Optimization of Cardiac Resynchronization Therapy

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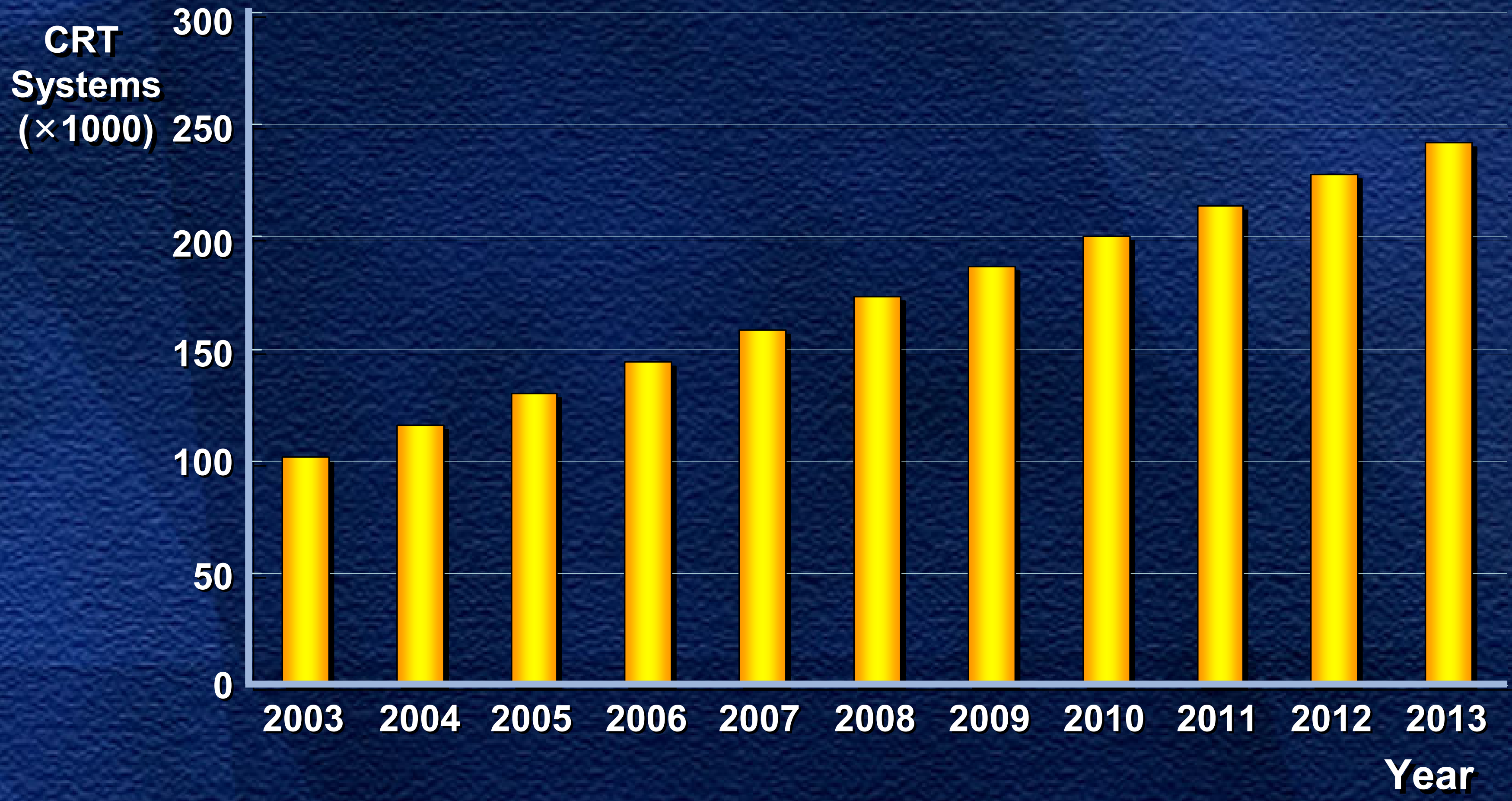
CRT Forecast



Medtronic '05

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Lack of a Favorable Response After CRT

- Absence of mechanical dyssynchrony despite wide QRS
- LV pacing lead in an inappropriate location
- Failure to optimize the CRT setting

Yu et al. J Cardiovasc Electrophysiol 2005;16:1–8

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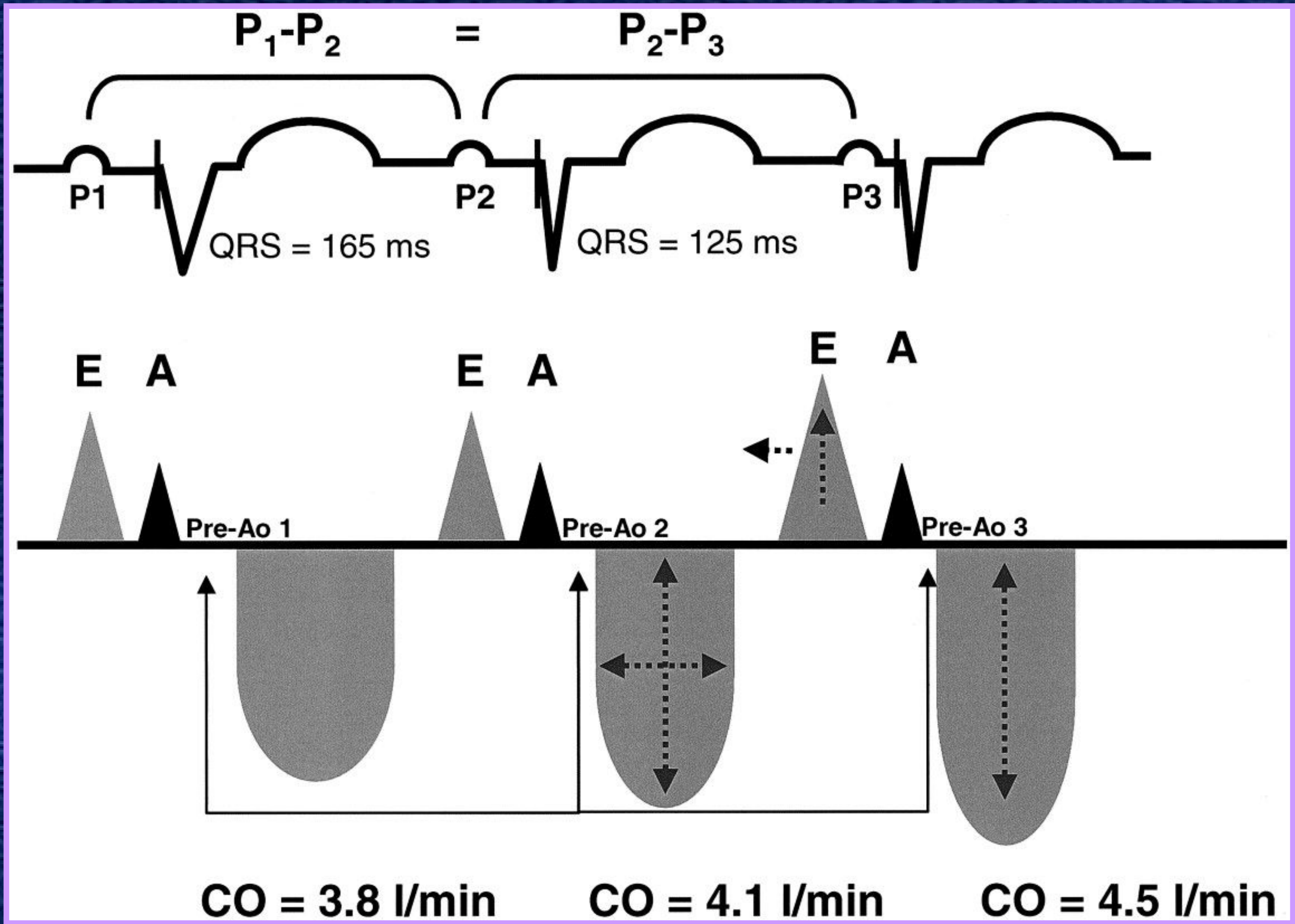
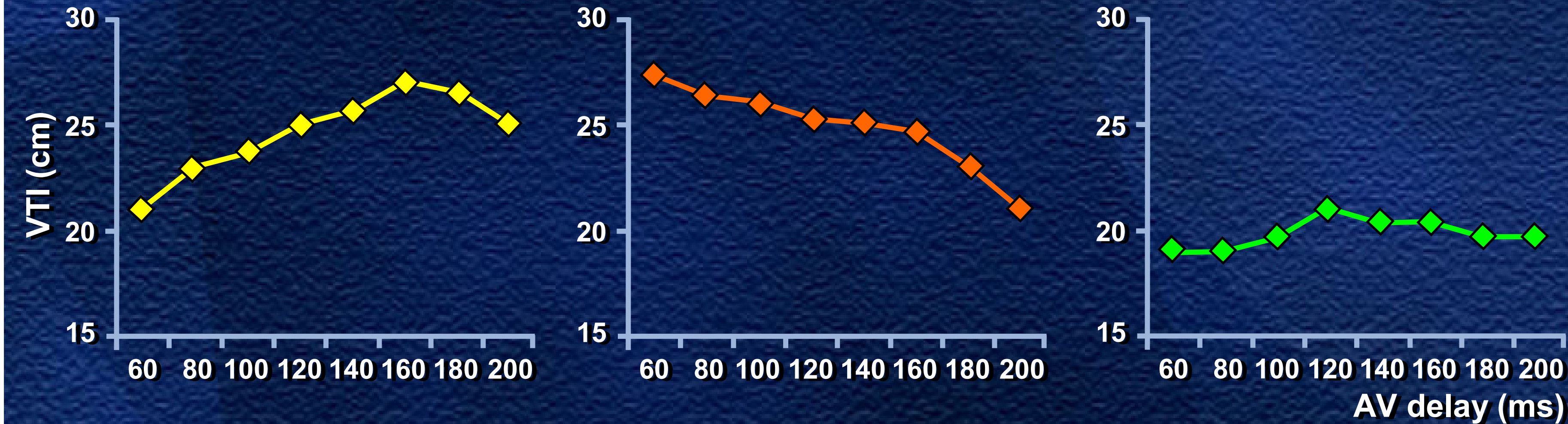
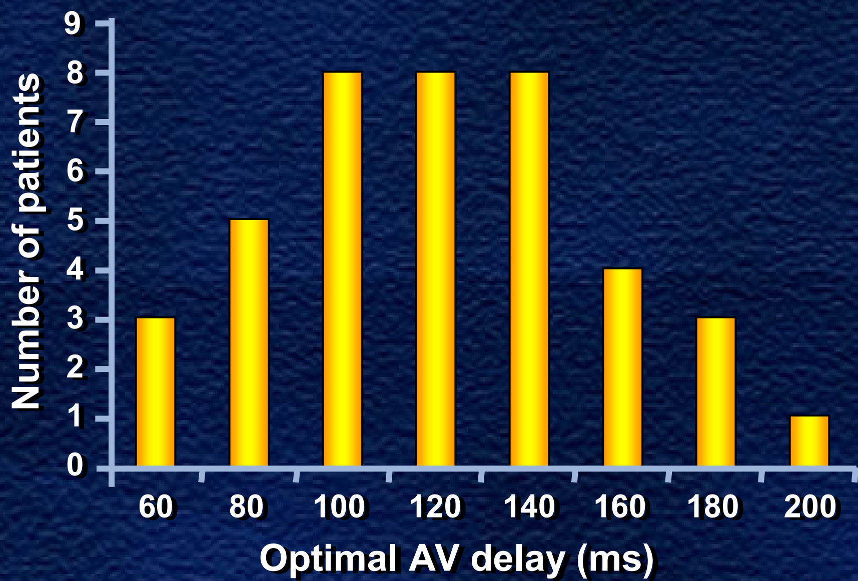
Is Optimization Necessary?



JACC 2005;46:2168-82

Is Optimization Necessary?
AV Delay





Sawhney NS et al.
Heart Rhythm 2004;1:562

Randomized Trial of AV Optimization

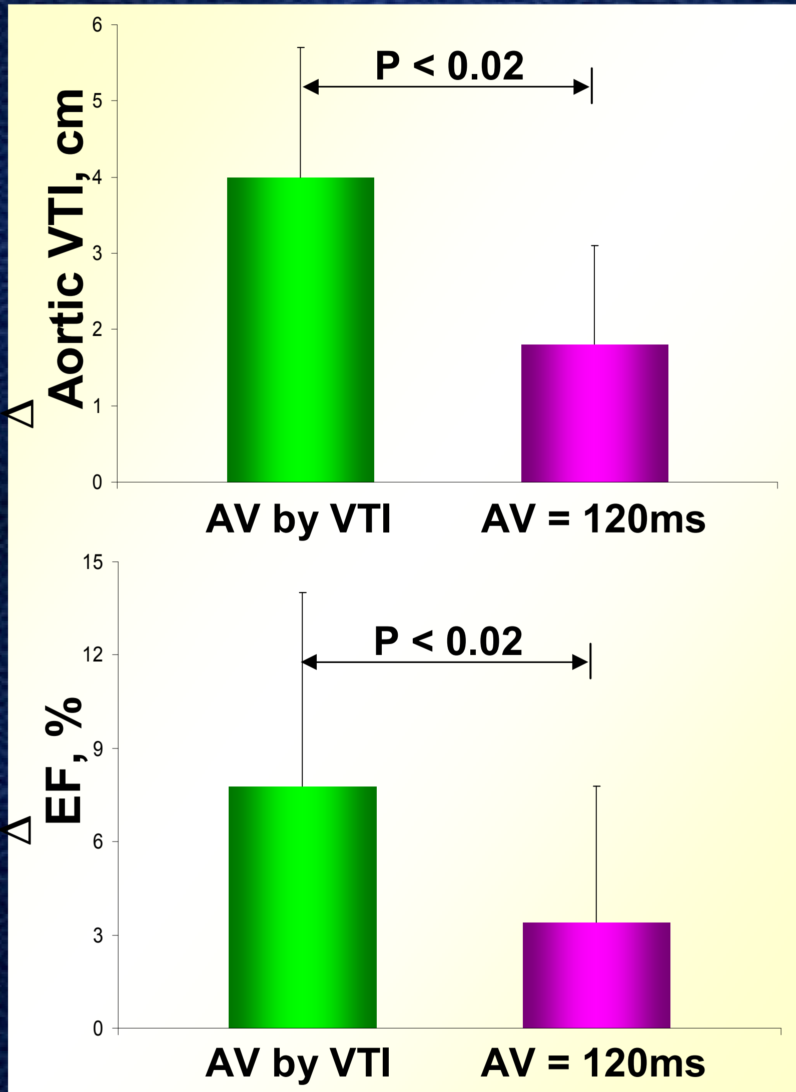
- Sawhney NS et al, Heart Rhythm 2004;1:562-567

- **N = 40**
- **Randomized, prospective clinical trial of AV Opt.**

  Group 1: max. CO (VTI) by Doppler

  Group 2: Empirical delay of 120ms
- **Follow up : 3 months x NYHA & QOL**
- **Results :**

  Acute increase in CO and EF: Group 1 > Group 2



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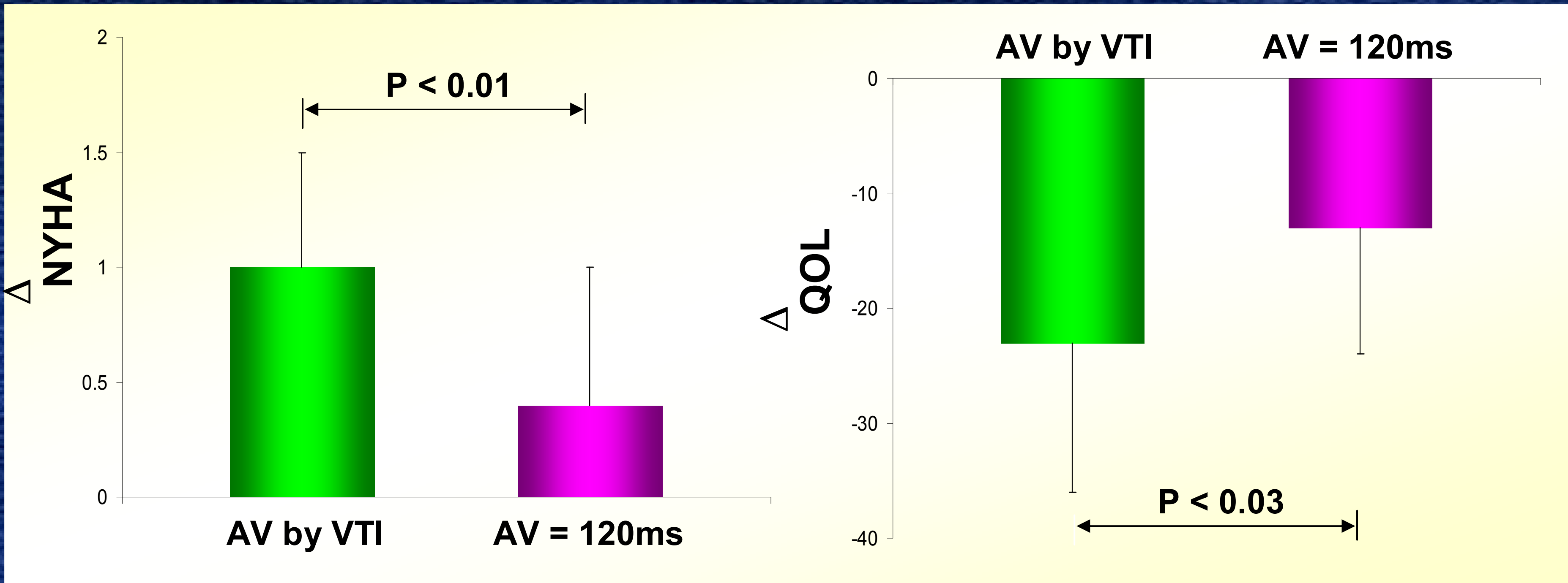
Randomized Trial of AV Optimization

- Sawhney NS et al, Heart Rhythm 2004;1:562-567

- **Results :**

  At 3 month, AV optimized group has greater improvement in NYHA class & QOL score



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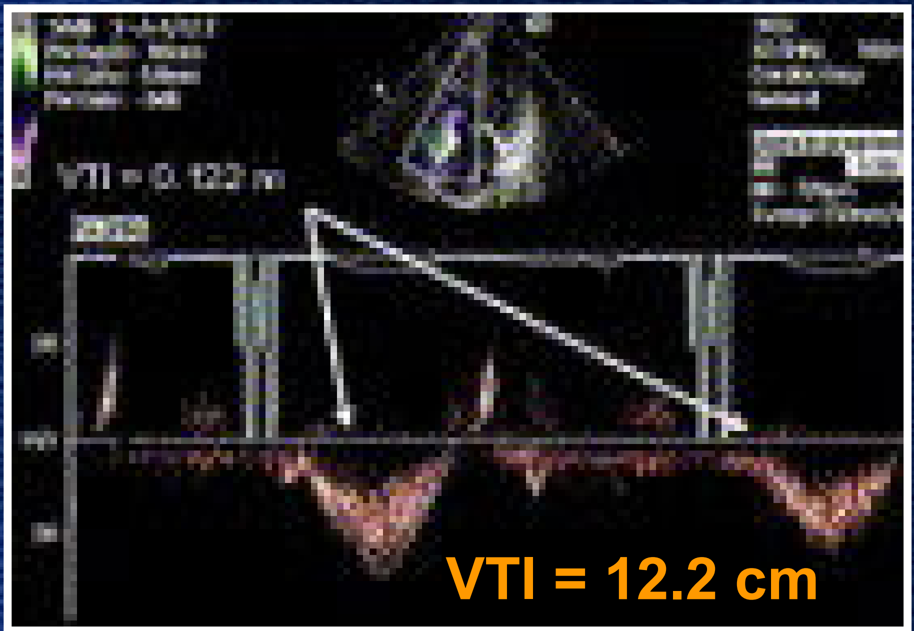
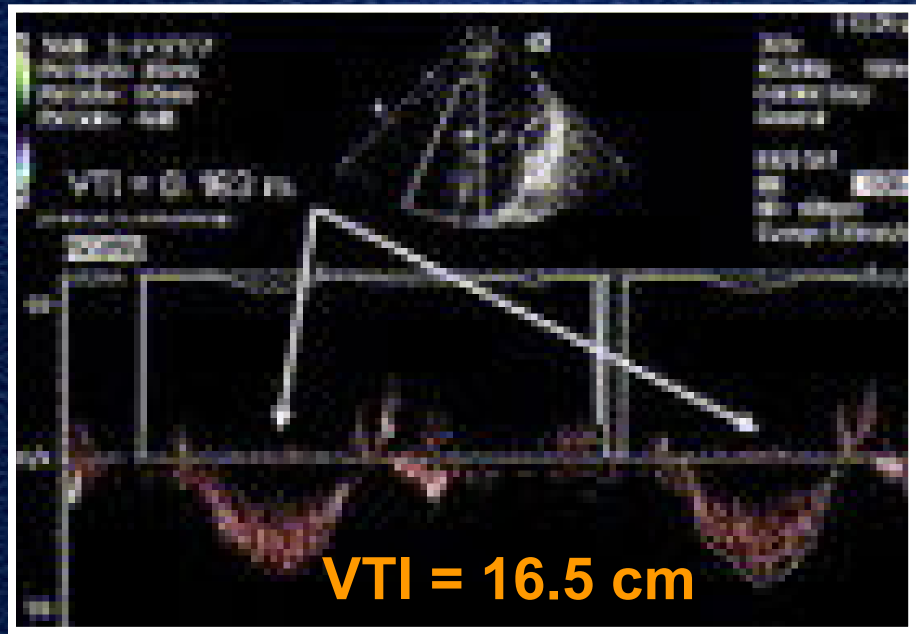
Is Optimization Necessary?
VV Interval



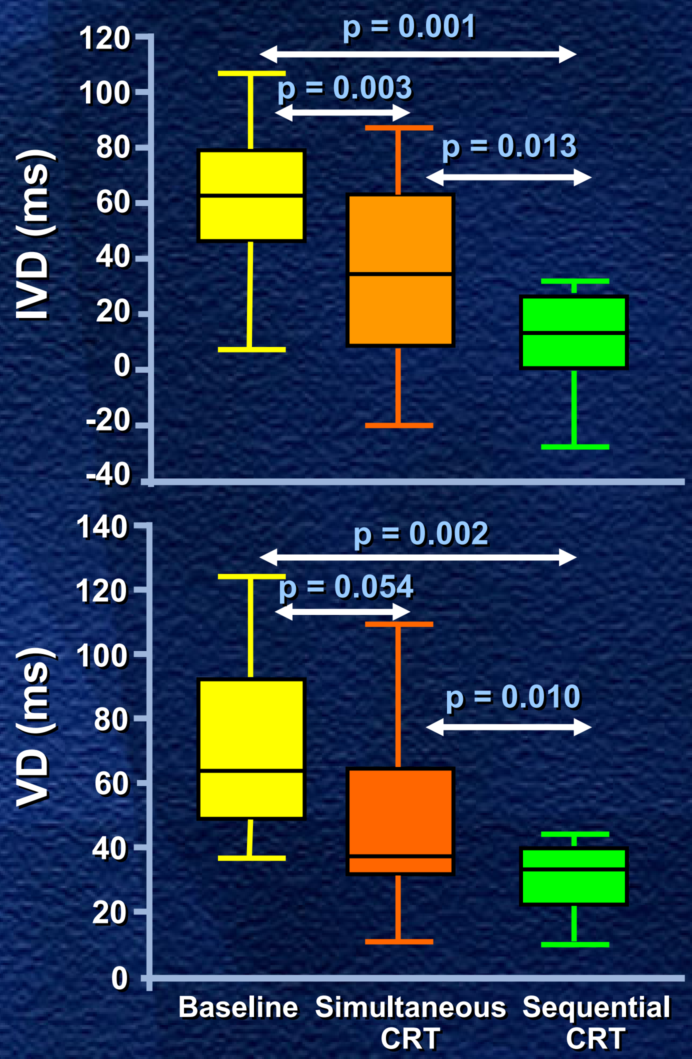


Simultaneous Biventricular Pacing

Sequential Biventricular Pacing
VVI=40 ms (LV first)

Heart Rhythm 2005;2:1066

Is Optimization Necessary?
VV Interval



Highest VTI

- LV first (n=12)
- RV first (n=5)
- Simultaneous (n=3)

Heart Rhythm 2005;2:1066

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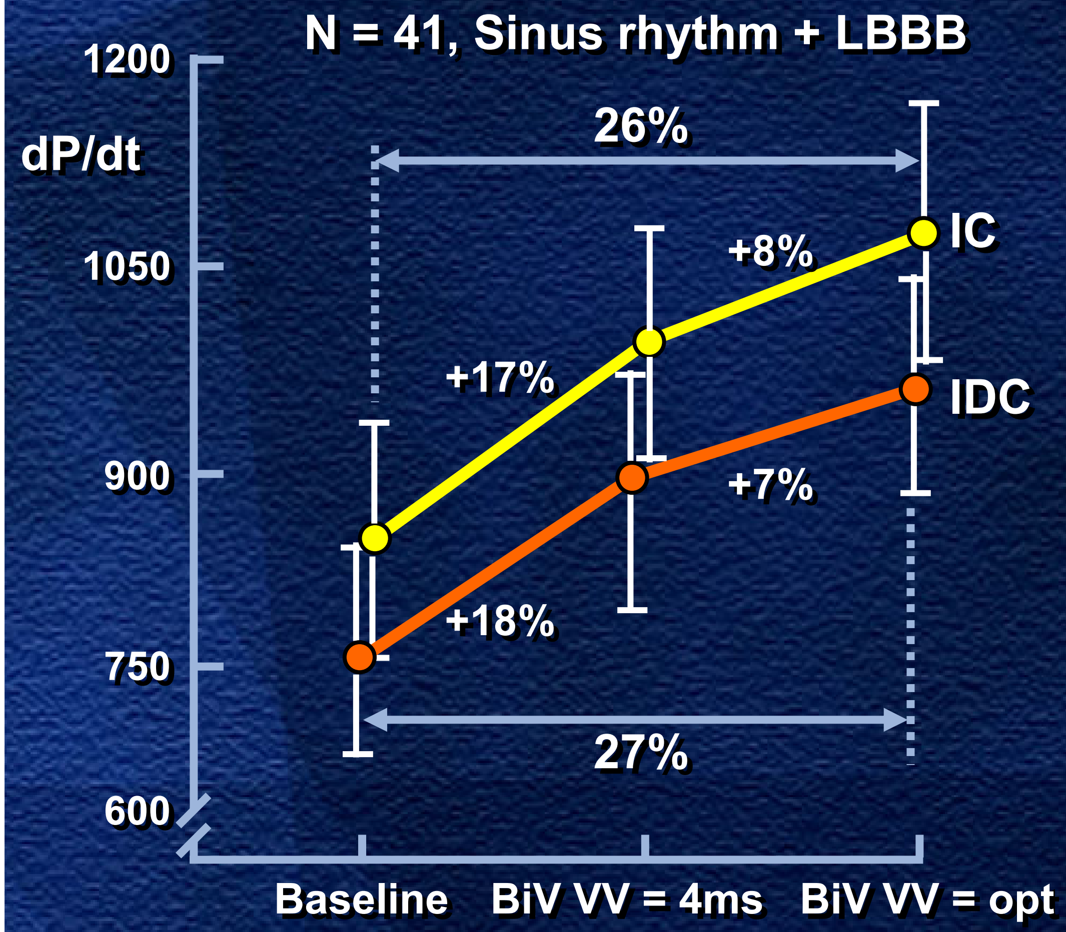
Is Optimization Necessary?
VV Interval

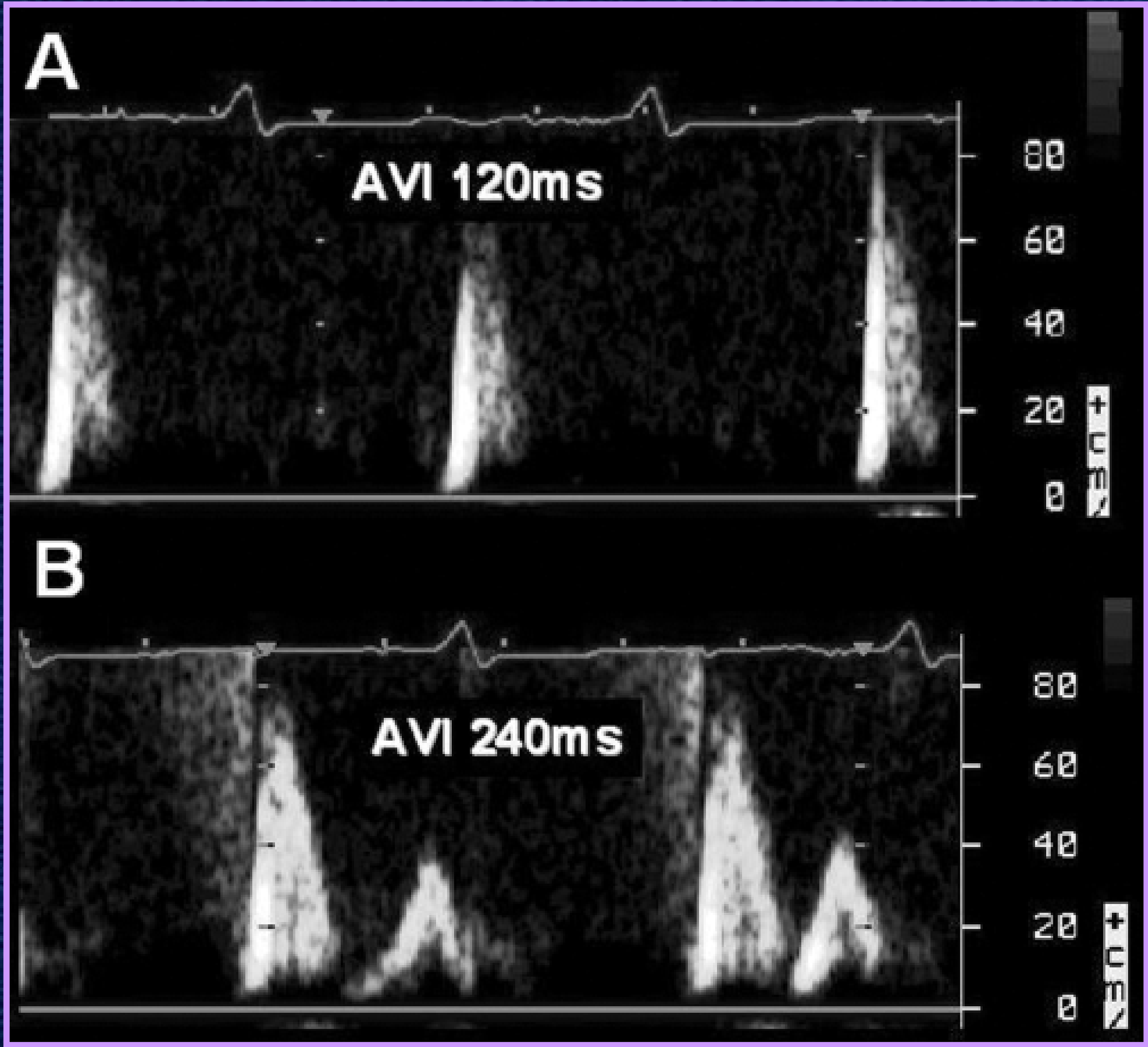


Maximum dP/dt

- LV first (n=44)
- RV first (n=3)
- Simultaneous (n=6)

AJC 2004;93:1500

AV Delay Optimization



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Goals of AV Optimization

- Optimized AV interval will ensure AV synchrony i.e. coordination of atria & ventricles
- Resulting in optimized hemodynamics :
  - Decreases pre-systolic time
  - Abolishes pre-systolic mitral regurgitation
  - Maximizes LV filling time
  - Increases cardiac output

Techniques of AV Optimization

Echocardiography

- Ritter's method
- Simplified inflow method
- Iterative method
- Maximal filling time
- Mitral VTI
- Aortic VTI

Finger Plethymography

Impedance Cardiography

Device Algorithms

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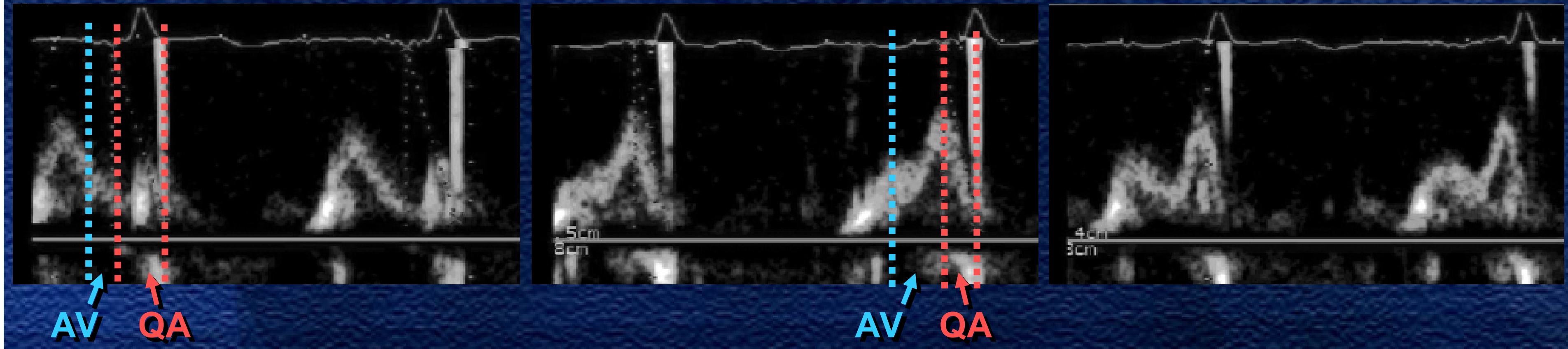
AV Delay Optimization

Ritter's Method

- AV delay are programmed to a short and to a long value that does not truncate the A wave
- QA interval = from QRS onset to end of A wave

$$AV_{opt} = AV_{long} - (QA_{short} - QA_{long})$$



Short AV: 50 ms
QA interval: 120 ms

Long AV: 150 ms
QA interval: 80 ms

Optimal AV Delay?

Optimal AV delay = 150 – (120-80) = 110 ms

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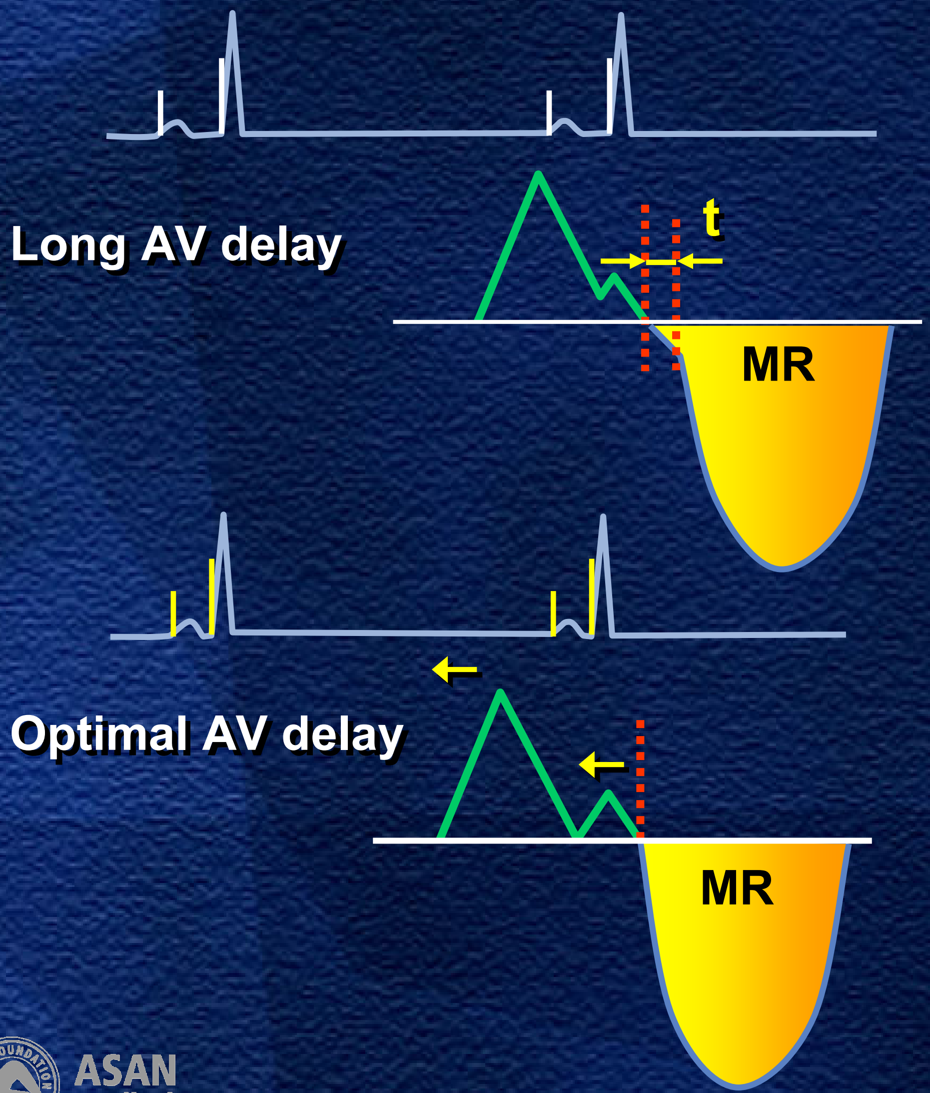
AV Delay Optimization

Simplified Mitral Inflow Method



Optimal AV delay

= Long AV delay - t

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AV Delay Optimization
Iterative Method

- Used in the CARE-HF trial
- Start from long AV settings (e.g. 75% of intrinsic AV interval) with steps of -20ms and measure C.O. from LVOT
- Stop when A wave truncation is observed
- Then increase AV with steps of +10ms until optimal cardiac output is obtained

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AV Delay Optimization

Iterative Method

CO at AV*long* (130 ms)

= 2.97 L/min

CO at AV*short* (30 ms)

= 2.94 L/min

CO at optimal AV (90 ms)

= 3.10 L/min

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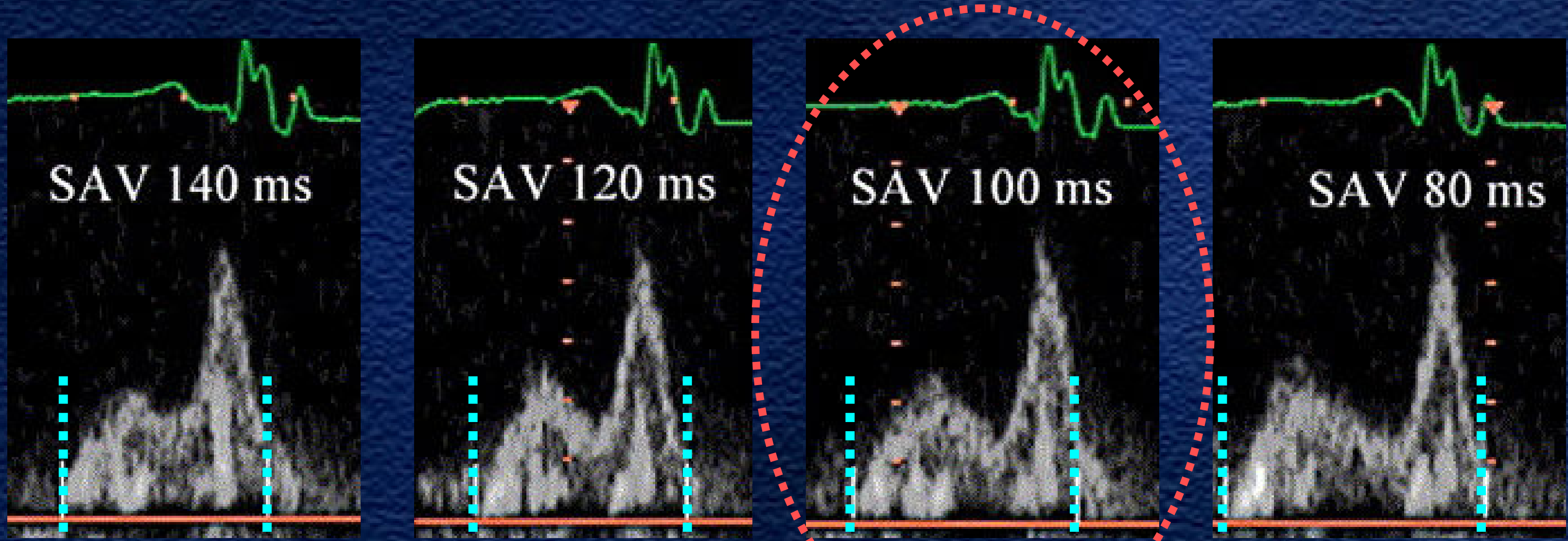
Courtesy of Dr. CM Yu

AV Delay Optimization

Maximal Filling Time



EA dur	370 ms	386 ms	395 ms	412 ms

- Sensed AV delay ↓ EA duration ↑
- At 80 ms, A wave is abbreviated

Optimal AV delay by EA duration = 100 ms

- Difficult to judge abbreviation of A wave

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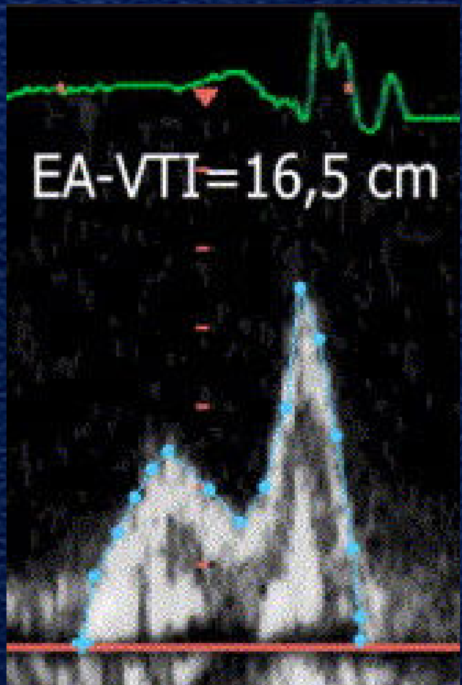
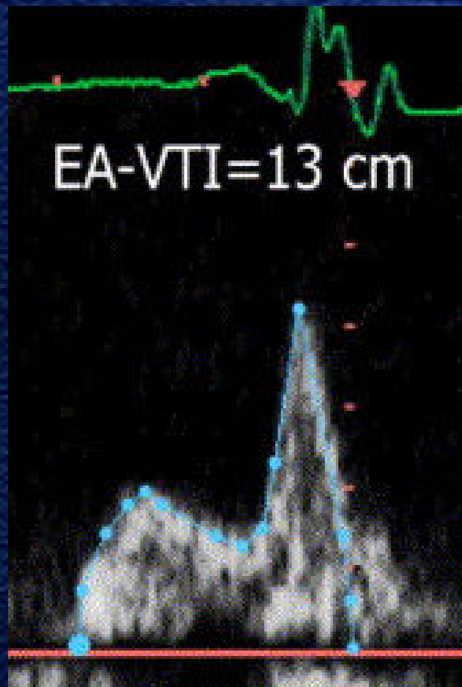
AV Delay Optimization
Mitral Inflow VTI Method

- Pulsed-wave recording of transmitral VTI (maximal VTI of E and A waves)





SAV	**120 ms**	**100 ms**
EA-VTI	**16.5 cm**	**13 cm**

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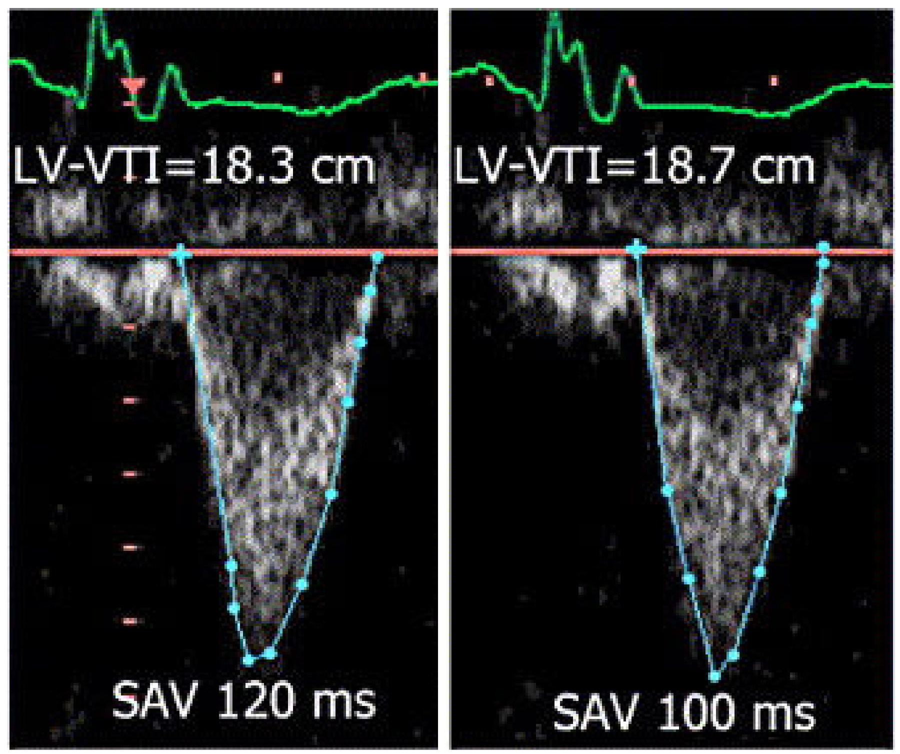
AV Delay Optimization
Aortic VTI Method



- Measure aortic VTI at different AV settings
- CW Doppler more stable
- Longer than AV interval by Ritter's method

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AV Delay Optimization

Head-to-Head Comparison

LV dP/dt_{max} for comparing 4 different methods (maximal filling time, mitral VTI, aortic VTI, and Ritter's formula) in 30 patients

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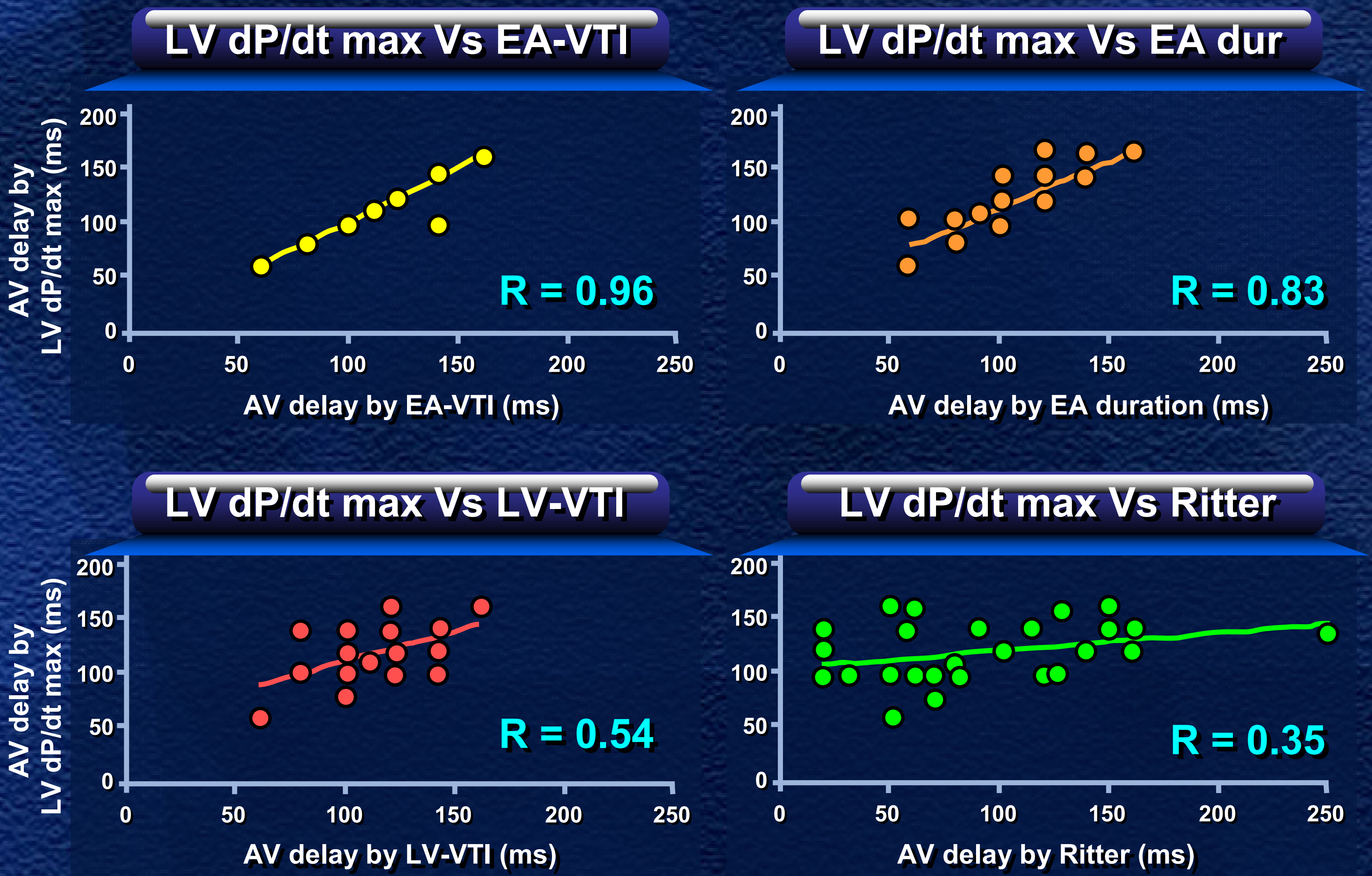
AJC 2006;97:552

AV Delay Optimization
Head-to-Head Comparison



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AJC 2006;97:552

VV Interval Optimization

- Affecting inter- and intraventricular synchrony
- Persistent regional electrical / mechanical delay after BiV pacing – reasons;
  - Non-uniform depolarization of myocardium due to underlying myocardial disease
  - Suboptimal location of LV (& RV) leads

Goals of VV Optimization

- Further reduce electrical / mechanical dyssynchrony
- Further improve cardiac function
- Convert non-responders to responders ?

Techniques of VV Optimization

- **Maximal Cardiac Function**
  Doppler Echo: Maximal Cardiac Output
  Minimal Myocardial Performance Index
- **Minimal Systolic Asynchrony**
  TDI, Tissue Tracking (published methods)
  e.g. Ts-SD, Displacement, etc
- **Acute Hemodynamics**
  TDI, Tissue Tracking (published methods)
  e.g. Ts-SD, Displacement, etc
- **Device Specific**
  Peak Endocardial Activation (Sorin)
  QuickOpt (SJM)

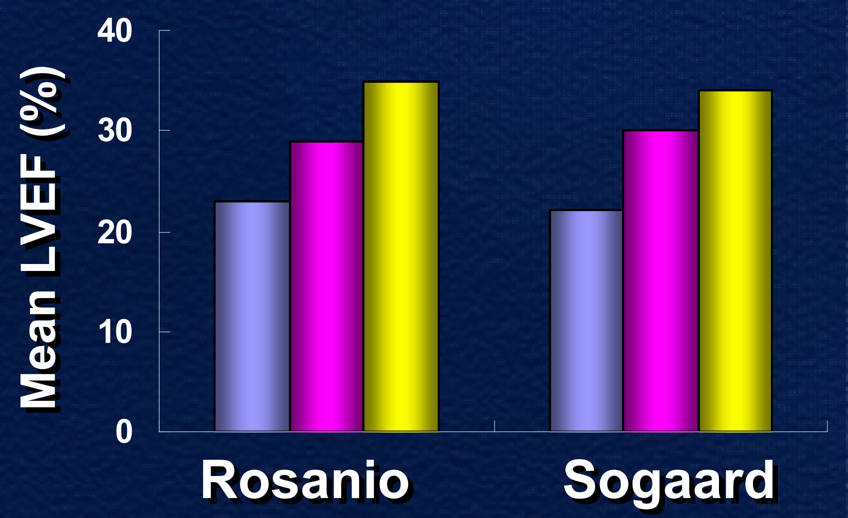
Additional Data Supporting the Effectiveness of Timing Cycle Optimization

Rosanio, et al. AHA Abstract, 2003

- N=22
- V-V Delay of 0 for first 2 mo
- Echo based optimization of V-V delay at 2 months

Sogaard, et al. Circ. 2002

- N=20
- Optimal V-V Delay based on echo TDI
- Acute data shown. After 3 mo. LVEF further improved to 39% (P<0.01)



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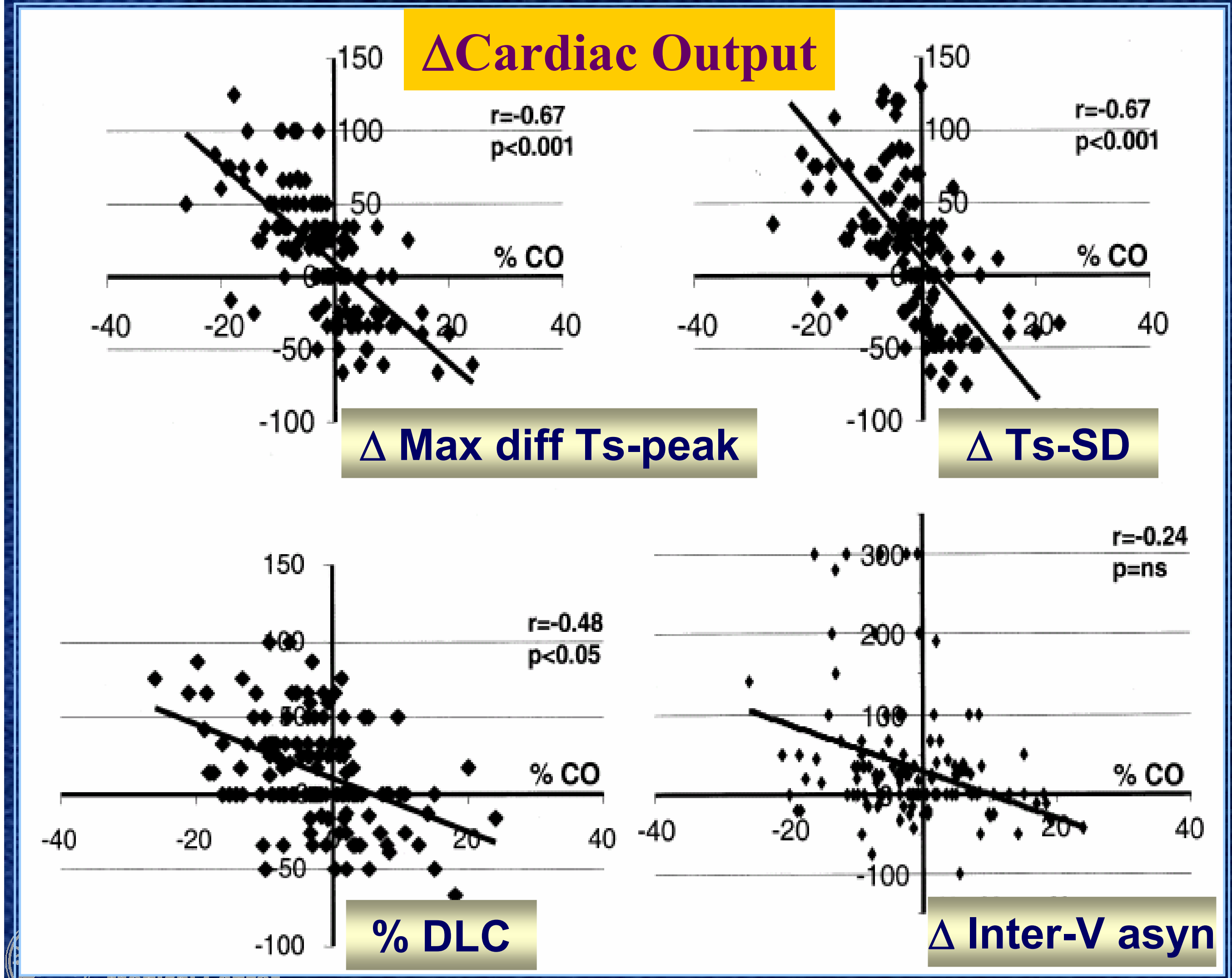
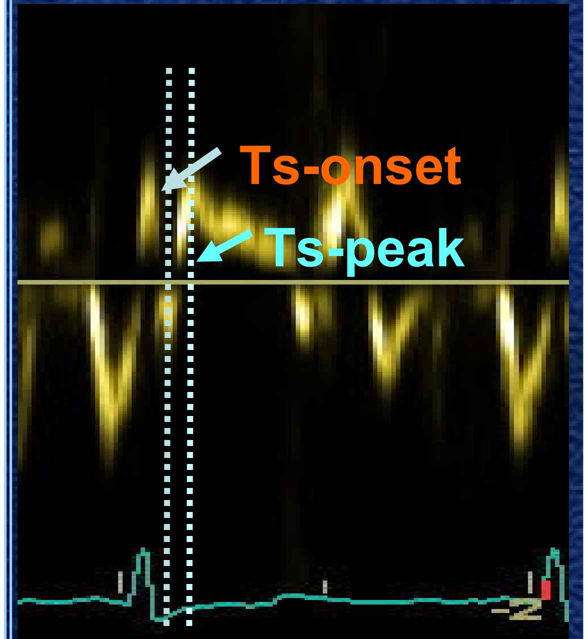
Further Improvement of Intra-Ventricular Asynchrony by V-V Optimization

– Bordachar P et al, JACC 2004;44:2157-65





V-V Opt by echo with C.O. at LVOT

Further Improvement of Intra-Ventricular Asynchrony by V-V Optimization

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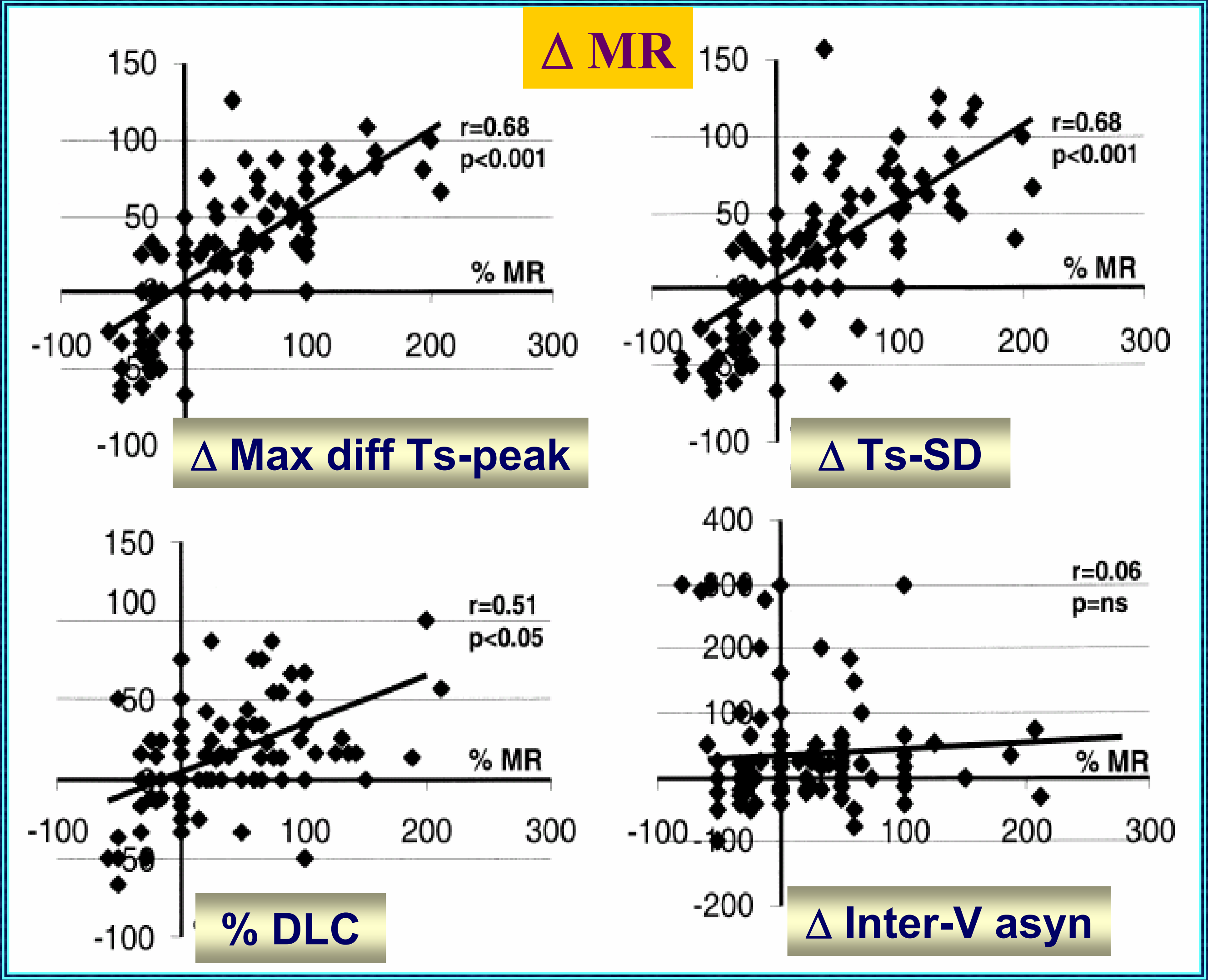


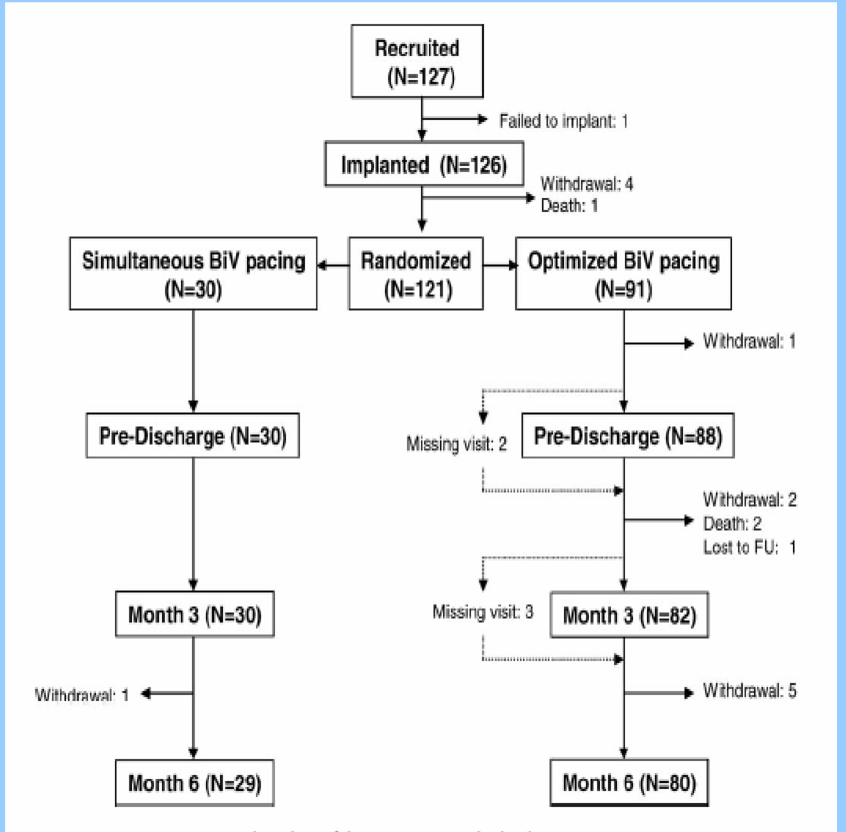
Issues on Early Studies of V-V Optimization

- Improvement of cardiac function as the primary target
- Methods : MPI (*Porciani MC et al, Am J Cardiol 2005;95:1108-10*)
  +dp/dt (*Kurzidim K et al, PACE 2005;28:758-61*)
- Non-randomized study with small sample size
- End-points are the same as the parameter used → biased towards conclusion of in favor of "sequential" BiV pacing

Simultaneous BiV Vs Optimized V-V Delay in CRT -RHYTHM II ICD Study

Boriani G et al, Am Heart J 2006;151:1050-8

- N = 121 with CRT-D
- Randomized to simul. BiV or V-V Optim (1:3)
- Follow up: 6 months
- End points:
  NYHA, 6MHW, QOL
- V-V Optim by C.O. at pre-D/C:
  80, -40, -20, 0, +20, +40 & +80 ms in random order

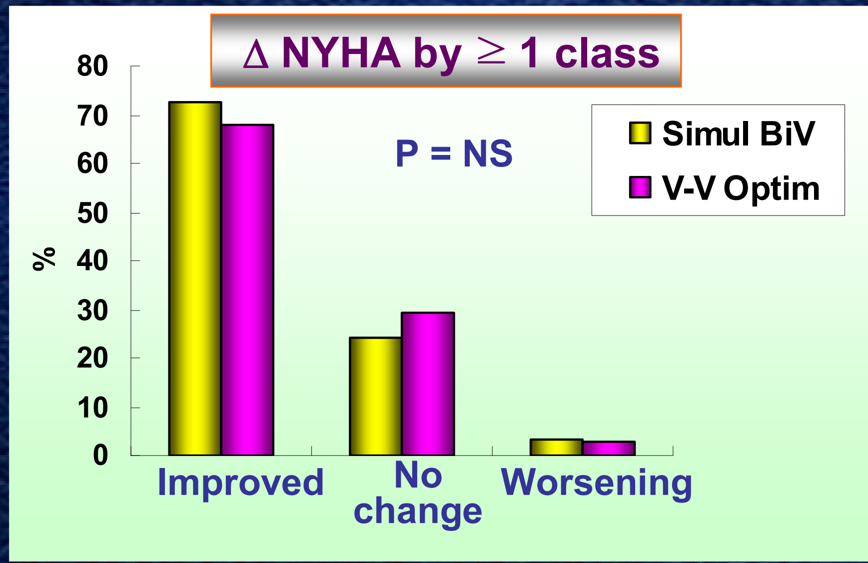


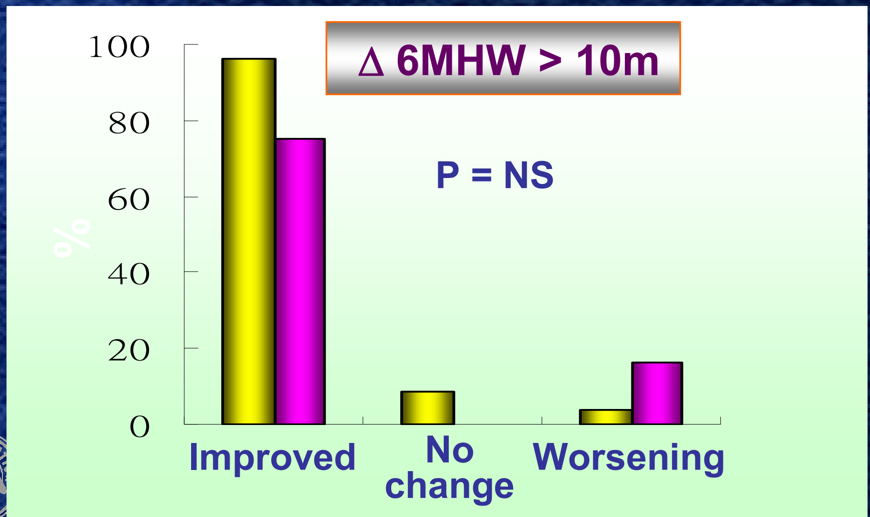
Flow chart of the RHYTHM II study development.

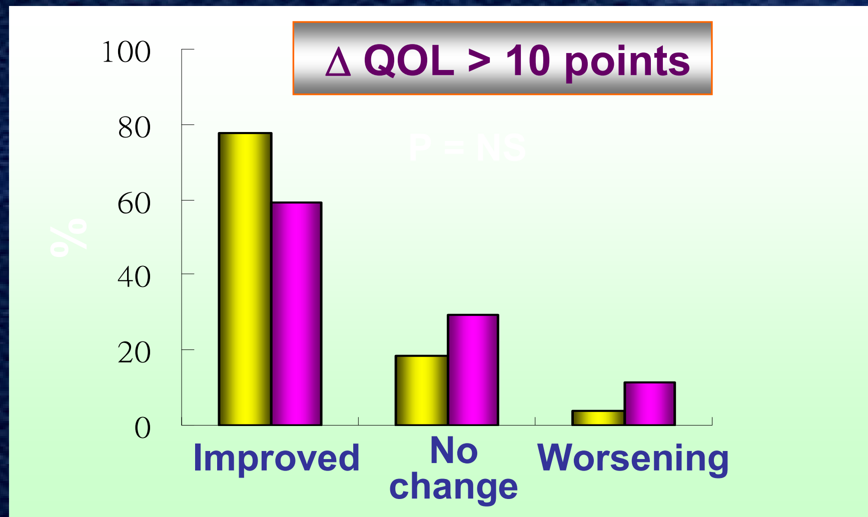
Simultaneous BiV Vs Optimized V-V Delay in CRT -RHYTHM II ICD Study

Boriani G et al, Am Heart J 2006;151:1050-8

	V-V (ms)	Patients (n [%])
Ventricle stimulated first		
Left (n = 31)	20	11 (12.5)
	40	13 (14.8)
	80	7 (8.0)
Right (n = 30)	20	8 (9.1)
	40	16 (18.2)
	80	6 (6.8)
Simul BiV (n =25))	0	25 (28.4)
Missing data	-	2 (2.3)







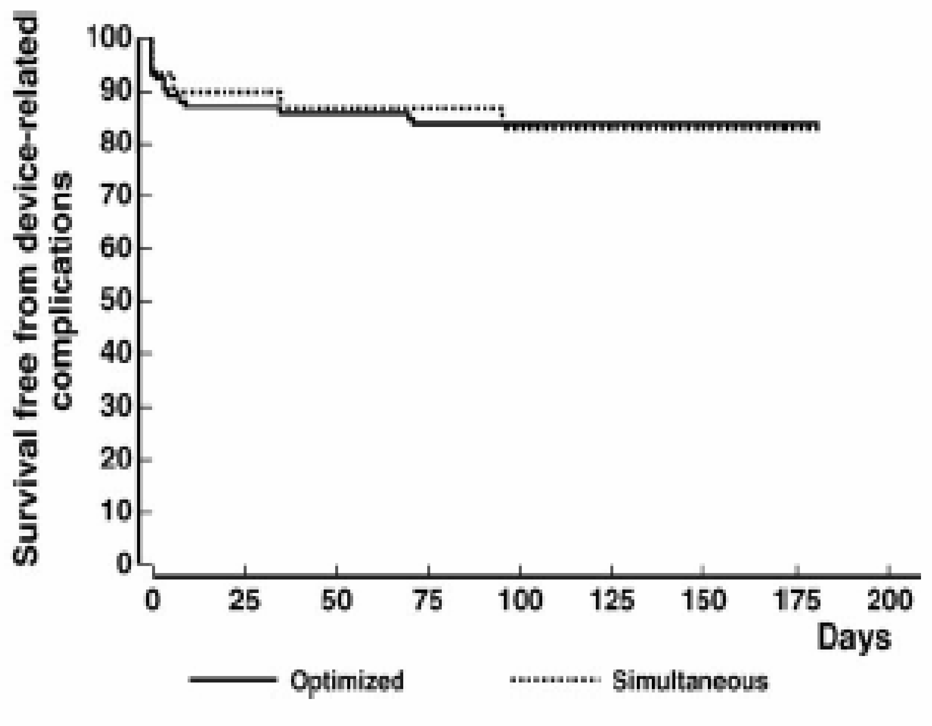
Simultaneous BiV Vs Optimized V-V Delay in CRT -RHYTHM II ICD Study

Boriani G et al, Am Heart J 2006;151:1050-8

Actuarial survival free from device-related complications

Conclusion :

V-V Optimization conferred **no additional benefit** compared with simultaneous BiV pacing



Actuarial survival free from device-related complications.

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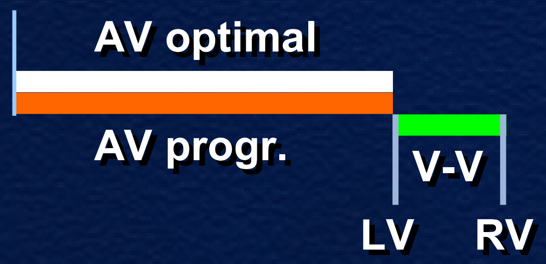
VV Interval Optimization

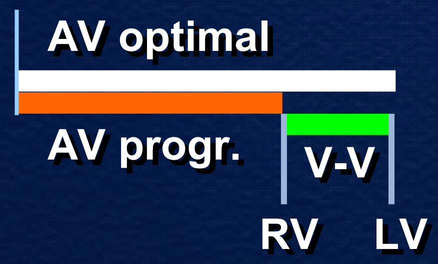
Modification of AV Delay

LV first



AV progr. = AV optimal

RV first



AV progr. = AV optimal - VV

- LV first (Guidant): only RV-based timing

AV progr. = AV optimal + VV

PACE 2006;29:1416

Device-Based Algorithms

Guidant's Expert Ease for Heart failure algorithm

- data of the PATH-CHF I and II studies
- optimal sensed and paced AV delay based on the patient's QRS width and intrinsic AV interval

Peak endocardial acceleration (PEA)

- measured by a RV lead equipped with a microaccelerometer located on its distal end (Sorin group, Milano, Italy)
- automatic measurement of optimal AV and VV intervals

CRT Optimization: Problems

- Supine versus exercise;
  longer optimal AV delay during exercise
- Optimal AV interval may vary considerably during follow-up;
  how often?
- Scant incremental benefit on clinical outcome, especially of VV interval;
  due to growth in numbers of CRT implantations, many centers may find it difficult to perform optimization in all patients.

Is Optimization Necessary?
AV Delay

Randomized, prospective clinical trial

Group 1 (n=20)	Group 2 (n=20)
Optimized AV delay	Empiric delay 120ms

	Group 1	Group 2	p
Δ Ao VTI, cm	4.0 ± 1.7	1.8 ± 3.6	<.02
EF, %	7.8 ± 6.2	3.4 ± 4.4	<.02
NYHA	1.0 ± 0.5	0.4 ± 0.6	<.01
QOL score	23 ± 13	13 ± 11	<.03

Sawhney NS et al, Heart Rhythm 2004;1:562