Is The ATP Necessary for The Device Setting?

2021.11.13

최의근

서울대학교병원 순환기내과

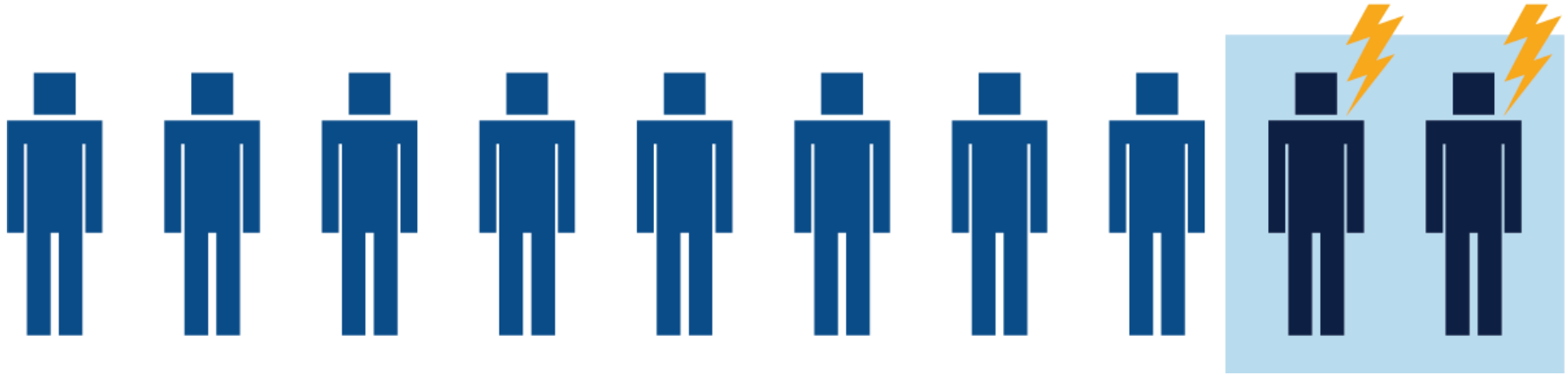
SEOUL NATIONAL UNIVERSITY HOSPITAL

Disclosure

- **Relationships with commercial interests:**
  - **Grants/Research Support:** Bayer, BMS/Pfizer, Biosense Webster, Chong Kun Dang, Daiichi-Sankyo, Medtronic, Samjinpharm, Sanofi-Aventis, Seers Technology, Skylabs, and Yuhan. No fees are directly received personally
  - **Speakers Bureau/Honoraria:** Bayer, BMS/Pfizer, Biosense Webster, Chong Kun Dang, Daiichi-Sankyo, Samjinpharm, Sanofi-Aventis

The importance of shock reduction

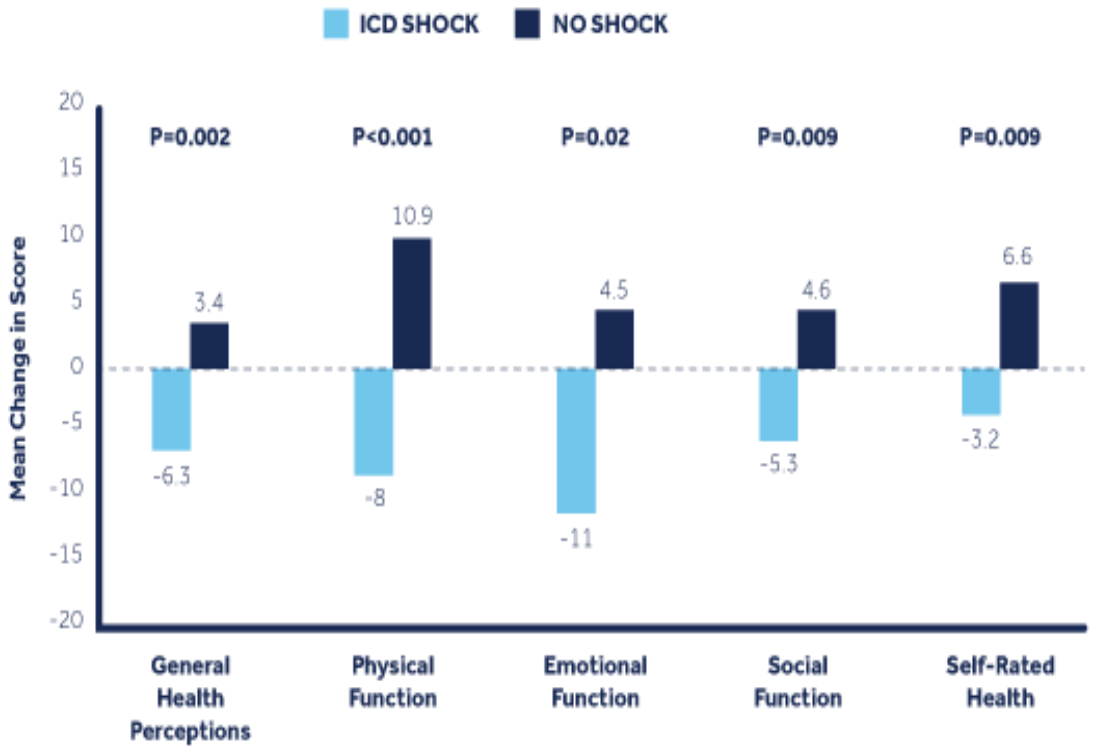
- ICDs save many lives, however historical data has shown that inappropriate shocks occur in 20-30% of the patients over the lifetime of the device.[1]



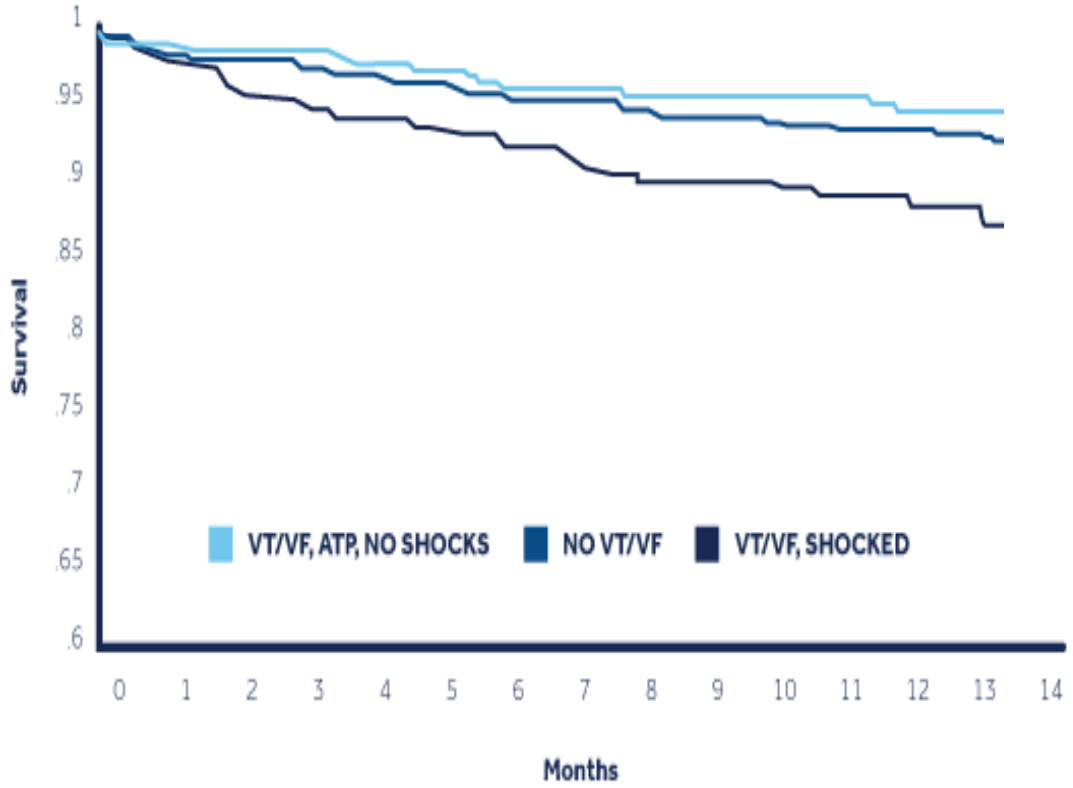
N Engl J Med. 2008; 359(10): 1009-1017.

Why avoiding shocks is important?

Effect of ICD Shocks on Patient Quality of Life[2]



ICD shock on Mortality risk[7]



N Engl J Med. 2008; 359: 999-1008.

What is anti-tachycardia pacing (ATP)?

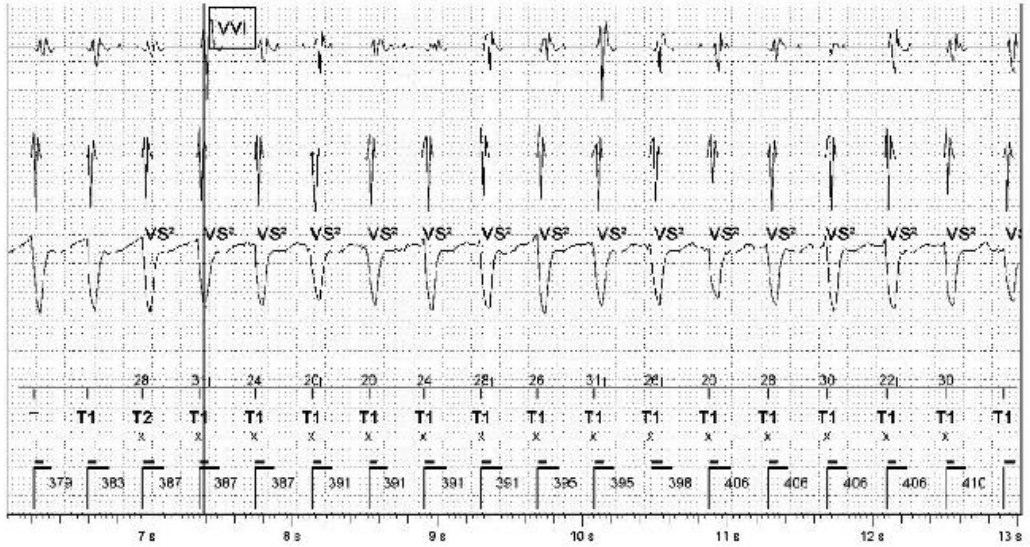
- One or more trains of pacing stimuli (usually 8 impulses for each train) conventionally expressed as a percentage of the tachycardia cycle length for a given RR interval, from the onset of the preceding R wave
- Pace stimulation delivered at very short coupling intervals (i.e., < 84%) is more likely to enter a reentrant circuit but also accelerate the arrhythmia
- Efficacy of terminating VT by ATP: basal >> apex = RVOT
- ATP sequences successfully interrupted 78%-94% of slow VT (< 188 bpm), with an acceleration rate between 2% and 4%

Episode: VT-1 (148 min-1 / 405 ms)

5 Jan 2016 4:26

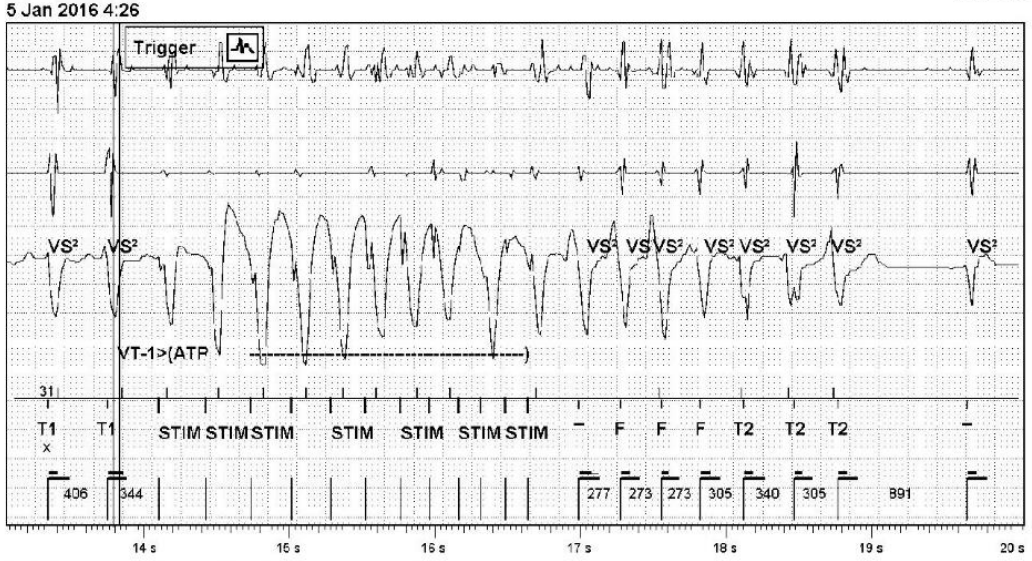
1: A Sense Amp AutoGain (5,5 mm/mV)
2: V Sense Amp AutoGain (0,8 mm/mV)
3: Discrimination AutoGain (2,2 mm/mV)
4: Markers

Sweep Speed: 25 mm/s



Episode: VT-1 (148 min-1 / 405 ms) (Continued)

5 Jan 2016 4:26



Parameters

			VT-1	VT-2	VF
Mode	VVI	Zone Configuration	120 min-1	160 min-1	214 min-1
Base Rate	40 min-1	Detection Criteria	ATP x3	ATP x3	ATP x1
		Therapy **(ENABLED)**	ATP x8	25,0 J	30,0 J
			30,0 J	30,0 J	36,0 J
			Off	36,0 J x2	36,0 J x4

Capture & Sense	A	V
V. AutoCapture		Off
Pulse Amplitude (Margin)		2,5 V (2.5:1)
Pulse Width		0,5 ms
AutoSense	Off	On
Sensitivity (Safety Margin)	0,5 mV (2:1)	Auto A

Diagnostics Summary Since 4 Jan 2016

VP	0 %
AT/AF Burden	0%

VT/VF Episodes: 4 Since 4 Jan 2016

	VT-1	VT-2	VF
Episodes	4	0	0
ATP Delivered	4	0	0
Shocks Delivered	0	0	0

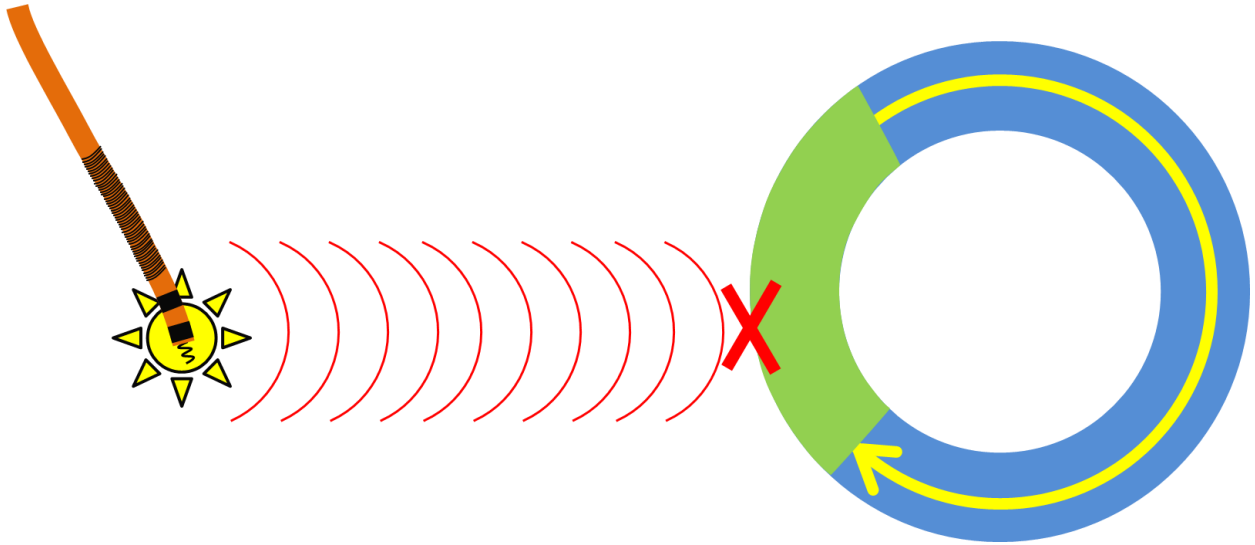
SVT Episodes: 0
Non-sustained Episodes: 0

Benefit of ATP

- To avoid painful shock
  - ATP is rarely noticed by patients and therefore well tolerated
- Battery life of the device
- Shock therapy is associated with a higher risk of mortality

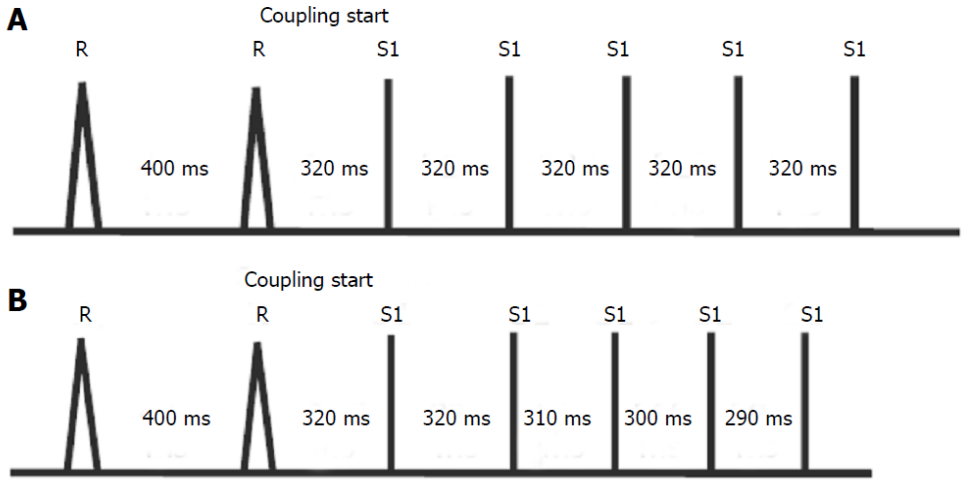
Chance of arrhythmia interruption by ATP

- Conduction time from pacing stimulus site to the reentrant circuit
- Duration of the excitable gap
- Presence of anatomic/functional barriers
- State of the sympathetic nervous system



Types of ATP

	Programmable parameters (recommended range)	Strengths	Weaknesses
Burst	R-R coupling interval: 84%–90%	Use of 88% R-R coupling proven effective and less likely to accelerate/destabilize	Fixed cycle length will not successfully penetrate the circuit in all cases
	No. of pulses delivered: 8–15 pulses	Diagnostic value entrainment data (ie, postpacing interval) even when ineffective	
	No. of sequences: 1–2	Easy to understand and program	
Ramp/scan	Sequential decremental from fixed R-R interval: 84%–90%	Decreasing coupling intervals may penetrate the circuit when burst fails (the ramp)	More likely to accelerate or destabilize the rhythm
	No. of pulses: 8-12	Allows rapid trial of varying coupling intervals (the scan)	Advanced programming required
	Decrement interval: 10–20 ms		
	Max limit: 200 ms recommended		



Not a clear difference in the efficacy of burst and ramp for treatment of non-FVT, in ischemic and nonischemic cardiomyopathies.

Fast VT

A Randomized Study to Compare Ramp Versus Burst Antitachycardia Pacing Therapies to Treat Fast Ventricular Tachyarrhythmias in Patients With Implantable Cardioverter Defibrillators

The PITAGORA ICD Trial

Background—In patients with implantable cardioverter-defibrillators (ICDs), antitachycardia pacing (ATP) is highly effective in terminating fast ventricular tachycardias (FVTs) and lowers the use of high-energy shocks, without increasing the risk of arrhythmia acceleration or syncope.

Methods and Results—The aim of the PITAGORA ICD trial was to randomly compare 2 ATP strategies (88% coupling interval burst versus 91% coupling interval ramp, both 8 pulses) in terms of ATP efficacy, arrhythmia acceleration, and syncope. Two hundred six ICD patients (83% male, 67±11 years) were enrolled. FVT episodes with cycle lengths between 240 and 320 ms were treated by 1 ATP sequence and, in the event of failure, by shocks. Over a median follow-up of 36 months, 829 spontaneous ventricular tachyarrhythmia episodes were detected in 79 patients. Episode review identified 595 episodes as true ventricular arrhythmias in 72 patients; devices classified 111 (18.7%) episodes as VF, 216 (36.3%) as FVT, and 268 (45.0%) as VT. Fifty-six patients had 214 treated FVT episodes—2 FVTs self-terminated before ATP release; 44 (79%) of these had at least 1 effective ATP intervention, and 34 (61%) were spared ICD shocks. Burst terminated 100 of 133 (75.2%) FVT episodes, whereas ramp terminated 44 of 81 (54.3%; P=0.015). Acceleration occurred in 9 of 214 (4.2%) FVT episodes treated: 6 episodes in 3 ramp patients and 3 episodes in 3 burst patients. Two patients—1 in each group—suffered 1 syncopal event associated to a nonterminated FVT episode.

Conclusions—Burst is significantly more efficacious than ramp in terminating FVT episodes. As the first therapy for FVT episodes, ATP carries a low risk of acceleration or syncopal events. (***Circ Arrhythmia Electrophysiol*. 2009;2:146-153.**)

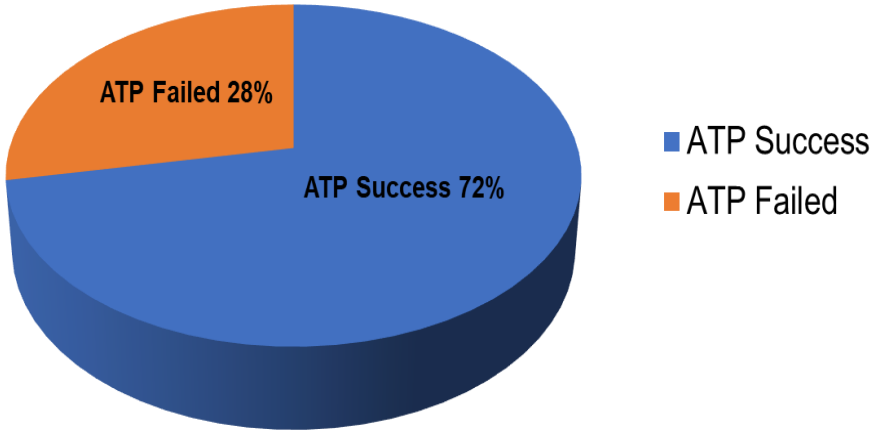
Circ Arrhythmia Electrophysiol. 2009;2:146-153

PainFREE Rx I and Rx II

Patient Population	PainFREE Rx Ⅰ: 220 patients enrolled Apr 98-Nov 99 PainFREE Rx Ⅱ: 634 patients enrolled Jan 01-Mar 02
Study Design	**Prospective**, PainFREE Rx Ⅰ: non-randomized PainFREE Rx Ⅱ: **randomized** 2 arms : **1. Standardized ATP as fist therapy for FVT** **2. Shock as first therapy for FVT**
Outcome	**ATP for Fast VTs is highly effective, equally safe, and improves quality of life compared to shock**
Programming Strategy	Program ATP as first therapy for Fast VTs (188-250bpm)

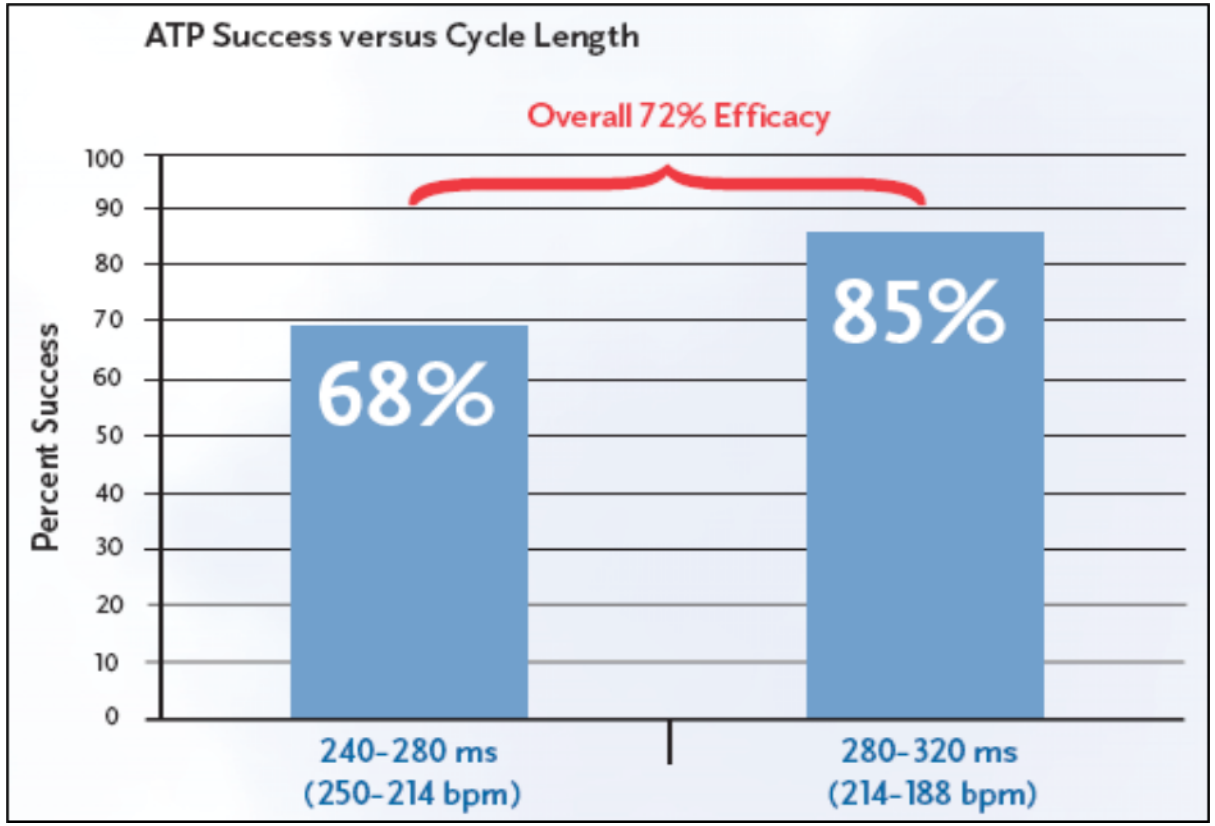
PainFREE Rx I and RxII

ATP Successfully Terminated 3 out of 4 Fast VTs



	ATP Arm	Shock Arm
Acceleration (≥ 10% ↓ in CL)	n = 4 2%	n = 2 1%
Syncope FVT	n = 2 0.7%	n = 1 0.7%

Even with very fast VT (214-250 bpm) the success rate of ATP is quite high

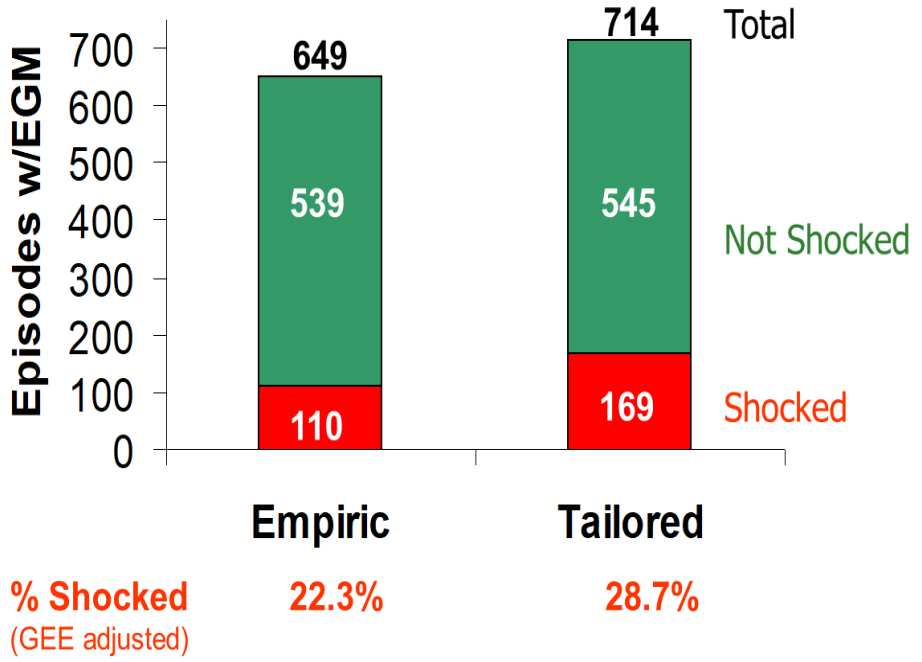


[1] Wathen MS, et al. *Circulation*. 2004;110:2591-2596.
[2] Wathen MS, et al. *Circulation*. 2001;104:796-801.

A Comparison of Empiric to Physician-Tailored Programming of Implantable Cardioverter-Defibrillators

Results From the Prospective Randomized Multicenter EMPIRIC Trial

Patient Population	900 patients enrolled Aug 02-Oct 03 Primary and Secondary prevention
Study Design	Prospective randomized, non-inferiority 2 arms : 1. **Standardized ICD programming**(EMPIRIC) 2. **Physician-tailored programming**(TAILORED)
Outcome	EMPIRIC ICD programming is at least as effective for VT/VF detection and therapy as physician-tailored programming
Programming Strategy	Use standardized programming • ATP for Fast VTs (200-250bpm) • 18/24 VF NID • PR Logic ON



Detection	Threshold (bpm)	Beats to detect	Therapies
VF	250	18 out of 24	30 J × 6
FVT	200	18 out of 24	1 × burst, 30 J × 5
VT	150	16	2 × burst, 1 × ramp, 30 J × 3

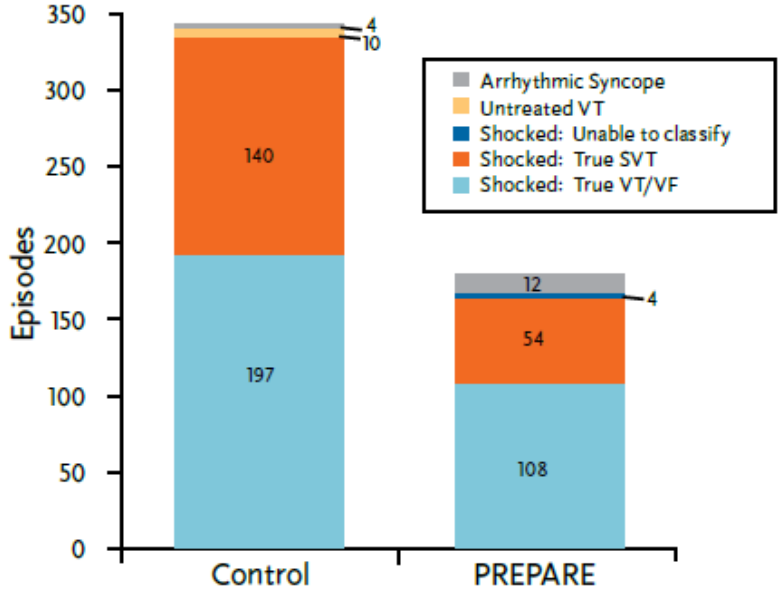
J Am Coll Cardiol 2006;48:330-9

Strategic Programming of Detection and Therapy Parameters in Implantable Cardioverter-Defibrillators Reduces Shocks in Primary Prevention Patients

Results From the PREPARE (Primary Prevention Parameters Evaluation) Study

Patient Population	700 patients enrolled Oct 03-May 05 **Primary prevention ONLY**
Study Design	Prospective non-randomized cohort Study : 1. PREPARE detection setting 2. Historical control : physician-tailored from EMPIRIC(ICD) and MIRACLE(CRT)
Outcome	63% reduction in unnecessary shocks for PREPARE patients
Programming Strategy	Consider PREPARE programming for primary prevention patients : • **VF NID 30/40** • Fast detection rate at 182bpm • **ATP** for Fast VTs

SHOCKED EPISODES WERE REDUCED BY 63%[2]



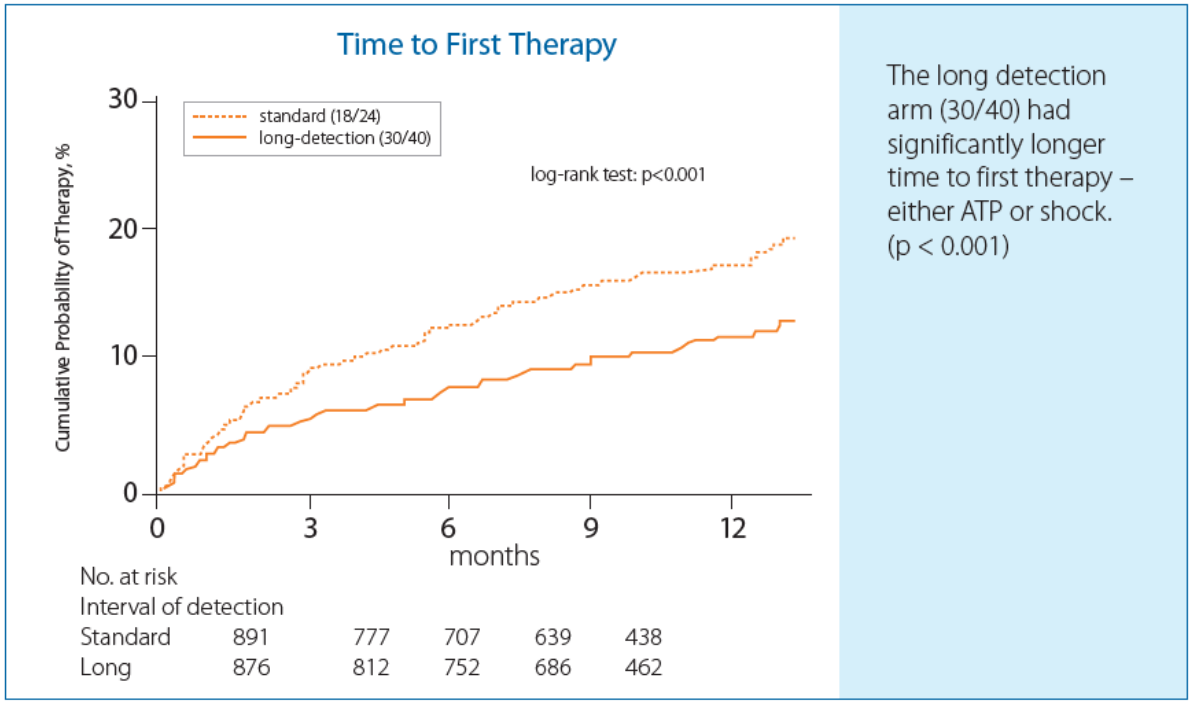
	Control	PREPARE	Relative Reduction
Morbidity index incidence density (events/pt-yr) p = 0.003*	0.69	0.26	-62%[1]
Shocked episodes/pt-yr p = 0.003*	0.69	0.26	-63%[2]

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

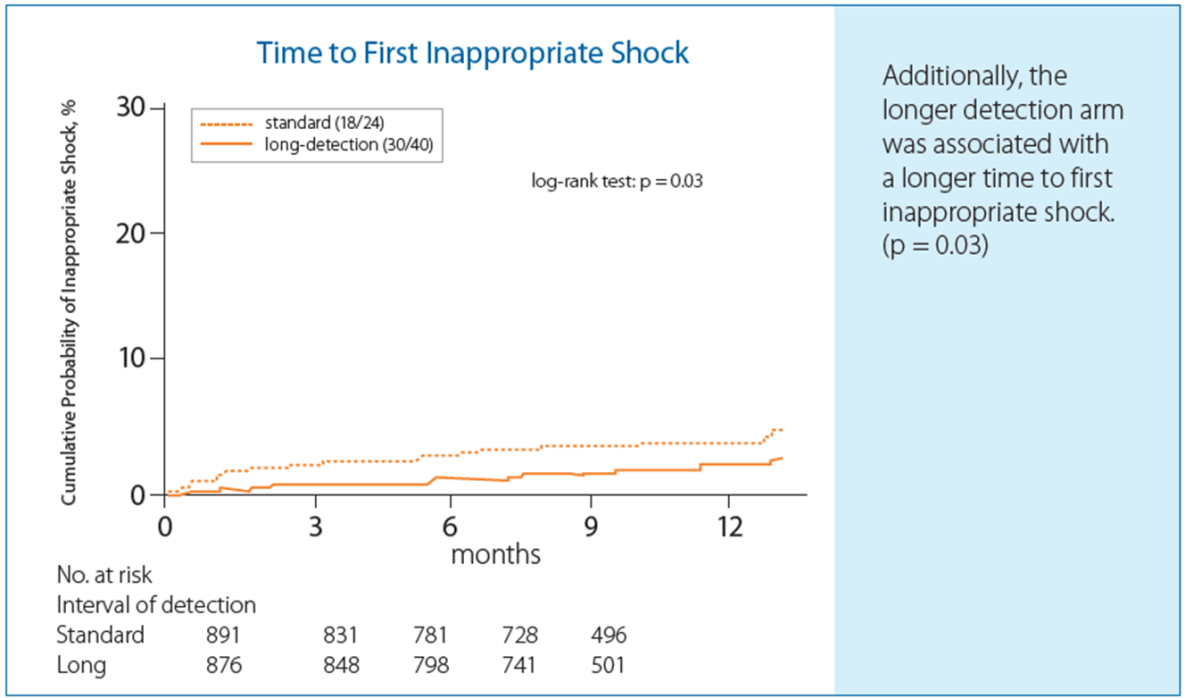
J Am Coll Cardiol 2008;52:541–50

The ADVANCE III Randomized Clinical Trial

To assess whether increasing the **number of detection intervals** is an effective strategy in any type of ICD with the capability of delivering ATP during capacitor charge



The long detection arm (30/40) had significantly longer time to first therapy – either ATP or shock. ($p < 0.001$)



Additionally, the longer detection arm was associated with a longer time to first inappropriate shock. ($p = 0.03$)

Long detection arm showed a **37% reduction** in the number of **overall therapies** ($p<0.001$), 23% reduction in the number of shocks ($p=0.060$) and 42% reduction in the number of ATP therapies ($p<0.001$)

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

Fundamental principles of programming

(1) prolonged detection for the VF zone (18 out of 24 and 30 out of 40)

(2) delayed detection time in any window

(3) SVT discrimination criteria up to 200 bpm

(4) ATP as first therapy for FVT

(5) first shock at maximum energy in the VF zone to reduce the risk of multiple shocks

Reduction in Inappropriate Therapy and Mortality through ICD Programming

Arthur J. Moss, M.D., Claudio Schuger, M.D., Christopher A. Beck, Ph.D., Mary W. Brown, M.S., David S. Cannom, M.D., James P. Daubert, M.D., N.A. Mark Estes III, M.D., Henry Greenberg, M.D., W. Jackson Hall, Ph.D.,* David T. Huang, M.D., Josef Kautzner, M.D., Ph.D., Helmut Klein, M.D., Scott McNitt, M.S., Brian Olshansky, M.D., Morio Shoda, M.D., David Wilber, M.D., and Wojciech Zareba, M.D., Ph.D., for the MADIT-RIT Trial Investigators†

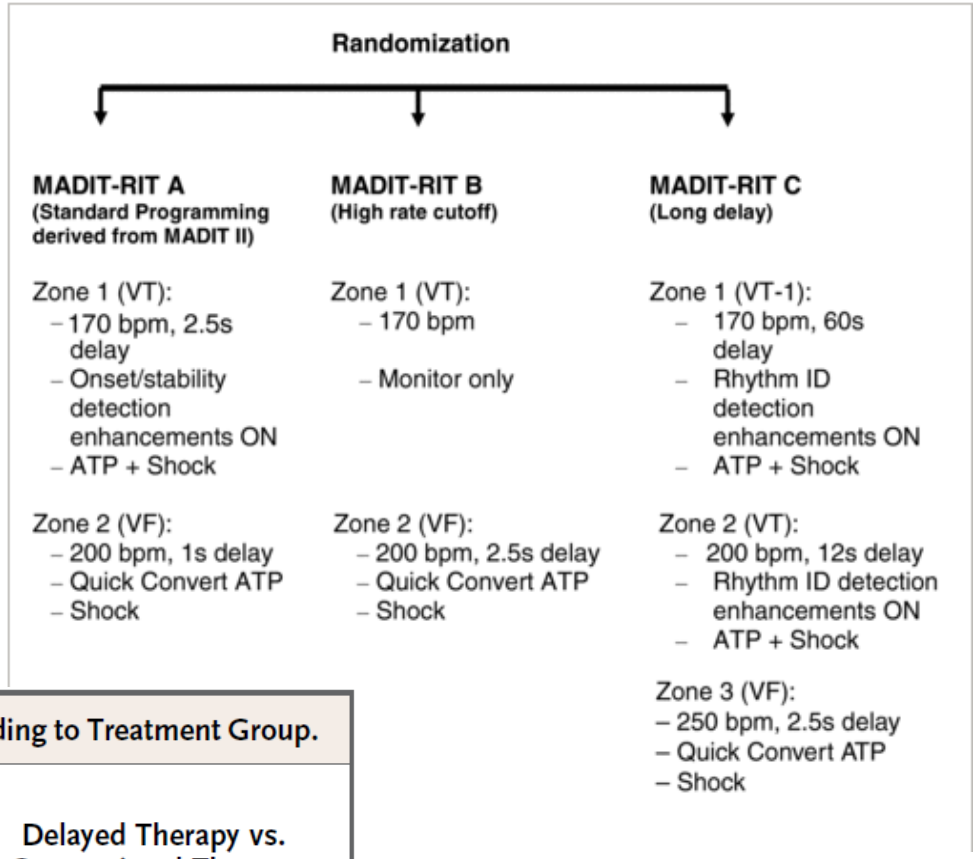
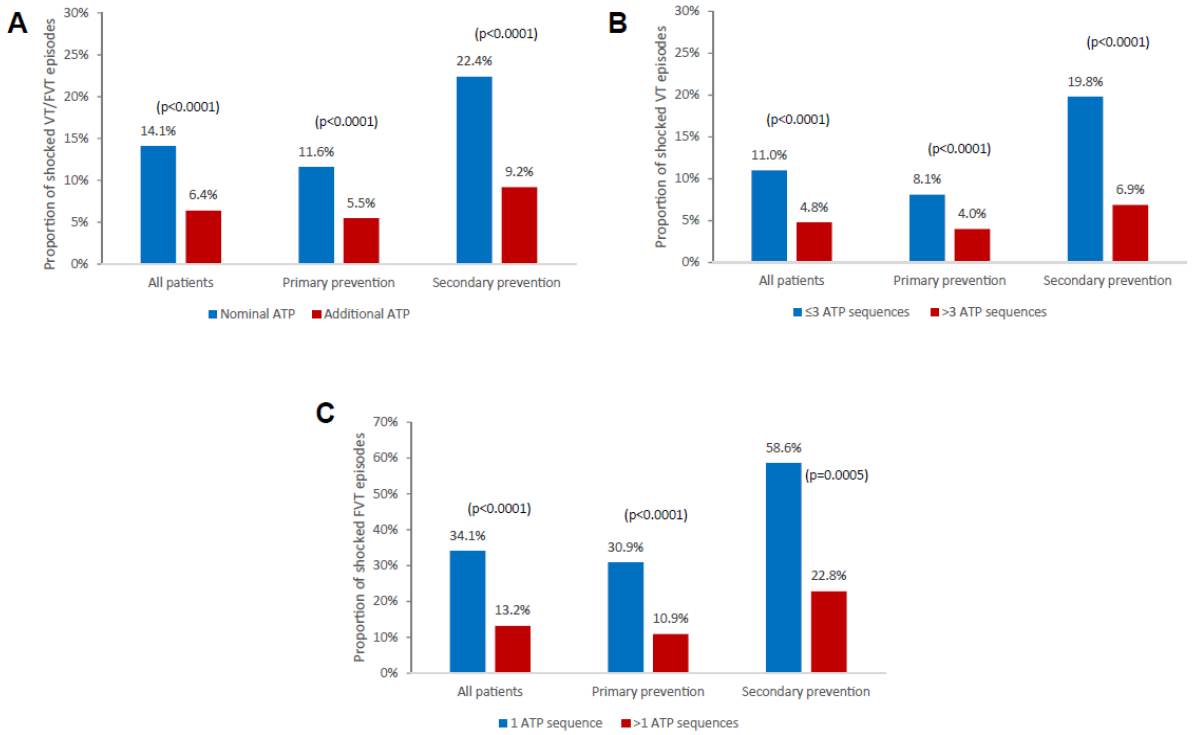


Table 3. Hazard Ratios for a First Occurrence of Inappropriate Therapy, Death, and a First Episode of Syncope According to Treatment Group.

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	
				Hazard Ratio (95% CI)	P Value	Hazard Ratio (95% CI)	P Value
	no. of patients						
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

N Engl J Med 2012;367:2275-83.

Additional antitachycardia pacing programming strategies further reduce unnecessary implantable cardioverter-defibrillator shocks



- Nominal settings for the Medtronic devices provide 3 ATP sequences in the VT zone when enabled, 1 ATP sequence in the FVT zone if used, and 1 ATP sequence during charging in the VF zone
- Additional ATP sequences for either the VT (>3) or the FVT (>1) zone

Programming more than the nominal number of ATP sequences in both the VT and FVT zones is associated with a lower occurrence of implantable cardioverter-defibrillator shocks in clinical practice

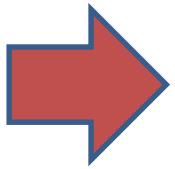
Joung B et al. Heart Rhythm 2020;17:98–105

Tachycardia Therapy Programming Recommendations	Class of Recommendation	Level of Evidence
It is recommended in all patients with structural heart disease and ATP-capable ICD therapy devices that ATP therapy be active for all ventricular tachyarrhythmia detection zones to include arrhythmias up to 230 bpm, to reduce total shocks except when ATP is documented to be ineffective or proarrhythmic.	I	A
It is recommended in all patients with structural heart disease and ATP-capable ICD therapy devices that ATP therapy be programmed to deliver at least 1 ATP attempt with a minimum of 8 stimuli and a cycle length of 84%–88% of the tachycardia cycle length for ventricular tachyarrhythmias to reduce total shocks, except when ATP is documented to be ineffective or proarrhythmic.	I	A
It is indicated to program burst ATP therapy in preference to ramp ATP therapy, to improve the termination rate of treated ventricular tachyarrhythmias.	I	B-R
It is reasonable to activate shock therapy to be available in all* ventricular tachyarrhythmia therapy zones, to improve the termination rate of ventricular tachyarrhythmias.	IIa	C-EO
*Rarely, to limit patient discomfort and anxiety, hemodynamically stable slow VT can be treated without programming a backup shock.		
It is reasonable to program the initial shock energy to the maximum available energy in the highest rate detection zone to improve the first shock termination of ventricular arrhythmias unless specific defibrillation testing demonstrates efficacy at lower energies.	IIa	C-LD

2015 HRS/EHRA/APHRS/SOLAECE expert consensus statement on optimal implantable cardioverter-defibrillator programming and testing

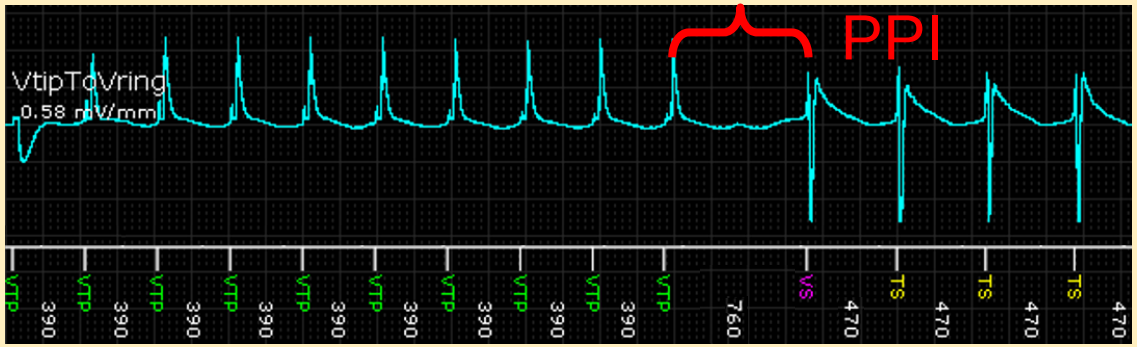
Pts with inherited cardiac channelopathies

- the index clinical arrhythmia is polymorphic VT or VF:
- usually lack an organized reentry and are rarely interrupted by pacing,



ATP would not be routinely programmed

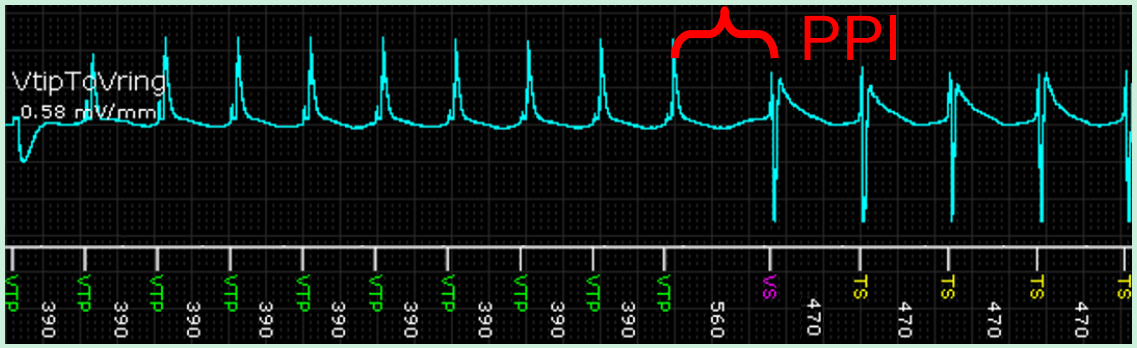
Intrinsic ATP algorithm logic



Loss of Capture | Reset Zone | **Failure to Reset**

Post Pacing Interval

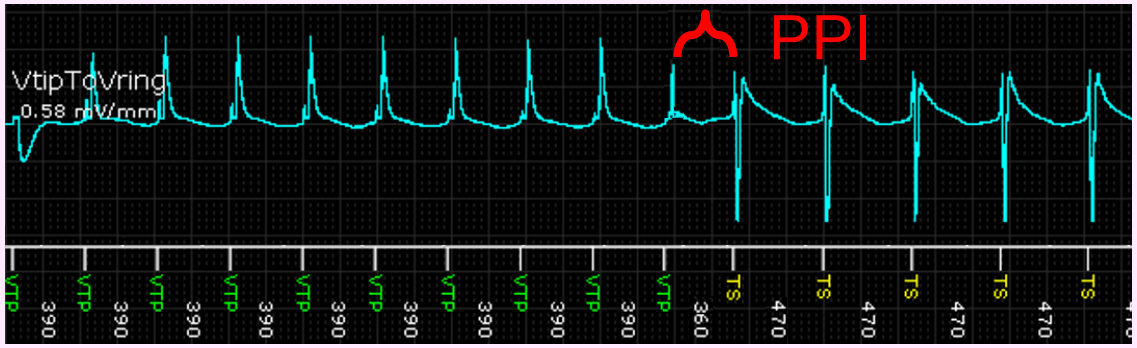
Add S1 stimuli



Loss of Capture | **Reset Zone** | Failure to Reset

Post Pacing Interval

Shorten S2



Loss of Capture | Reset Zone | Failure to Reset

Post Pacing Interval

Lengthen S2, Add S3

Take Home Messages

- ATP : safe, effective and painless therapy for VTs, reduction of unnecessary shocks and an improvement of clinical outcome, patients' quality of life and device longevity
- Fast VT (188 bpm-250 bpm) : burst >> ramp
- Optimal number of impulses: minimum 8
- Prolonged detection, delayed detection, SVT discrimination, etc
- Limitation: 2nd prevention, channelopathies

Seoul National University Hospital Cardiac Arrhythmia Laboratory

SNUH EP lab
Seil Oh, MD, PhD
Eue-Keun Choi , MD, PhD
So-Ryoung Lee, MD, PhD
Su-Hwa Kim, MD
Soonil Kwon, MD
Hyo-Jeong Ahn, MD

SNUBH EP lab
Il-Young Oh, MD, PhD
Youngjin Cho, MD
Ji Hyun Lee, MD

SMG-SNU Boramae Medical Center EP lab
Woo-Hyun Lim, MD

Animal Lab
Moo-Kang Kim
Ae-Sun Yoon

Clinical Research
Ji-Hee Min
Hye-Jin Song
So-Hee Kim
Byung-Sook Kim

University of Liverpool and Liverpool Chest & Heart Hospital
Gregory Y. H. Lip, MD

Soongsil University
Kyung-Do Han, PhD

Thank you for your attention