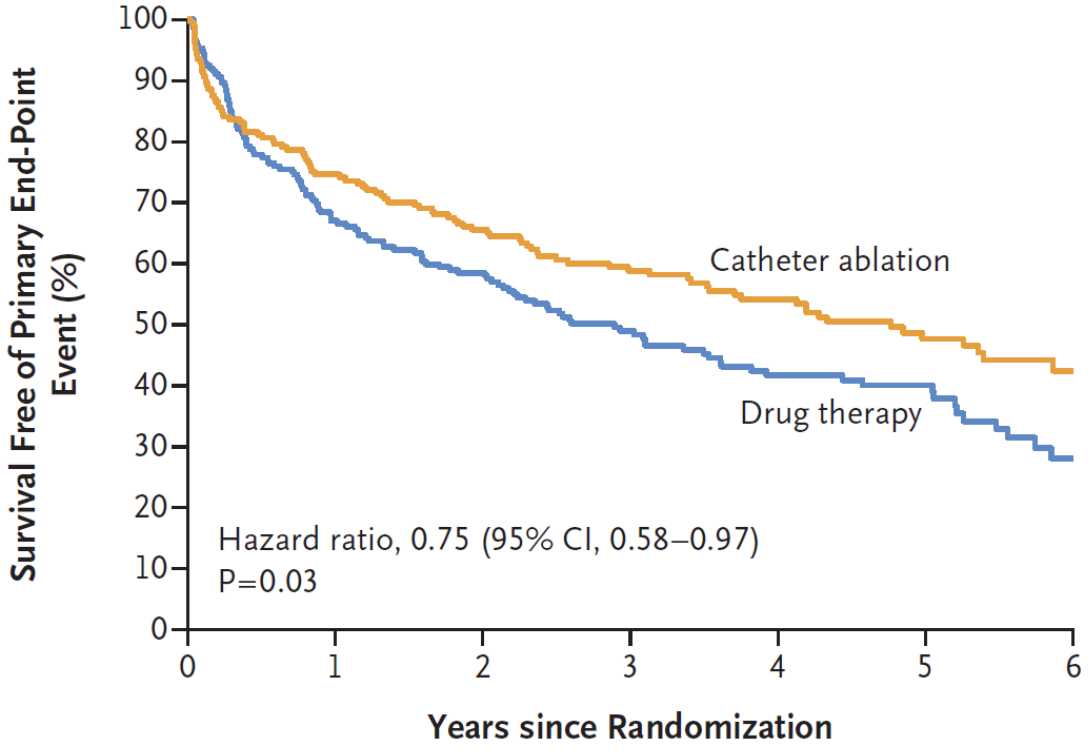
Randomized Trials Primary Outcomes

Catheter Ablation or Antiarrhythmic Drugs for Ventricular Tachycardia

VANISH2 Trial 2025

416 patients with prior MI and VT in the absence of AAD, randomized to ablation or AAD therapy

Primary Outcome: Composite of death, appropriate ICD shock, VT Storm, VT treated emergently



No. at Risk

Catheter ablation	203	149	129	95	75	48	24
Drug therapy	213	142	123	81	57	37	13

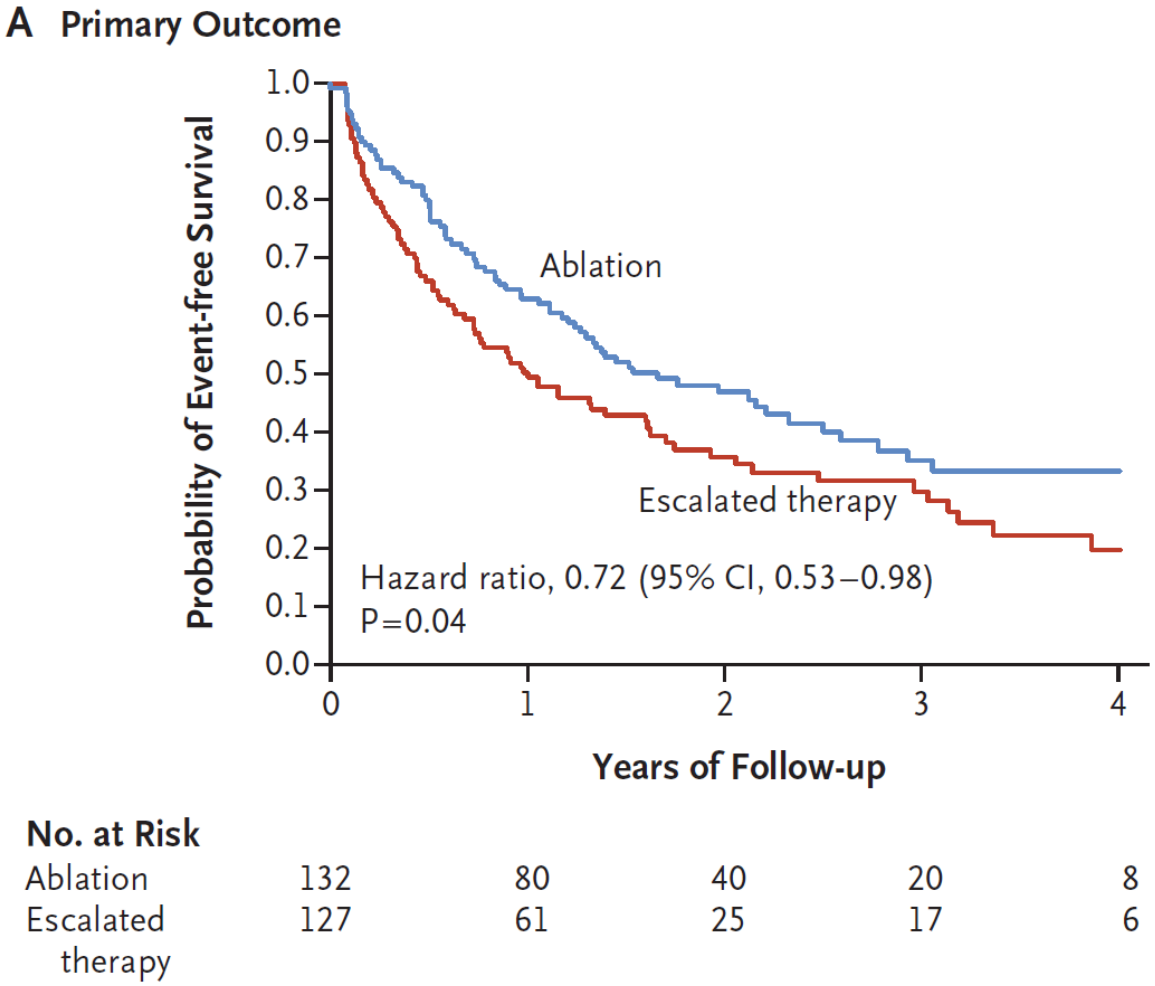
Randomized Trials Primary Outcomes

Ventricular Tachycardia Ablation versus Escalation of Antiarrhythmic Drugs

VANISH Trial 2016

259 patients with prior MI and VT despite AAD, randomized to ablation or escalation of AAD therapy

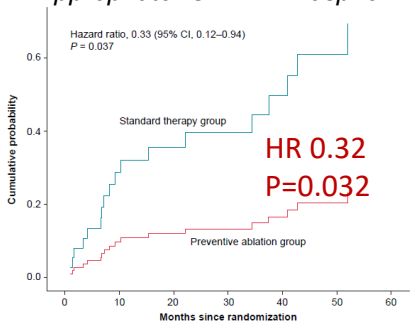
Primary Outcome: Composite of death, appropriate ICD shock, VT Storm



Randomized Trials of Catheter Ablation: Primary Outcomes

Primary Preventive

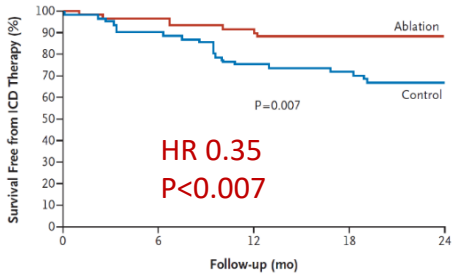
Appropriate ICD Rx / Hosp for VT



PREVENTIVE VT
Zizek *Europace* 2024

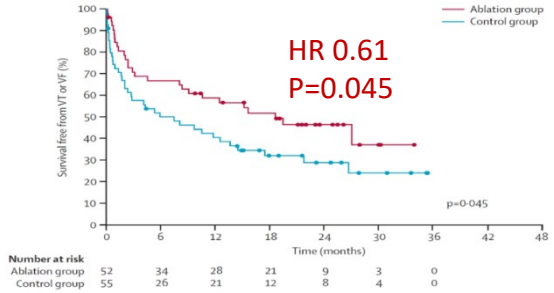
First Line Rx Ablation vs Control

Freedom from appropriate ICD Rx



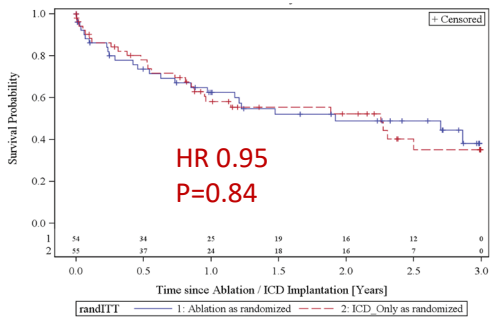
SMASH VT
Reddy *NEJM* 2007

Freedom from VT/VF



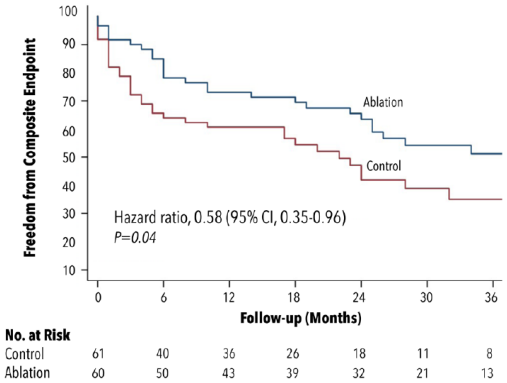
VTACH
Kuck *Lancet* 2010

Freedom from VT/VF



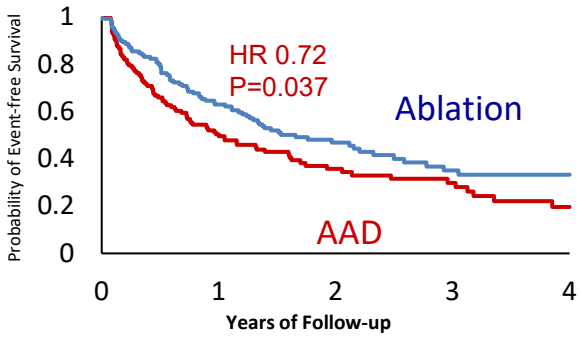
SMS
Kuck *CircAE* 2017

Freedom from VT/VF



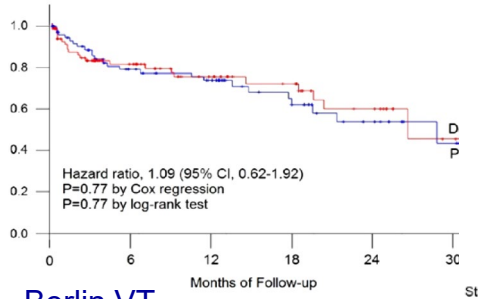
PAUSE
Tung Circulation 2022

Freedom from Shock/Death/Storm



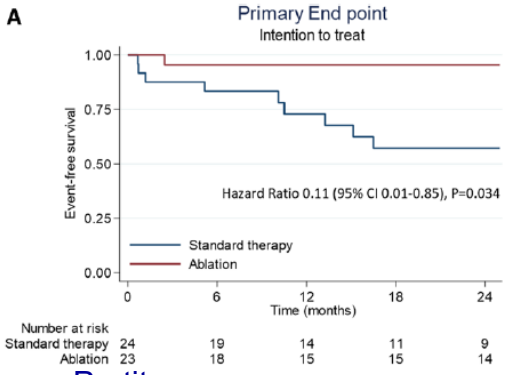
VANISH 2016

Freedom from Death/HF hosp/VA hosp



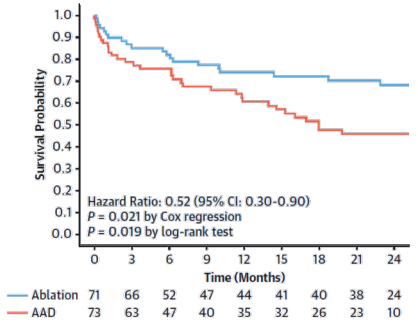
Berlin VT
Willems *Circulation* 2020

Freedom from death/Worse HF



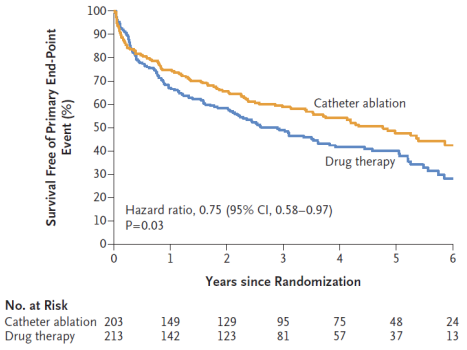
Partita
Della Bella *Circulation* 2022

Freedom from CVdeath/ AppropShock/ HFhosp/ Treatment Complications



Survive VT
Arenal *JACC* 2022

Freedom from Death/Storm/Shock/VT in ER



VANISH2 2025

Drug-Refractory, Ablation vs AAD

Early vs Late Intervention

First Line Ablation vs AAD

Meta-analysis (without VANISH2)

- VT Recurrence: RR 0.82 (95%CI 0.70-0.97)
- Appropriate shock: RR 0.62 (95%CI 0.44-0.89)
- Storm: RR 0.72 (95%CI 0.54-0.95)
- Death: RR 0.94 (95%CI 0.69-1.29)

Reddy 2023

Meta-analysis (without VANISH2)

- Major complications: 8.2%
  - Perforation/tamponade
  - CVA
  - Vascular access complications, major bleeding
  - Heart block
  - Heart failure

Ablation complications VANISH2

Adverse events within 30 days of an ablation

Event	Catheter Ablation 203 Patients 240 Procedures	Antiarrhythmic Drug 213 Patients 79 Procedures	All procedures 319 Procedures (%)
Death	2*	0	2 (0.6%)
Vascular injury (Pseudoaneurysm)	5	1	6 (1.9%)
Major Bleeding	2‡	0	2 (0.6%)
Stroke	3	0	3 (0.9%)
Decompensated heart failure	4	3	7 (2.2%)
Cardiac perforation	1	0	1 (0.3%)
Sepsis	1	0	1 (0.3%)
Peripheral embolism	1	0	1 (0.3%)
Endocarditis	0	1	1 (0.3%)
Pericarditis/effusion *(treated with colchicine)*	1	0	1 (0.3%)
Heart block (persistent)	2	1	3 (0.9%)
Other adverse events†	9	6	15 (4.7%)
Total Patients Experiencing Non-Fatal Events	23	10	

Ablation complications VANISH2

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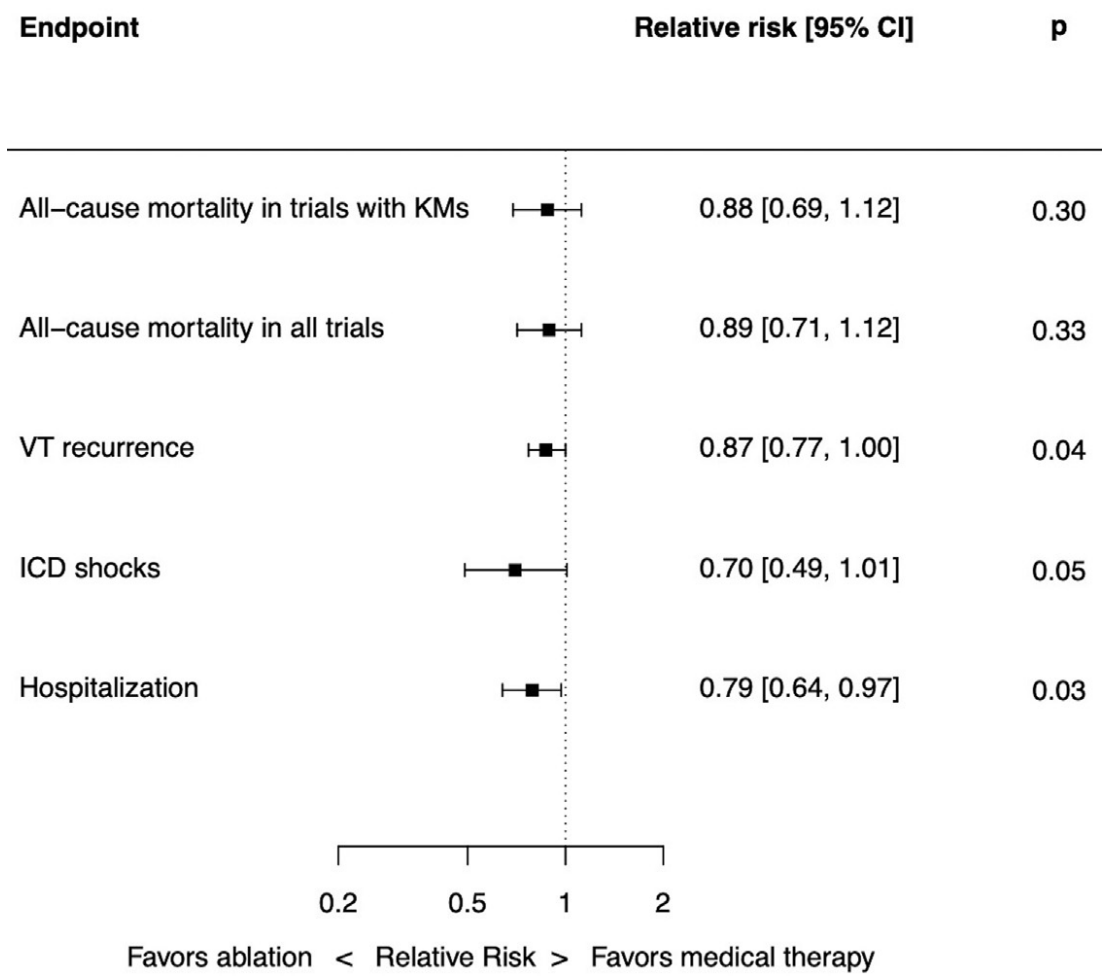
Death 2/319
Nonfatal Stroke 2/319
Perforation 1/319

Need to Consider the Alternative!

- Ablation versus drugs

Meta-analysis



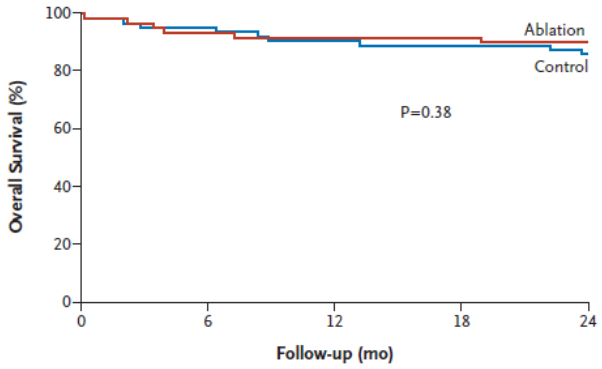
SMASH VT, 2007
VTACH, 2010
CALYPSO, 2014
VANISH, 2016
SMS, 2017
ERASE VT, 2017
PARTITA, 2022
SURVIVE VT, 2022
VANISH2, 2024

Berlin VT 2020

Reddy 2025 JACC EP

Randomized Trials of Catheter Ablation: Mortality

First Line Rx Ablation vs Control



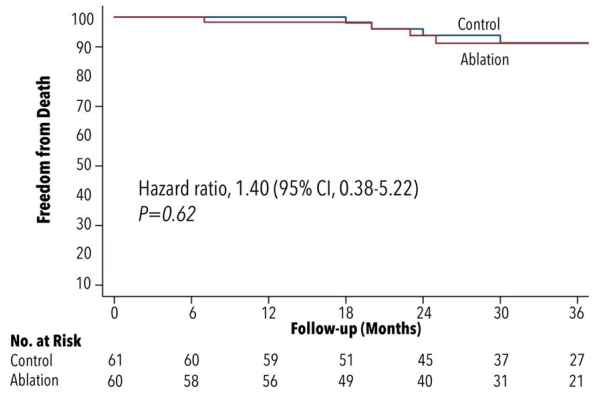
SMASH VT
Reddy *NEJM* 2007

HR 1.32
95%CI 0.35-4.94
P=0.68

VTACH
Kuck *Lancet* 2010

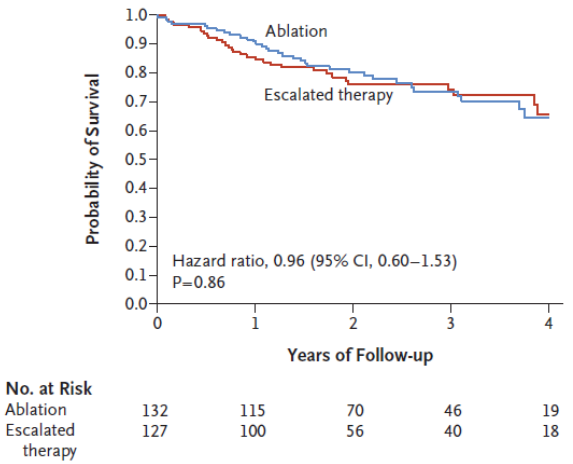
HR 0.82
95%CI 0.34-1.97
P=0.65

SMS
Kuck *CircAE* 2017

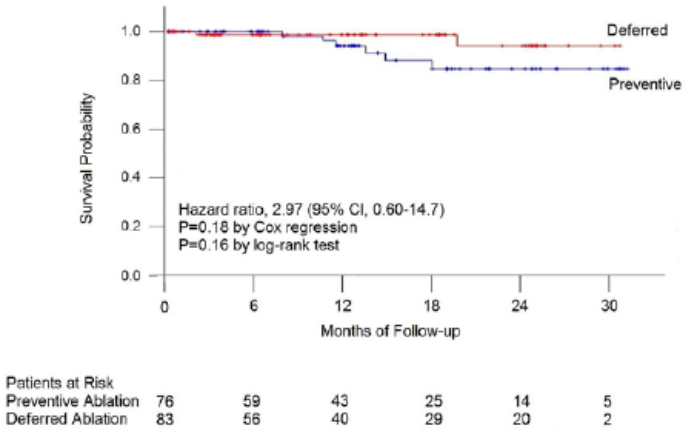


PAUSE
Tung Circulation 2022

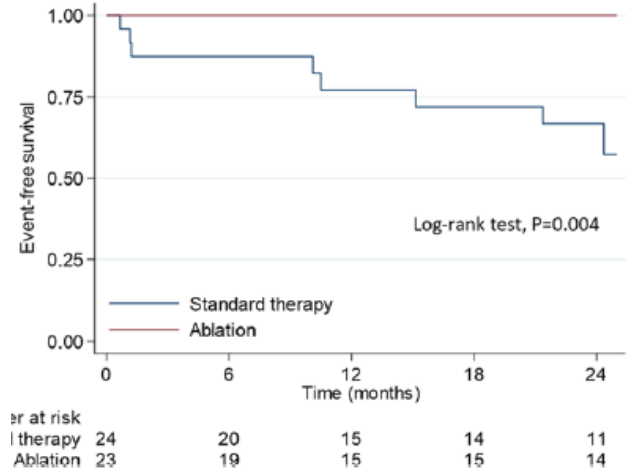
Drug-Refractory, Ablation vs AAD



VANISH 2016

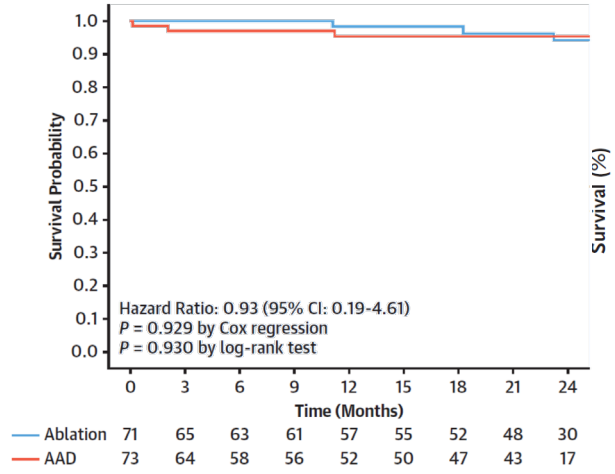


Berlin VT
Willems *Circulation* 2020

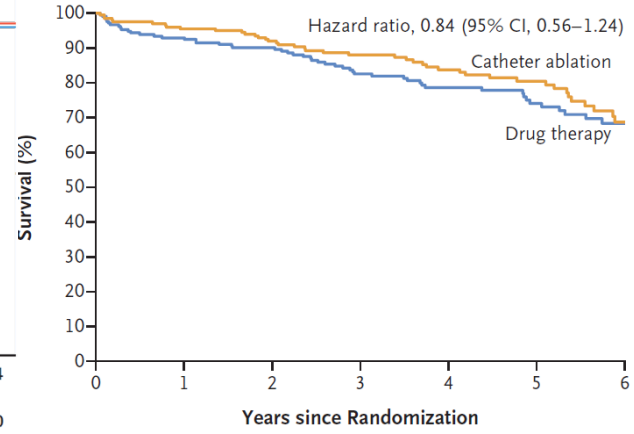


Partita
Della Bella *Circulation* 2022

Early vs Late Intervention



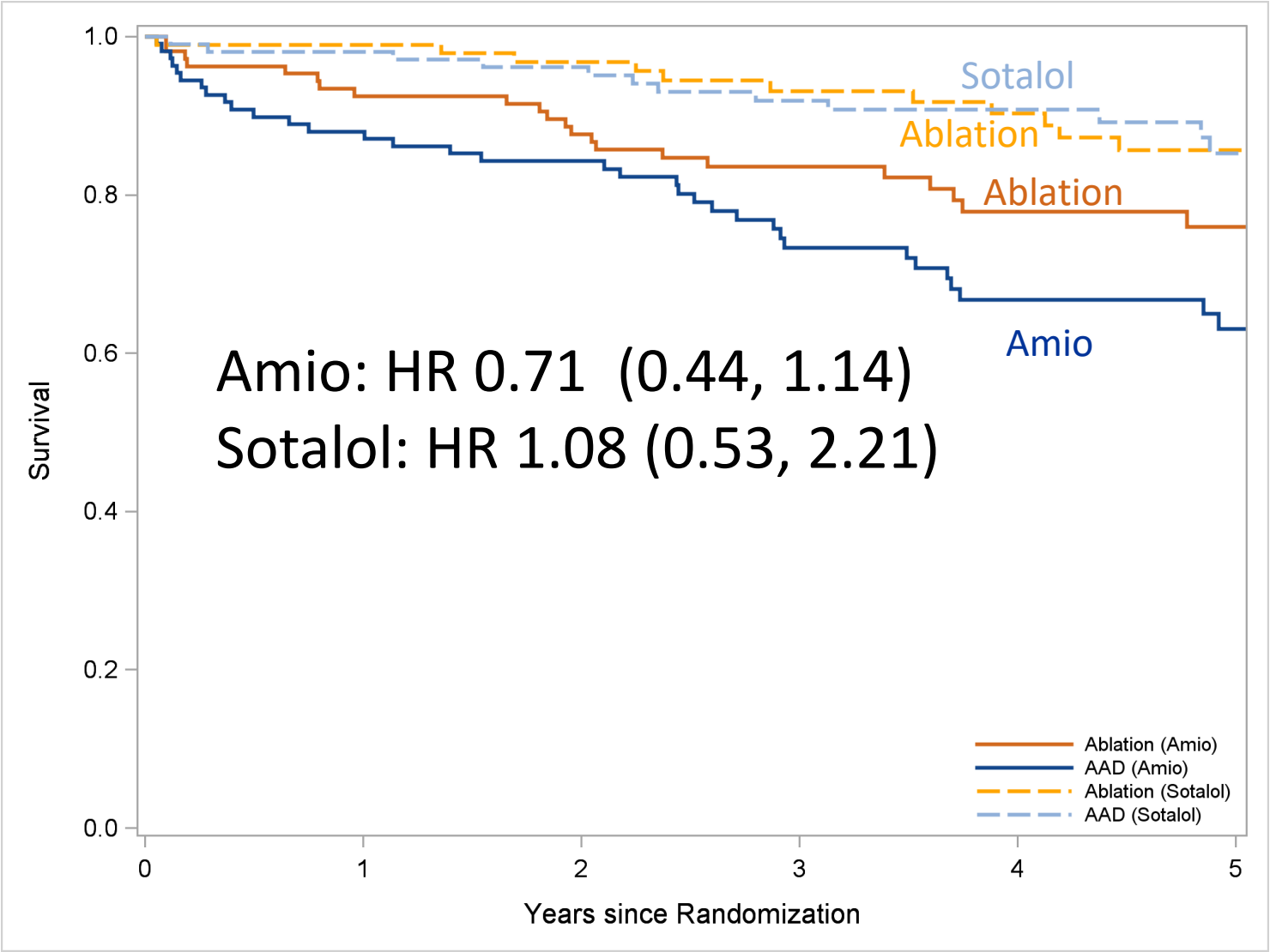
SURVIVE VT
Arenal JACC 2022



VANISH2 2025

First Line Ablation vs Amio

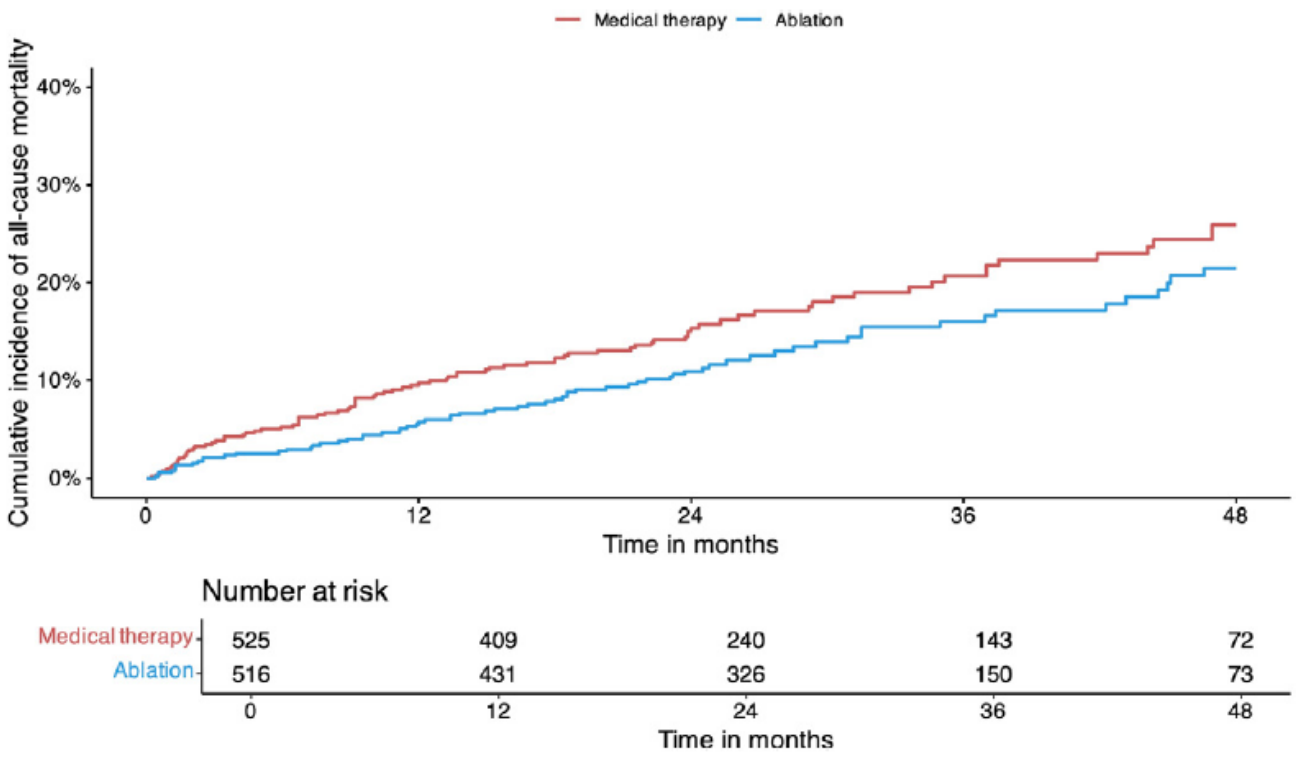
VANISH2 Mortality By Drug Stratum



VANISH2

Meta-analysis: mortality

FIGURE 1 Kaplan-Meier Plot for All-Cause Mortality Comparing VT Ablation to Medical Therapy



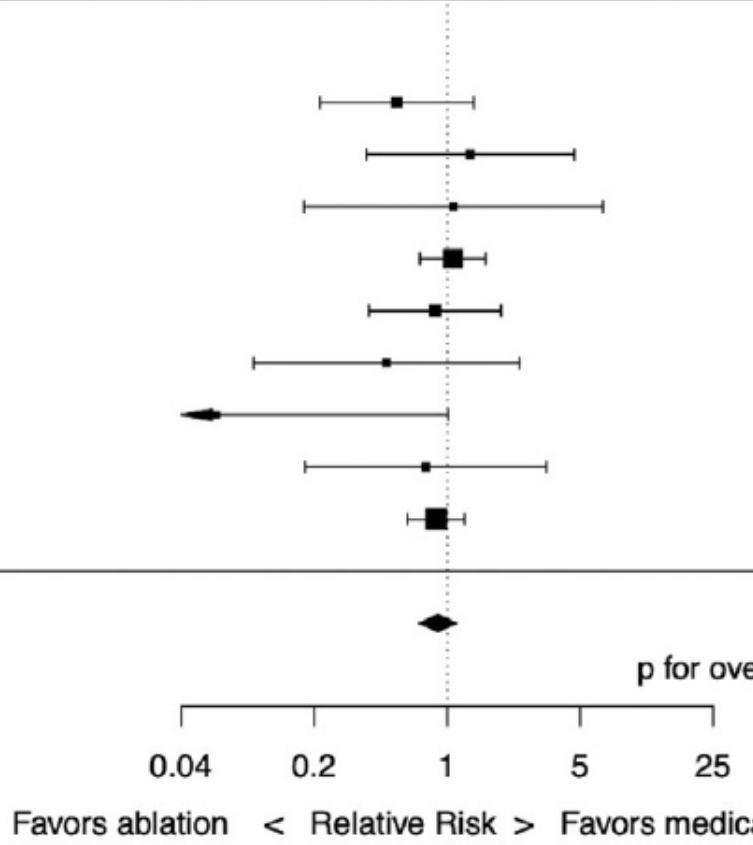
VT = ventricular tachycardia.

Reddy JACCEP 2025

Meta-analysis: mortality

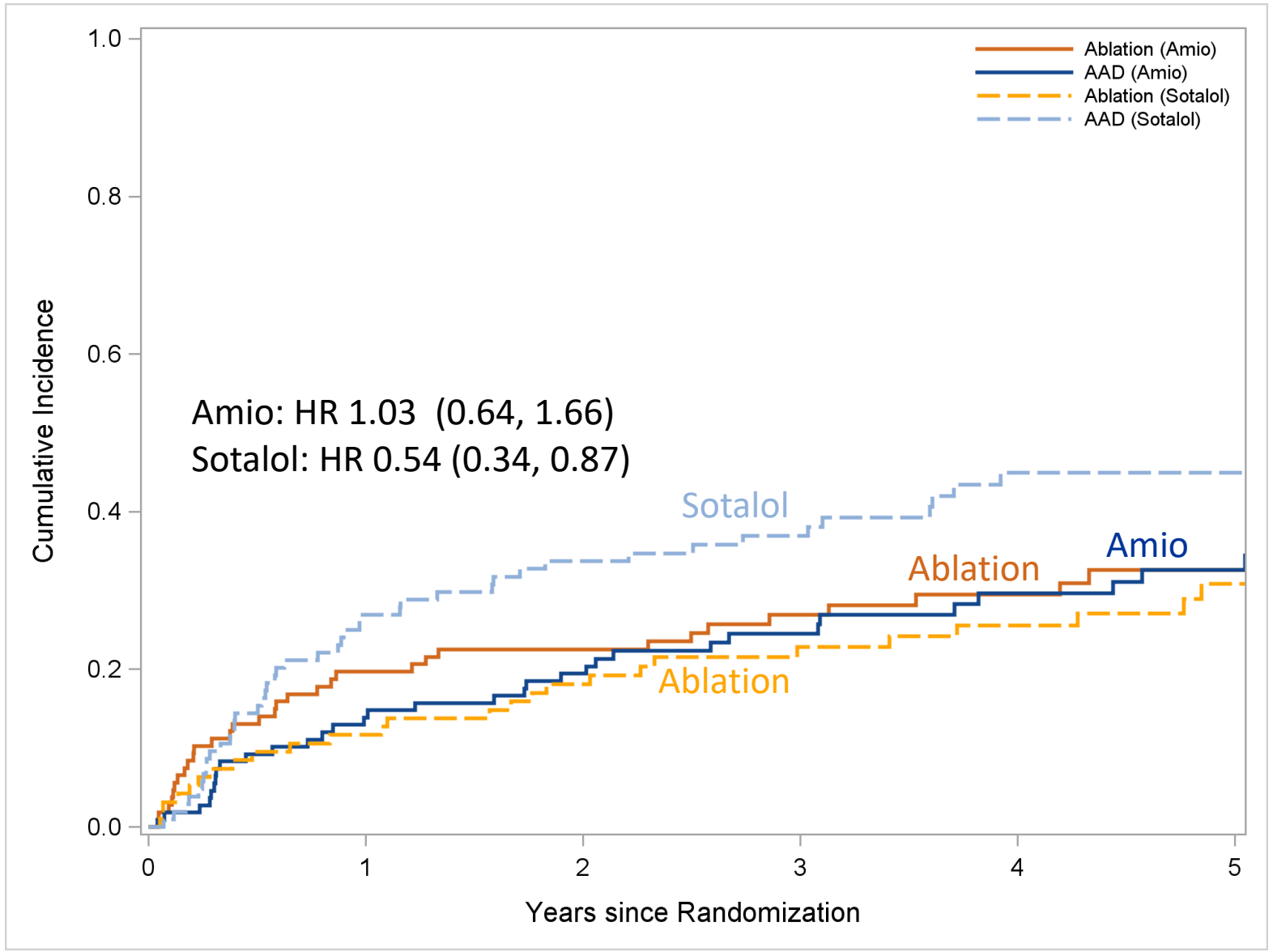
FIGURE 2 Forest Plots for VT Ablation Compared With Medical Therapy, and All-Cause Mortality

Study and Year	Ablation Events	Ablation N	Medical therapy Events	Medical therapy N	Weight (%)	Relative risk [95% CI]
Relative risk of all–cause mortality in trial–level meta–analysis						
SMASH VT, 2007	6	64	11	64	5.9	0.55 [0.21, 1.39]
VTACH, 2010	5	52	4	55	3.3	1.32 [0.38, 4.66]
CALYPSO, 2014	2	13	2	14	1.6	1.08 [0.18, 6.57]
VANISH, 2016	36	127	35	132	32.9	1.07 [0.72, 1.59]
SMS, 2017	9	54	11	57	8.1	0.86 [0.39, 1.92]
ERASE VT, 2017	2	26	4	25	2.0	0.48 [0.10, 2.40]
PARTITA, 2022	0	23	8	24	0.7	0.06 [0.00, 1.00]
SURVIVE VT, 2022	3	71	4	73	2.4	0.77 [0.18, 3.32]
VANISH2, 2024	45	203	54	213	43.2	0.87 [0.62, 1.24]
REML Model for All Studies (Q = 6.44, df = 8, p for heterogeneity = 0.60; I^2 = 0.0%)						0.89 [0.71, 1.12]
Prediction interval –0.34 – 0.11						p for overall effect = 0.330

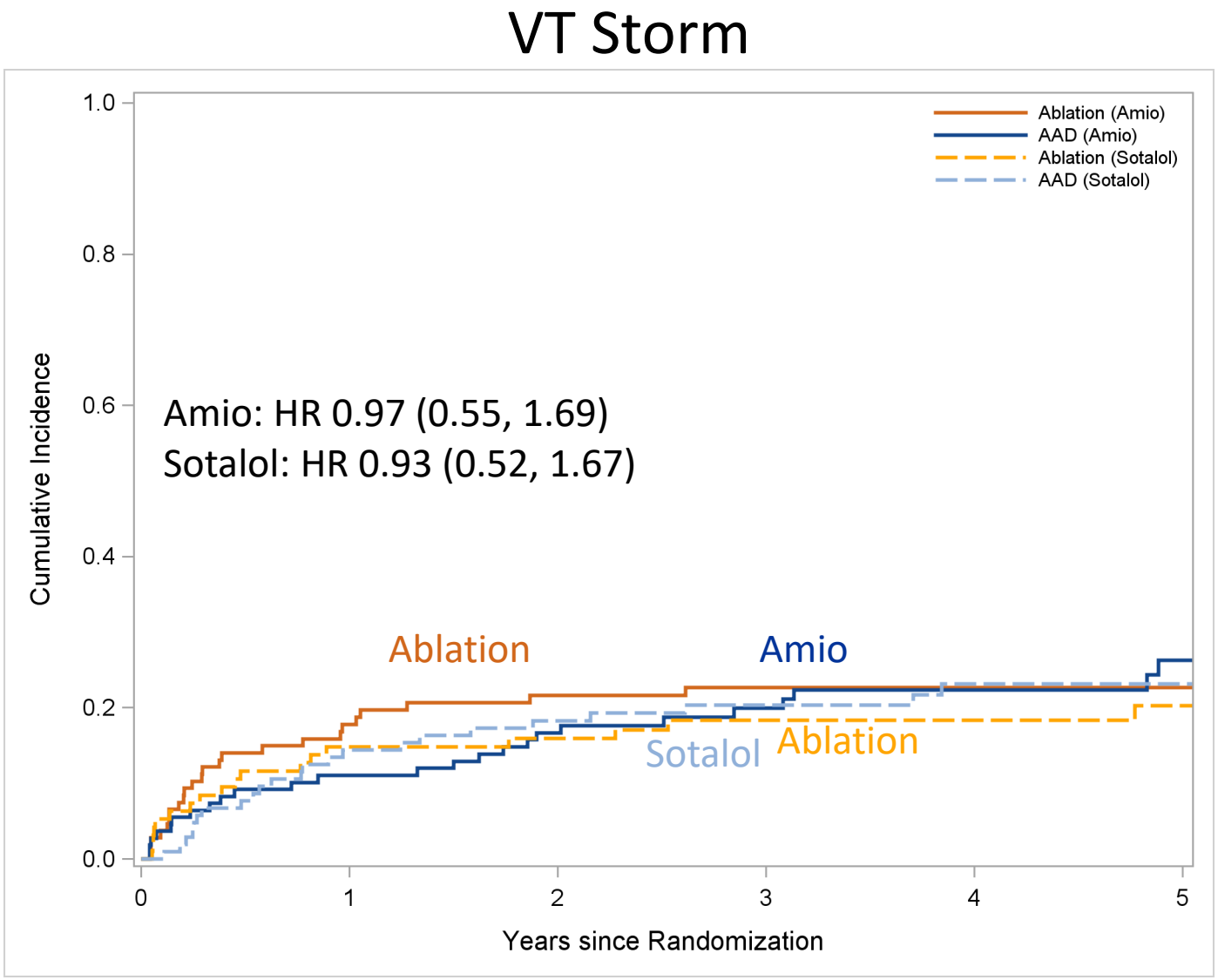


Reddy JACCEP 2025

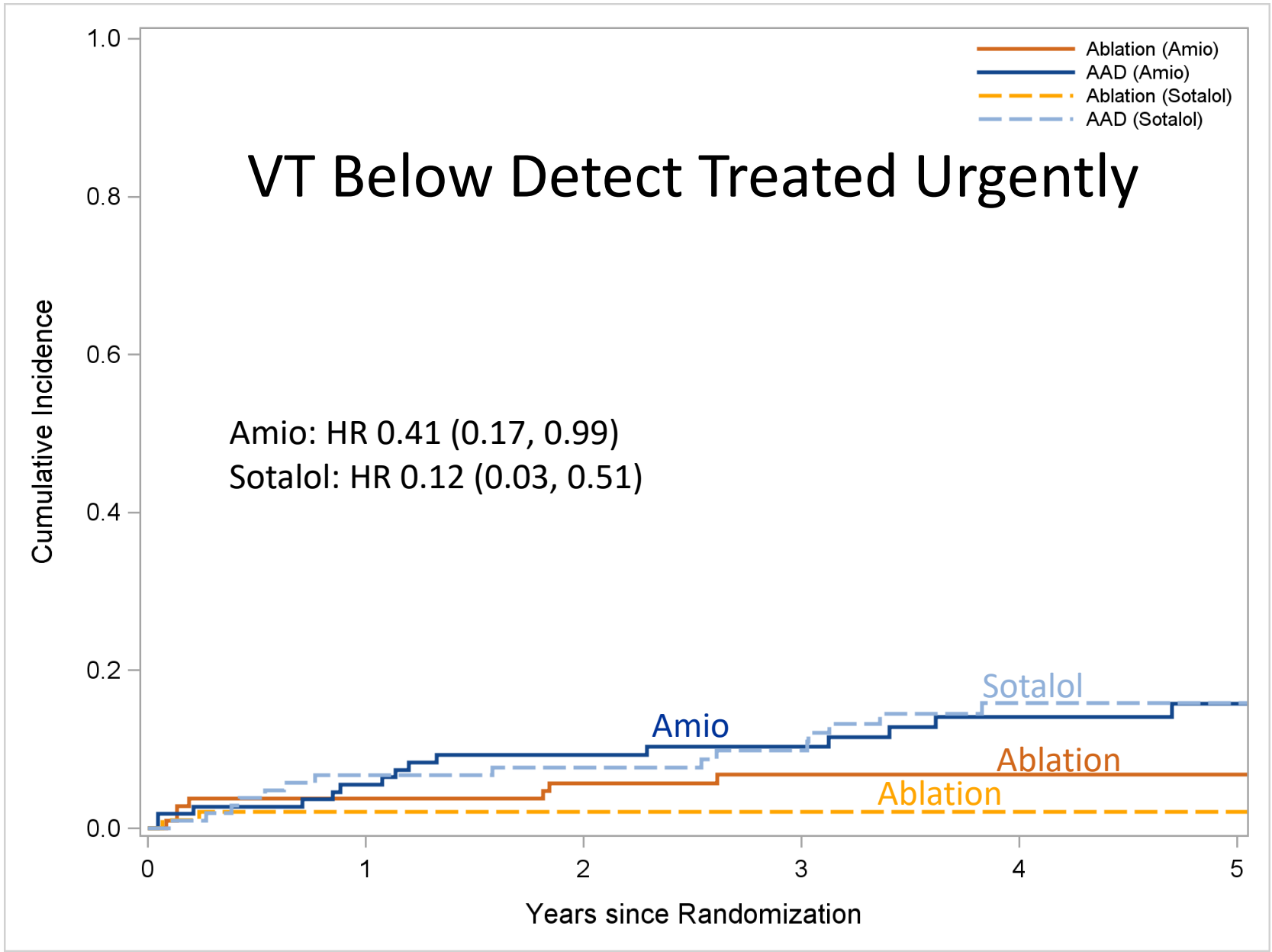
VANISH2 Outcomes By Drug Stratum



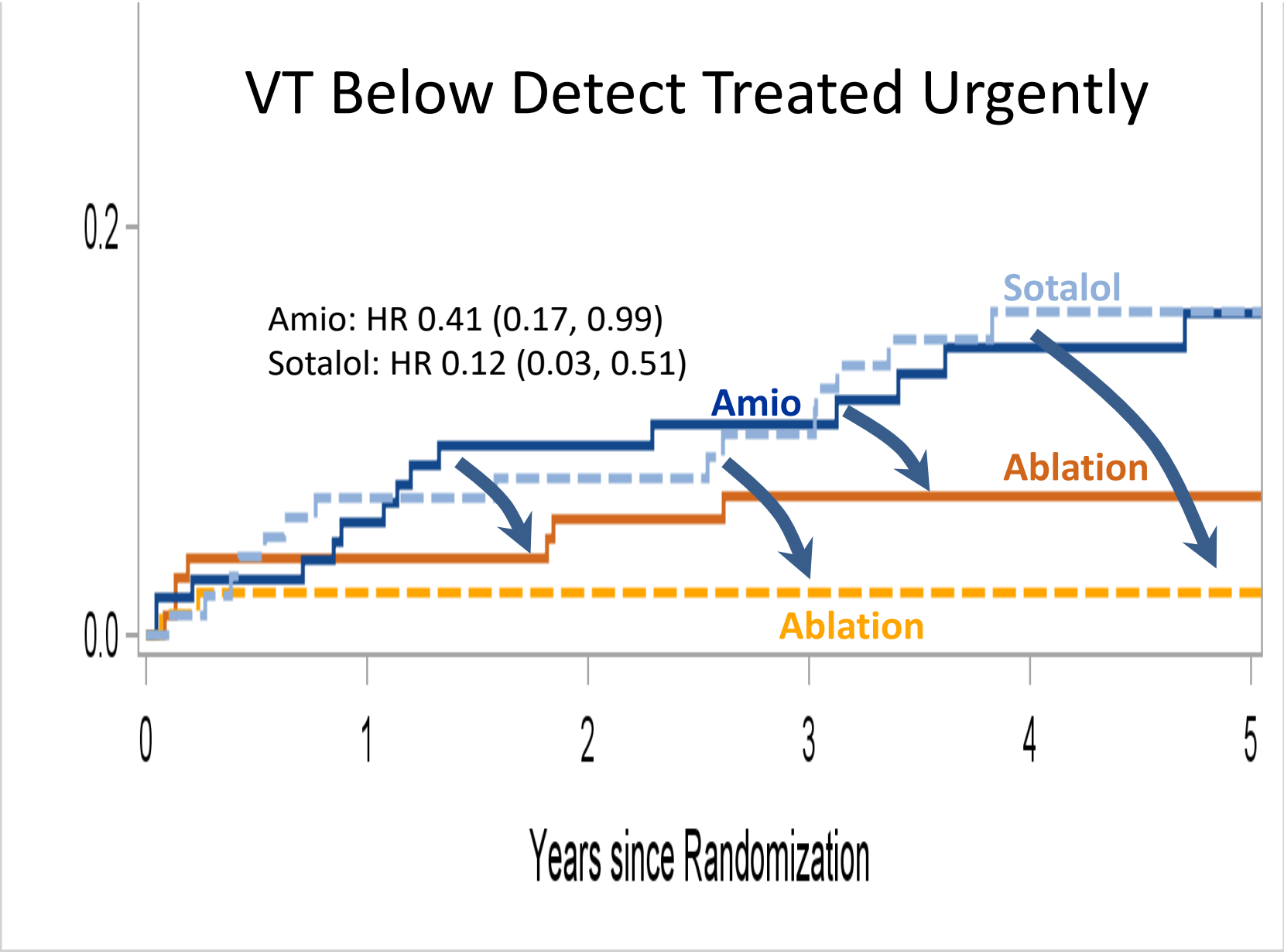
VANISH2 Outcomes By Drug Stratum



VANISH2 Outcomes By Drug Stratum



VANISH2 Outcomes By Drug Stratum



Safety

	Ablation Group (N=203)	Antiarrhythmic Drug Group (N=213)
Death	22.2%	25.4%
Serious Nonfatal Adverse Events	28.1%	30.5%

Adverse Events within 30d of Ablation (selected)

	Ablation	Drug
Death	1%	0
Major Bleeding	1%	0
Perforation	0.5%	0
Stroke	1.5%	0
Decompensated heart failure	2%	1.4%

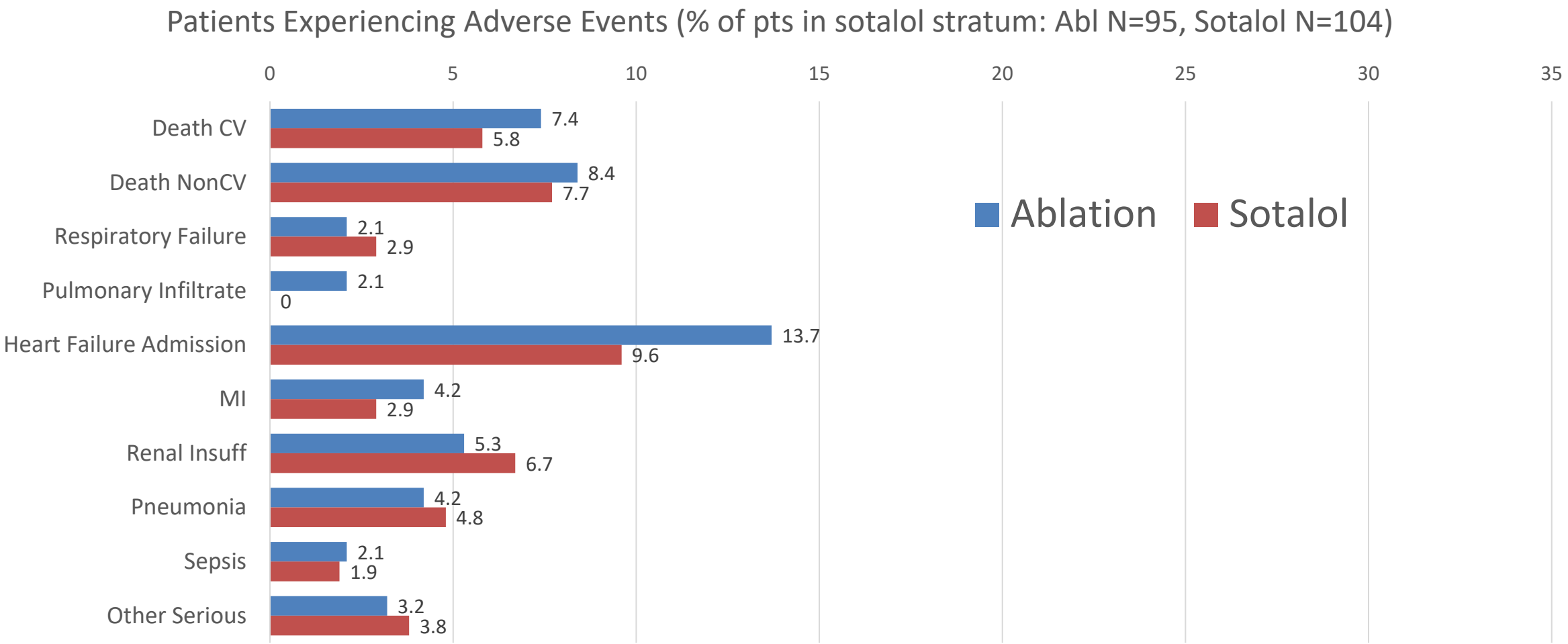
VANISH 2

Safety

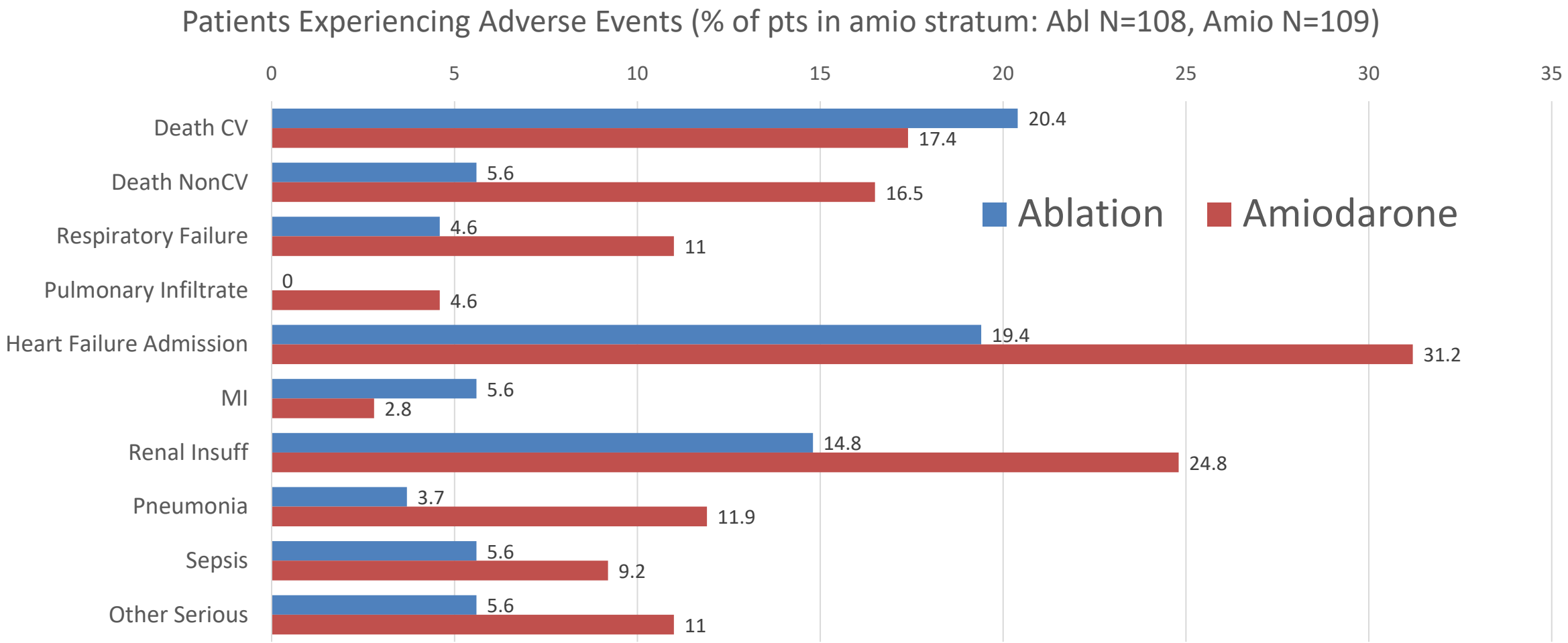
Drug Attributed Adverse Effects (selected) Leading to Reduction / Discontinuation

	Ablation	Drug
Death (pulmonary toxicity)	0	0.5%
Heart Failure Admission	0	0.5%
Pulmonary Infiltrate/Fibrosis	0.5%	3.3%
Hyperthyroidism	2%	3.3%
Liver dysfunction	0	2.4%
Neurotoxicity	0	2.4%
Bradycardia symptomatic	0	1.4%
Total Nonfatal	3.4%	21.6%

Treatment-Related Adverse Events: *Sotalol eligible*



Treatment-Related Adverse Events: *Amio eligible*



VANISH

Adverse Effects

Amiodarone-treated:

- 3x higher non-cardiac death (5.6% vs 16.5%)
- 2x higher resp failure (4.6% vs 11%)
- Pulmonary infiltrates/fibrosis (0 vs 4.6%)
- Pneumonia (3.7 vs 11.9%)
- HF hospitalization 19.4% vs 31.2%)

Can Ablation Improve Survival?

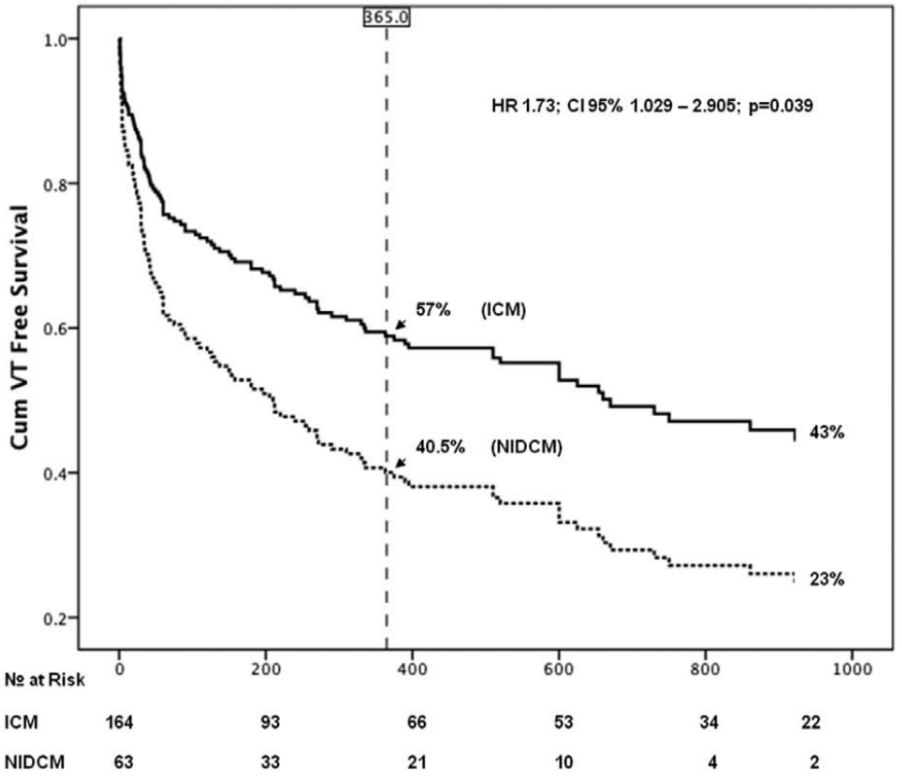
Maybe…but this would be difficult to prove!

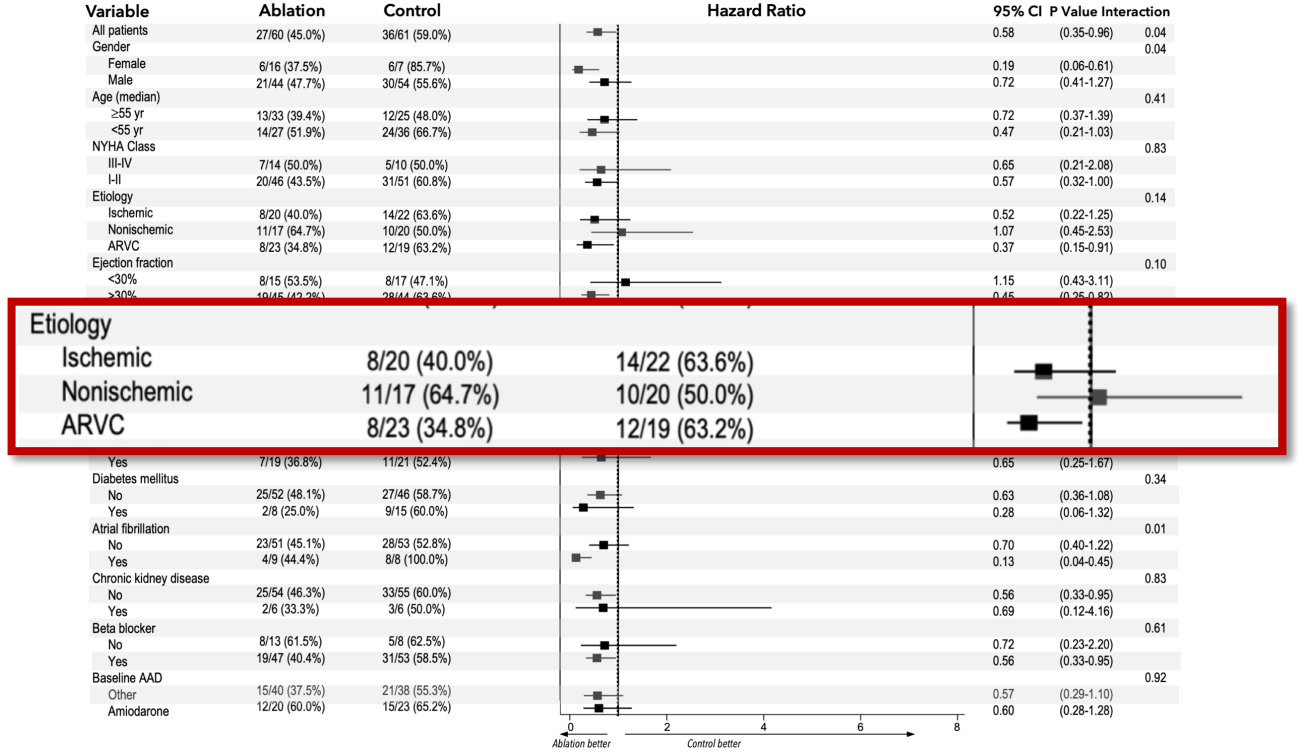
Arrhythmic Death is Infrequent with an ICD

VANISH2 Causes of Death

Event	Catheter Ablation N=203	Antiarrhythmic N=213
Fatal Events		
Non-cardiac death	14 (6.9%)	26 (12.2%)
Cardiovascular death	29 (14.3%)	25 (11.7%)
Unexpected cardiovascular death	3 (1.5%)	4 (1.9%)
Myocardial infarction	1 (0.5%)	2 (0.9%)
Congestive Heart Failure	12 (5.9%)	12 (5.6%)
Post CV Intervention	2 (1.0%)	1 (0.5%)
Ventricular Arrhythmia	3 (1.5%)	1 (0.5%)
Post non-CV surgery	0	3 (1.4%)
Stroke	3 (1.5%)	0
Other Cardiovascular	5 (2.5%)	2 (0.9%)
Unknown cause of death	2 (1.0%)	3 (1.4%)

A brief comment about NICM





HELP VT Dinov
Circulation 2014

PAUSE SCD Tung
Circulation 2022

When should we ablate?

- In Ischemic CM without storm or bad HF
  - Ablation had better efficacy than Sotalol
- In Ischemic CM with storm or bad HF
  - Ablation had similar efficacy to Amiodarone, but perhaps better safety
- In Ischemic CM with VT despite AADs
  - Ablation better than drug escalation (similar to new onset Amio)
- In NICM
  - Ablation's role … after drug failure? Special cases?

What we do not know

- *WHEN* should we intervene
- How best to treat VT in NICM
- VT in women
- Role of newer ablation techniques
- Best treatment for VT Storm?