Strategies to Minimise Right Ventricular Pacing

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Why should we minimise RV pacing?

Sinus node disease, tachy devices and intermittent AV block

Deleterious Effects of RV Pacing

Physiological Effects:

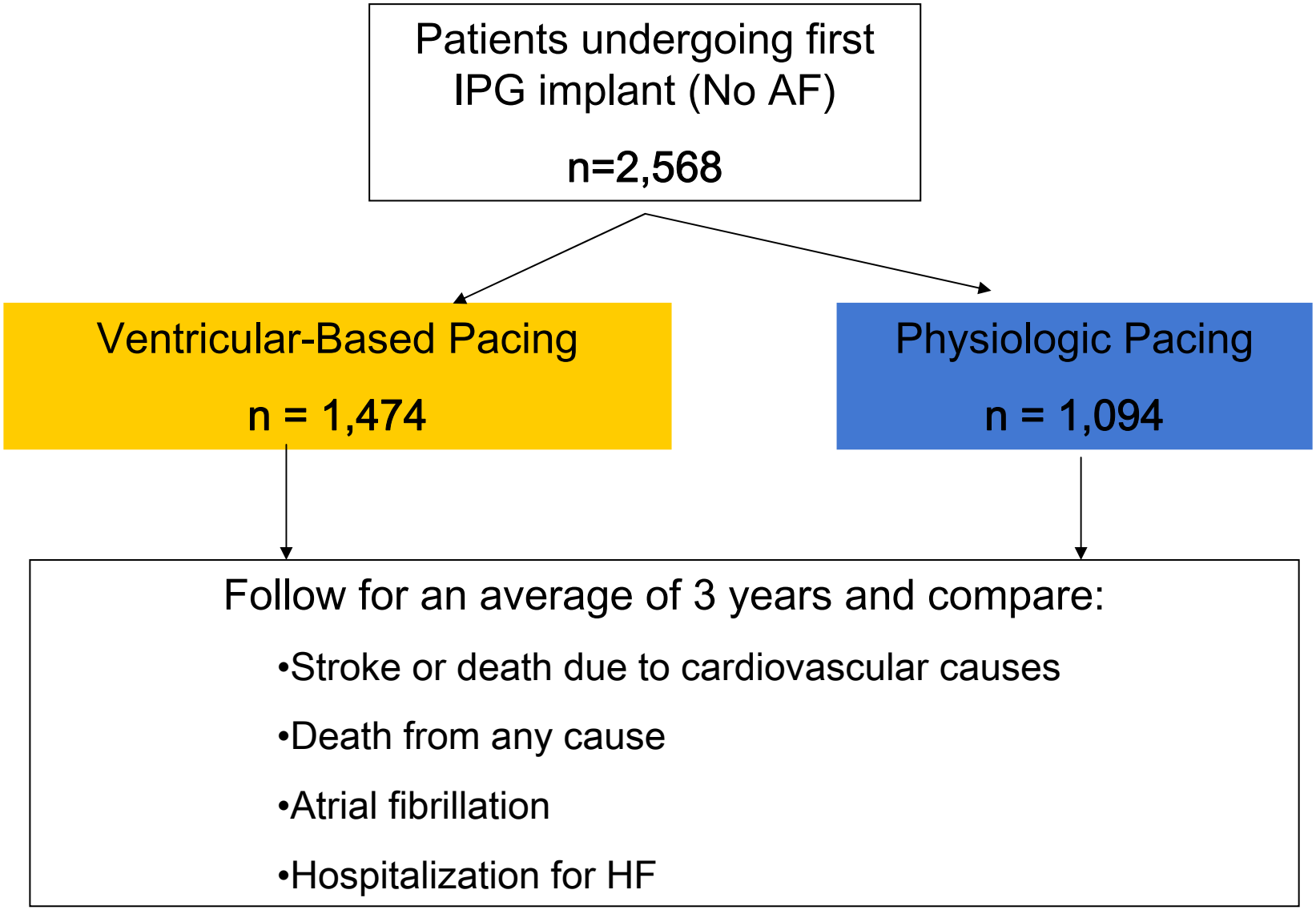
- Left atrial dilatation
- Increased ventricular dysynchrony
- Adverse ventricular remodelling

Potential Clinical Effects:

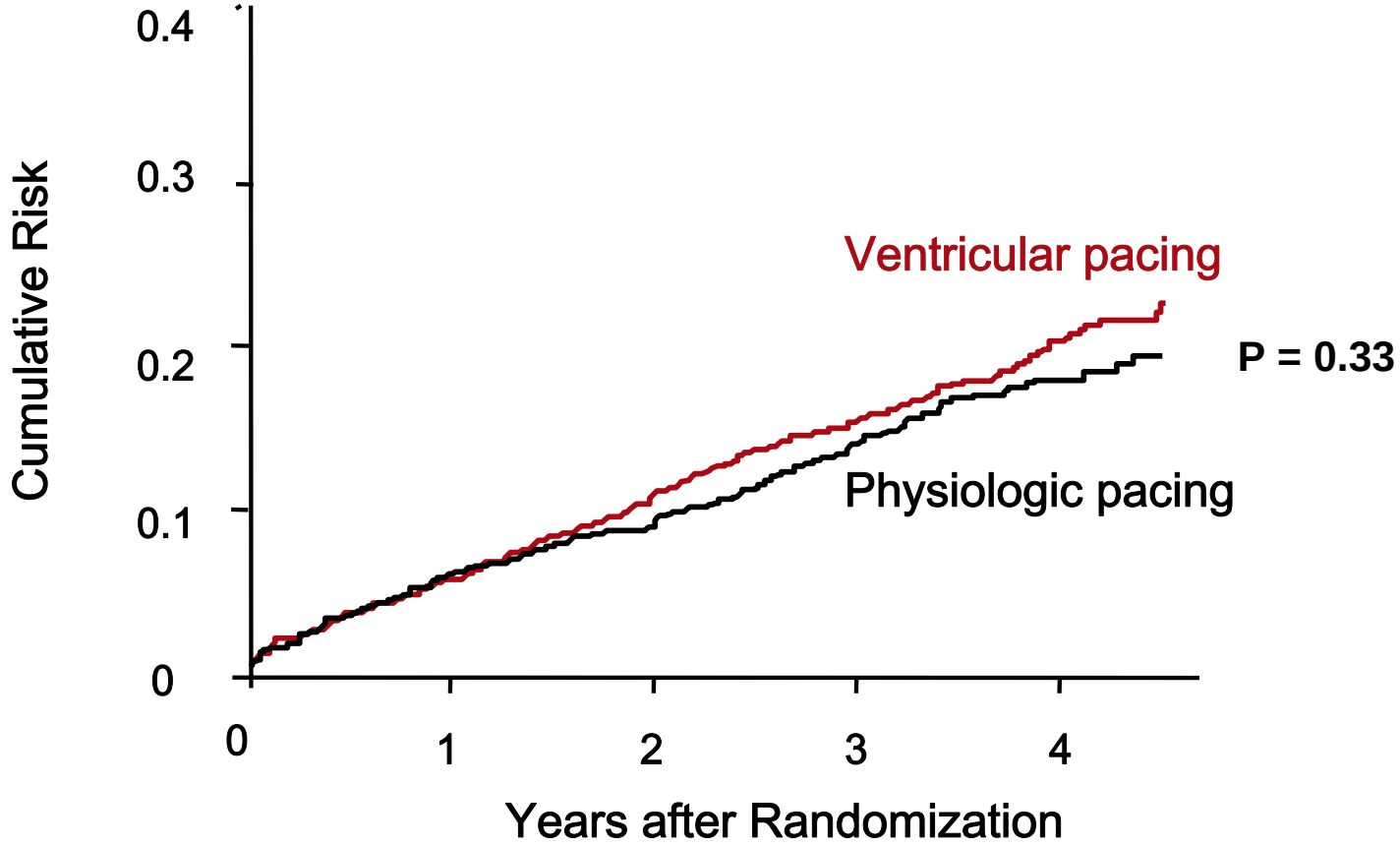
- Increased AF
- Increased heart failure
- Increased CV mortality

Canadian Trial of Physiologic Pacing (CTOPP)

Study Protocol



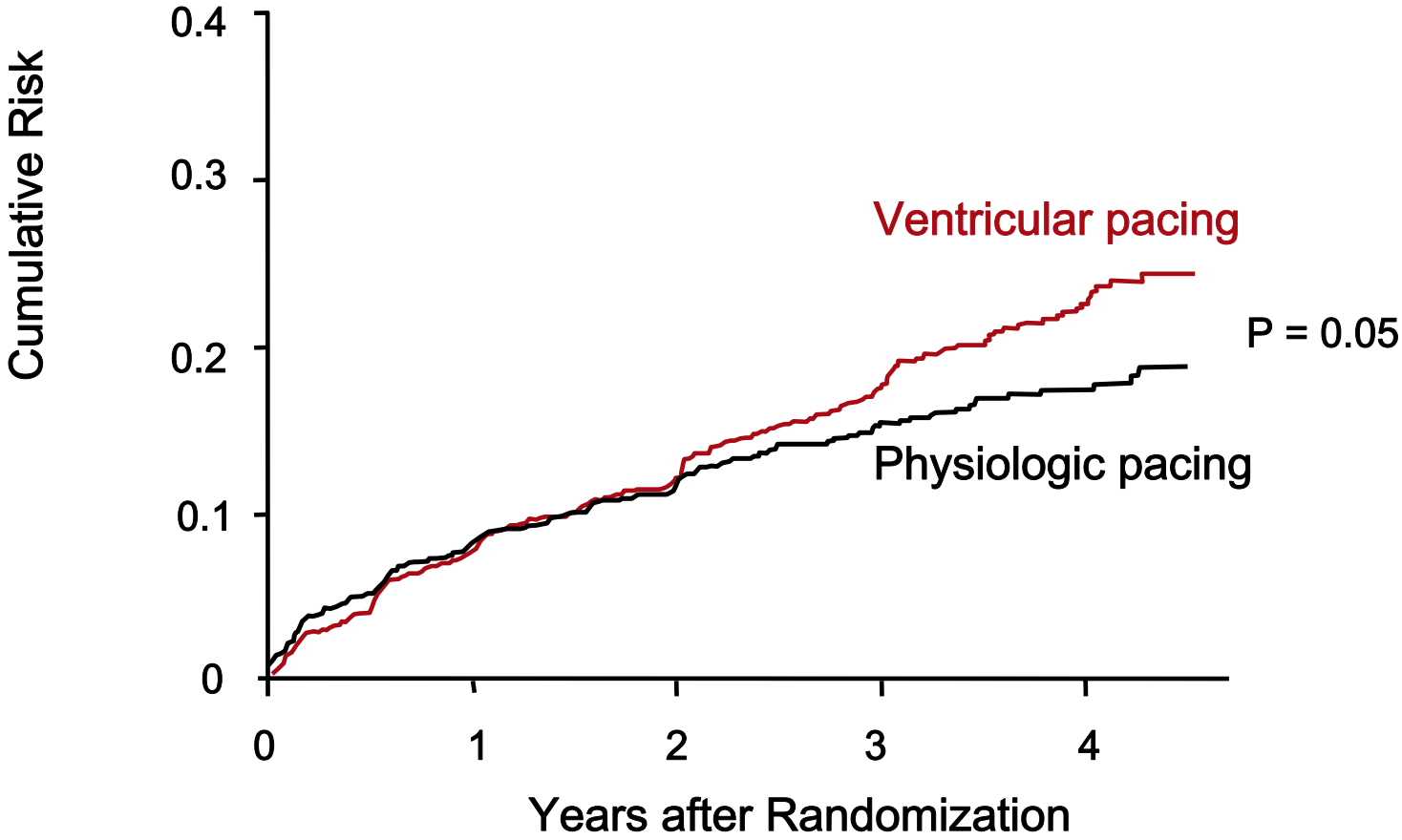
CTOPP
Cumulative Risk of Stroke or Cardiovascular Death



No. at risk:					
Ventricular pacing	1474	1369	1259	847	366
Physiologic pacing	1094	1005	954	637	287

Connolly S et al. N Engl J Med 2000; 342: 1385-91.

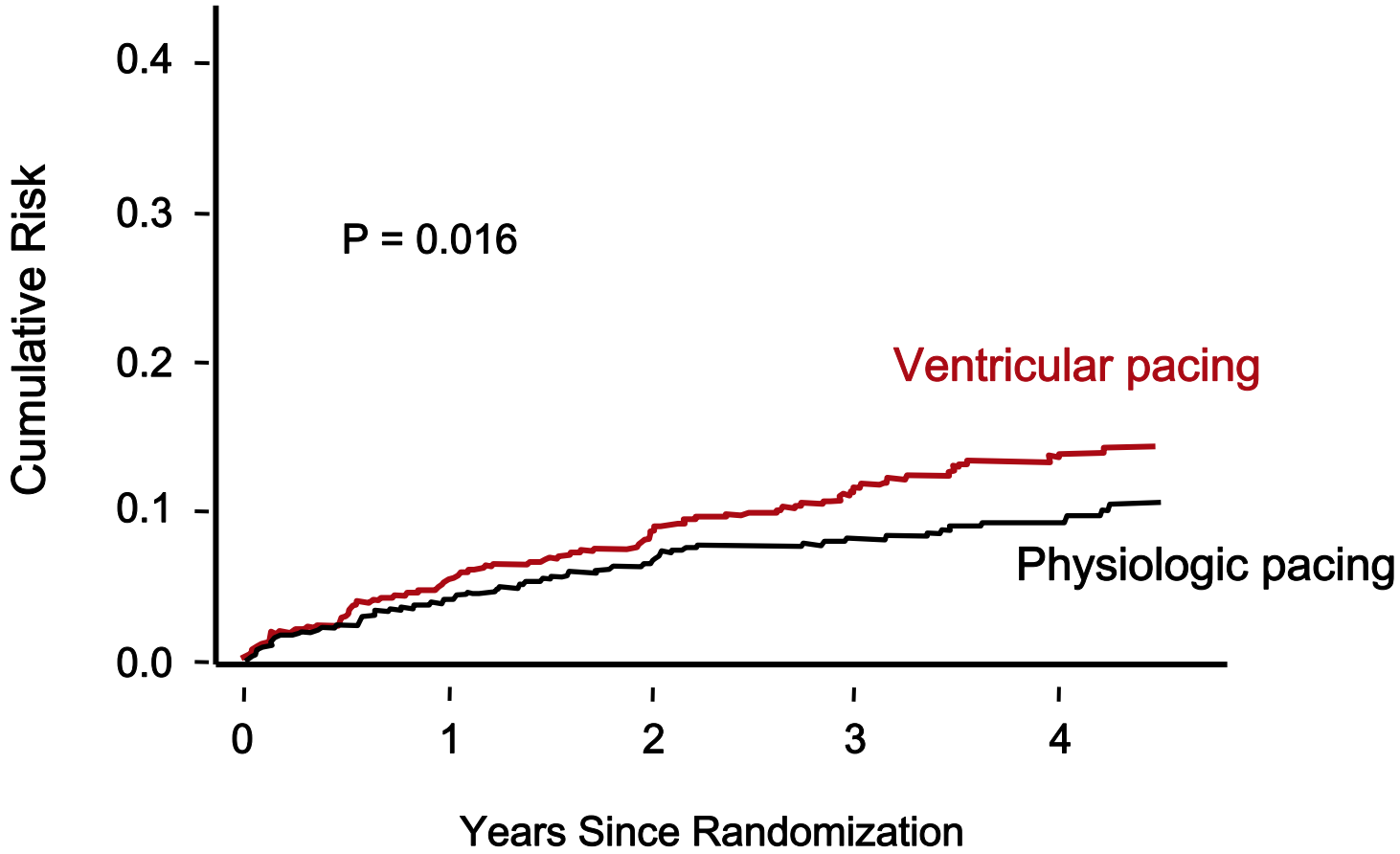
CTOPP
Cumulative Risk of any AF



No. at risk:					
Ventricular pacing	1474	1276	1127	731	303
Physiologic pacing	1094	936	857	559	250

Connolly S et al. N Engl J Med 2000; 342: 1385-91.

CTOPP
Cumulative Risk of Chronic AF



Number At Risk	V	1474	1317	1180	779	331
	P	1094	975	906	601	269

Skanes A, et al. J Am Coll Cardiol 2001; 38: 167-72.

CTOPP
Conclusions

Physiologic pacing (dual-chamber or atrial) provides little benefit over ventricular pacing for the prevention of stroke or death due to cardiovascular causes.

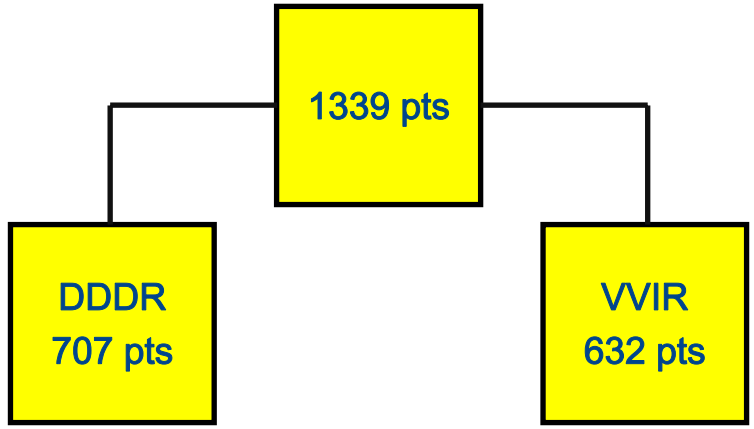
Physiologic pacing does provide a reduction in the relative risk of atrial fibrillation.

MOST (MO**de Selection T**rial)
Objectives

Study the effect of cumulative % of RV pacing in DDDR and VVIR mode on Heart Failure Hospitalization (HFH) and AF in sinus node disease patients with QRS duration <120 ms

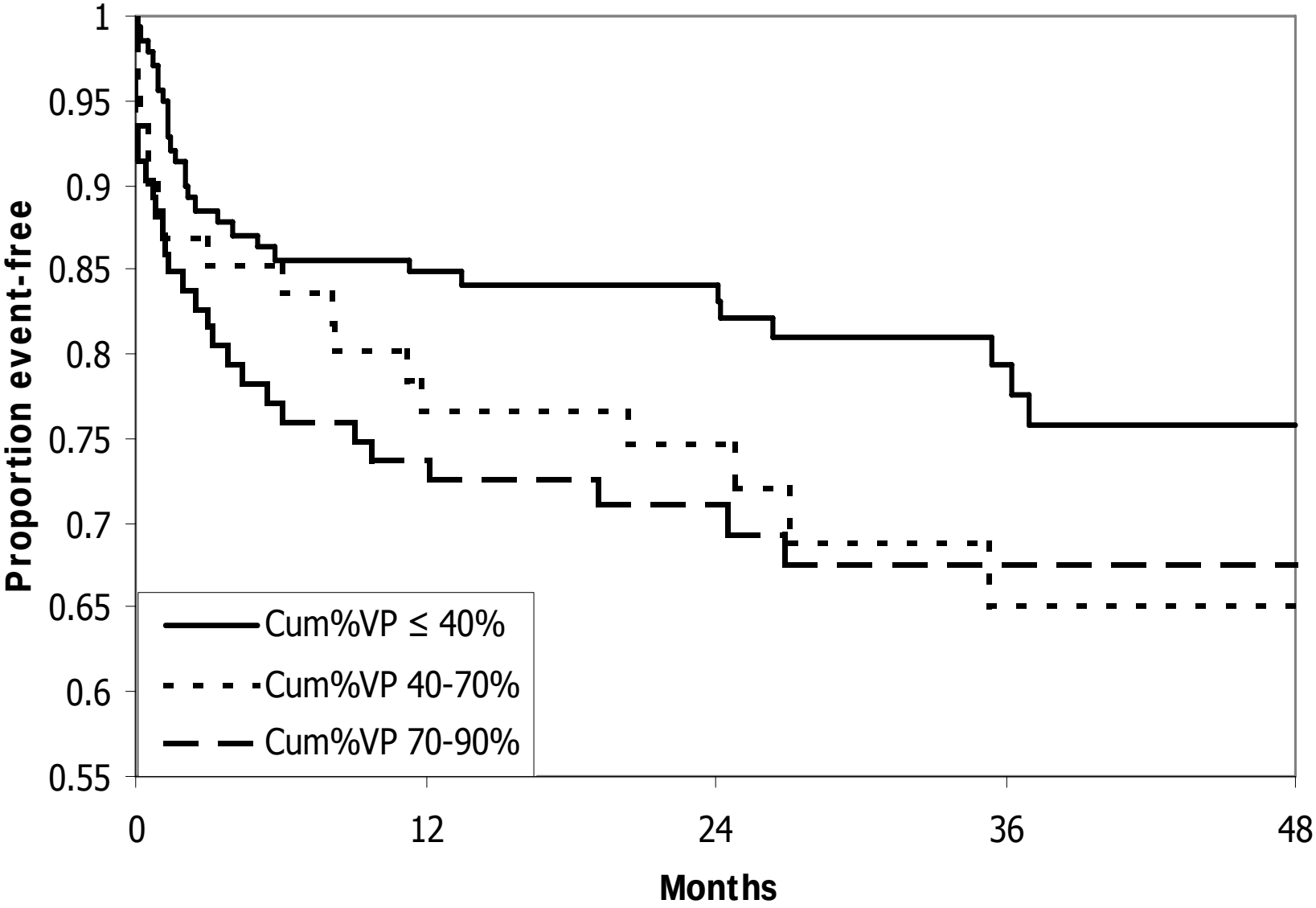
MOST
Randomisation & Characteristics

- Patients with SND
- QRSd < 120 ms
- Median EF 55%
- Mild or no CHF
- >50% history of atrial tach



- PR interval <200 ms or mildly prolonged
- DDDR and VVIR: lower rate ≥ 60, upper rate ≥ 110 bpm
- DDDR: AV delay between 120 – 200 ms
- 90% Ventricular Pacing in DDDR: due to AV < PR
- 58% Ventricular Pacing in VVIR

MOST
DDDR Results – 1st Incidence of AF



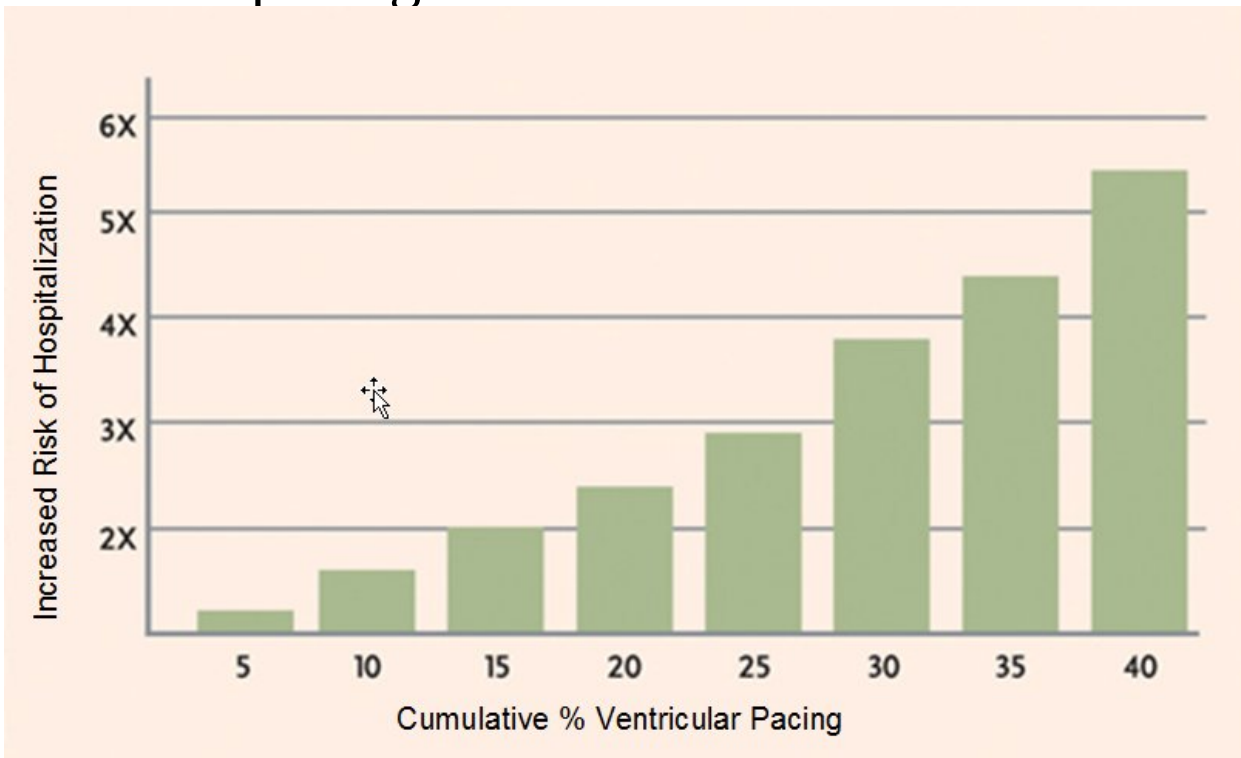
MOST Sub-study
RV Pacing and Heart Failure Hospitalization (HFH)

V-pacing is > 40%

- HFH risk is constant

V-pacing < 40%

- Each 10% reduction in V-pacing = 54% RRR for HFH
- 2% when pacing was minimized to < 10%



Sweeney MO, et al. Circulation 2003;23:2932-2937

MOST
Conclusions

Increased RV pacing has a detrimental effect on long-term clinical outcomes

- Increased risk of AF
- Increased risk of heart failure hospitalization

"Functional" AAIR pacing is superior to DDDR when %V-pacing is high (>40%)

David Trial
Objectives, Hypothesis, End Points

Study Objectives

Compare dual chamber with back-up single chamber pacing in pts with standard ICD indication (LVEF <40%, no pacing indication)

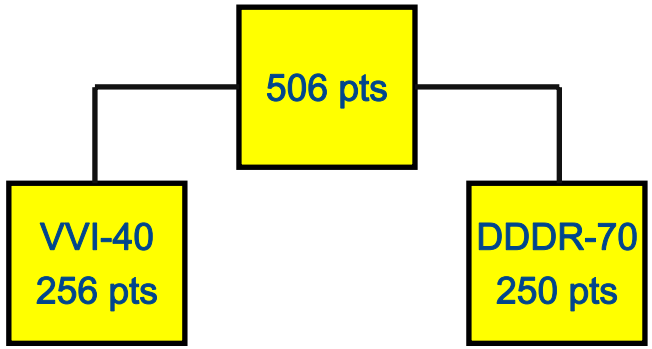
Hypothesis

DDD(R) 70 bpm is superior to VVI 40 bpm

End points

1. time to death
2. time to 1st hospitalization for congestive heart failure

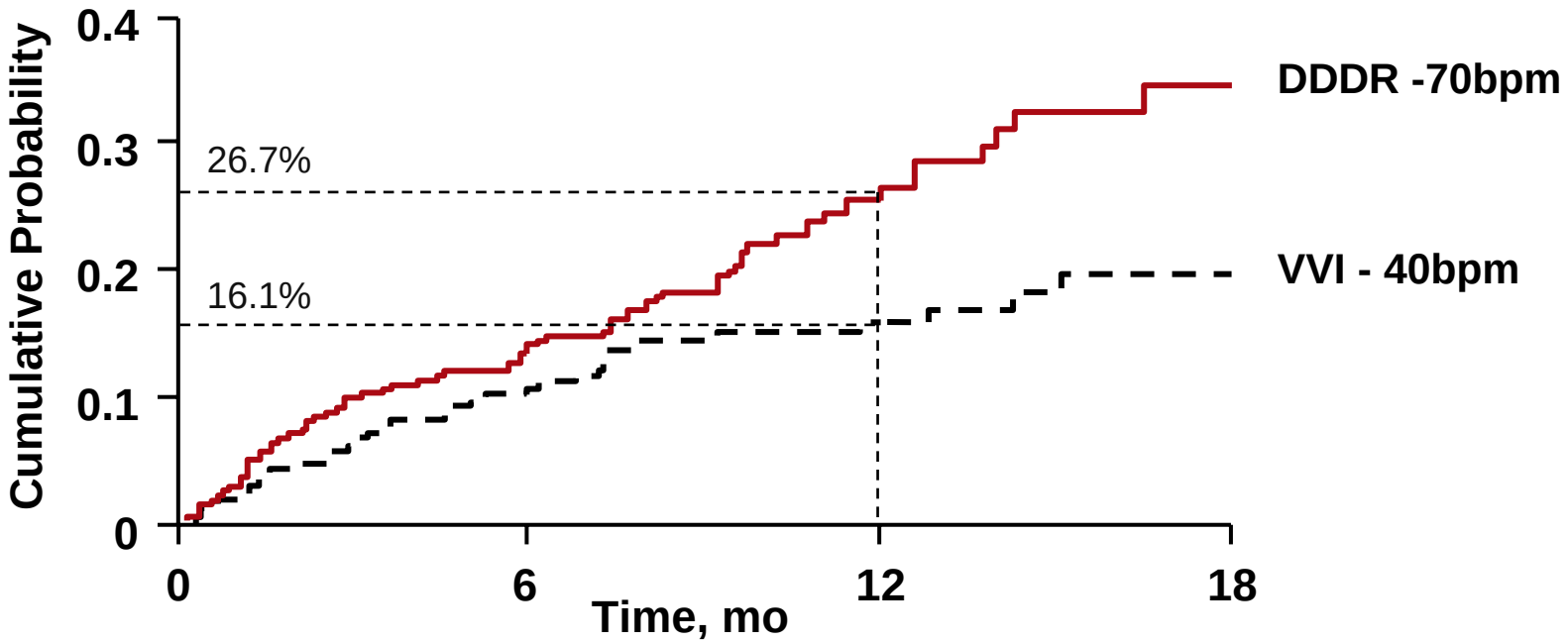
David Trial
Design, Randomization, Typical Result

Design	Single blinded, parallel-group, randomized clinical trial	
Randomization		
Typical result	RV pacing 4%	RV pacing 70%

DAVID Trial

Endpoint: Death or 1st Hospitalization for New or Worsened CHF

Relative Hazard (95% CI), 1.61 (1.06-2.44)



No at Risk				
DDDR	250	159	76	21
VVI	256	158	90	25

DAVID Trial
Conclusion

In patients with:

standard ICD indication
no pacing indication
LVEF ≤ 40%

DDDR-70 (no AV delay recommendation) versus VVI-40 offers:

no clinical advantage
may be detrimental by increasing the combined endpoint of death or HFH

DAVID II showed no difference between AAI 70 and VVI 40

i.e. detrimental effects of RV pacing are NOT rate related

How can we minimise RV pacing?

Minimising RV Pacing
Options

AAI pacing

VVI/DDI pacing at low rate

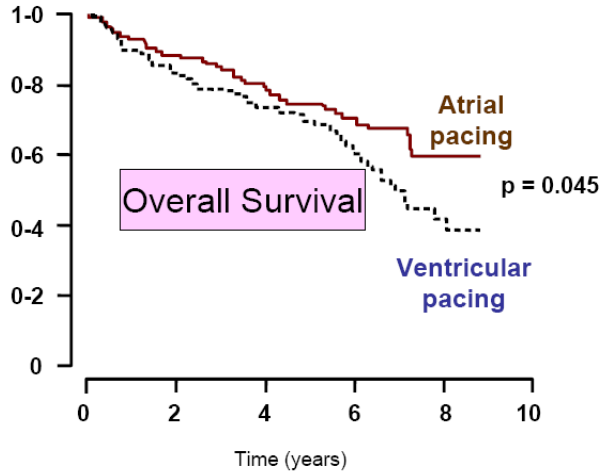
DDD with long AV delay

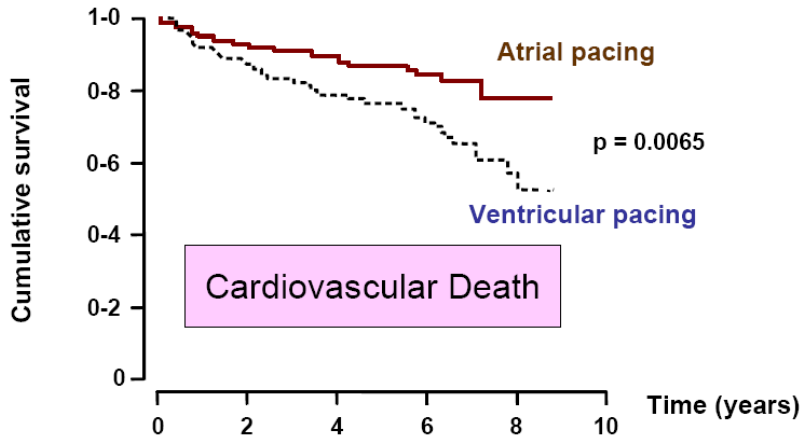
Search AV hysteresis

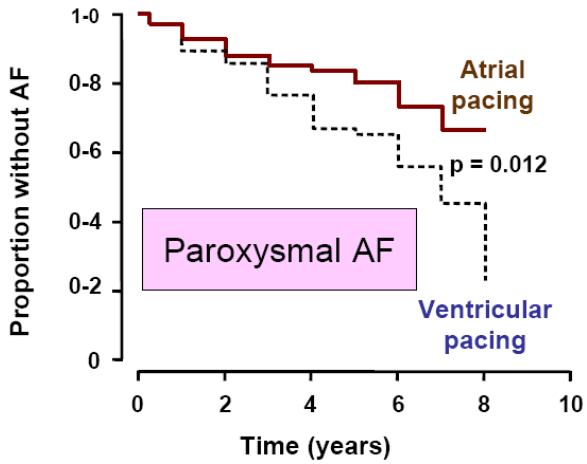
Advanced algorithms

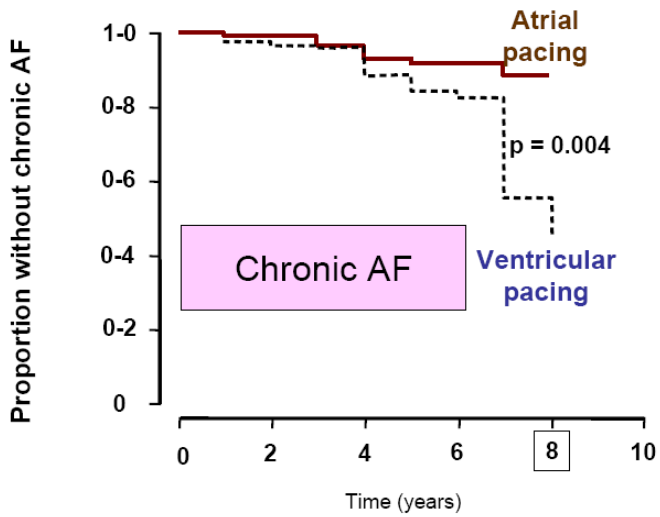
AAI Pacing

Danish Study
AAI vs VVI in SND

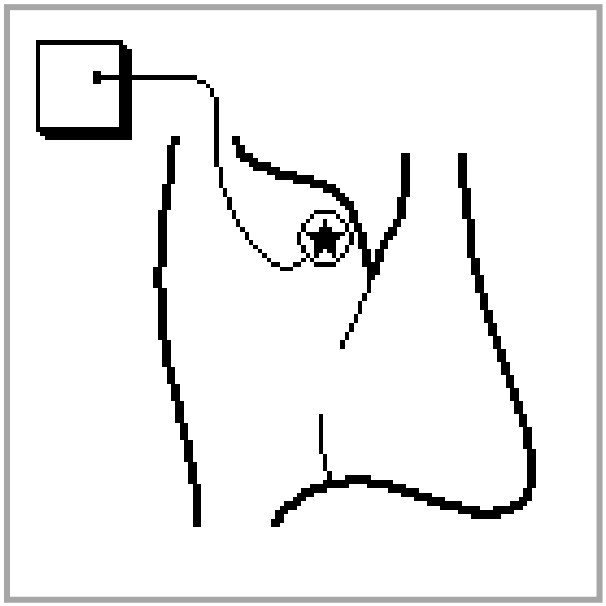








Potential Problems with AAI Pacing



Development of AV Block requiring ventricular pacing

Development of atrial fibrillation with bradycardia requiring ventricular pacing

Development of CHB in SND

Study	Mean Follow-Up Time	Incidence of CHB	Annualized Incidence
Rosenqvist 1989	3 years	Median 2.1% Range: 0-11.9%	Median: 0.6% Range: 0-4.5%
Andersen 1997	8 years	3.6%	0.6%
Brandt 1992	5 years	8.5%	1.8%
Sutton 1986	3 years	8.4%	2.8%
Rosenqvist 1986	2 years	4.0%	2.0%
Rosenqvist 1985	5 years	3.3%	0.7%
Hayes 1984	3 years	3.4%	1.1%

VVI/DDI at Low Rate

Dual-chamber Pacing With Long AV Delay

DDD Pacing
Options

Traditionally designed to pace the RV

Ideal dual-chamber pacemaker would:

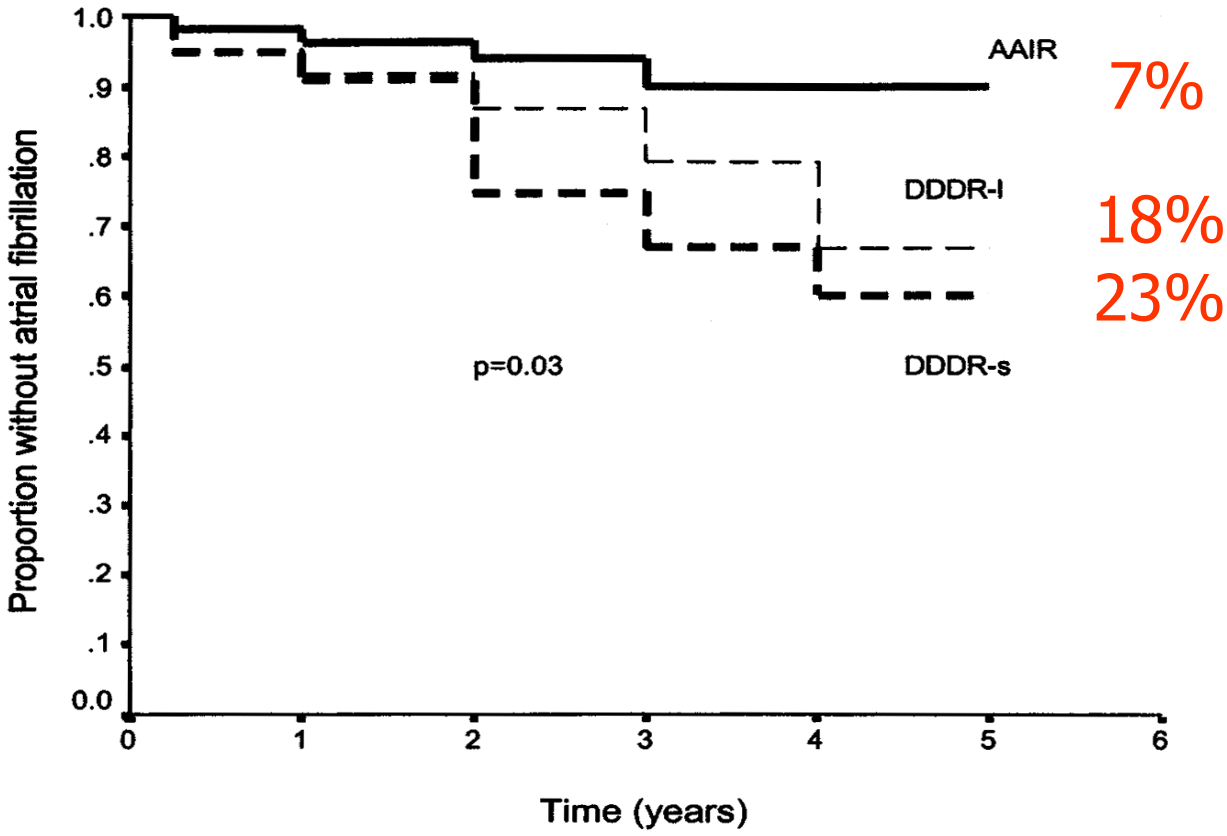
- Provide atrial pacing
- Minimize ventricular pacing
- Provide RV pacing if AV Block or slow AF develops

Danish II Study
Freedom from AF by Pacing Mode

177 patients

AAIR v DDDR with short AVD v DDDR with long AVD

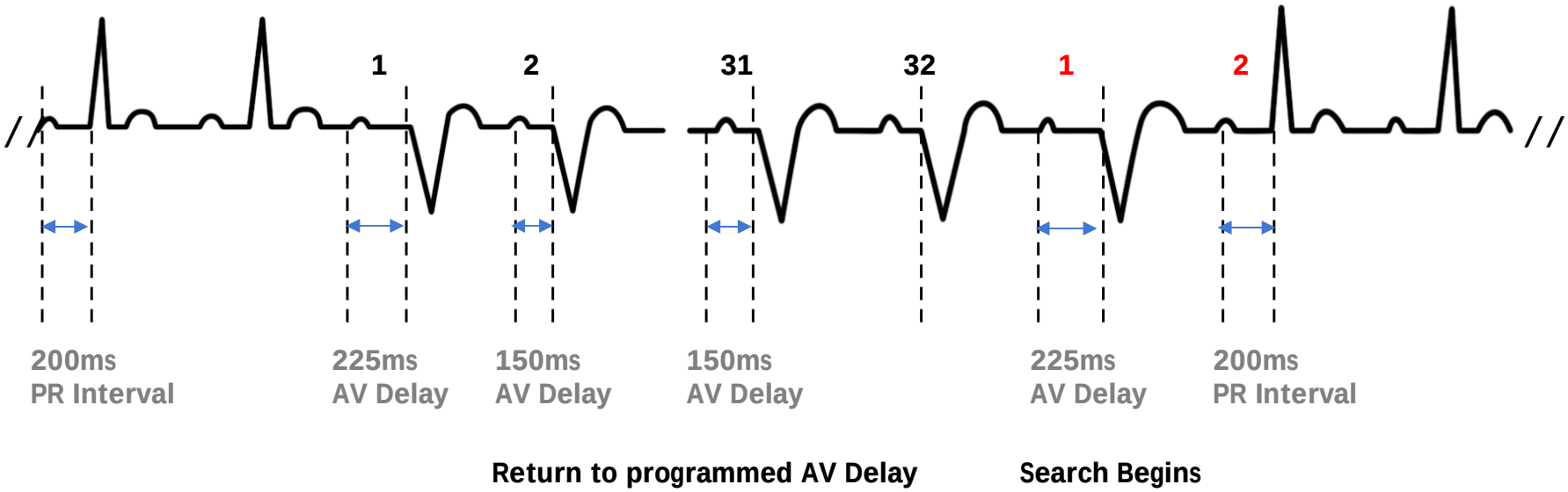
3 year follow-up



AV Search Hysteresis

AV Search Hysteresis
The Algorithm

Two AV delays - **Extended** if there is normal conduction, **Normal** when there is no normal conduction. AVSH increases the programmed AV delay by a programmable percentage (**offset**). If an intrinsic conduction is present, the increased AV delay is maintained until a paced beat is required. After a paced impulse is delivered after the Long AVD, the AVD switches to the normal AVD for a programmable number of cycles (nominal 32) followed by a search. During the search the AV Delay is extended again to the Long value (AVD + offset)

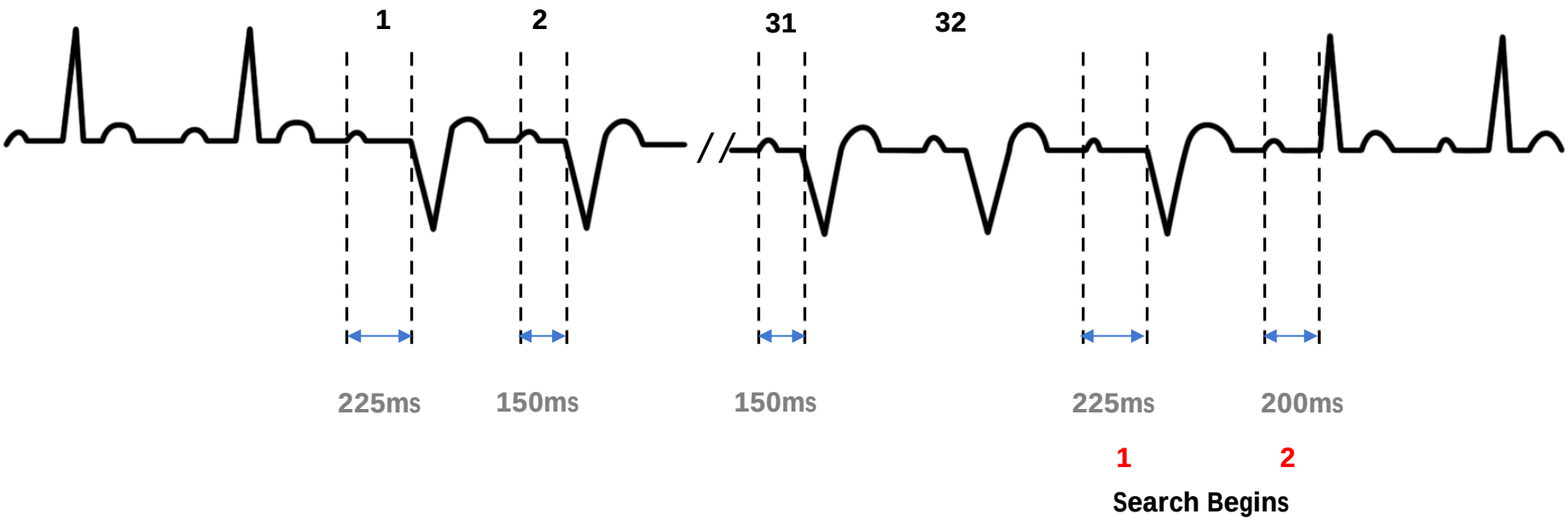


AV Search Hysteresis

Successful Search

AV Delay	150ms
AV Increase	50%
AV Search Interval	32 cycles

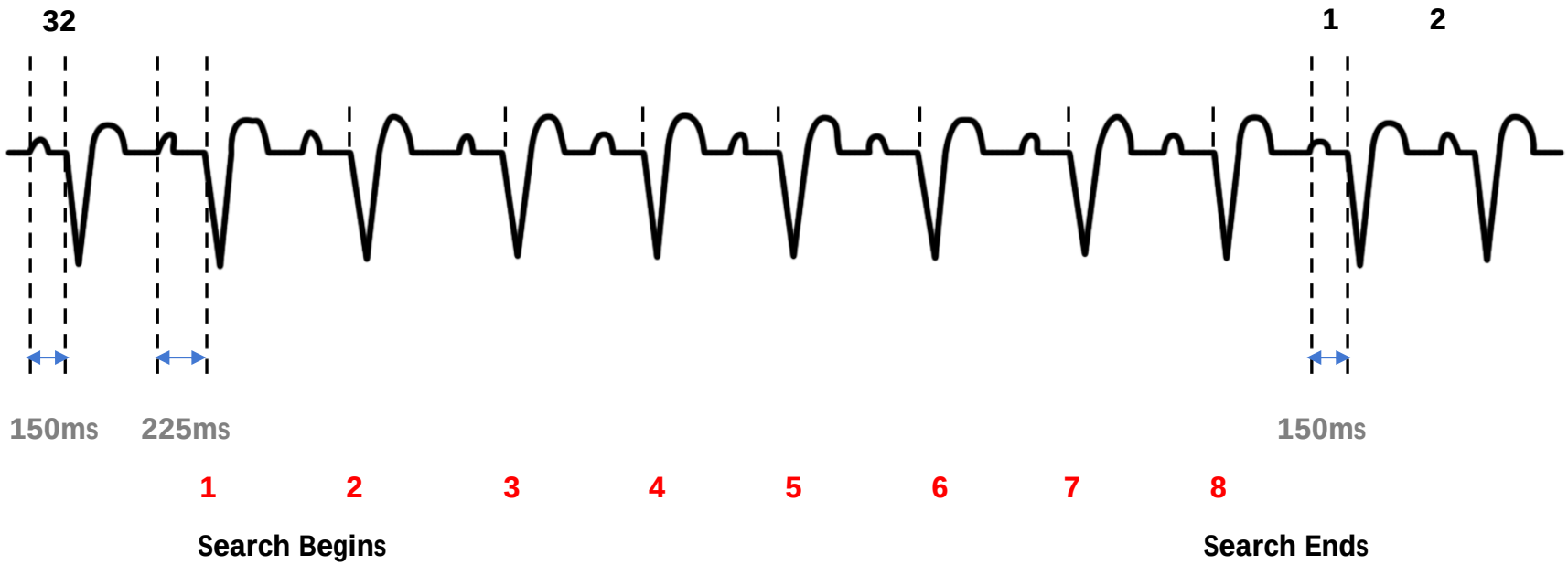
During the search the AV Delay is extended to the Long value
Intrinsic conduction occurs again so the Long value is maintained



AV Search Hysteresis
Unsuccessful Search

AV Delay	150ms
AV Increase	50%
AV Search Interval	32 cycles

NO intrinsic conduction during the search
AVD returns to the normal AV delay after 8 beats and repeats sequence
The AVD switches to the normal AVD for a programmable number of cycles (nominal 32) followed by a search

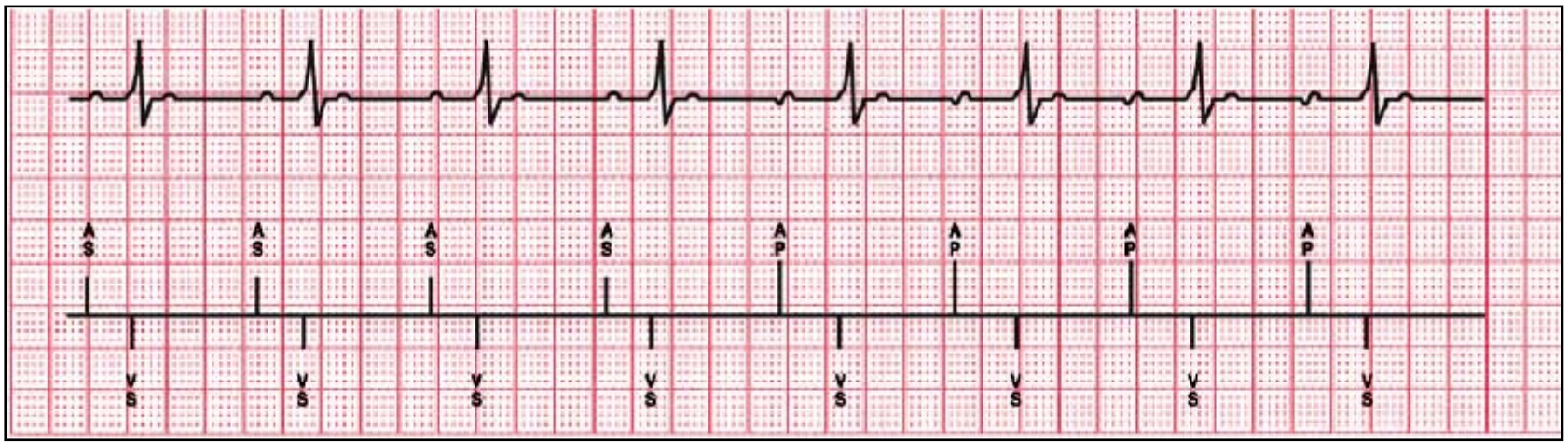


Managed Ventricular Pacing (MVP)

Functional AAIR pacing with backup dual chamber ventricular support in the presence of transient or persistent loss of conduction

MVP Basic Operation

AAI(R) Mode
Atrial based pacing allowing intrinsic AV conduction

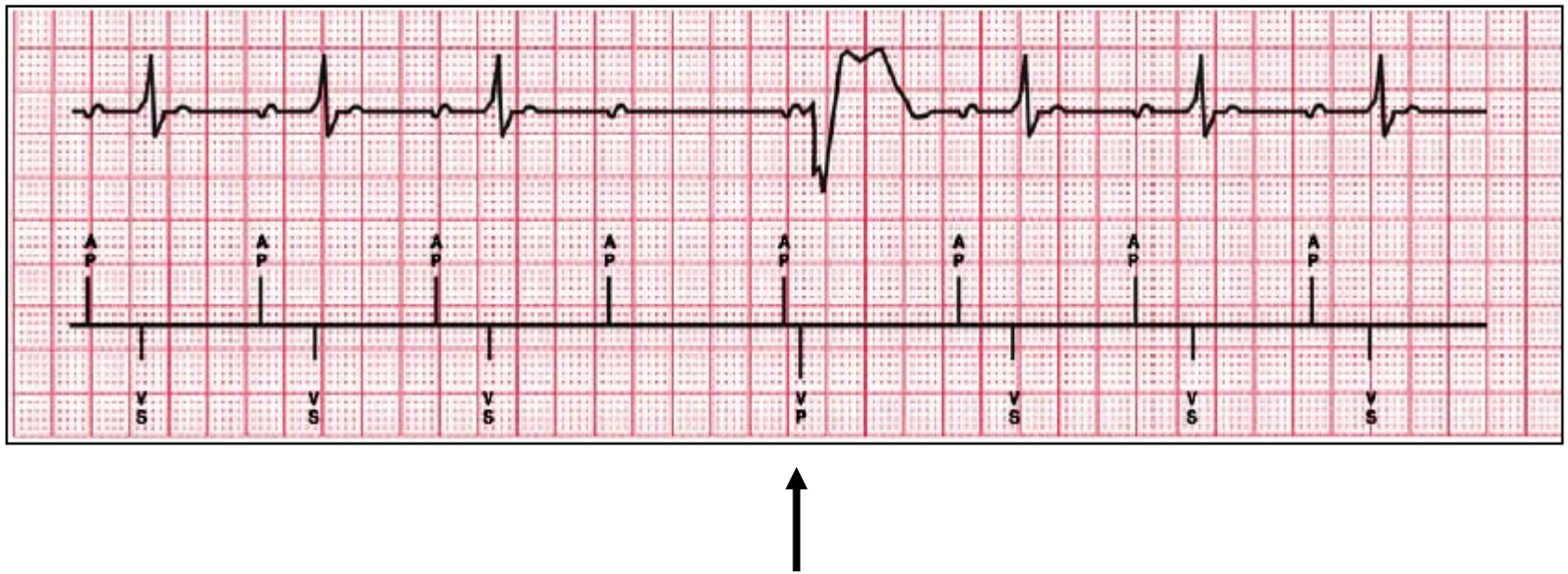


PR Intervals are only restricted by the underlying atrial rate or sensor rate; VS events simply need to occur prior to the next AS or AP.

MVP Basic Operation

Ventricular Backup

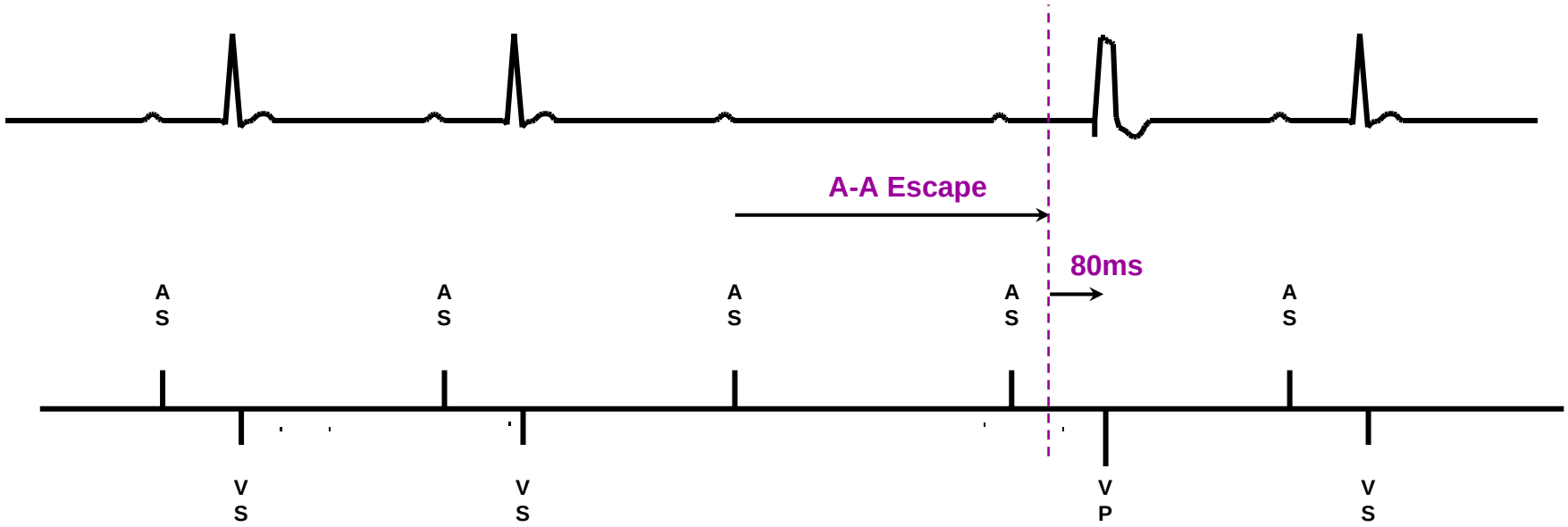
Ventricular pacing only as needed in the presence of transient loss of conduction



MVP Operating Details

V Back-up Pace

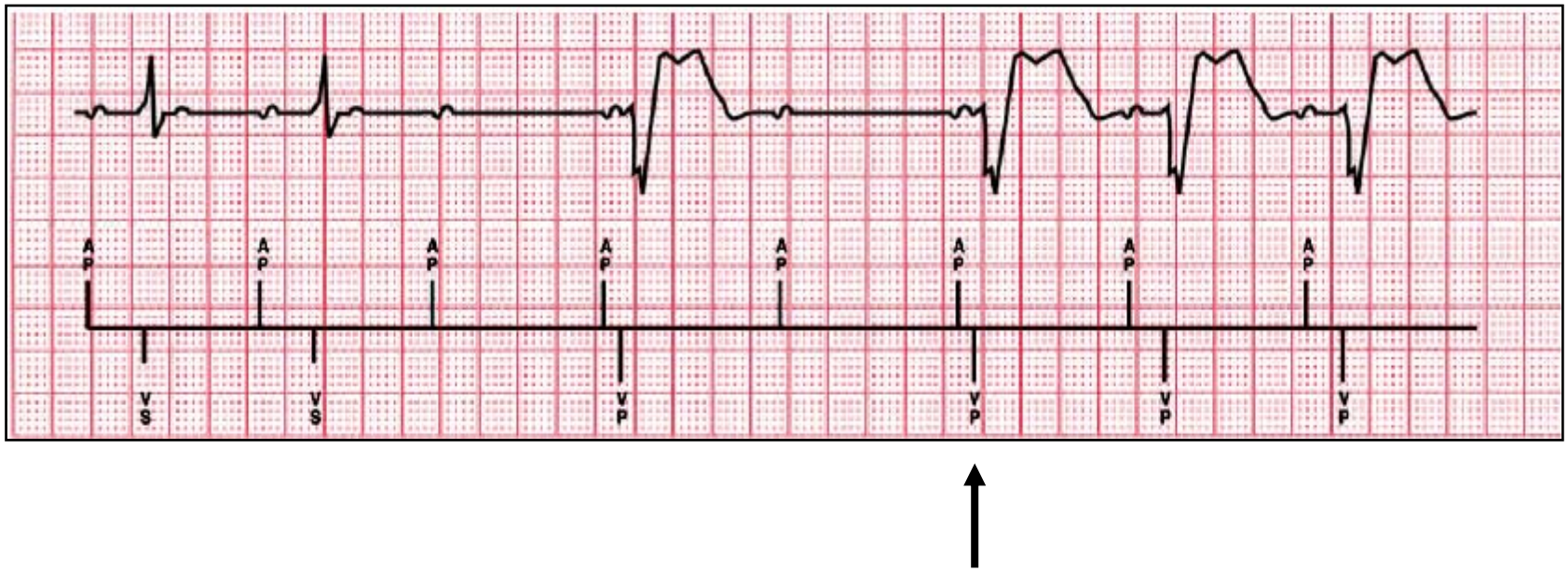
- Scheduled after any A-A interval without V-Sense
- Delivered 80 ms after the scheduled A-Pace (or the inhibited A-Pace)
- Uses programmed V-amplitude and pulse width



MVP Basic Operation

DDD(R) Switch

Ventricular support if loss
of A-V conduction is persistent

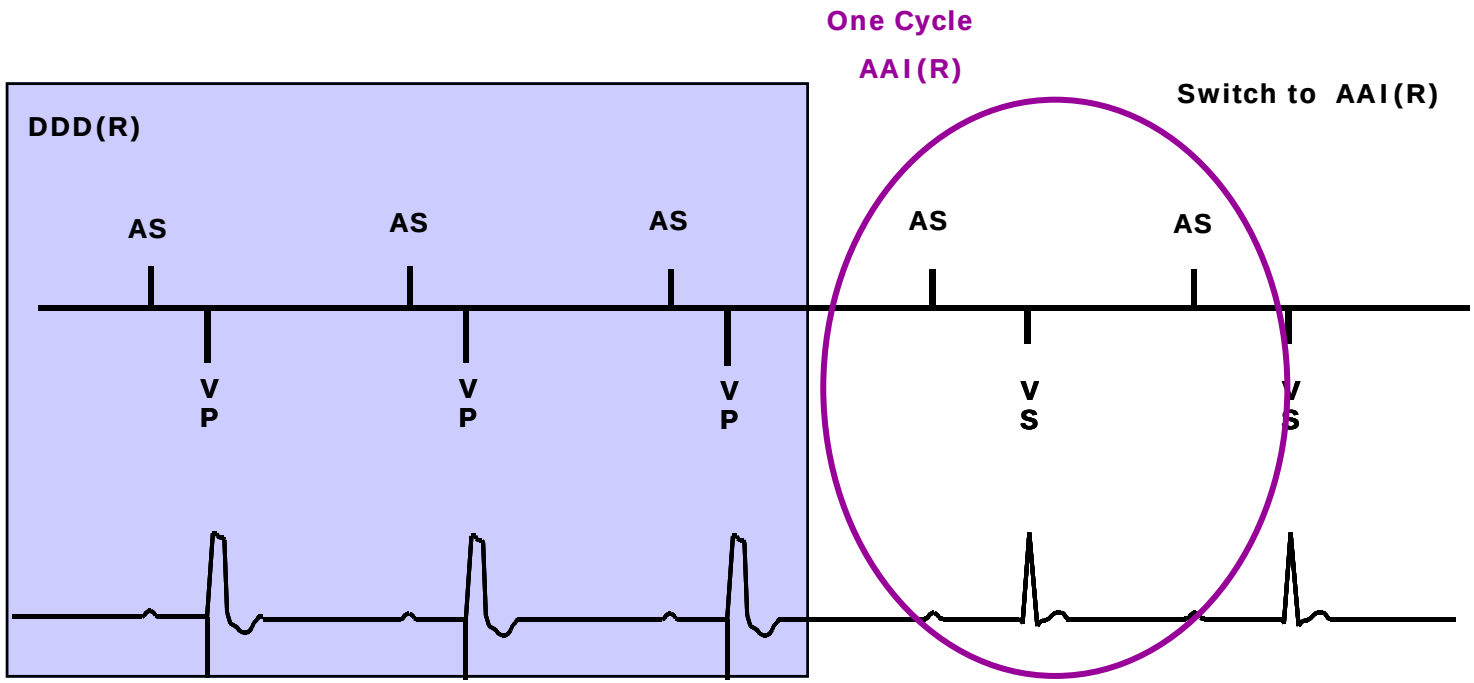


Successful AV Conduction Check

AV Conduction Check (1 beat)

Scheduled every 1, 2, 4, 8 min. . . Up to 16 hrs after a transition to DDD(R) has occurred

Temporarily uses AAI(R) timing to monitor for a conducted VS during one A-A interval

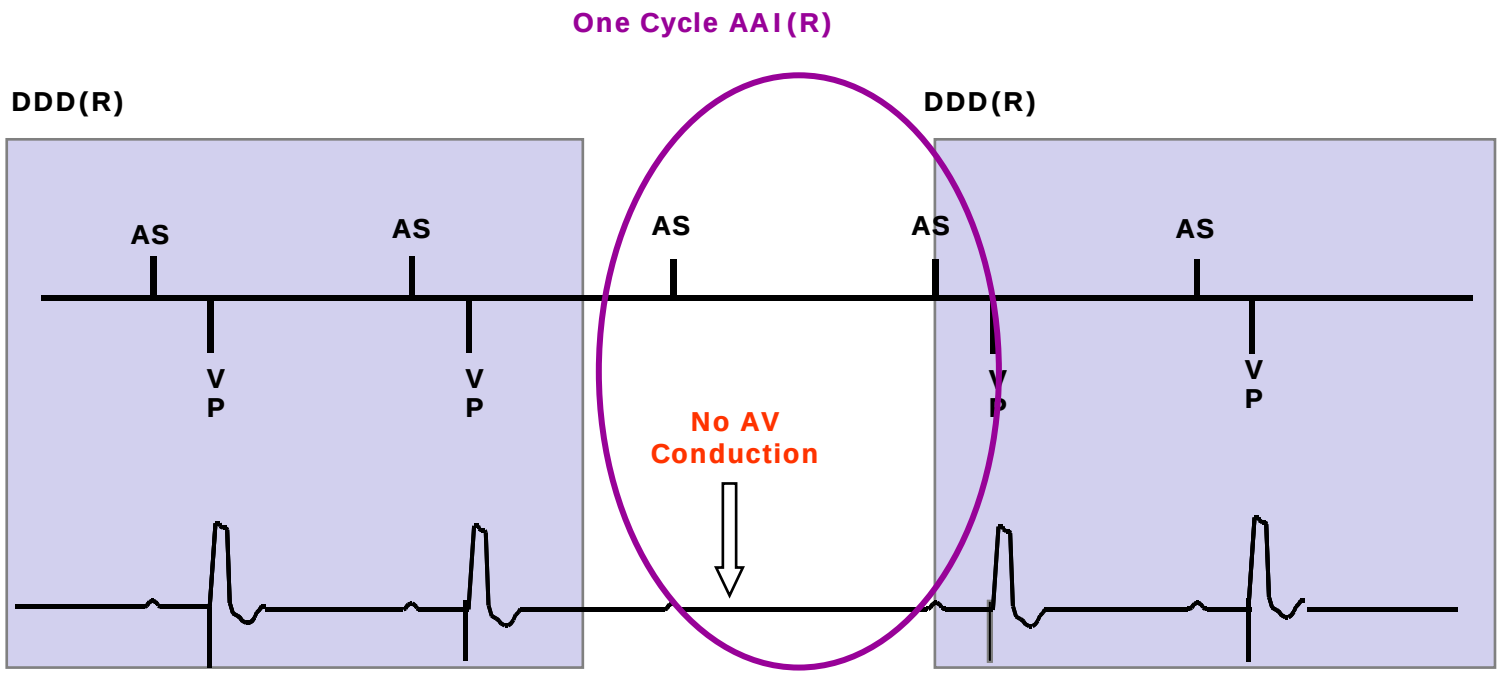


Failed AV Conduction Check

Scheduled conduction check fails to find conducted VS

Mode returns to DDD(R)

Next conduction check scheduled to occur at 2x the previous time interval (1, 2, 4, 8 min. . . 16 hrs)



MVP Enhanced Timing Rules

Dynamic ARP (Atrial Refractory Period)

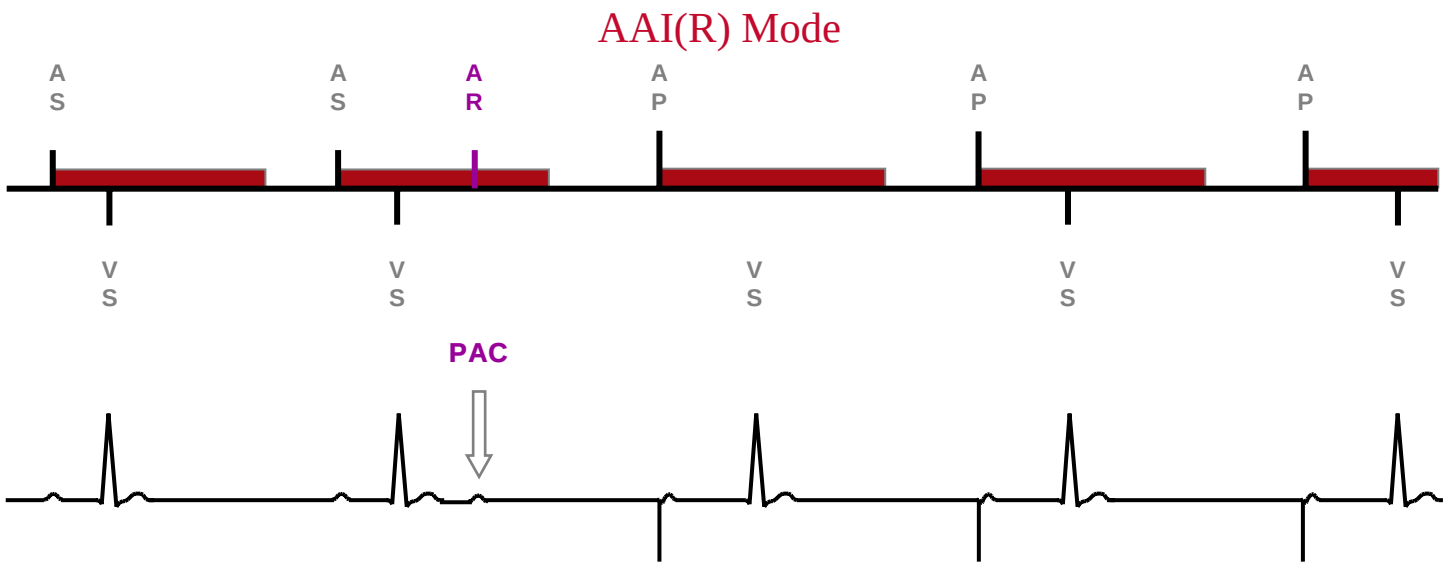
Avoids inappropriate switches to DDD(R) mode in the presence of non-conducted PACs and far-field R-waves, and only resets the A-A escape interval after true P-waves

Set to:

600 ms if heart rate is slower than 75 bpm

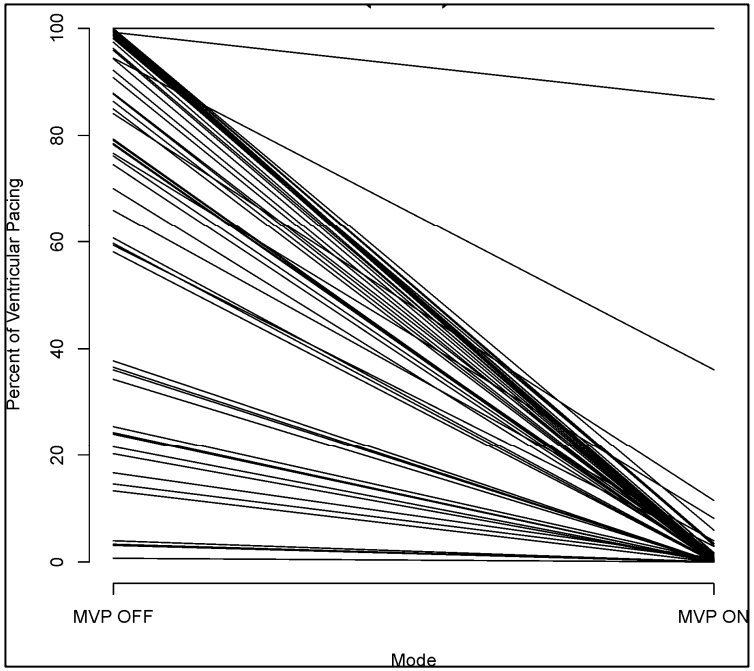
75% of R-R cycle length if heart rate is 75 bpm or faster

ARP cannot be longer than 600 ms



Effects of MVP on %RV Pacing

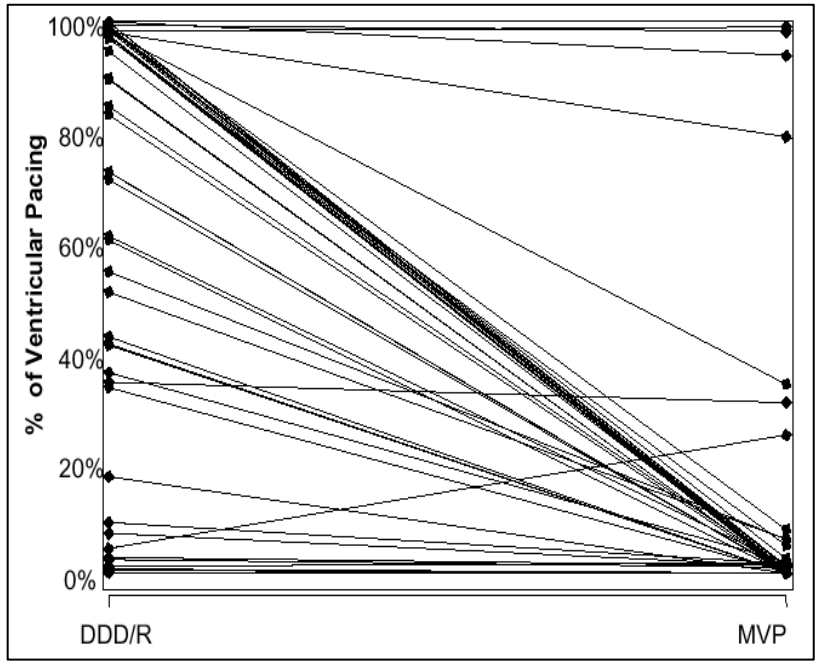
Marquis DR ICD Download Study (n = 69)



With MVP ON:
-Median %VP = 0.1%
-Mean %VP = 4.1%
-Median relative reduction of VP = 99.9%

Mueller M, April 2004. Medtronic, Inc. Data on file.

EnRhythm IPG Clinical Study (n = 49)



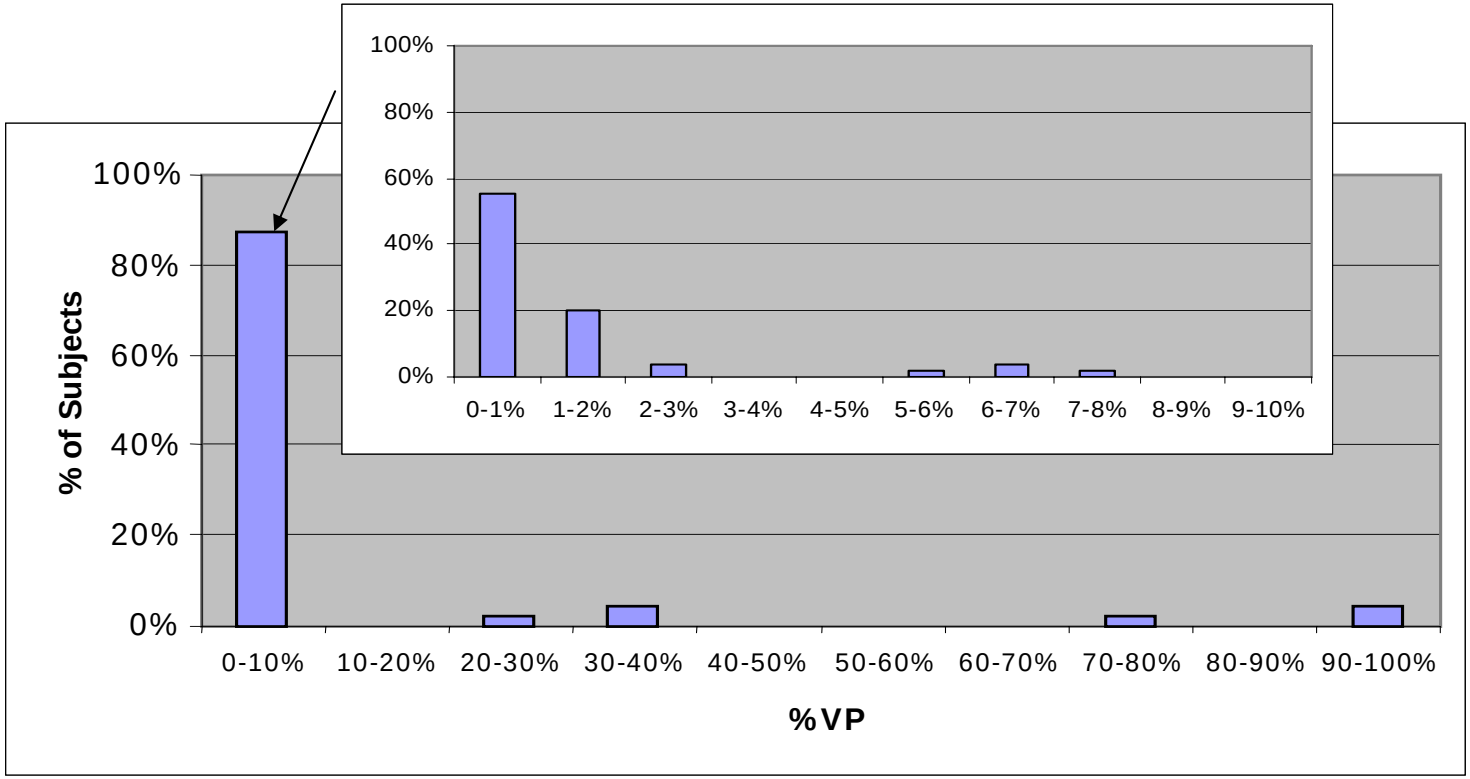
With MVP ON:
-Median %VP = 0.5%
-Mean %VP = 8.4%
-Median relative reduction of VP = 99.11%

Copeman C, January 2005. Medtronic, Inc. Data on file.

Effects of MVP on %RV Pacing

EnRhythm IPG Clinical Study (n=49)

Nearly 80% (79.6%) of patients had less than 3% V-pacing



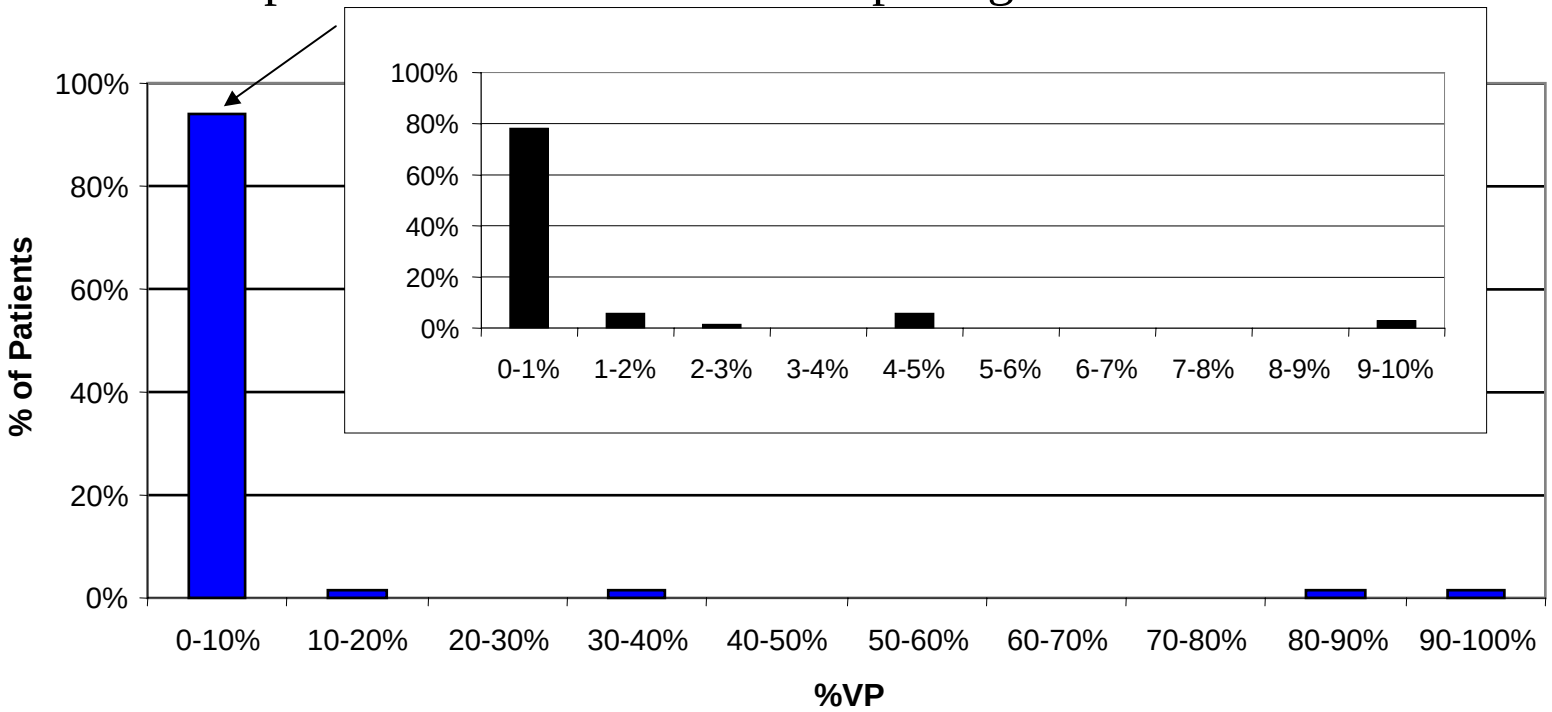
Copeman C, January 2005. Medtronic, Inc. Data on file.

Effects of MVP on %RV Pacing

Marquis DR ICD MVP Download Study (n=69)

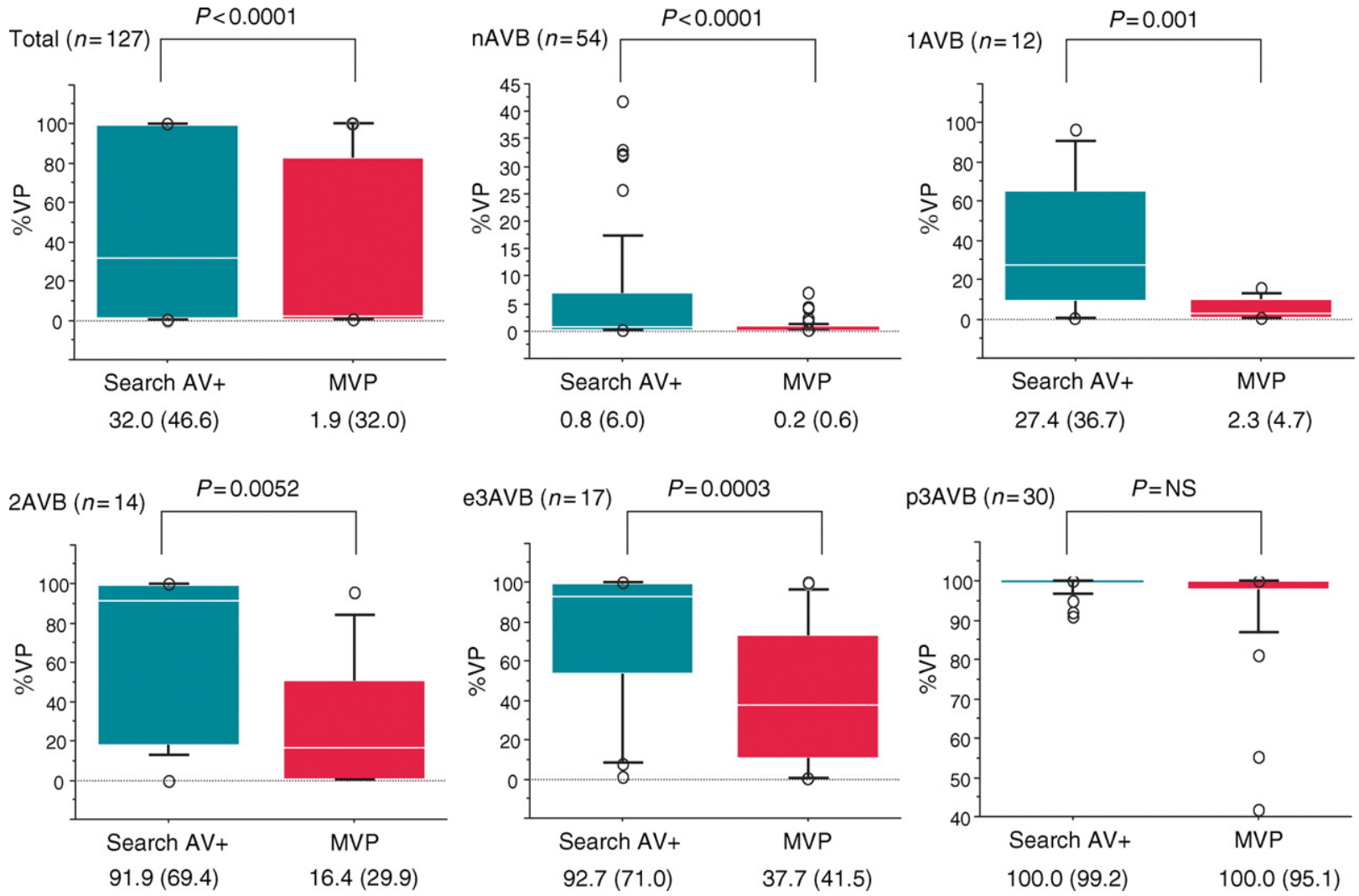
78% of patients had less than 1% V-pacing

Over 90% of patients had less than 5% V-pacing



Mueller M, April 2004. Medtronic, Inc. Data on file.

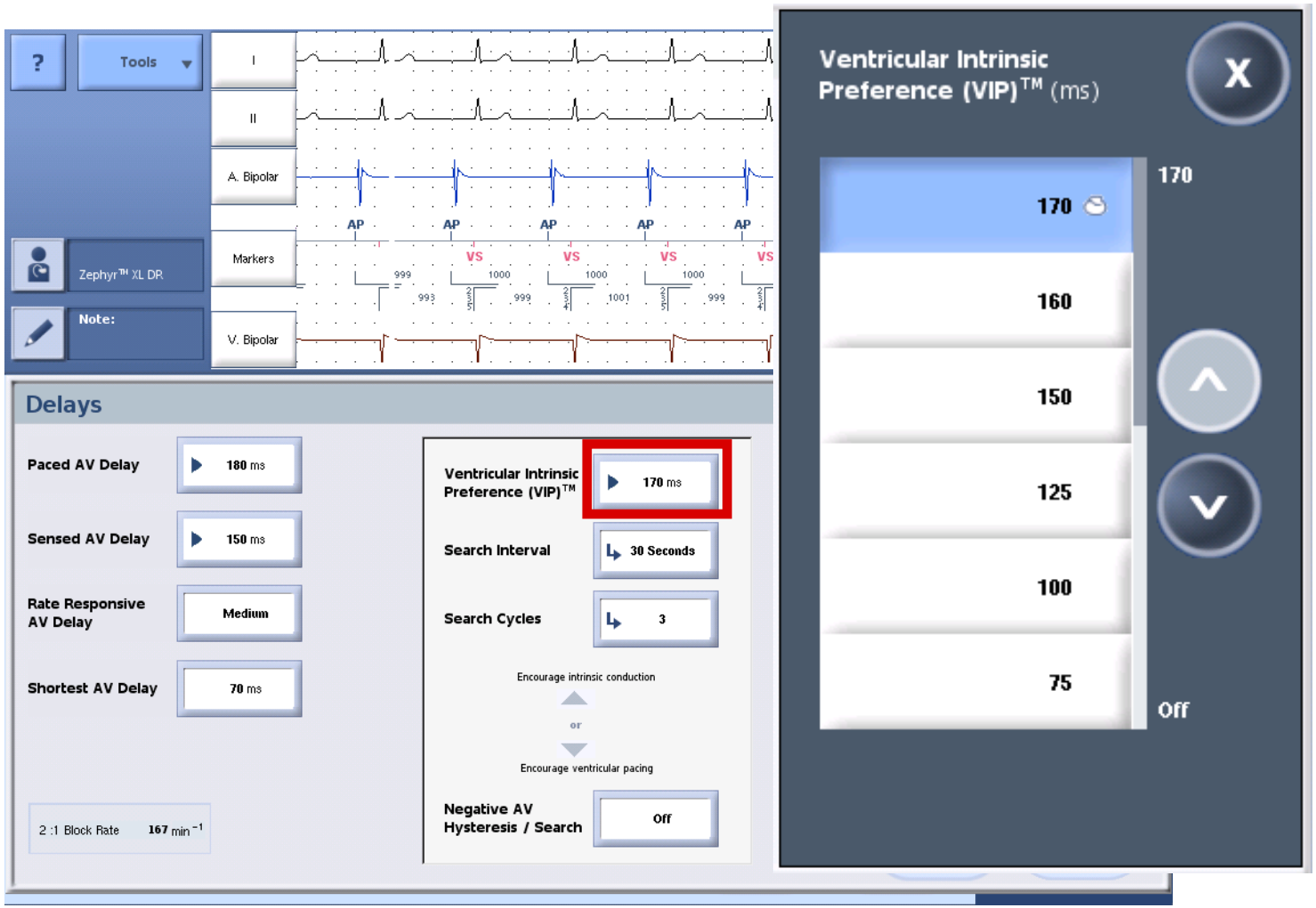
IDEAL RVP (**Ide**ntify the Best **Al**gorithm for Reducing Unnecessary **R**ight **V**entricular **P**acing) Study



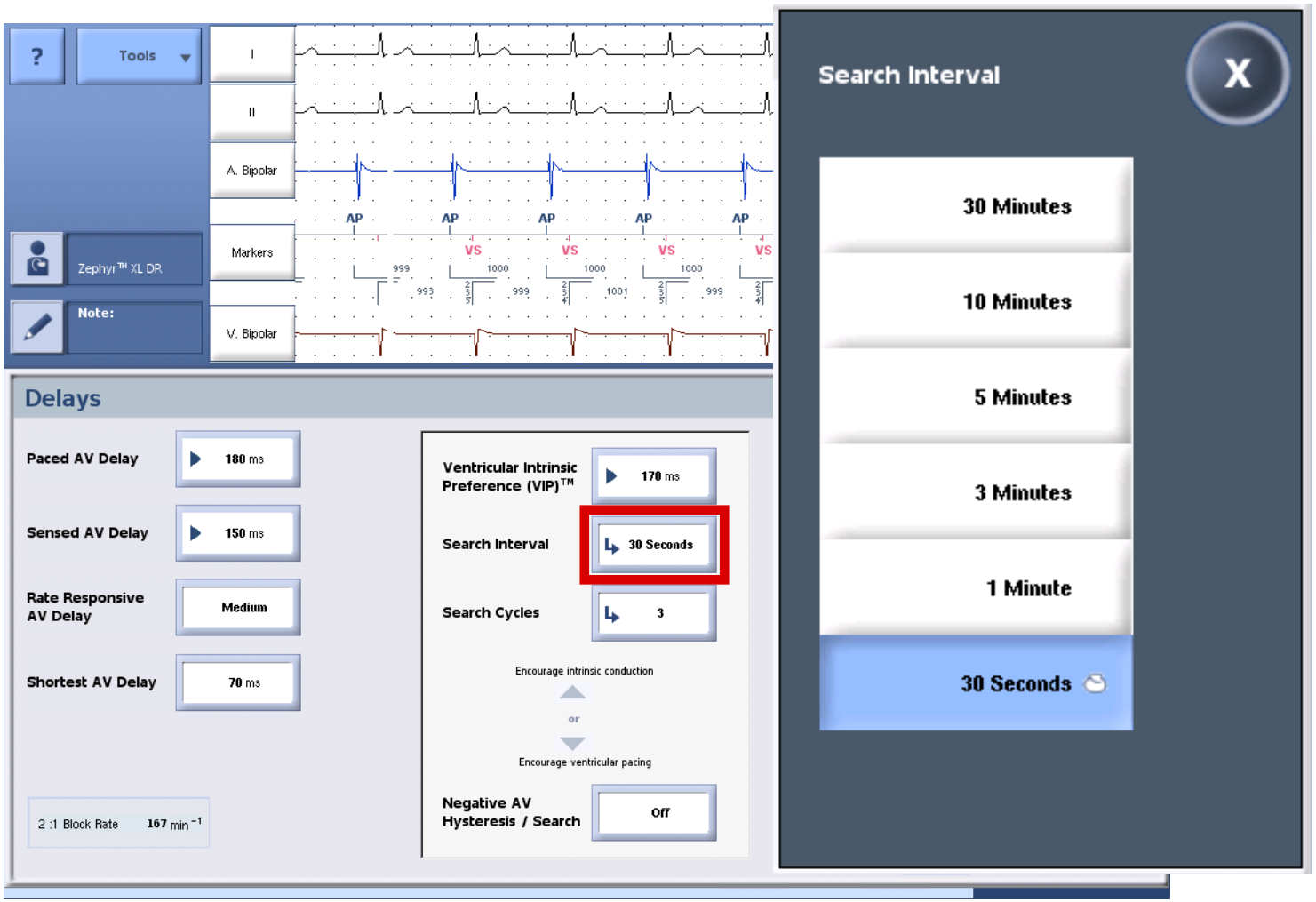
Murakami, Y. et al. Europace 2009

VIP (Ventricular Intrinsic Preference)

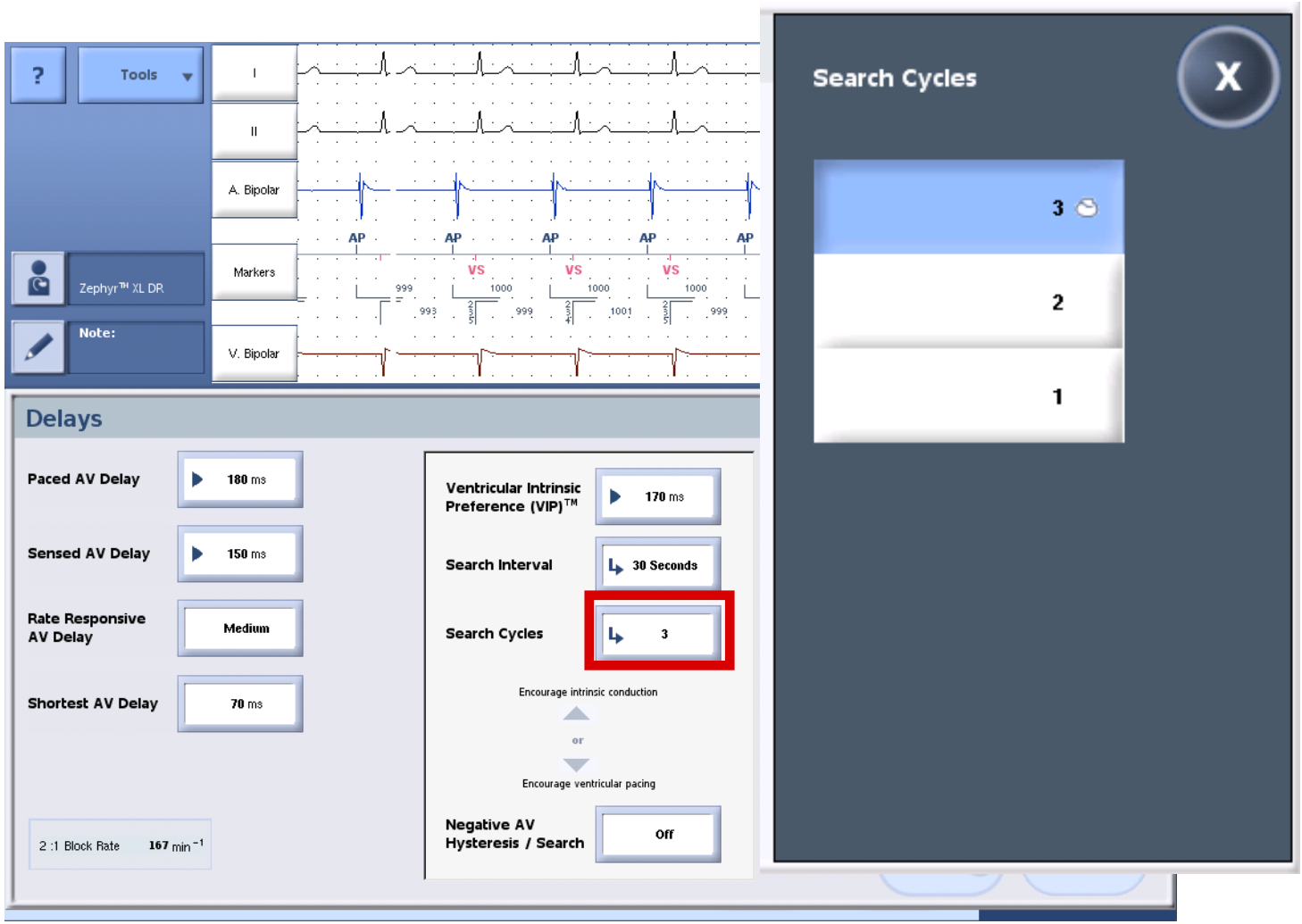
VIP
AV Extension



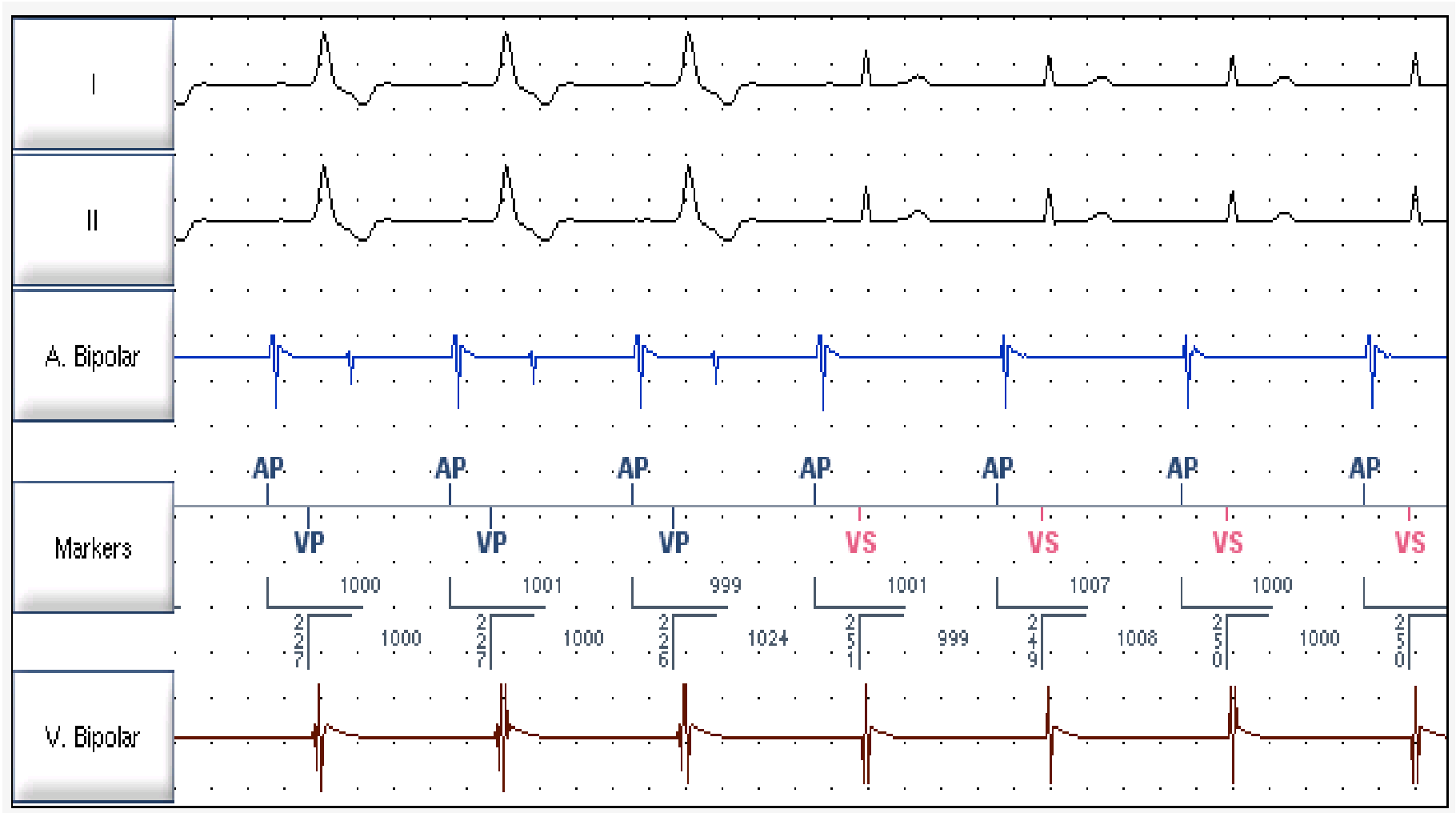
VIP
Search Interval



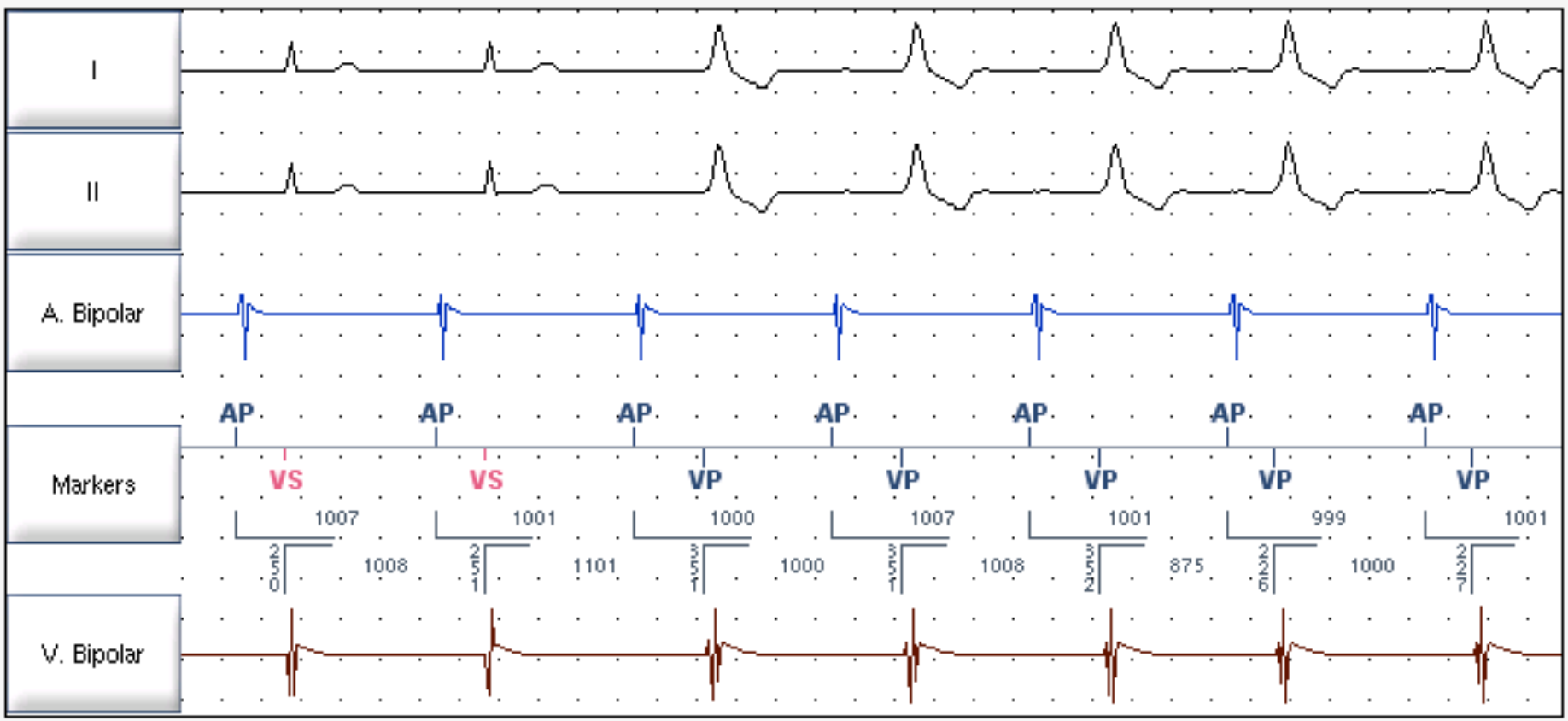
VIP
Search Cycles



VIP
Activation



VIP
Deactivation



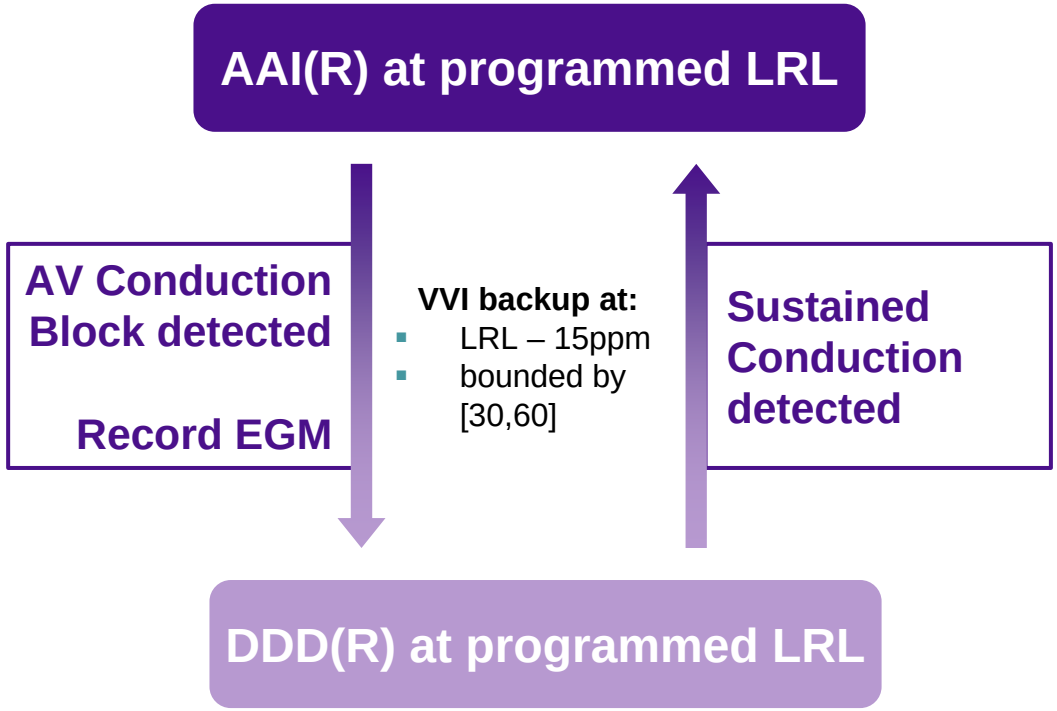
VIP v AAI ↔ DDD
Intermittent CHB

VIP provides immediate ventricular support at the first blocked ventricular event

AAI ↔ DDD occurs only after block, creates long ventricular intervals

AAI ↔ DDD will not occur if ventricular escape rhythm during block is sufficiently fast: sustained AV dissociation

Reverse Mode Switch

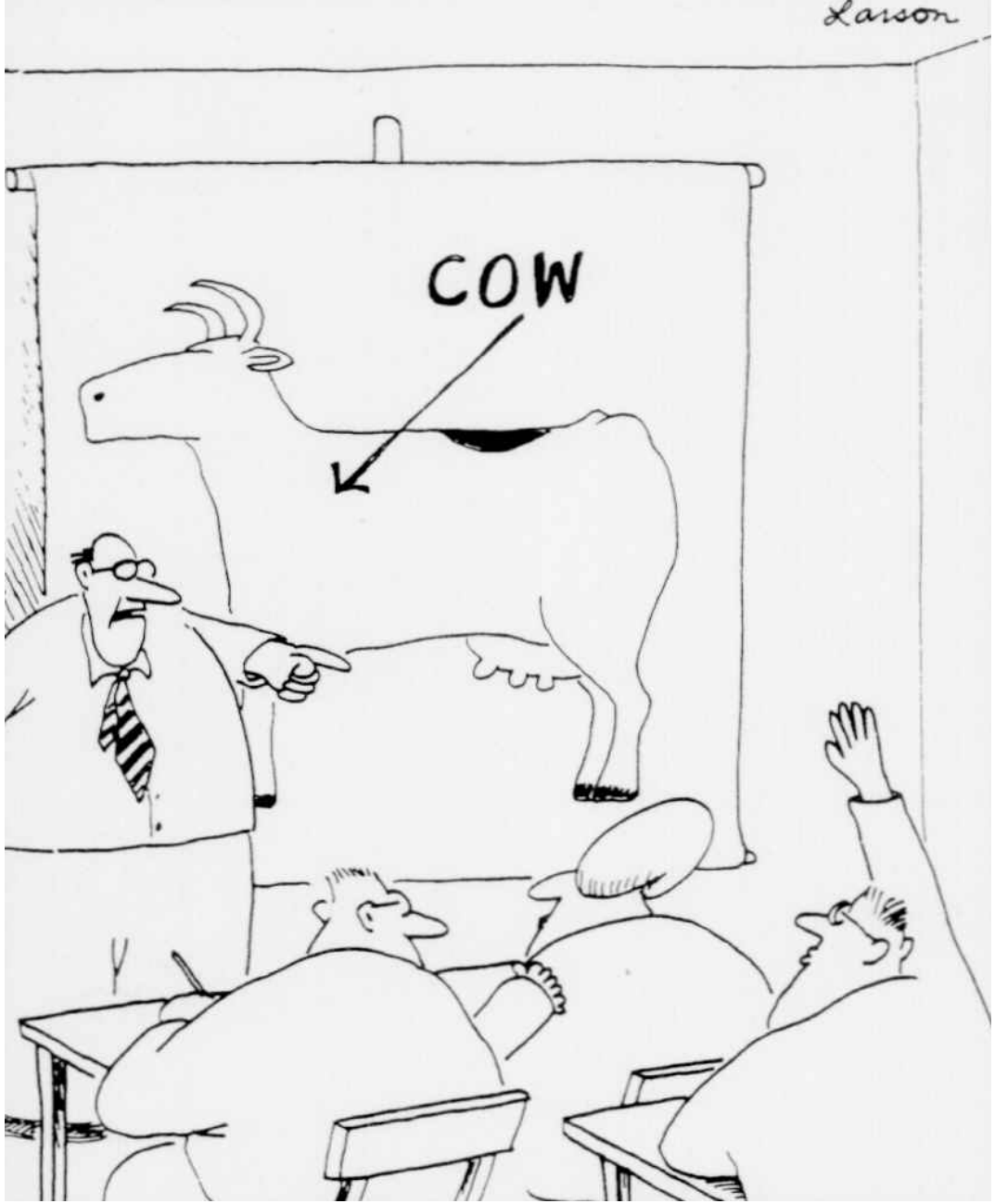


AV Conduction Block:

- 3 blocked ventricular events in a rolling window of 11 beats
  - Ventricular pacing
  - Ventricular sensing at least 150 ms slower than atrial pacing rate (LRL or SIR)

Sustained conduction

- Periodically engage AV search+:
  - 2 Ventricular Pacing in a rolling window of 10 beats to fail
  - 25 Ventricular sensing to succeed



"Yes…. I believe there's a question there in the back"