

Optimal ICD programming

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Optimal ICD programming

ICD shock-reduction strategies

Overview

Rate and Duration for Initial Detection

SVT-VT discrimination

Antitachycardia Pacing

Bradycardia pacing

Conventional Definitions of ICD shocks

- **Appropriate**
 - ICD shocks for VT or VF
- **Inappropriate**
 - ICD shocks for SVT, EMI, lead noise, oversensing, etc.

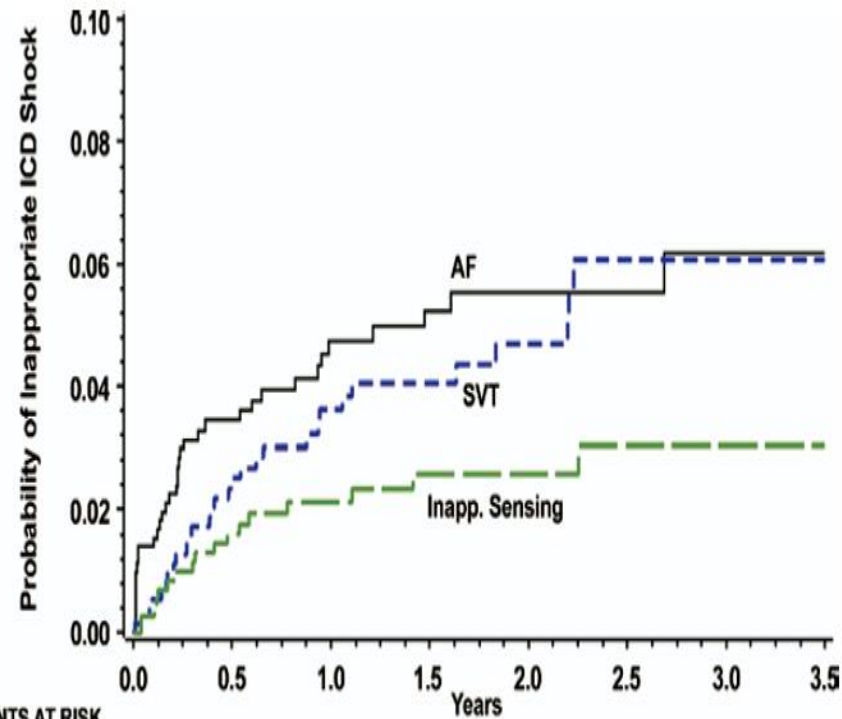
Wilkoff et al. JACC 2008;52:541-50

Frequency of Inappropriate ICD shocks in MADIT II

Table 1 Patients Experiencing Inappropriate ICD Shocks

Shock Therapy Group	Patients (n)	Percent
One or more inappropriate shock episodes	83	11.5
1 inappropriate shock episode	51	7.1
2-4 inappropriate shock episodes	23	3.2
≥5 inappropriate shock episodes	9	1.3
Both inappropriate and appropriate shock episodes	27	3.8
Inappropriate but not appropriate shock episode(s)	56	7.8
No inappropriate shock episodes	636	88.5
Appropriate shock episode(s)	101	14.1
No appropriate shock episodes	535	74.4
Total patients	719	100.0

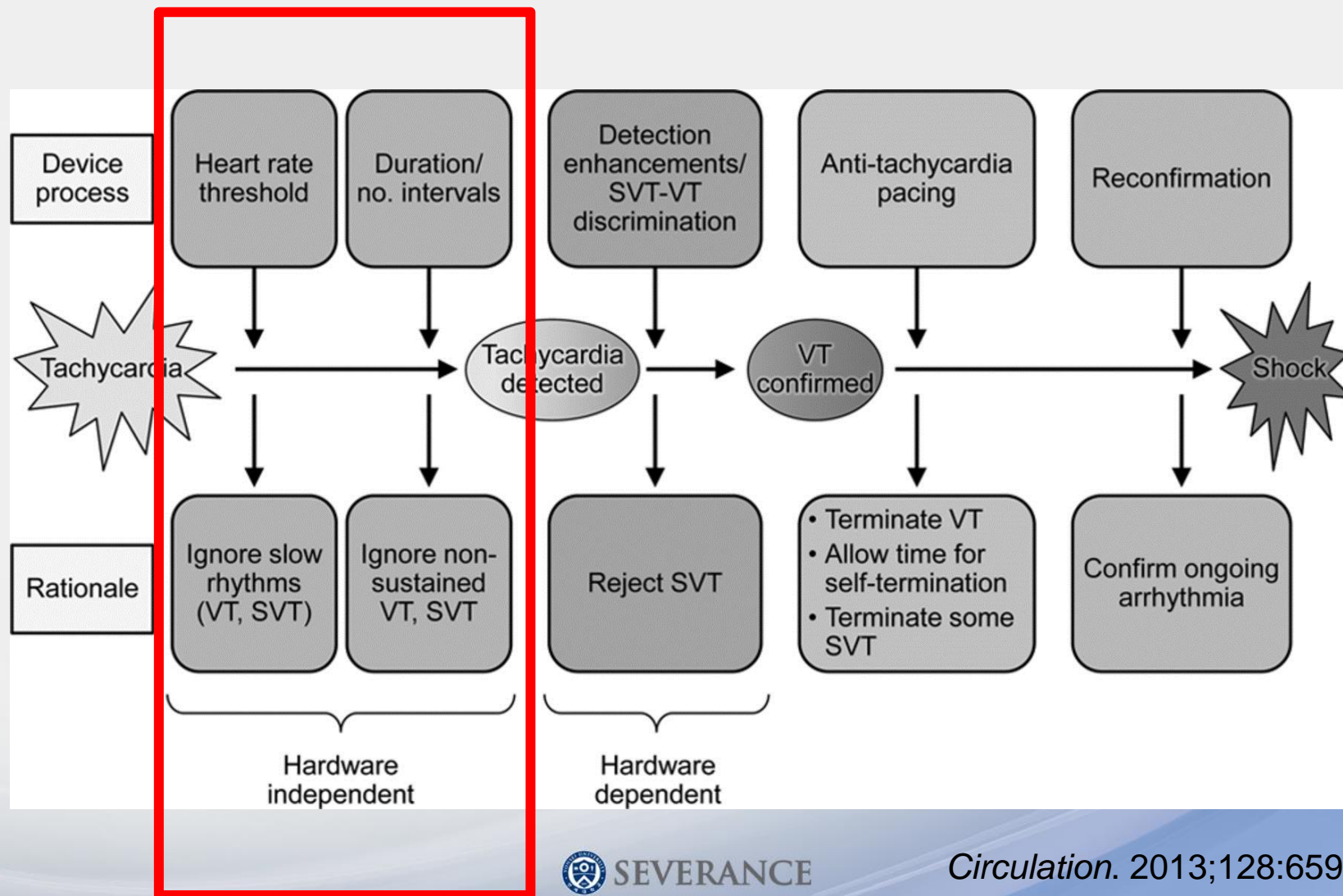
Inappropriate shock: 11.5%
Appropriate shock: 14.1%



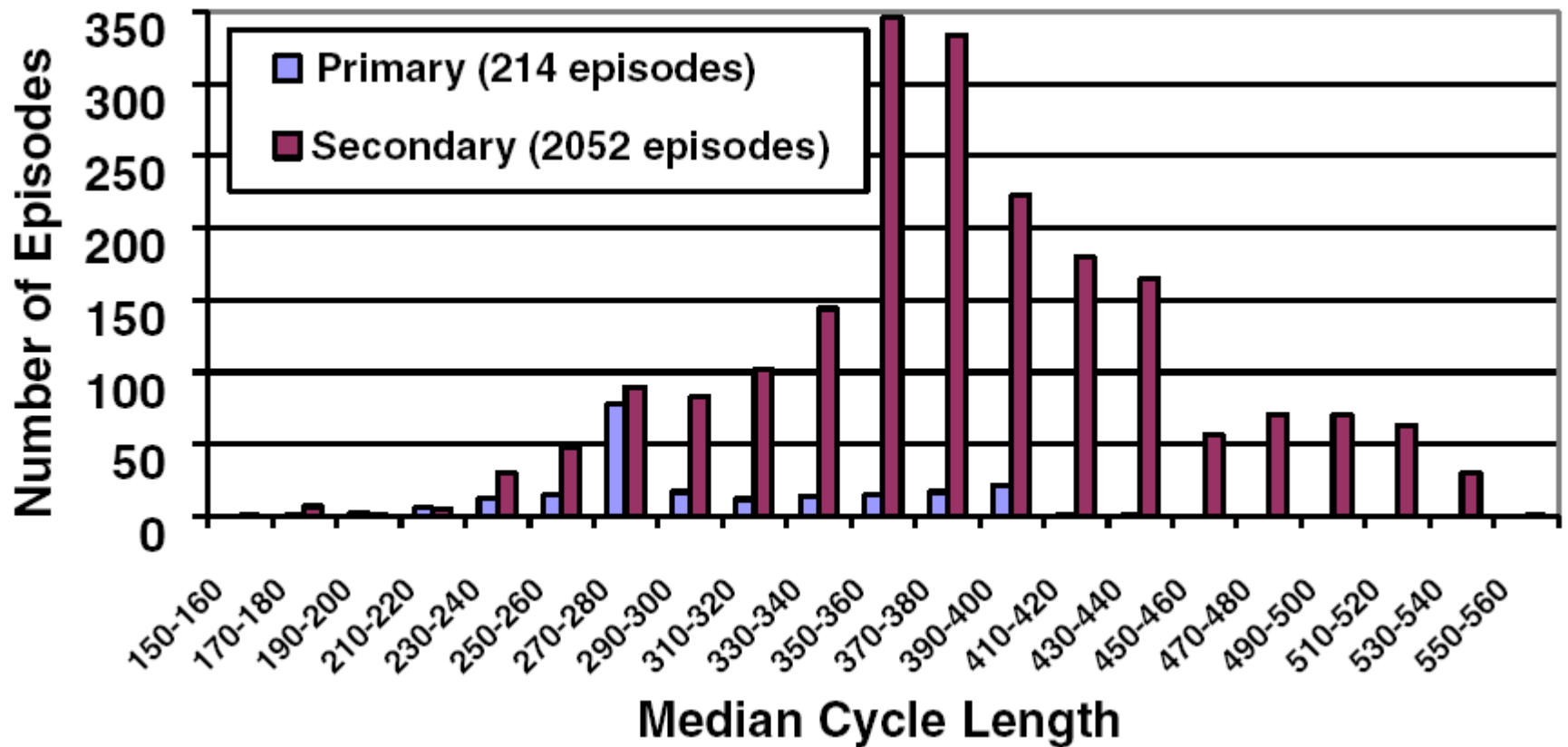
PATIENTS AT RISK

AF	719	462 (0.047)	242 (0.055)	94 (0.062)
SVT	719	464 (0.036)	241 (0.047)	92 (0.061)
Inapp. Sensing	719	474 (0.021)	251 (0.026)	98 (0.031)

ICD Shock-Reduction Strategies: Overview



Appropriately Detected Episodes



303 ± 54 ms vs 366 ± 71 ms, P < 0.0001

Wilkoff B, et al. JCE 2004;15:1002-9

PREPARE: Programming (Primary Prevention Parameters Evaluation)

Table 1 PREPARE VT/VF Programming Parameters

	Detection	Threshold	Beats to Detect	Therapies
VF	On	250 beats/min	30 of 40	30 to 35 J (max output) × 6
FVT	via VF	182 beats/min	30 of 40	Burst (1 sequence), 30 to 35 J (max output) × 5
VT	Monitor	167 beats/min	32	Off

Supraventricular tachycardia criteria on (dual chamber, biventricular implantable cardioverter-defibrillator): atrial fibrillation/flutter, sinus tachycardia (1:1 VT-ST boundary = 66%); supraventricular tachycardia criteria on (single chamber): wavelet morphology discrimination (match threshold = 70%); supraventricular tachycardia limit = 300 ms; burst antitachycardia pacing: 8 intervals, pacing cycle length = 88% of tachycardia cycle length.

FVT = fast ventricular tachycardia; PREPARE = Primary Prevention Parameters Evaluation study; VF = ventricular fibrillation; VT = ventricular tachycardia; VT-ST = ventricular tachycardia-sinus tachycardia.

240 ms
(250 bpm)

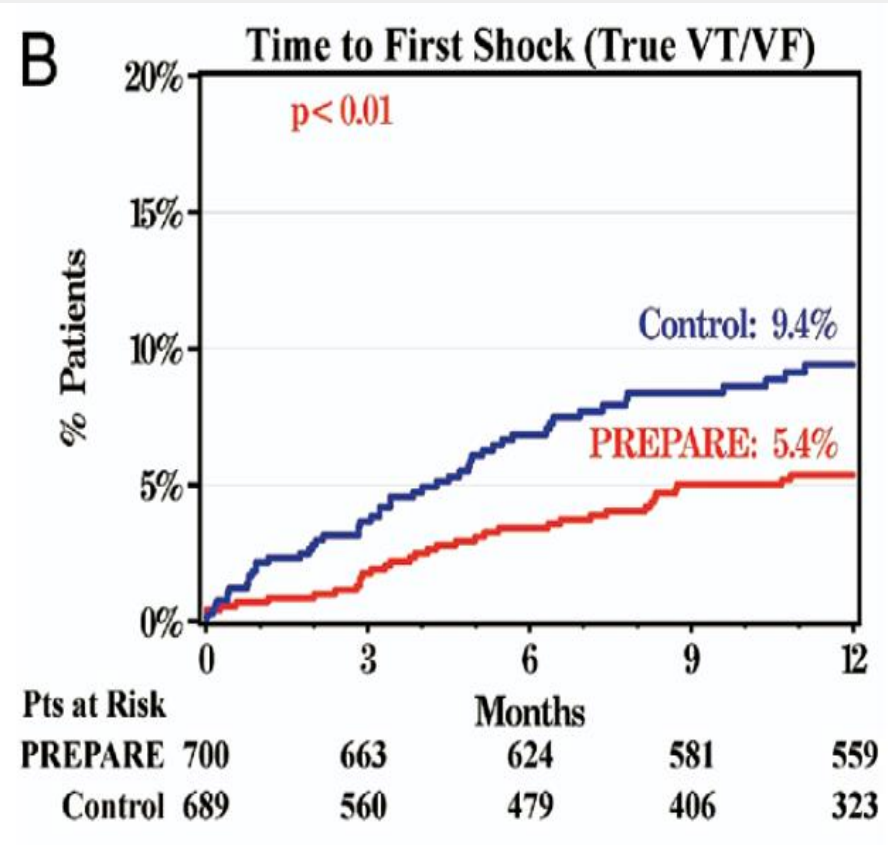
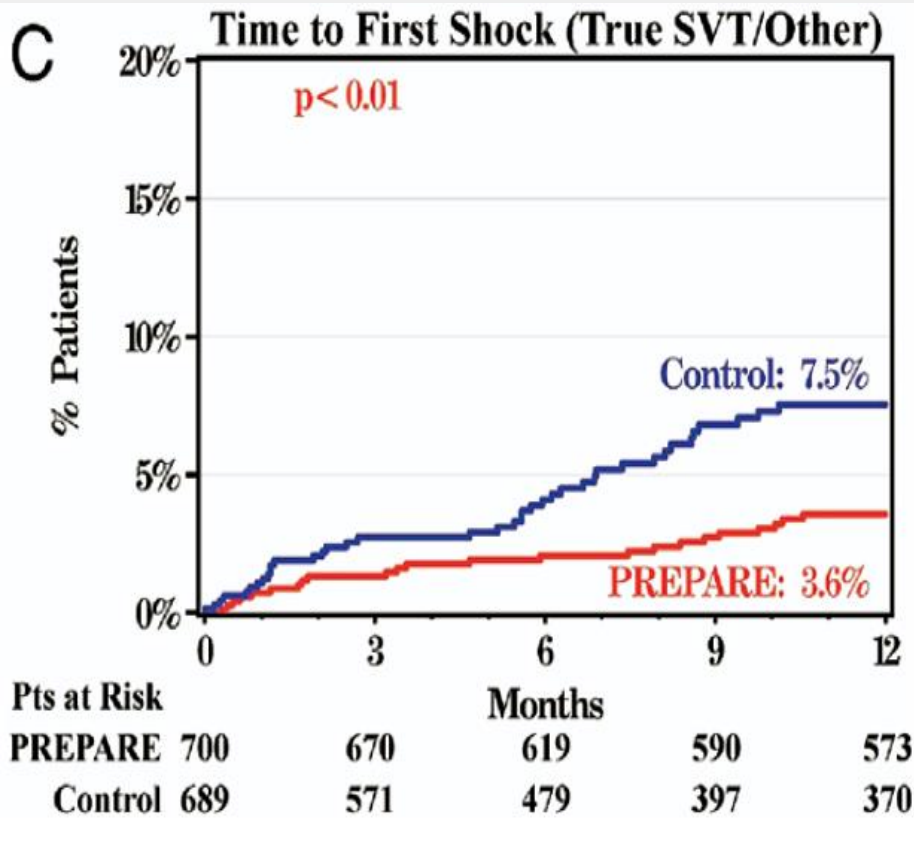
330 ms
(182 bpm)



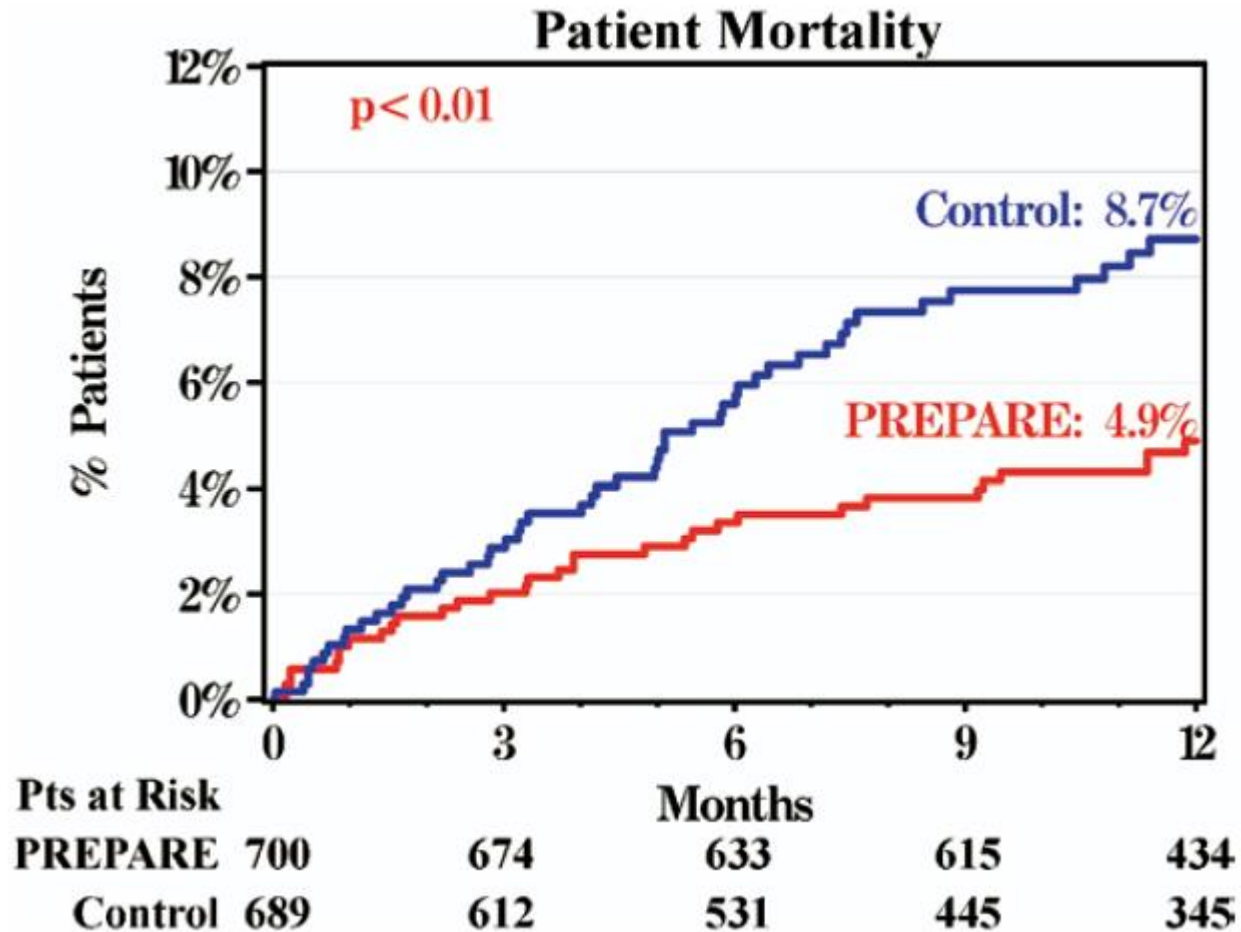
PREPARE: Shock Frequency

Inappropriate Shocks

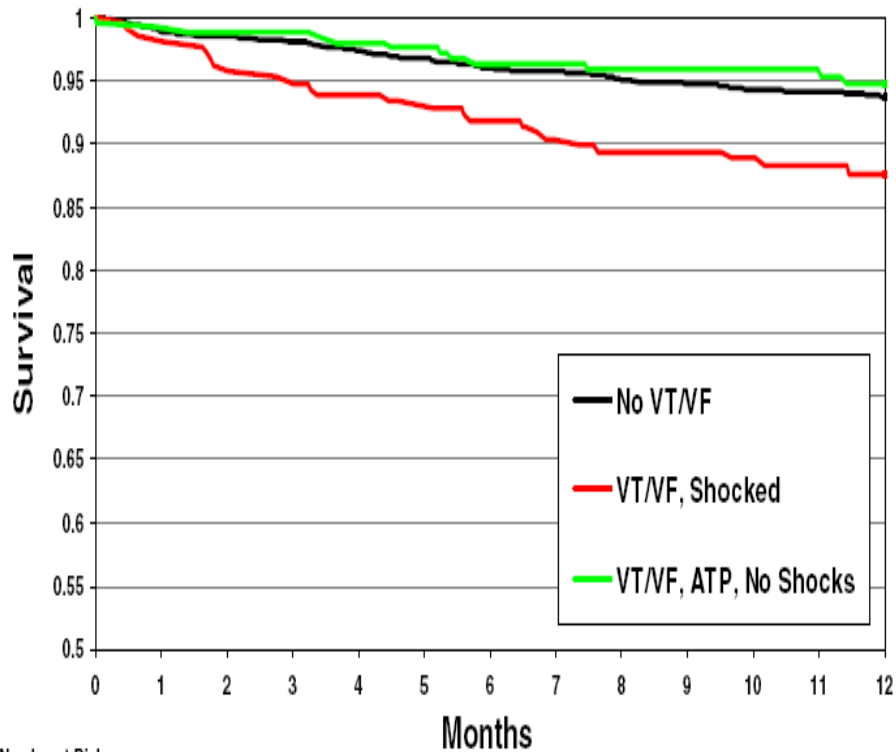
Appropriate Shocks



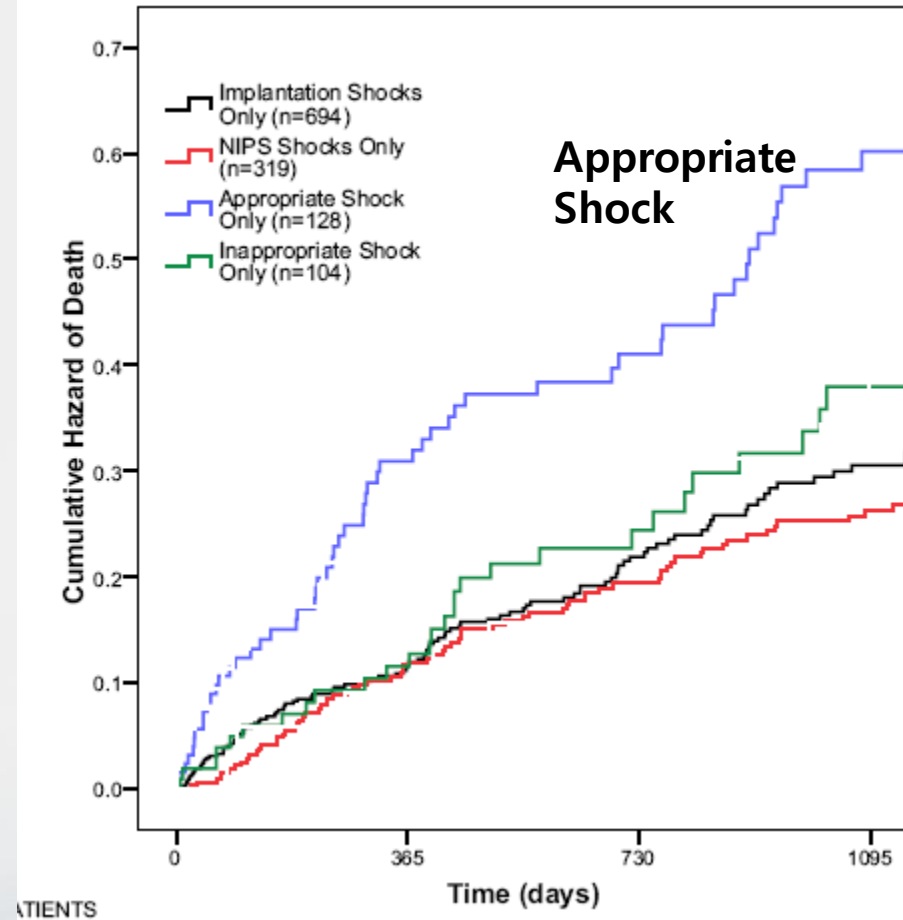
PREPARE: Overall Mortality



Harm from ICD Shocks?



Number at Risk	0	3	6	9	12
No VT/VF (N=1671)	1584	1472	1355	1266	812
VT/VF, Shocked (N=211)	201	186	172	162	97
VT/VF, ATP, No Shocks (N=253)	247	229	206	196	126



Sweeney et al. Heart Rhythm 2010;7:353-60

Bhaynani et al. Heart Rhythm 2010;7:755-60

MADIT-RIT

(Reduction in Inappropriate Tx)

1500 Patients with Primary Prevention ICD Indication:

	Slow VT	Fast VT	VF
Conventional	170-199 bpm 2.5 sec		≥ 200 bpm 1 sec
High-Rate			≥ 200 bpm 2.5 sec
Delayed Detection	170-199 bpm 60 sec	200-249 bpm 12 sec	> 250 bpm 2.5 sec

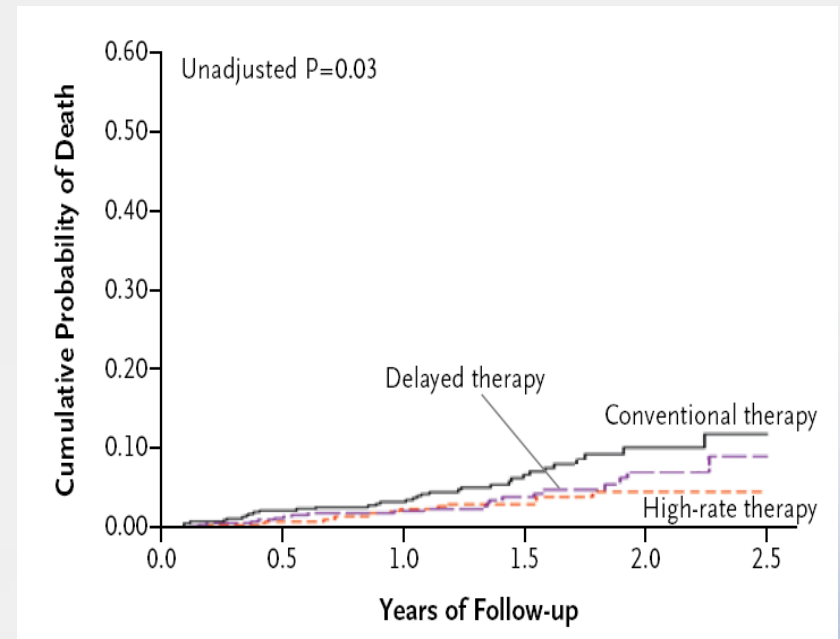
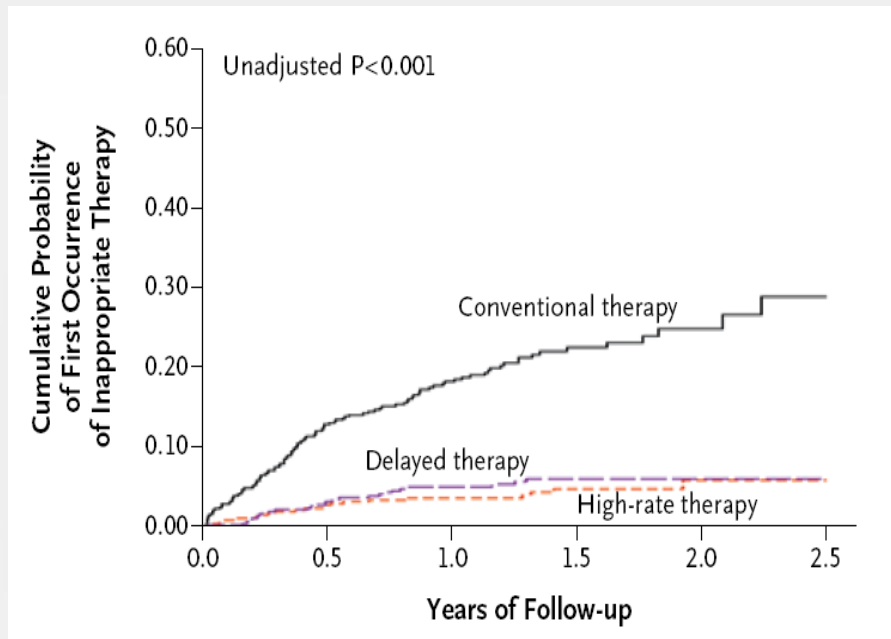
Table 2. First Occurrence, Any Occurrence, and Total Occurrences of Appropriate and Inappropriate Device Therapy According to Treatment Group.*

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
Any occurrence of therapy — no. of patients (%)					
Appropriate therapy					
Shock	28 (5)	26 (5)	19 (4)	0.86	0.25
Antitachycardia pacing	111 (22)	38 (8)	20 (4)	<0.001	<0.001
Inappropriate therapy					
Shock	31 (6)	14 (3)	15 (3)	0.01	0.03
Antitachycardia pacing	104 (20)	20 (4)	25 (5)	<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

* Crude rates of the first occurrence of therapy and any occurrence of therapy were compared with the use of chi-square tests, and mean counts of total occurrences of therapy were compared with the use of negative binomial regression models.

MADIT-RIT

(Reduction in Inappropriate Tx)



Inappropriate Therapy

Hazard Ratios:

High rate: 0.21 (p < 0.001)

Delayed: 0.24 (p < 0.001)

Overall Mortality

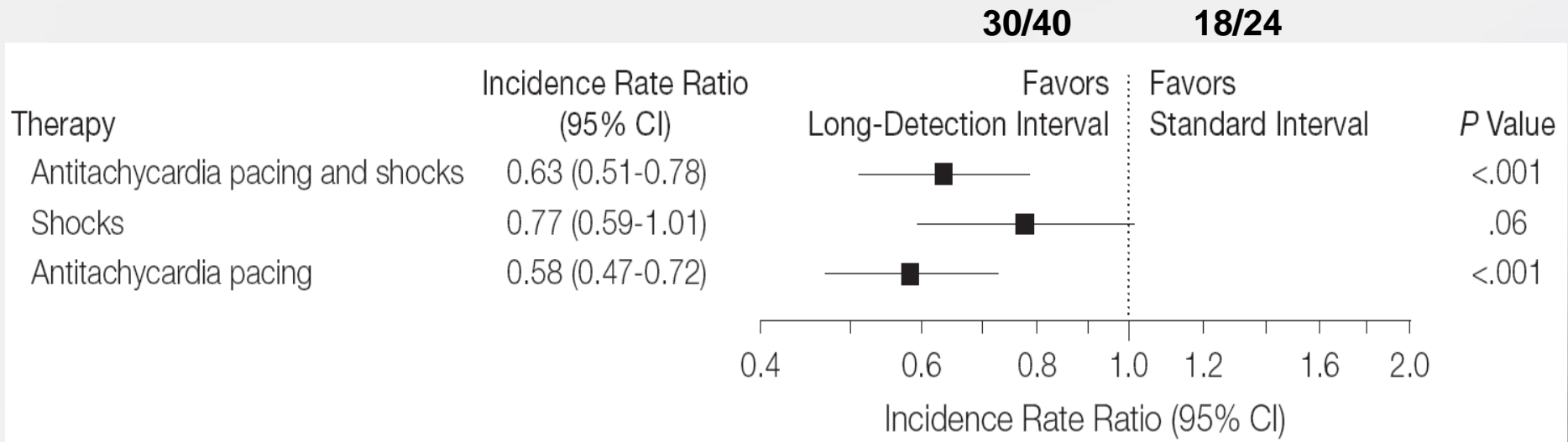
Hazard Ratios:

High rate: 0.45 (p = 0.01)

Delayed: 0.56 (p = 0.06)

Effect of Long-Detection Interval vs Standard-Detection Interval for ICD on ATP and Shock Delivery

Treatment Effect Regarding the Primary End Point and Its Components



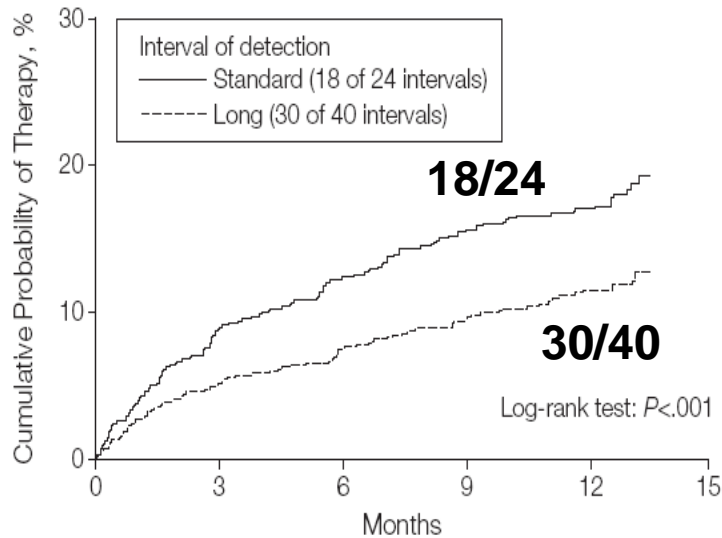
Long-Detection Interval (30/40)
Standard-Detection Interval (18/24)

ADVANCE III. JAMA. 2013;309(18):1903-1911

Effect of Long-Detection Interval vs Standard-Detection Interval for ICD on ATP and Shock Delivery

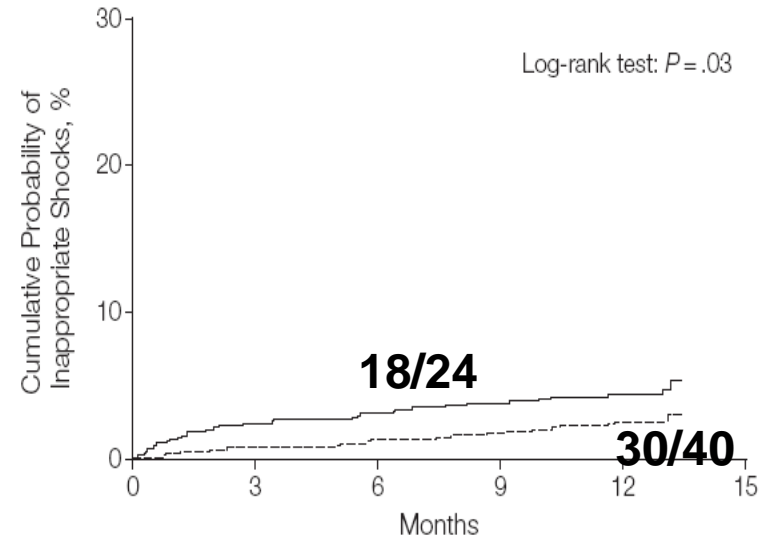
Treatment Effect Regarding the Primary End Point and Its Components

A Time to first therapy



No. at risk		Interval of detection				
Standard		891	777	707	639	438
Long		876	812	752	686	462

B Time to first inappropriate shock



No. at risk		Interval of detection				
Standard		891	831	781	728	496
Long		876	848	798	741	501

The analysis population included patients for whom device memory data were available for at least 1 follow-up visit.

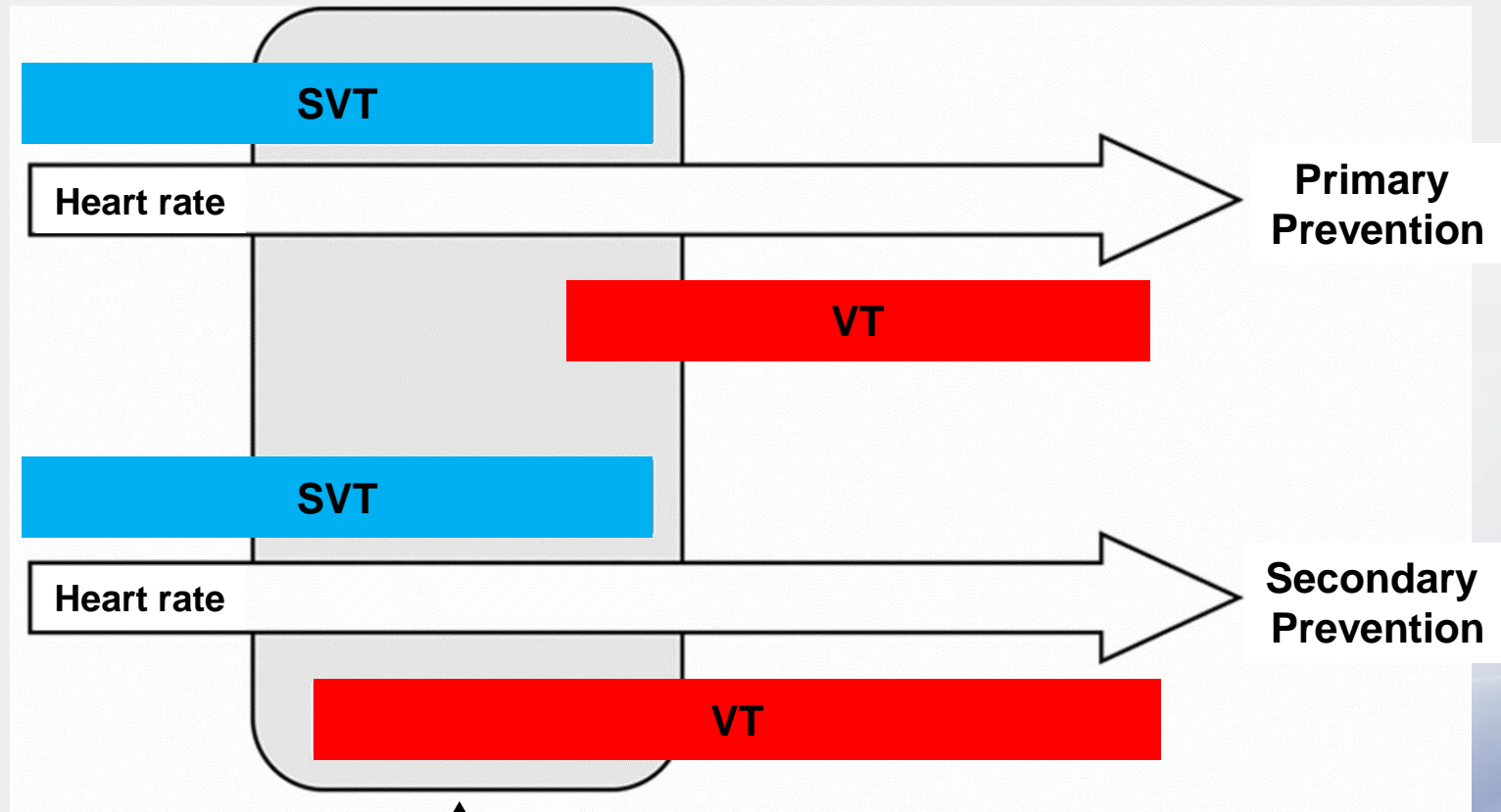
ADVANCE III. JAMA. 2013;309(18):1903-1911

ICD Programming for Primary Prevention of Sudden Death

Zone	Rate	Detection	Therapy
Therapy zone	200 bpm	5-9 second delay	ATP during charge, Maximum-energy shock
Monitor-only zone	170-199 bpm	9-60 second delay	None

Circulation. 2013;128:659-672

Tachycardia Detection: Heart Rate



**Overlap Zone:
Detection enhancement needed**

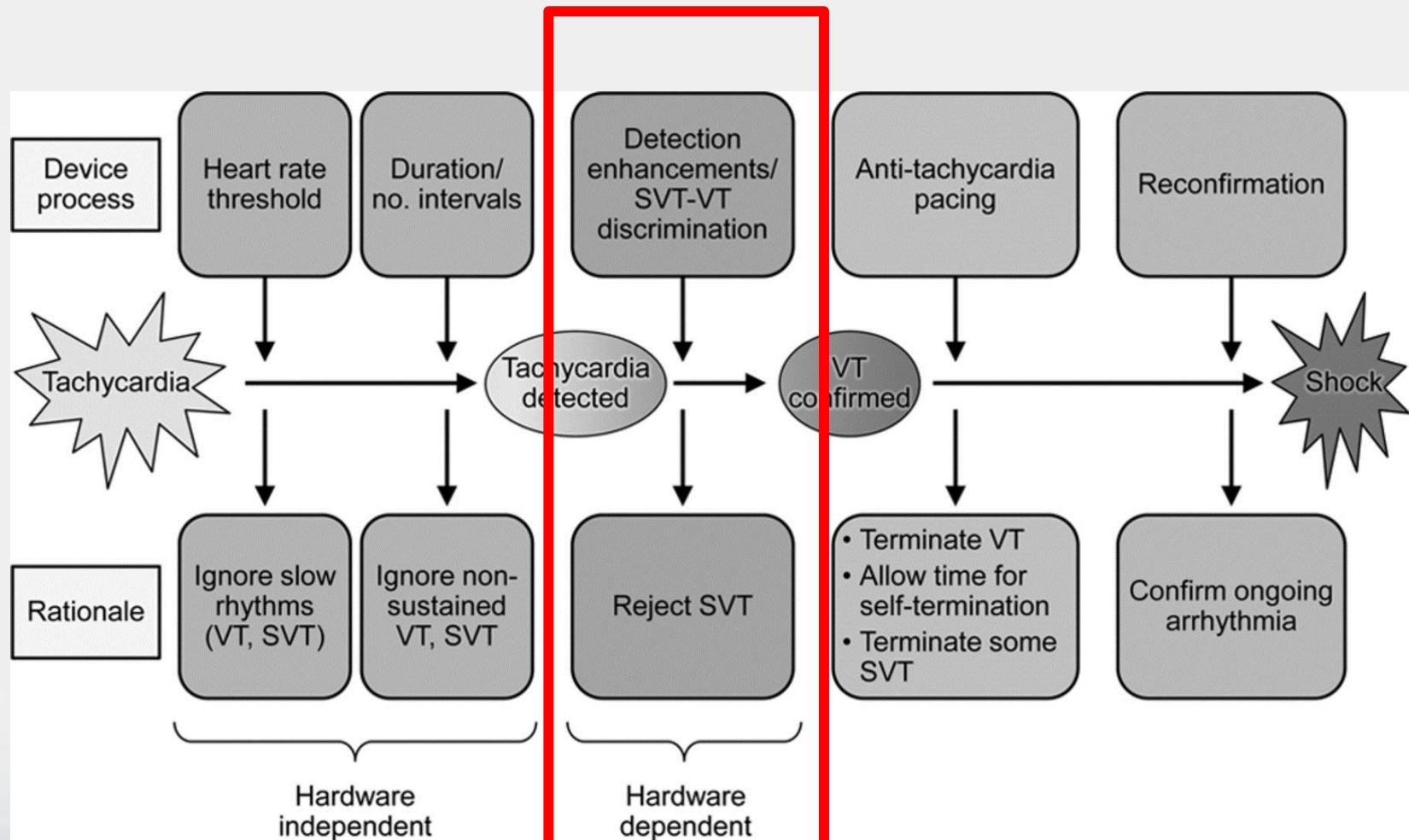
Circulation. 2013;128:659-672

Table I.

Suggested ICD Programming in Primary and Secondary Prevention*

		Primary Prevention	Secondary Prevention
DETECTION	General comments	Consider slower cutoff rates if receiving antiarrhythmic drugs	
	Monitoring zone	150 bpm	130–140 bpm
Rate cutoff	VT zone	182–220 bpm (250 bpm if FVT via VF with Medtronic ICDs)	10–20 bpm slower than clinical arrhythmia (30–60 ms) or 150–162 bpm if unknown
	VF zone	220 bpm	220 bpm
		Stability passive or on (with AVA if stability is used) with Association programmed to ANY; Onset: passive	
		Boston Scientific	VR and DR: Rhythm ID
		Sorin	VR: onset and stability DR: PARAD+
		Biotronik	VR: onset and stability DR: SMART
		Discriminator time out	Program off; more conservative programmers could extend short nominal values to 5 minutes
THERAPY	VT zone	Two bursts 8–10 pulses; 81–88% of BCL; 10 ms SCAN; readaptive	Four bursts (or mix of bursts and ramp); 8–10 pulses; 91–88% of BCL; 10 ms SCAN; readaptive
	VF zone	BIV ATP pacing in ischemic cardiomyopathy Maximal shocks (pending further data) ATP during (or before charging) Maximal shocks	

ICD Shock-Reduction Strategies: Overview



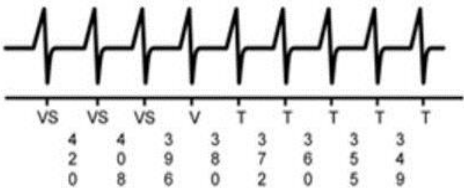
Single-Chamber Algorithms

Onset

Abrupt onset of VT

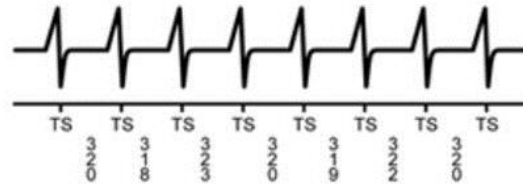


Slow warm up of sinus tachycardia

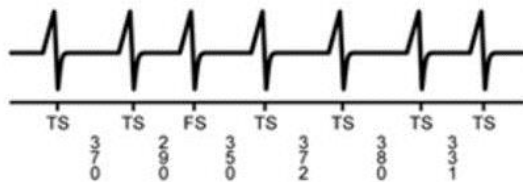


Stability

Stable RR intervals in VT

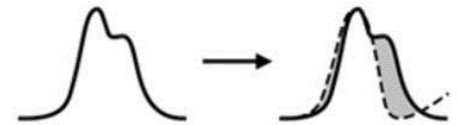


Irregular RR intervals in AF

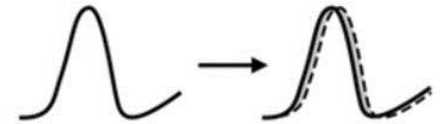


Morphology

VT – morphology does not match template

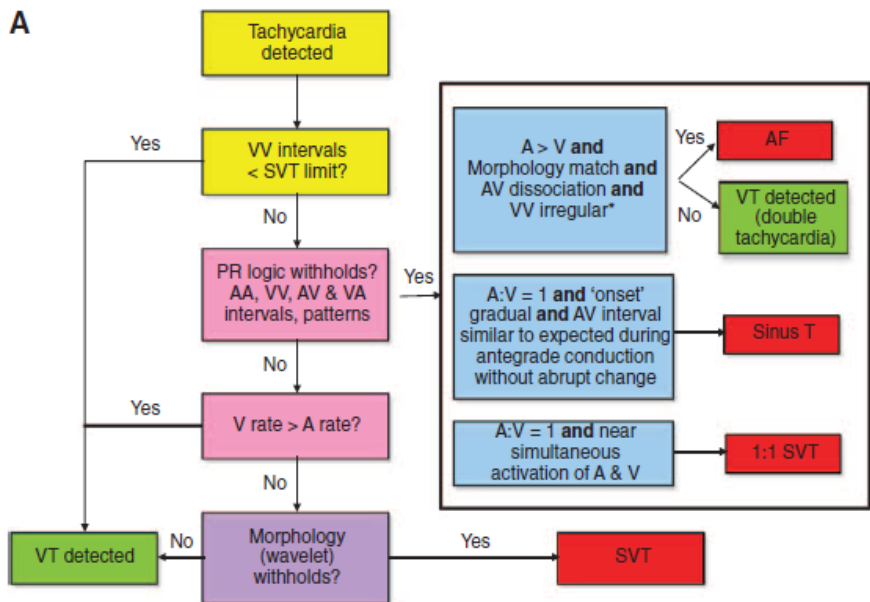


SVT – morphology matches template

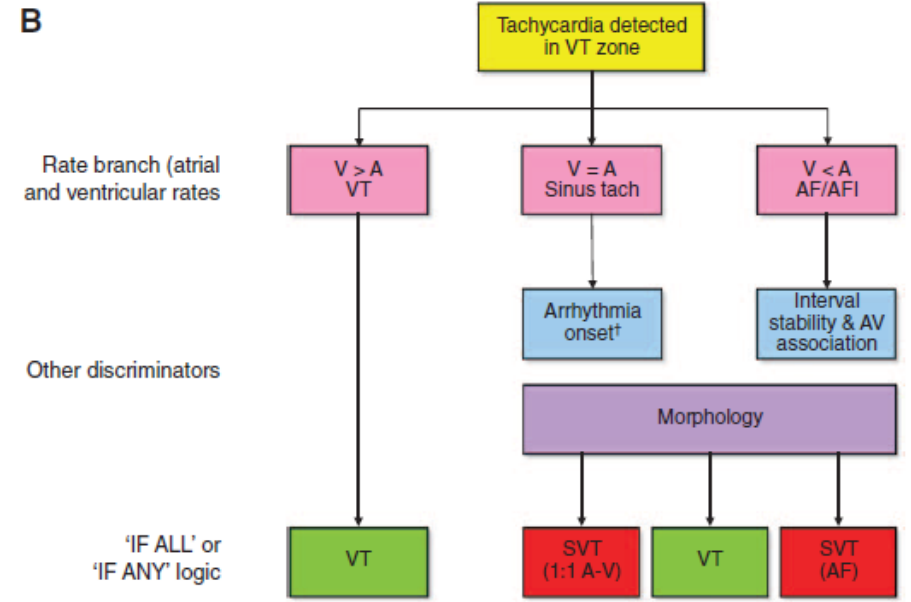


Dual-Chamber SVT-VT Discriminators

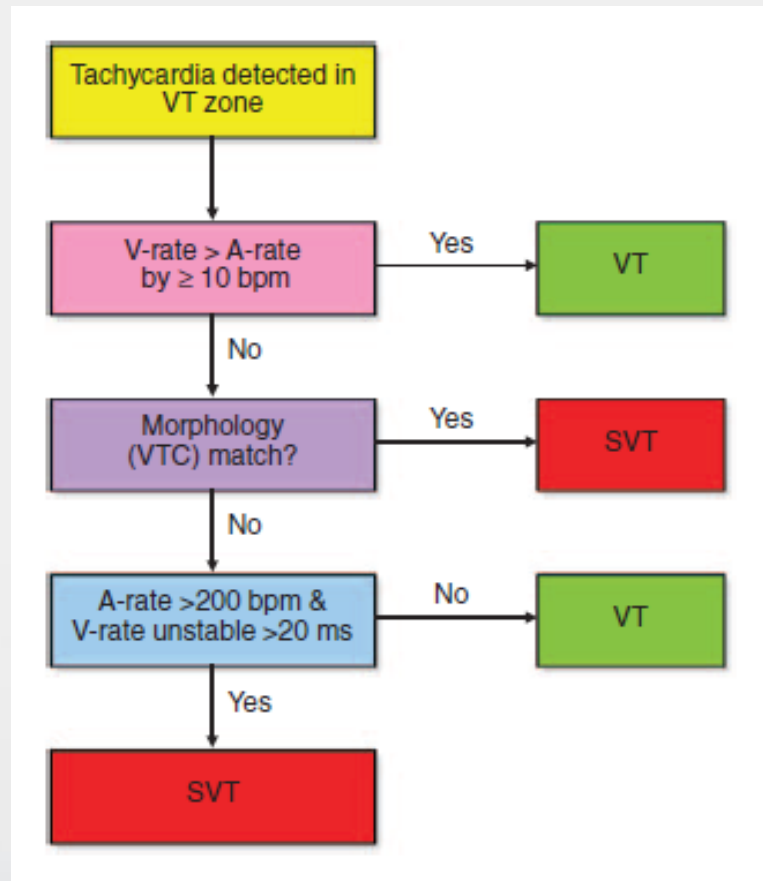
Medtronic (PR Logic)



St. Jude Medical (Rate branch algorithm)

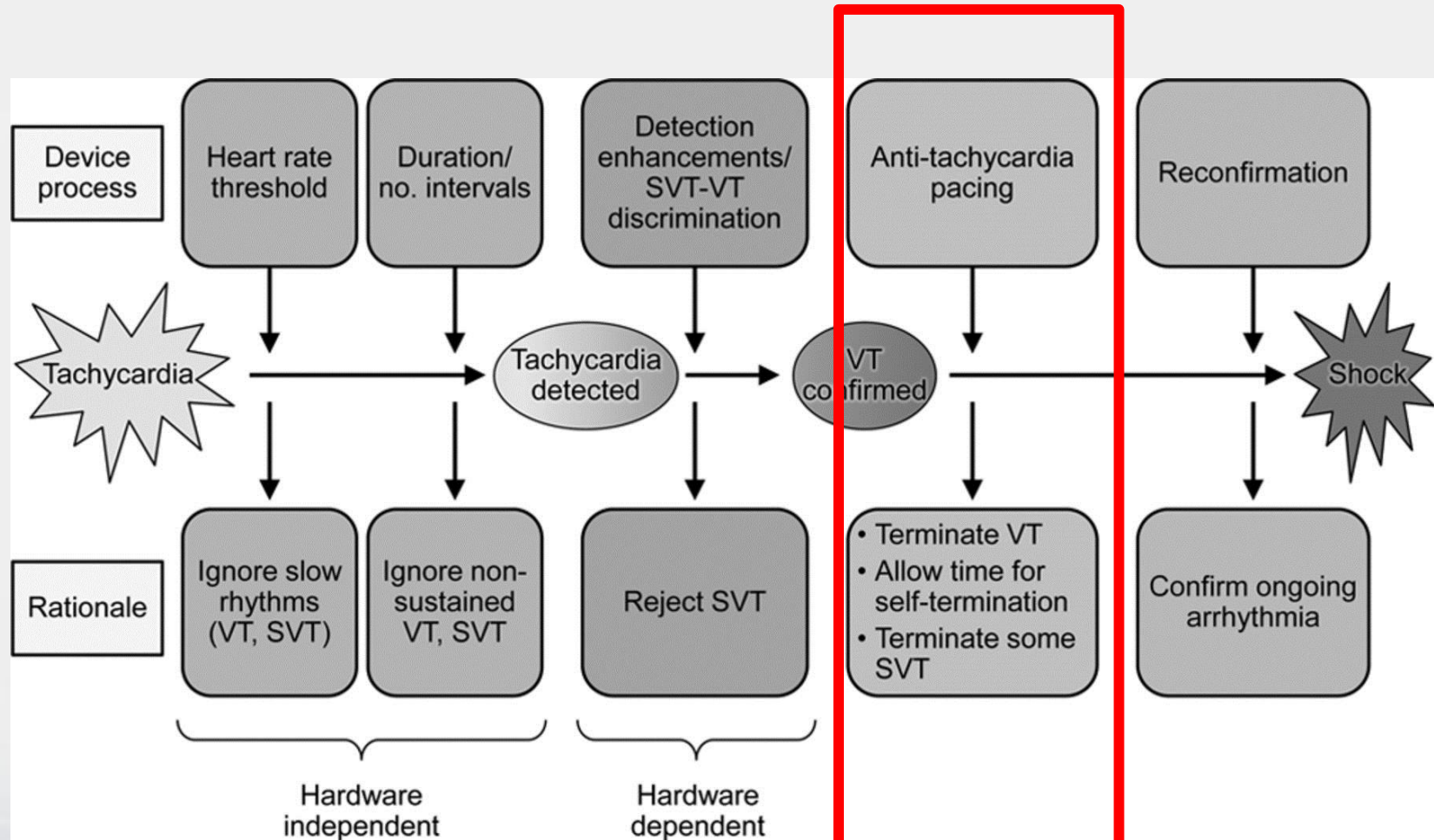


Dual-Chamber SVT-VT Discriminators



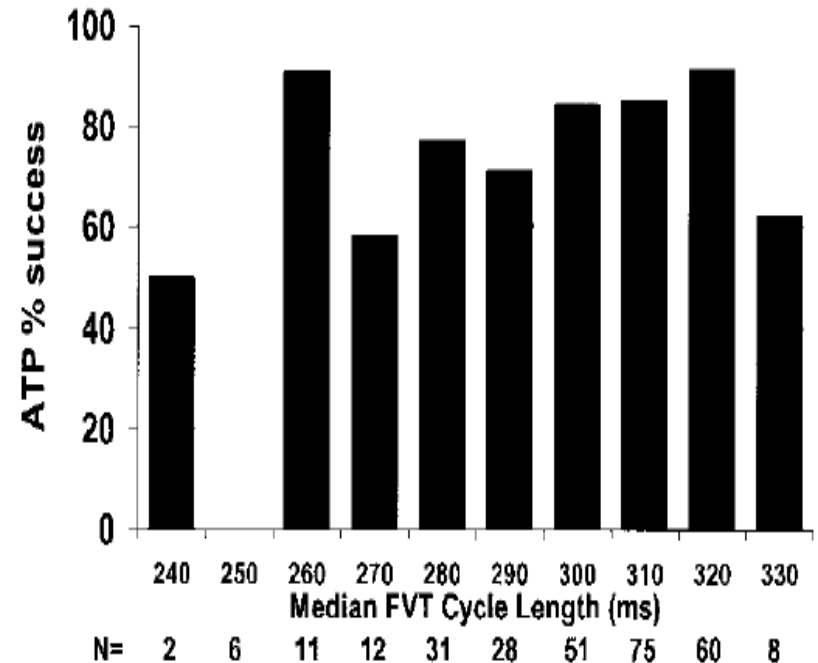
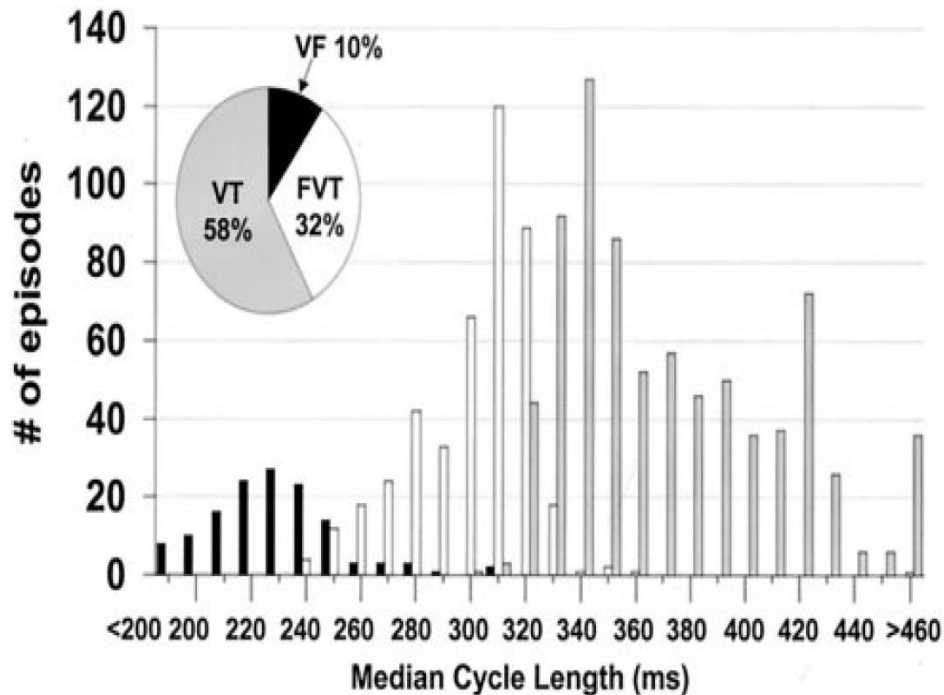
Boston Scientific (Rhythm ID)

ICD Shock-Reduction Strategies: Anti-tachycardia pacing



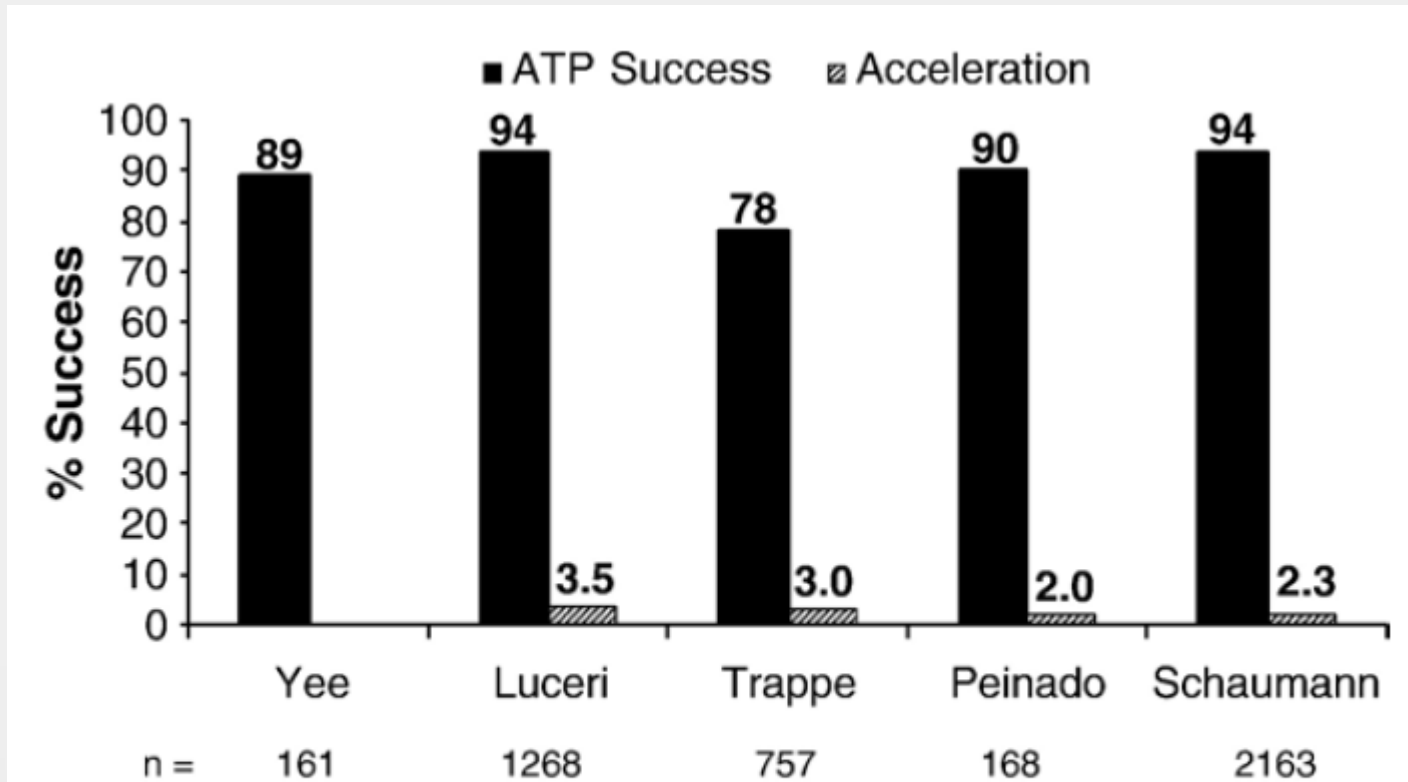
Frequency of Recorded HR during VT/VF: painFREE Rx II

VT > 320 ms (188bpm), FVT 320-240 ms (188-250 bpm), VF < 240 ms (250 bpm)



Compared with shocks, empirical ATP for FVT is highly effective, is equally safe, and improves quality of life.

ATP Success for Slow VT (<200 bpm)



Antitachycardia pacing success for “slow” VT (<200 beat/min).
n, Number of VT episodes documented with a rate <200 beat/min.

Programming Bradycardia Pacing

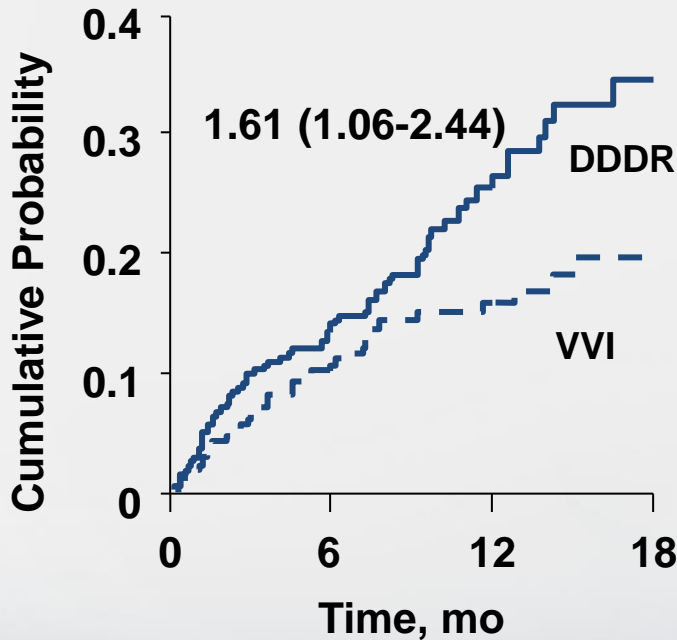
How to Program pacing for ICDs: DAVID

- **Standard ICD Indication**
 - LVEF < 40% with VT or VF
 - No bradycardia requiring pacing
 - No atrial arrhythmias
- **Therapy: Dual Chamber ICD**
 - VVI 40 bpm (1% RV pacing)
 - DDD 70 bpm (AV 180 ms: 60% RV pacing)

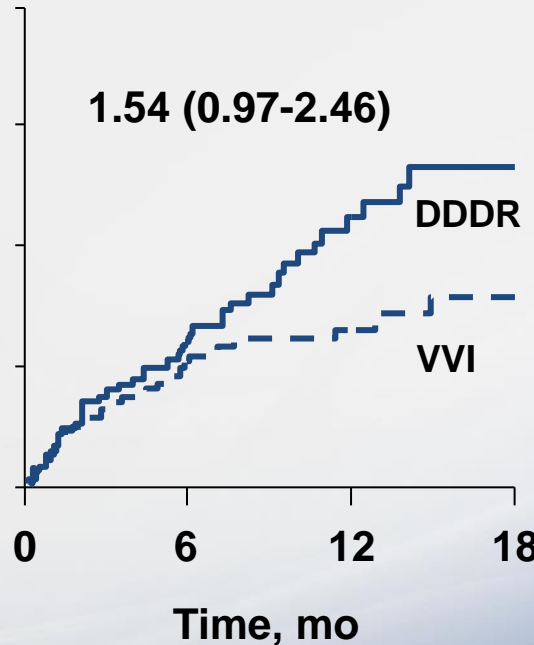
DAVID: Results

For patients with standard indications for ICD therapy, no indication for cardiac pacing, and an LVEF $\leq 40\%$

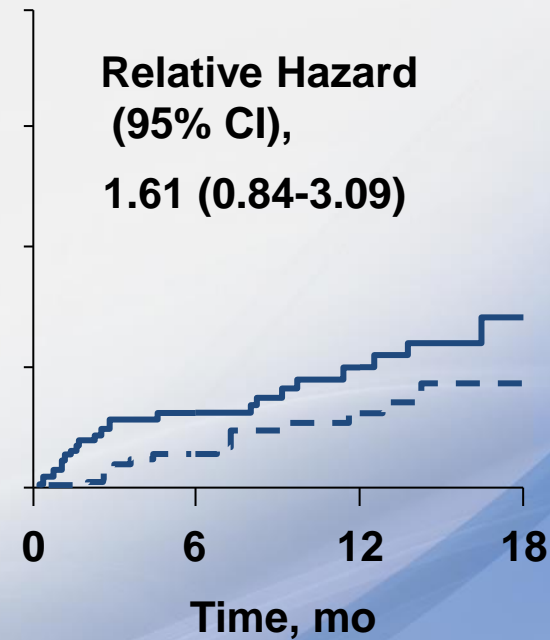
Death or First Hospitalization for New or Worsened CHF



First Hospitalization for New or Worsened CHF



Death From Any Cause

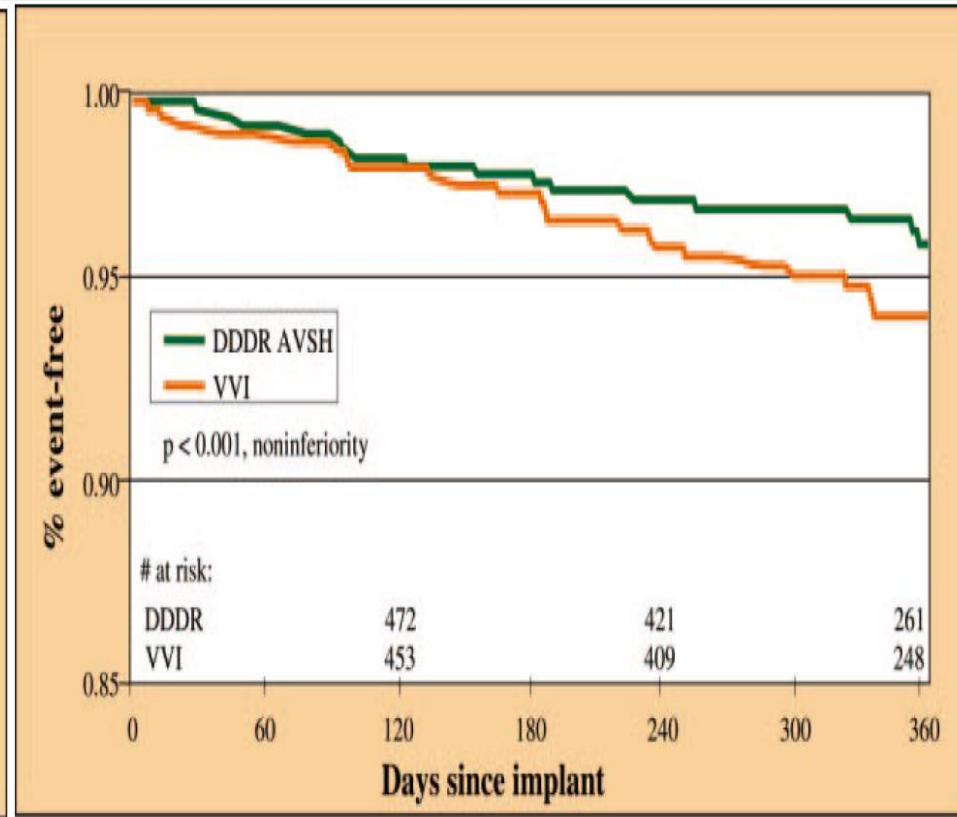
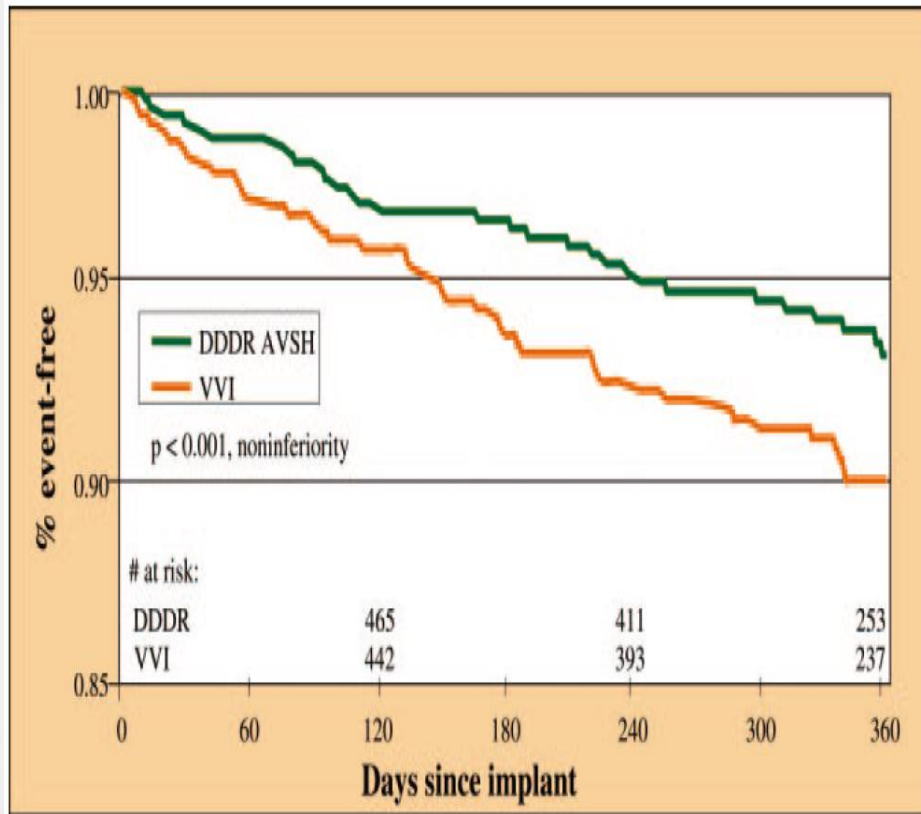


DAVID – Results

- Pacing percentage and outcome in the DDDR-70 group:
 - Two subgroups
 - % RV pacing $\leq 40\%$
 - % RV pacing 41%-100%
- Patients who survived to the 3-month follow-up visit had better 12-month event-free survival in the $\leq 40\%$ group.
 - 41%-100% RV Pacing 75.9%
 - $\leq 40\%$ RV Pacing 86.9%

Intrinsic RV

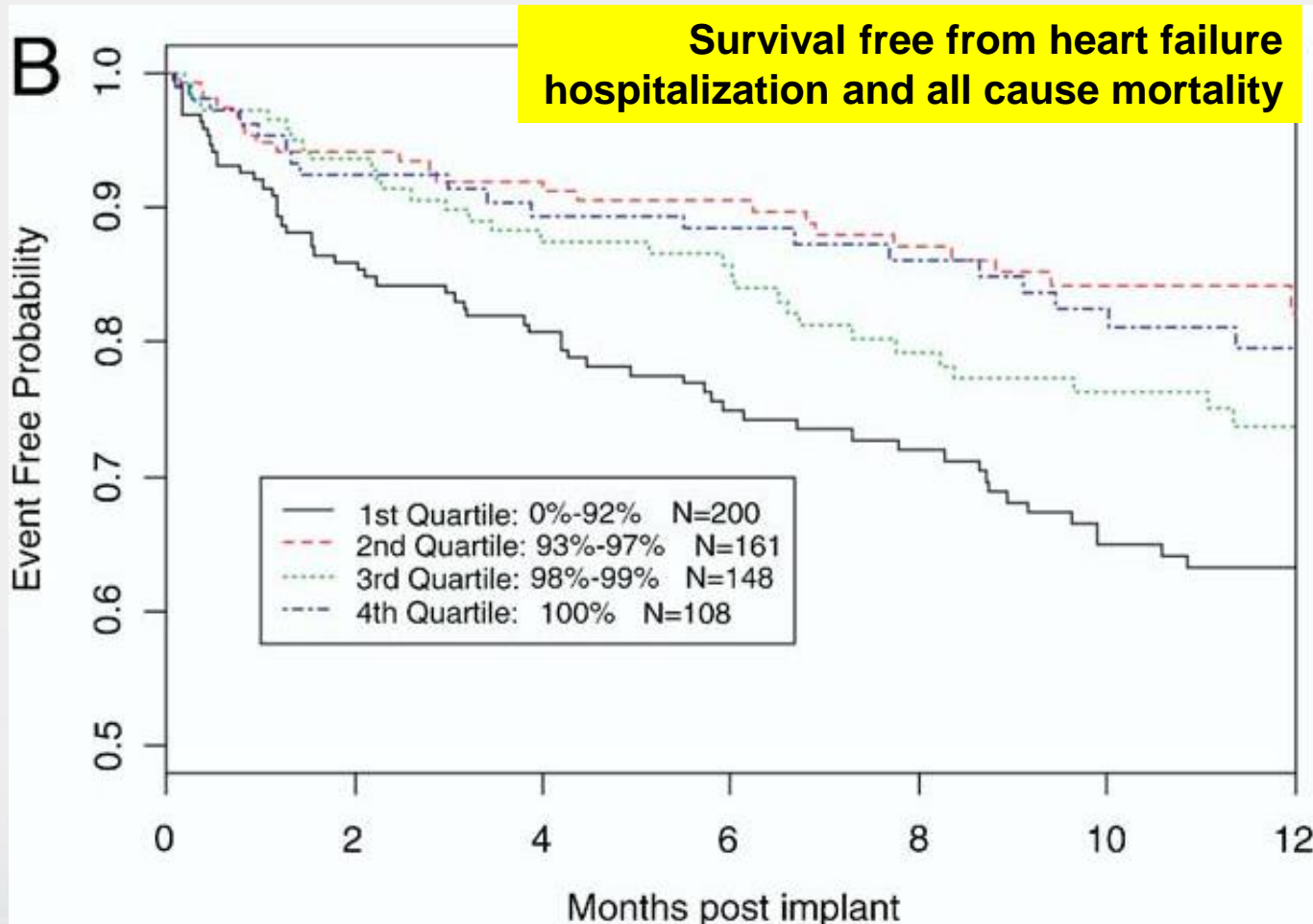
VVI versus DDD with AV Search Hysteresis



Event=Death or CHF hospitalization

Event=Death

% BiV Pacing and Outcomes after CRT in AF Patients



Paradox of Cardiac Device Therapy

- **The best outcomes for patients with defibrillators come from avoiding defibrillation unless absolutely necessary**
- **The best outcomes for patients with non-CRT pacemakers/ICDs come from avoiding ventricular pacing unless absolutely necessary (the opposite is true for CRT)**

ICD Programming: Simple Take Home Message

- For most ICD patients, the following programming demonstrated superior outcomes in randomized trials and should be considered the standard of care:
- Pacing: VVI 40 bpm (unless symptomatic bradycardia or CRT)
- Tachy: MADIT-RIT high rate cutoff
 - 170-199 bpm: monitor only
 - ≥ 200 bpm: 2.5 sec detection, ATPx1 then shock

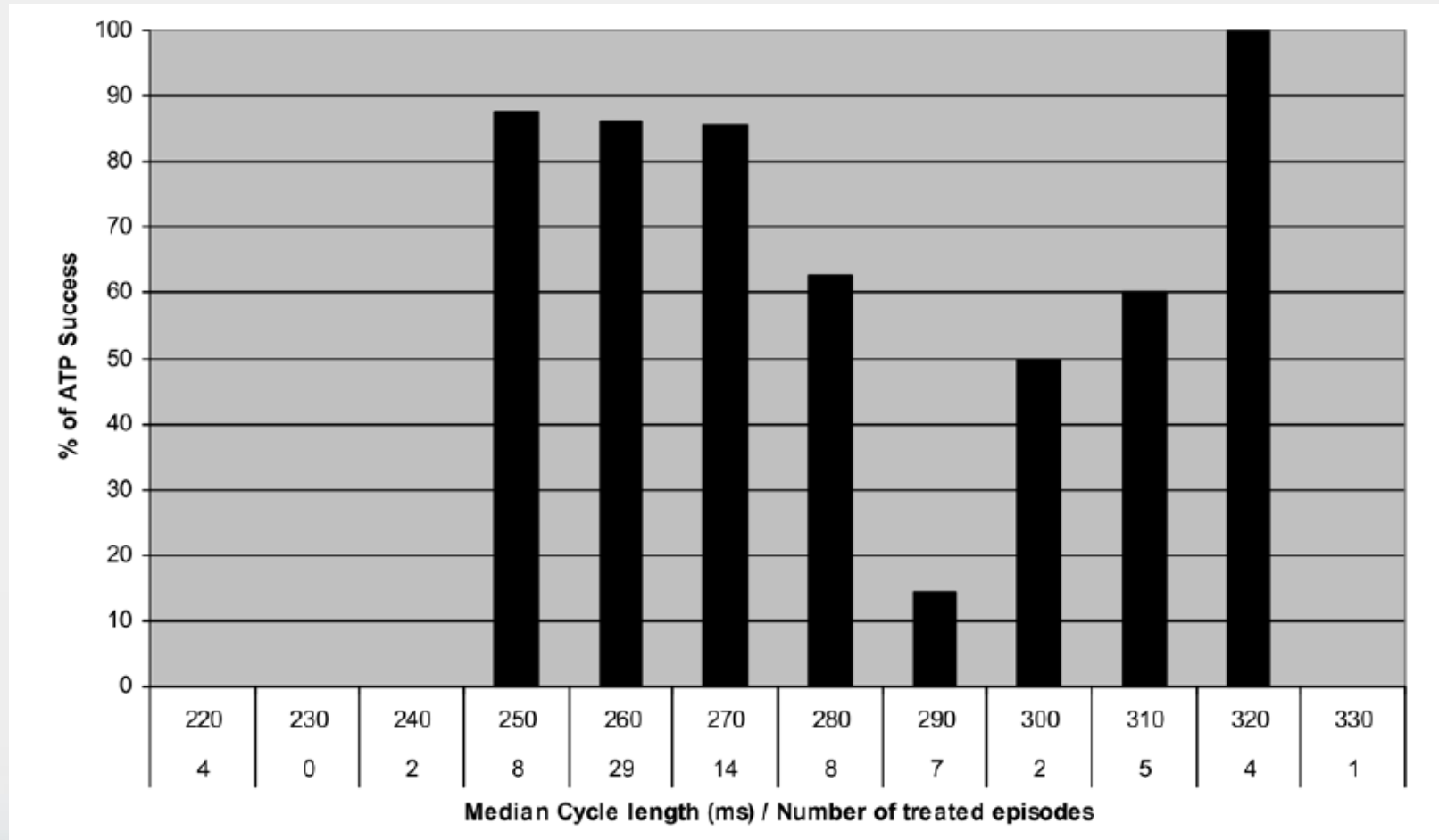
Thank you for your attention!



SEVERANCE

1885 Chejuwon
Cardiovascular Hospital

ATP Success by VT Cycle Length

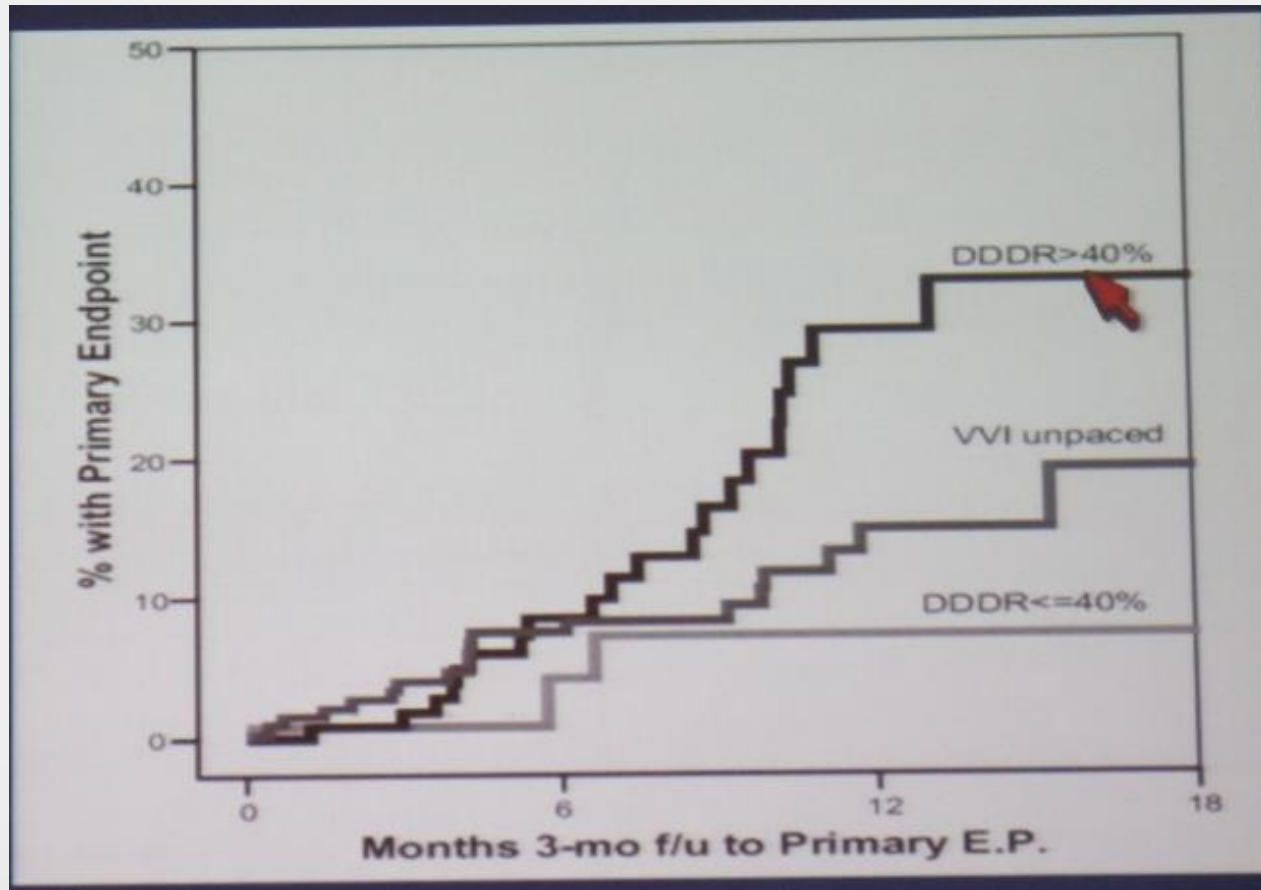


Schoels et al. Heart Rhythm 2007;4:879-85

Others

- **Single- Versus Dual-Chamber ICD Selection**
- **Detection Zones and SVT-VT Discriminator Programming**
- **Rhythm Discrimination in the s-ICD**
- **Redetection and Reconfirmation**
- **Programming Therapy Zones**
- **Shock Strength, Polarity, and DFT**
- **Optimization of Sensing to Prevent Shocks**
- **Preventing T-wave Oversensing**
- **Noise-Detection Algorithms**
- **Surveillance of Lead Fracture**
- **ICD programming during Electrical Storm**
- **Remote Monitoring**

DAVID: Analysis by % RV pacing



Endpoint: Death or Hospitalization for CHF

Required FVT Therapy

ATP Arm

Shock Arm

R_x1

Burst ATP

- 1 sequence
- 8 pulses
- 88% of VTCL

Shock DFT+10 J

R_x2

Shock DFT+10 J

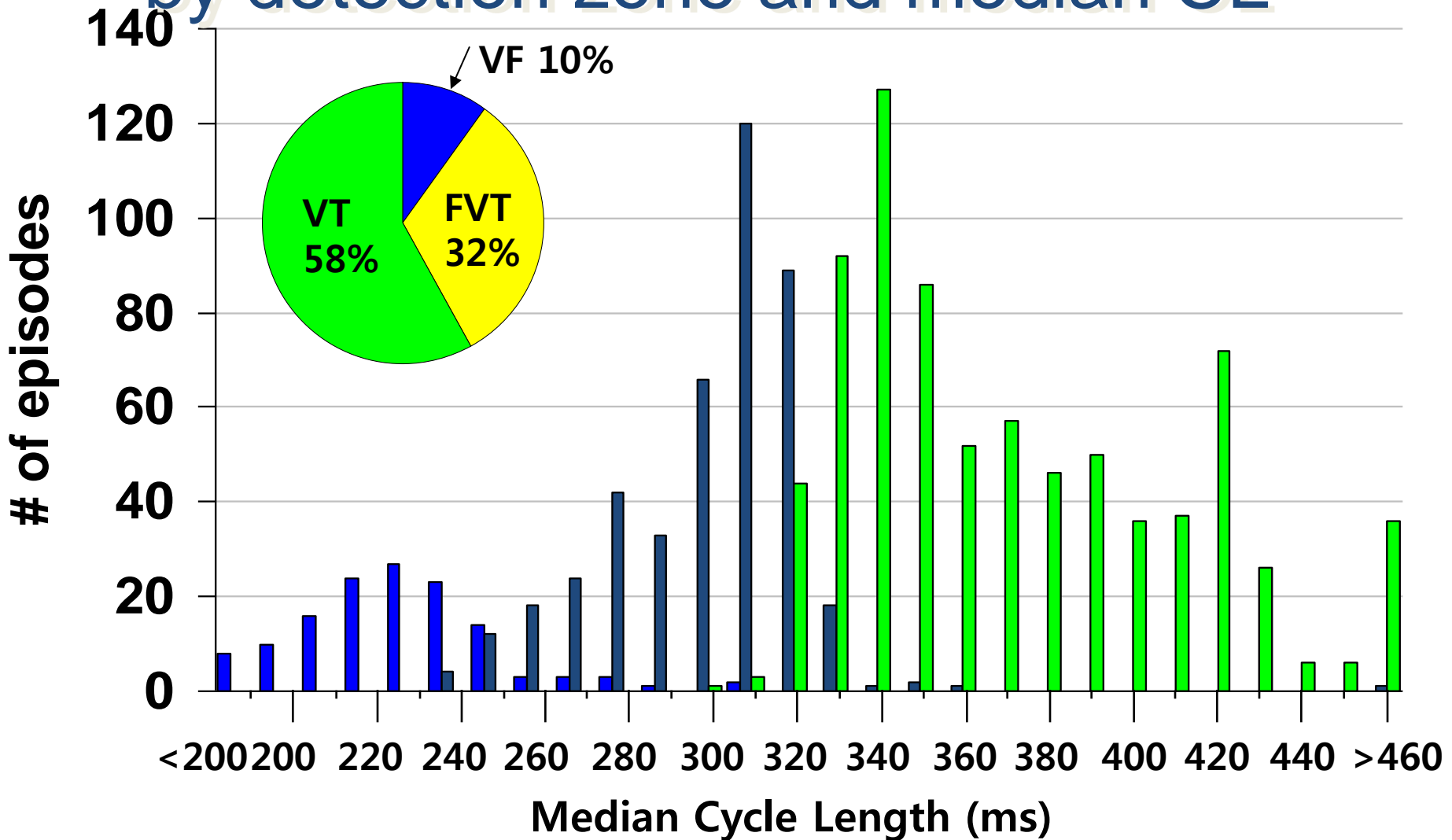
Shock max output

R_x3-6

Shock max output

Shock max output

Distribution of ventricular arrhythmias by detection zone and median CL

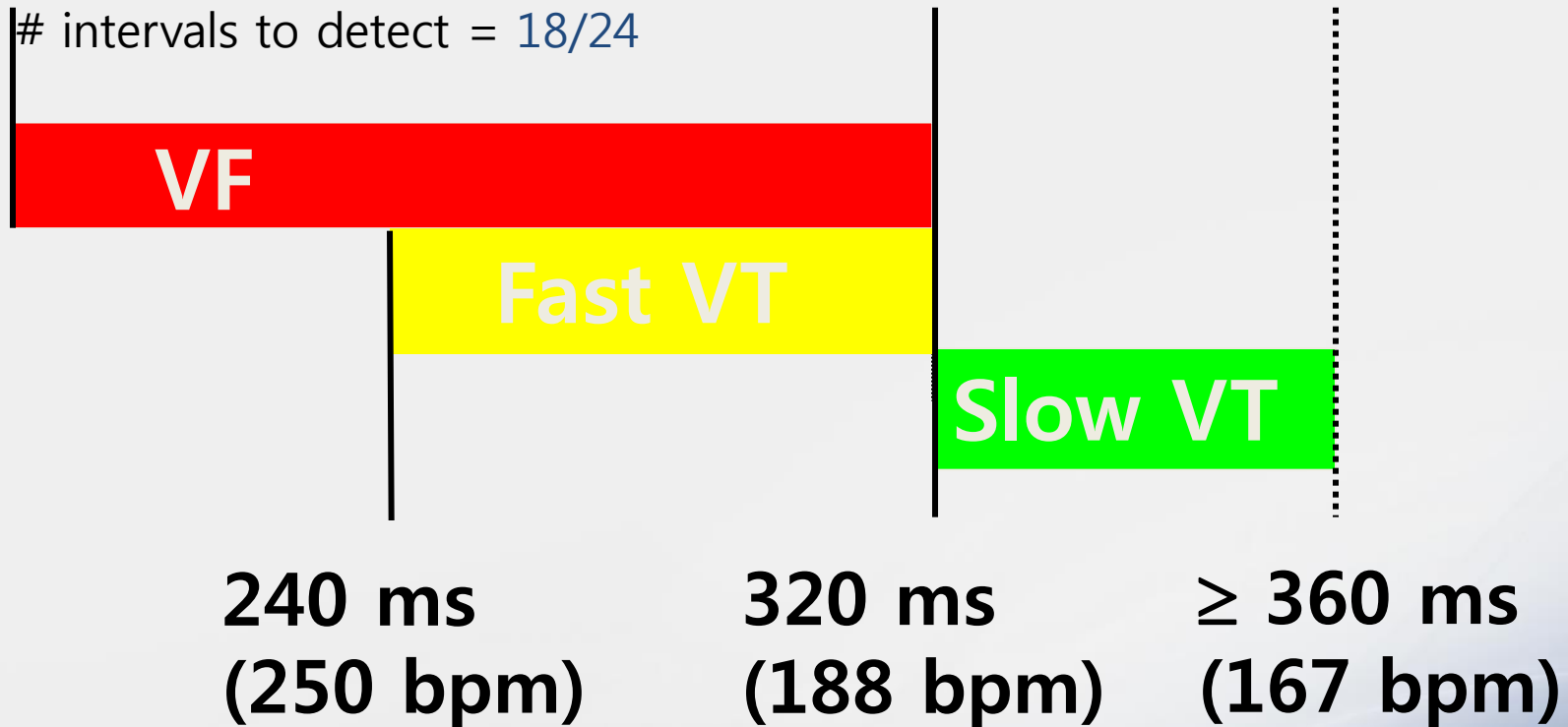


Tachycardia Detection: 1° Prevention

- **Primary prevention patients experience faster VTs with rates less likely to overlap SVT than secondary prevention**
- **Programming of faster VT rate cutoffs with prolonged detection time is recommended (PREPARE, RELEVANT, MADIT-RIT trials)**

Required Detection Programming Fast VT via VF

intervals to detect = 18/24



- PR Logic "ON" in all dual chamber ICDs
- SVT limit of 320ms

Hazard Ratios for a First Occurrence of Inappropriate Therapy, Death, and a First Episode of Syncope According to Treatment Group

Table 3. Hazard Ratios for a First Occurrence of Inappropriate Therapy, Death, and a First Episode of Syncope According to Treatment Group.

Variable	Conventional Therapy (N=514)	High-Rate Therapy (N=500)	Delayed Therapy (N=486)	High-Rate Therapy vs. Conventional Therapy		Delayed Therapy vs. Conventional Therapy	
	<i>no. of patients</i>			Hazard Ratio (95% CI)	P Value	Hazard Ratio (95% CI)	P Value
First occurrence of inappropriate therapy	105	21	26	0.21 (0.13–0.34)	<0.001	0.24 (0.15–0.40)	<0.001
Death	34	16	21	0.45 (0.24–0.85)	0.01	0.56 (0.30–1.02)	0.06
First episode of syncope	23	22	22	1.32 (0.71–2.47)	0.39	1.09 (0.58–2.05)	0.80

ICD Programming for Primary Prevention of Sudden Death

	2 ^o prevention	Therapy	2 ^o prevention
Monitor	130-140 bpm		130-140 bpm
VT	<ul style="list-style-type: none"> • 10-20 bpm < clinical • 150-162 bpm if unknown 	Burst x4	<ul style="list-style-type: none"> • 10-20 bpm < clinical • 150-162 bpm if unknown
VF	220 bpm	ATP during maximal shock	220 bpm

Circulation. 2013;128:659-672