

# Echocardiography in Resynchronization Therapy: San Antonio Echo Society

May 8, 2008

Joe M. Moody, Jr, MD

UTHSCSA and STVAHCS

I have no conflicts of interest related to this presentation.

## ASE EXPERT CONSENSUS STATEMENT

# Echocardiography for Cardiac Resynchronization Therapy: Recommendations for Performance and Reporting—A Report from the American Society of Echocardiography Dyssynchrony Writing Group *Endorsed by the Heart Rhythm Society*

John Gorcsan III, MD, Theodore Abraham, MD, Deborah A. Agler, RDMS, Jeroen J. Bax, MD, Genevieve Derumeaux, MD, Richard A. Grimm, DO, Randy Martin, MD, Jonathan S. Steinberg, MD, Martin St. John Sutton, MD, and Cheuk-Man Yu, MD, Pittsburgh and Philadelphia, Pennsylvania; Baltimore, Maryland; Cleveland, Ohio; Leiden, The Netherlands; Lyon, France; Atlanta, Georgia; New York, New York; Hong Kong, China

92 references, up to 2007.

Gorcsan J et al. J Am Soc Echocardiogr. 2008;21:191.

# Potential Conflicts of Interest

Theodore Abraham, MD received research grants from GE Ultrasound. Jeroen Bax, MD received research grants from GE, BMS, Guidant, Medtronic, and St. Jude. Richard Grimm, DO is on the Speaker Bureau and a Consultant on the Advisory Board of Medtronic. John Gorcsan, MD received research grants from Toshiba, GE, and Siemens; and is also a Consultant on the Advisory Board of Toshiba, GE, and Siemens. Jonathan Steinberg, MD received research grants from Medtronic, St. Jude, and Boston Scientific; and he is also a Consultant on the Advisory Board of Boston Scientific. Cheuk-Man Yu, MD received research grants from GE, Medtronic, and Pfizer; and is also on the Speaker Bureau of Medtronic and GE and a Consultant on the Advisory Board of Medtronic, Boston Scientific, and GE.

Phillips doesn't seem to be present on this list.

Gorcsan J et al. J Am Soc Echocardiogr. 2008;21:191.

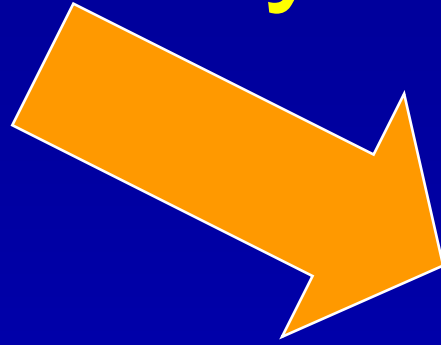
# Purpose of Report

- ... to evaluate the contemporary state of-the-art applications of echocardiography for CRT and to propose guidelines regarding current and potential future clinical applications. We acknowledge that this is a relatively young and rapidly changing field with new information being discovered continually. Because no optimal approach has yet been clearly defined, the strengths and limitations of the principal current techniques will be discussed along with practical recommendations.

# Cardiac Dyssynchrony

- Synchrony: Proper timing
- Dyssynchrony: Improper timing
- The problem: mechanical dyssynchrony impairs ventricular function
  - Ejection fraction largely unchanged
  - Stroke volume and ejection time reduced
  - Isovolumic contraction and relaxation times increased
- Mechanical dyssynchrony also has many molecular biological consequences

# Dyssynchrony



# Heart Failure

- Exercise Intolerance
- Left heart failure = Dyspnea
- Right heart failure = Edema

## Caveats:

- Not all dyssynchrony results in heart failure
- But dyssynchrony usually makes heart failure worse

# 3 Types of Dyssynchrony

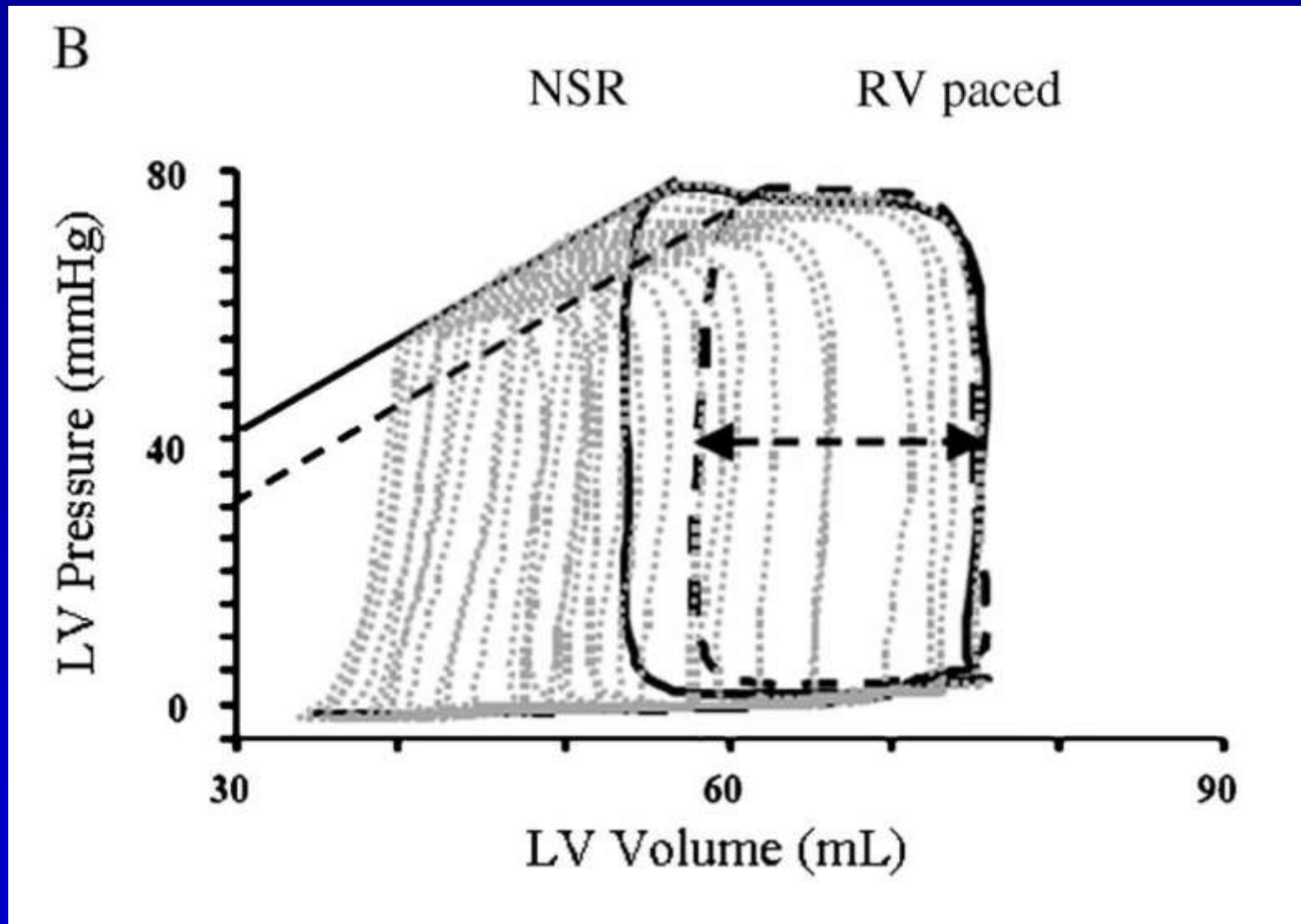
- Atrioventricular Dyssynchrony – abnormal connection between atrium and ventricles (on ECG, the PR interval)
- Interventricular Dyssynchrony – abnormal timing between RV and LV
- Intraventricular Dyssynchrony – abnormal timing between walls in the LV – Classically ECG of LBBB

# Dyssynchrony in LBBB

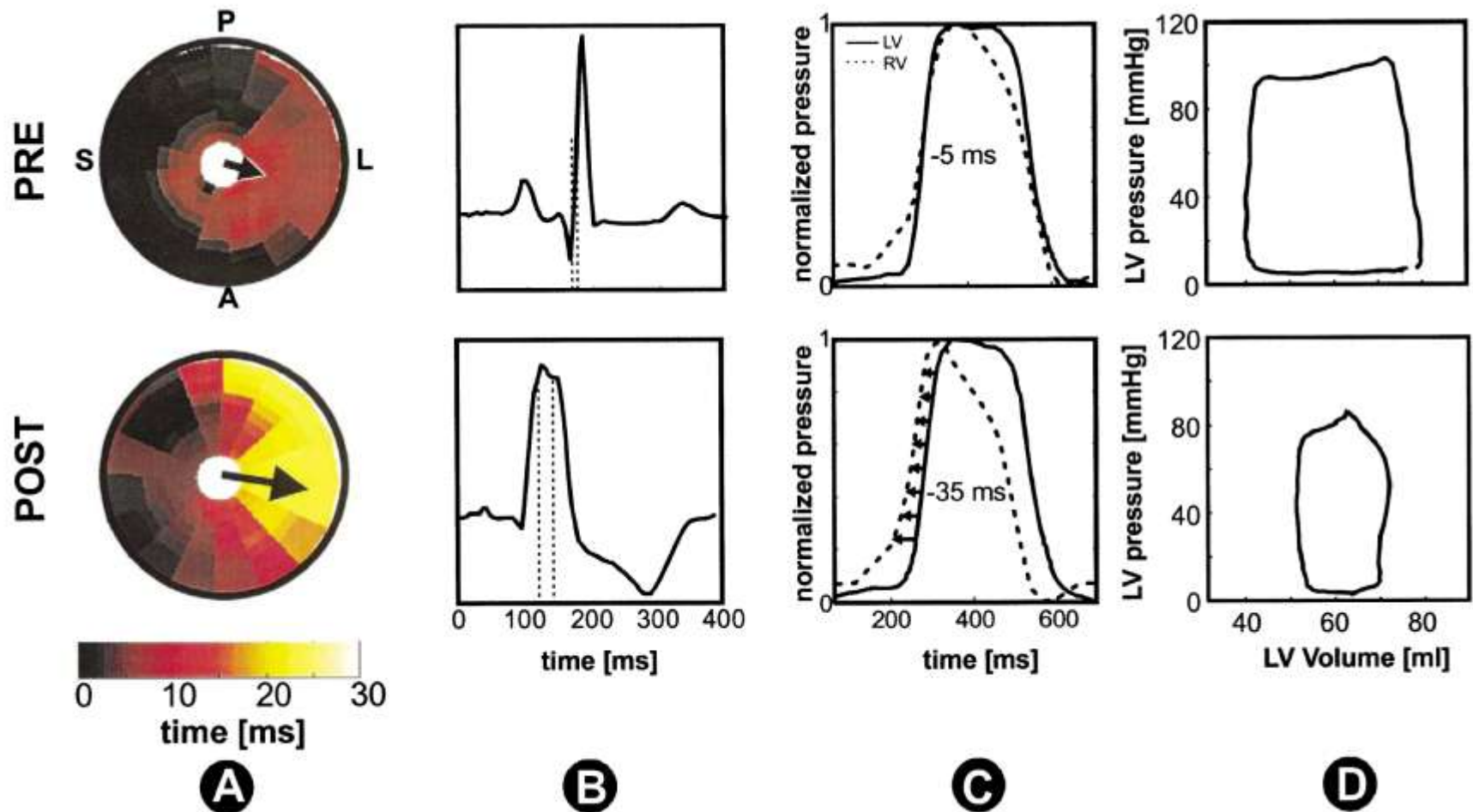
- IVS activates early – before LV ejection and typically stretches the posterolateral wall
- Posterolateral wall activates late – typically stretches the septal wall



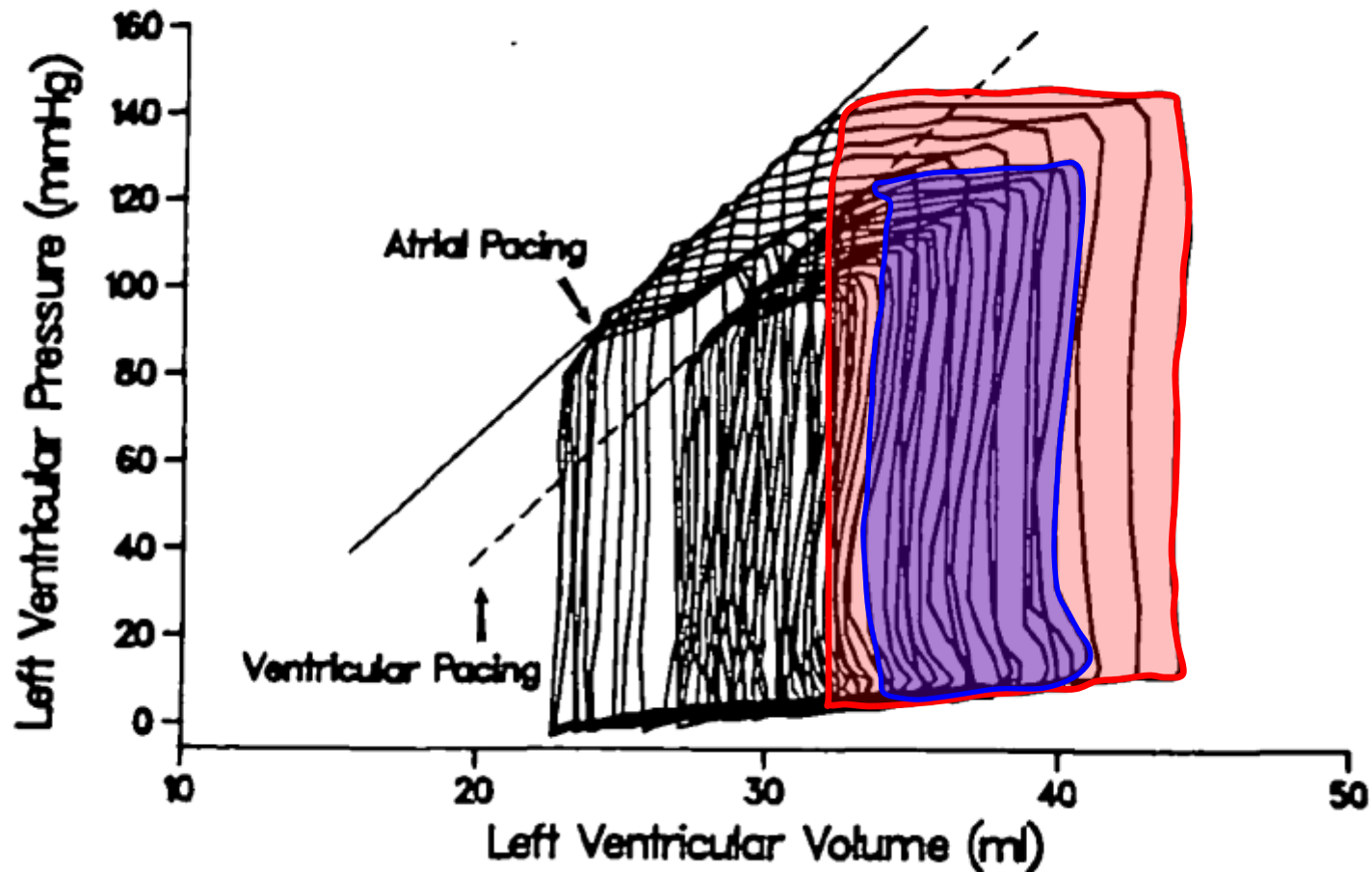
# Adverse Effect of RV Pacing: LBBB Pattern



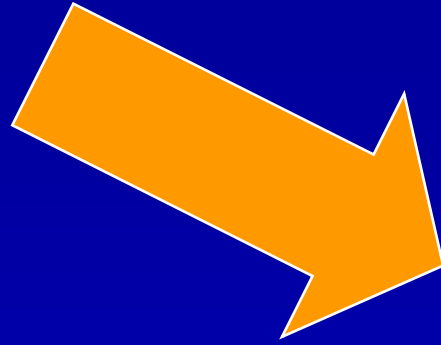
# Adverse Effect of LBBB induced in Dogs



# Adverse Effect of Ventricular Pacing induced in Dogs



# Resynchronization



Improved  
Heart Failure

## Caveats:

- Resynchronization is accomplished using insertion of biventricular pacemaker, a fairly difficult and definitely expensive procedure
- About 1/3 of patients do not improve with resynchronization therapy

# Indications for Cardiac Resynchronization Therapy

**Class I:** Patients with LVEF less than or equal to 35%, sinus rhythm, and NYHA functional class III or ambulatory class IV symptoms despite recommended, optimal medical therapy and who have cardiac dyssynchrony, which is currently defined as a QRS duration greater than 120 ms, should receive cardiac resynchronization therapy unless contraindicated. (*Level of Evidence: A*)

# Indications for Cardiac Resynchronization Therapy

**Class IIa:** ICD therapy combined with biventricular pacing can be effective for primary prevention to reduce total mortality by a reduction in SCD in patients with NYHA functional class III or IV, are receiving optimal medical therapy, in sinus rhythm with a QRS complex of at least 120 ms, and who have reasonable expectation of survival with a good functional status for more than 1 y. (*Level of Evidence: B*)

# Indications for Cardiac Resynchronization Therapy

**Class IIa:** Biventricular pacing in the absence of ICD therapy is reasonable for the prevention of SCD in patients with NYHA functional class III or IV HF, an LVEF less than or equal to 35%, and a QRS complex equal to or wider than 160 ms (or at least 120 ms in the presence of other evidence of ventricular dyssynchrony) who are receiving chronic optimal medical therapy and who have reasonable expectation of survival with a good functional status for more than 1 y. (*Level of Evidence: B*)

Guideline Sudden Cardiac Death. 2006.

# Indicators for Resynchronization

1. Good chronic medical therapy
2. LVEF  $<35\%$
3. Sinus rhythm
4. Persistent disabling cardiac failure symptoms (Class III-IV)
5. QRS duration  $>0.120$  sec

- No echo criteria



# Clinical Resynchronization Reports - 1

**Table 1** Summary of important clinical trials of cardiac resynchronization therapy

	MUSTIC	PATH-CHF	MIRACLE	MIRACLE-ICD
Inclusion criteria	NYHA III LVEF < 35% EDD > 60 mm 6-min walk < 450 m QRS ≥ 150 ms	NYHA III, IV QRS ≥ 120 ms	NYHA III, IV LVEF ≤ 35% EDD ≥ 55 mm QRS ≥ 130 ms	NYHA III, IV LVEF ≤ 35% EDD ≥ 55 mm QRS ≥ 130 ms ICD indication
Sample	58	40	453	369
End points	QOL, 6-min walk, peak VO <sub>2</sub> , HF hospitalization	Acute hemodynamics QOL, 6-min walk, HF hospitalization	QOL, NYHA class, 6-min walk, composite	QOL, NYHA class, 6-min walk
Study design	Single-blind, randomized, crossover	Single-blind, randomized, crossover	Double-blind, randomized, parallel- controlled	Double-blind, randomized, parallel-controlled
Treatment arms	CRT vs no pacing	CRT vs no pacing	CRT vs no pacing	CRT-D vs ICD
Major findings	CRT improved all end points, reduced hospitalization	CRT improved acute hemodynamics and chronic end points	CRT improved all end points; reduced HF hospitalization	CRT improved QOL and NYHA class only, and did not impair ICD function

# Clinical Resynchronization Reports - 2

	CONTAK	COMPANION	CARE-HF
Inclusion criteria	NYHA II-IV LVEF $\leq$ 35% QRS $\geq$ 120 ms ICD indication	NYHA III, IV LVEF $\leq$ 35% QRS $\geq$ 120 ms	NYHA III, IV LVEF $\leq$ 35% QRS $>$ 150 ms or QRS = 120-150 with dyssynchrony
Sample	333	1520	819
End points	Composite of mortality, HF hospitalization and VT/VF	Primary: all-cause mortality or hospitalization; secondary: all-cause mortality	All-cause mortality or unplanned hospitalization
Study design	Double-blind, randomized, parallel-controlled	Randomized, parallel-controlled	Randomized, parallel-controlled
Treatment arms	CRT-D vs ICD	CRT vs CRT-D vs no pacing	CRT vs no pacing
Major findings	CRT improved secondary end points; primary end points did not improve	CRT and CRT-D improved primary end point; CRT-D; reduced mortality	CRT improved primary end point and reduced all cause mortality

*CRT*, Cardiac resynchronization therapy; *CRT-D*, cardiac resynchronization therapy-defibrillator; *EDD*, left ventricular end-diastolic diameter; *HF*, heart failure; *ICD*, implantable cardioverter defibrillator; *LVEF*, left ventricular ejection fraction; *NYHA*, New York Heart Association; *QOL*, quality of life score; *VF*, ventricular fibrillation; *VO<sub>2</sub>*, maximal oxygen consumption; *VT*, ventricular tachycardia.

# Echo Evaluation Basics

- Quantifying mechanical dyssynchrony in a series of patients with heart failure is complex, and no single ideal method currently exists.
- A reasonable starting point is to examine the routine 2-dimensional (2D) echocardiographic images. Trained observers can often assess dyssynchrony visually as an early septal in-and-out motion described as septal flash or bounce in typical left bundle branch block dyssynchrony.

# Echo Evaluation: M-mode

- Septal to posterior wall motion delay
  - PSSA or PSLA views
  - Cursor at midventricular (papillary muscle) level
  - Sweep speed 50-100 mm/sec
  - Time between peak inward septal motion and peak inward posterior wall motion
  - Delay of >130 msec thought to predict response to CRT
- Problems: reproducibility is poor, so it is not advocated to be used in isolation
- Color TD (Tissue Doppler) M-mode has similar criteria for abnormality and similar limitations

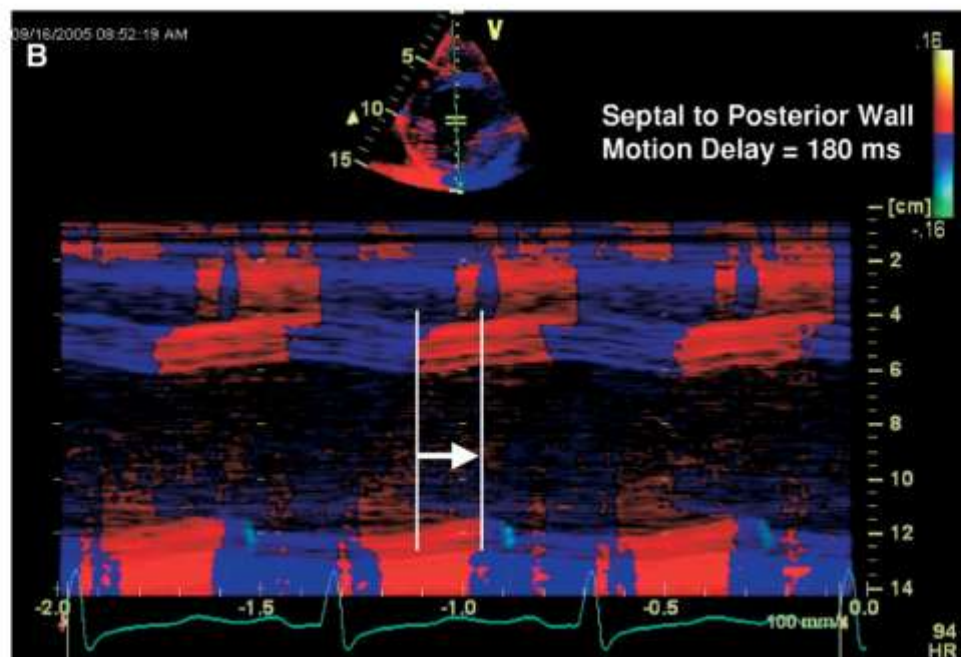
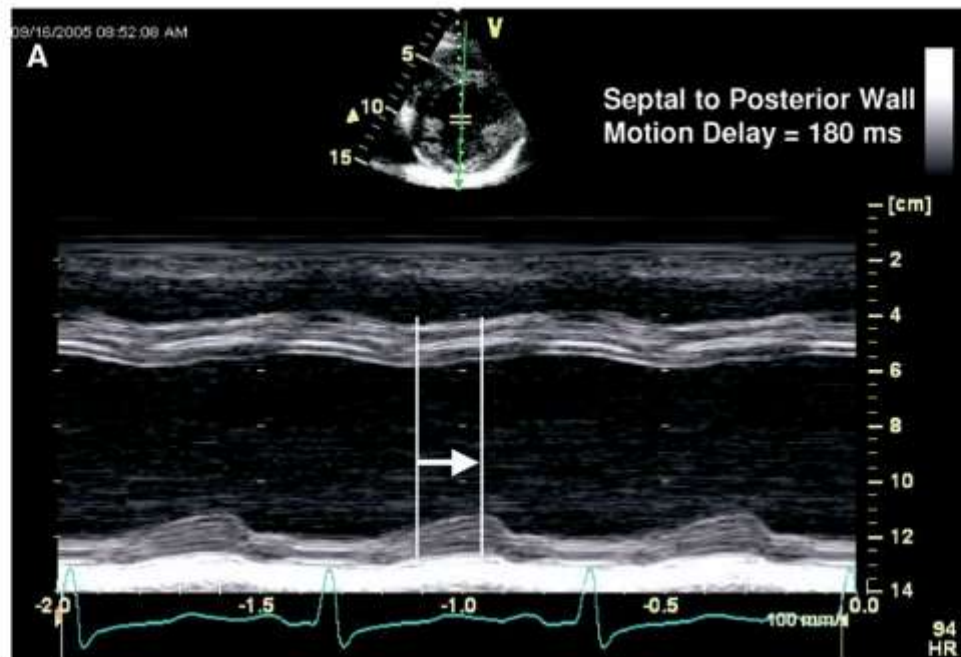


Figure 1 Routine M-mode (A) at midventricular level and color-coded tissue Doppler M-mode (B) demonstrating septal to posterior wall delay of 180 milliseconds, consistent with significant dyssynchrony ( $\geq 130$  milliseconds).

Gorcsan J et al. J Am Soc Echocardiogr. 2008;21:191.

# Echo Evaluation: Longitudinal TD (Tissue Doppler) Velocity

- Apical Window Longitudinal Shortening Velocity
  - Largest body of supporting publications
  - Principal method in clinical use
  - Limitations exist
- Two types
  - Color-coded TD
  - Pulsed TD

# Echo Evaluation: Color-Coded TD (Tissue Doppler) Acquisition

- Simpler
- More practical
- Preferred by consensus
- Requires 90 fps frame rate or more

# Color-Coded TD Procedure - 1

1. Noise free ECG with delineated QRS waveform
2. Optimize 2-D imaging
  - Maximal apical to near field LA (?LV) image
  - Overall gain and time-gain controls optimized for myocardial definition
3. Position LV in center of sector with vertical alignment for optimal Doppler motion
4. Depth setting set to include mitral annulus



# Color-Coded TD Procedure - 2

5. Activate color-TD and include entire LV in sector
  - Decrease sector depth and width to obtain adequate frame rate
  - Overall color gain optimized for clear myocardial definition
  - If available, activate time to peak velocity display
6. Suspend patient breathing during capture of 3-5 beats (respiration affects TD data)
  - More than 5 beats if arrhythmia

# Color-Coded TD Procedure - 3

7. Record 3 images – A4C, A2C, A3C=ALA
8. Determine LV ejection interval
  - Best from A5C or ALA view
  - Record PW Doppler of LVOT

# Color-Coded TD Procedure

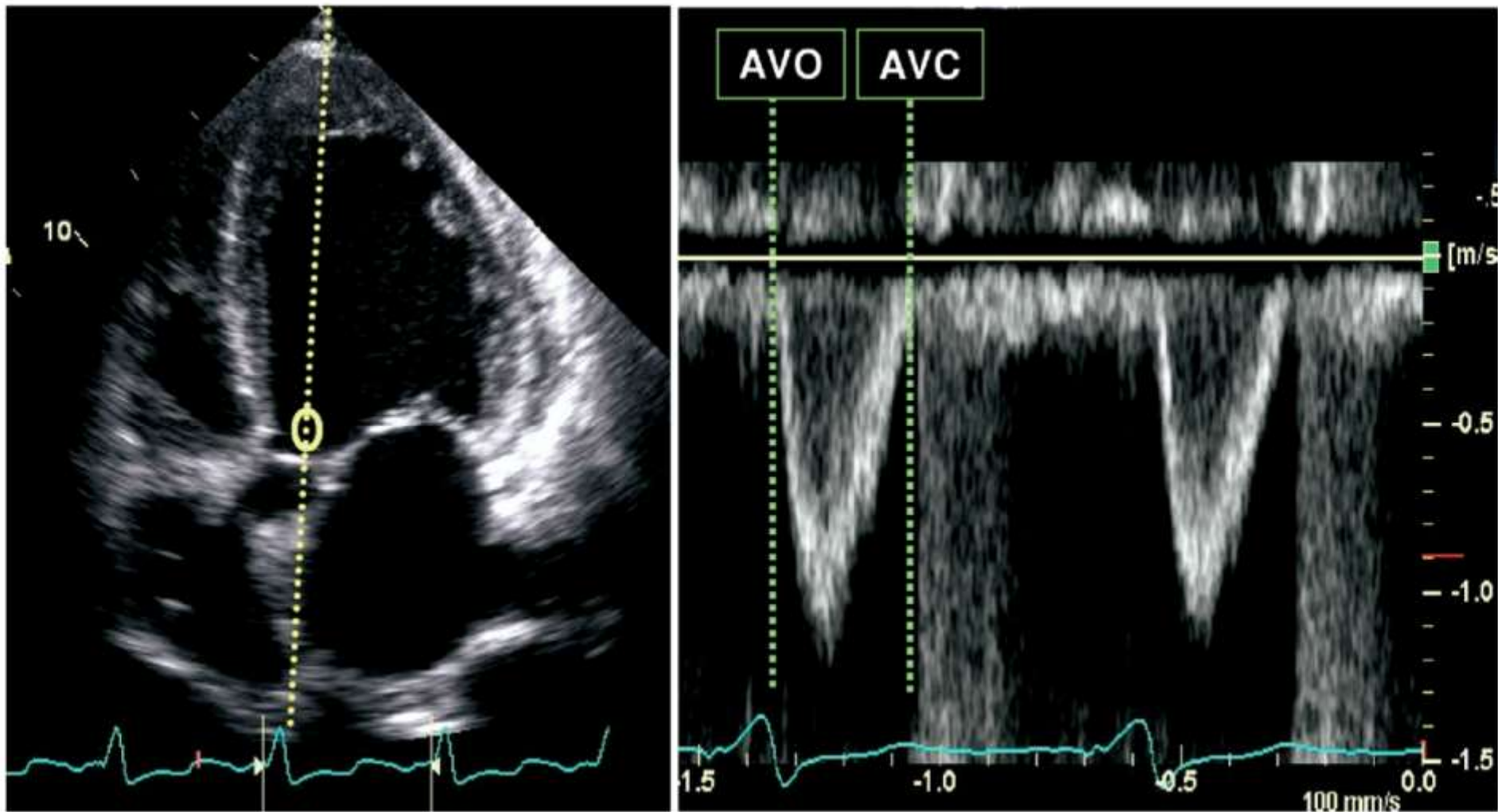


Figure 2 Determination of left ventricular ejection interval from pulsed Doppler of outflow tract. AVC, Aortic valve closure; AVO, aortic valve opening.

# Color-Coded TD Analysis (Offline) - 1

1. Determine timing of LV ejection
  - Use LVOT PW Doppler signal
  - Use ECG as time marker
  - Superimpose LV ejection onset and termination on TD time-velocity curves
2. Size and place regions of interest
  - 5x10 to 7x15 mm size
  - Basal and mid region (not apical)
  - Opposing sides of LV

# Color-Coded TD Analysis (Offline) - 2

3. Check for signal quality – seek physiologic components of time-velocity curves
  - Isovolumic contraction time (<60 ms from onset of QRS)
  - Ejection (S)
  - Rapid filling (E)
  - Atrial kick (A)

# Color-Coded TD Analysis (Offline)

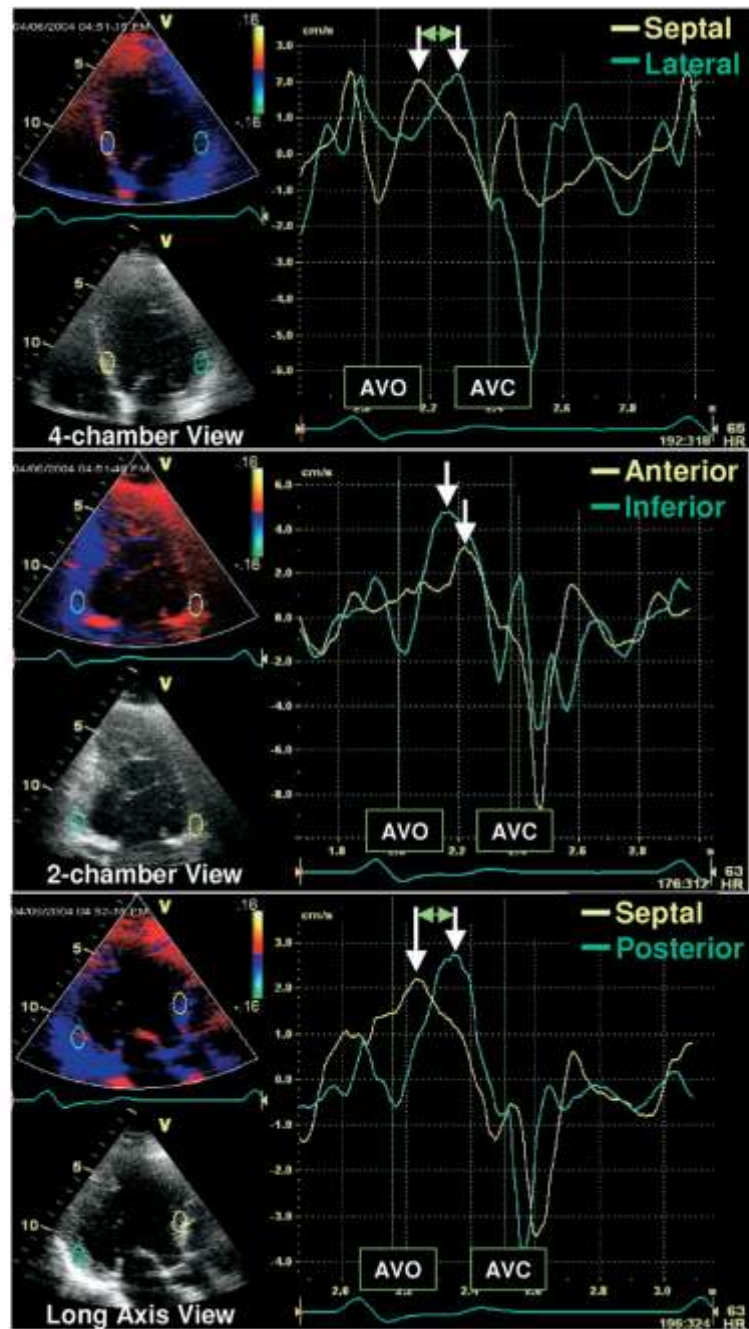


Figure 3 Color-coded tissue Doppler study from 3 standard apical views of patient who responded to resynchronization therapy. Time-velocity curves from representative basal or midlevels are shown. Maximum opposing wall delay was seen in apical long-axis view of 140 milliseconds between septum and posterior wall, consistent with significant dyssynchrony ( $\approx 65$  milliseconds).



# Color-Coded TD Analysis (Offline)

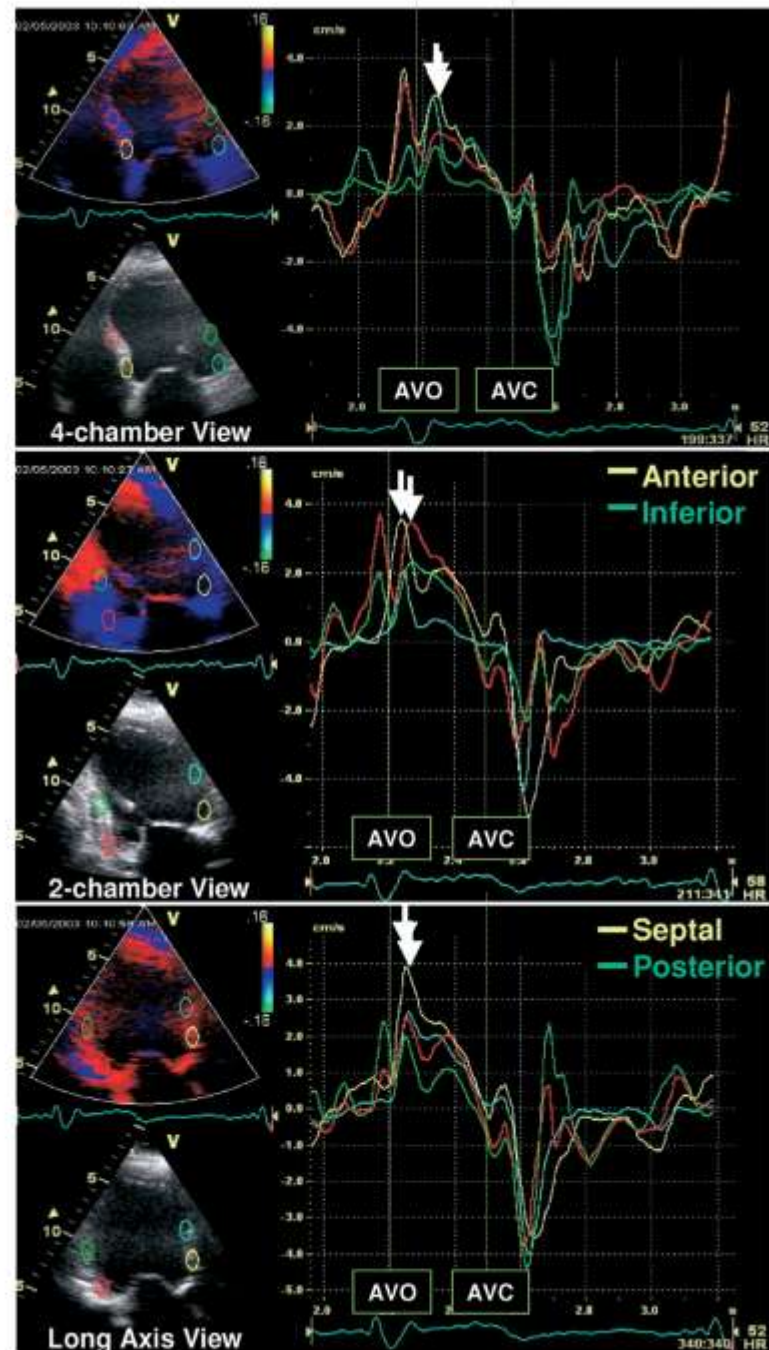


Figure 4 Color-coded tissue Doppler study from 3 standard apical views of patient who did not respond to resynchronization therapy. Time-velocity curves from both basal and midlevels show no significant opposing wall delay less than 65 milliseconds.

# Color-Coded TD Analysis (Offline) - 3

4. Manually adjust each of the 4 regions of interest both longitudinally and laterally within LV wall to obtain most reproducible peak systolic velocity
  - This is a critical step
  - Attempt to delineate one peak
  - If 2 peaks remain, measure the earliest
5. Determine time from onset of QRS to peak S for each of 12 regions
  - Alternate: determine in each view the time delay between opposing walls



# Color-Coded TD Analysis (Offline) - 3

6. Average the time to peak values in minimum of 3-5 beats to reduce effect of beat-to-beat variability (more beats if arrhythmia)
  - Atrial fibrillation – no data to support doing synchronization analysis at all
  - Not currently recommended: using peak velocities occurring post-systolic (after aortic valve closure)

# Color-Coded TD: Clinical Studies

- “The majority of studies have used color-coded TD to assess LV dyssynchrony and predict outcome, and it is the consensus of this writing group that this is currently the preferred approach.”

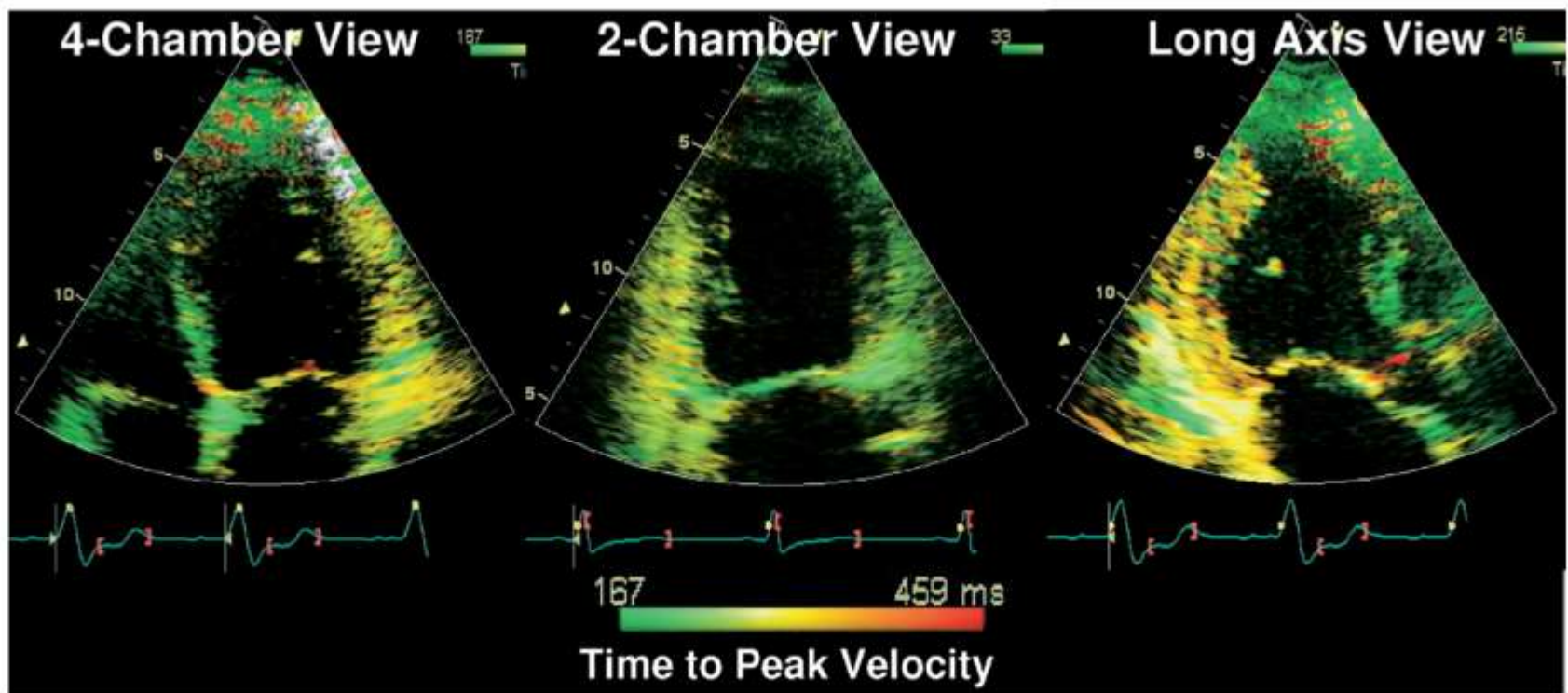
# Color-Coded TD: Measuring Clinical Response

- NYHA Clinical classification
- 6-minute walk test
- Reverse remodeling (>15% reduction in LVEDV)
- Other measurements
  - Degree of MR
  - LVET or myocardial performance index (MPI, Tei index,  $(IVRT+IVCT)/LVET$ , nl <0.40)

# Color-Coded TD: Measuring Dyssynchrony

- 2-site method (basal septal vs basal lateral)
- 4-site method (basal septal or lateral or anterior or inferior)
- 12-site analysis (basal and mid of 2 walls in 3 views)
  - Yu index = standard deviation of the time to peak velocity in 12 views >33msec (technically demanding)
  - Maximal difference of time to peak velocity >100 msec
- Tissue synchronization imaging – color code for time to peak velocity – not as accurate in some studies, so not recommended as sole method

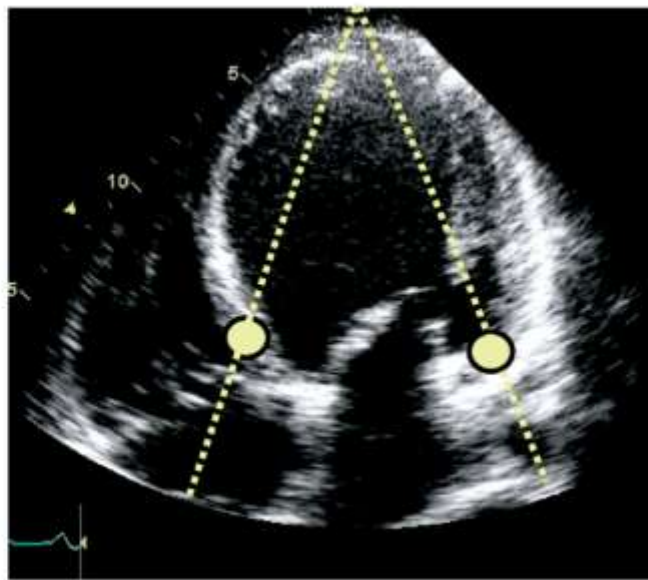
# Quick Color-Coded TD: Tissue Synchronization Imaging



**Figure 5** Tissue Doppler study from 3 standard apical views demonstrating color coding of time to peak velocity data from patient with dyssynchrony who responded to resynchronization therapy. Lateral wall (4-chamber view) and posterior wall (apical long-axis views) are color-coded *yellow-orange*, indicating delay in time to peak velocity.

# Pulsed TD: Measuring Dyssynchrony

- Sample volume 1 cm
- Set velocity scale to maximize time-velocity curve
- Set sweep speed to 50-100 mm/sec
- Identify the reproducible time-velocity curve during the study – not possible off line
- Disadvantages – takes more time, less reproducible (breathing, movement, HR change)



# Pulsed TD: Measuring Dyssynchrony

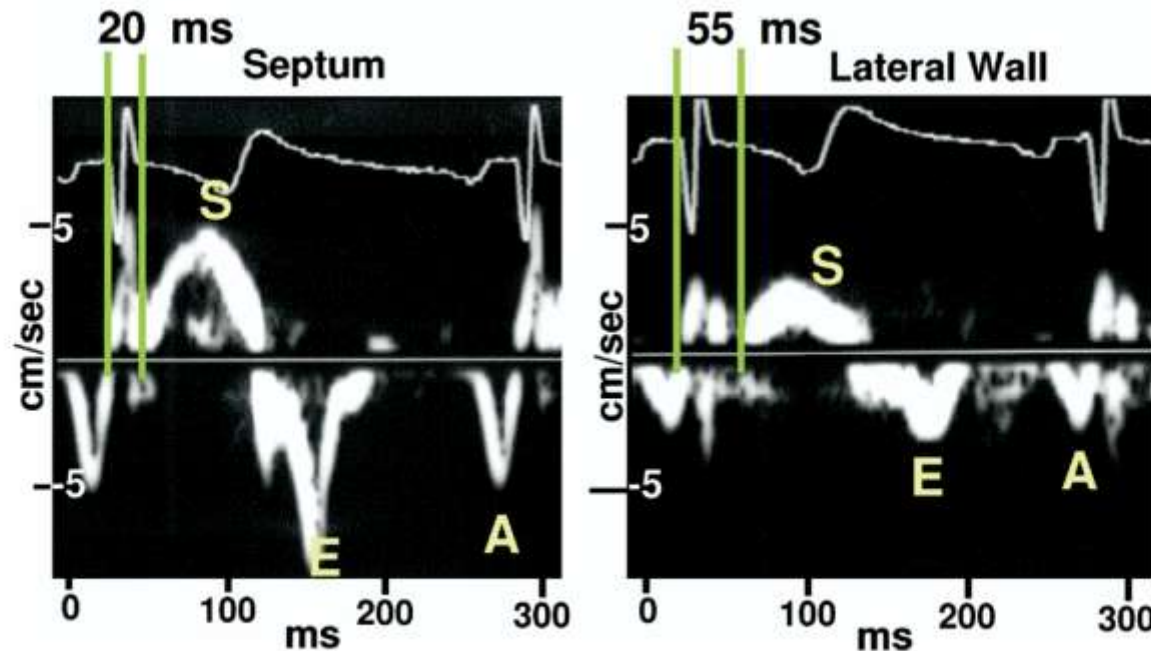


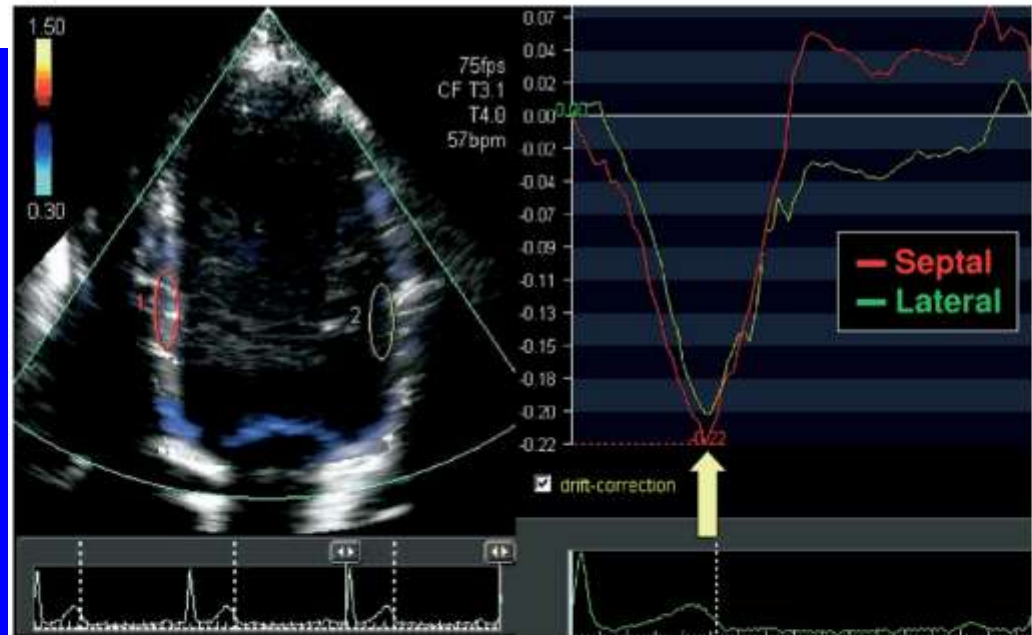
Figure 6 Pulsed tissue Doppler demonstrating dyssynchrony with delayed time to onset systolic velocity in lateral wall, as compared with septum in patient with left bundle branch block before resynchronization therapy.

# TD: Longitudinal Strain, Strain Rate, and Displacement

- Basic Definition: Strain is a change in the shape of the ventricular wall during the cardiac cycle – a change in distance between 2 points in the wall
- With strain, there will be unequal velocities in myocardial segments
- Disadvantages – angle-dependence; signal-to-noise ratio; passive motion may mislead
- Speckle-tracking may prove to be an advance
- Not currently recommended



# TD: Longitudinal Strain, Strain Rate, and Displacement



B

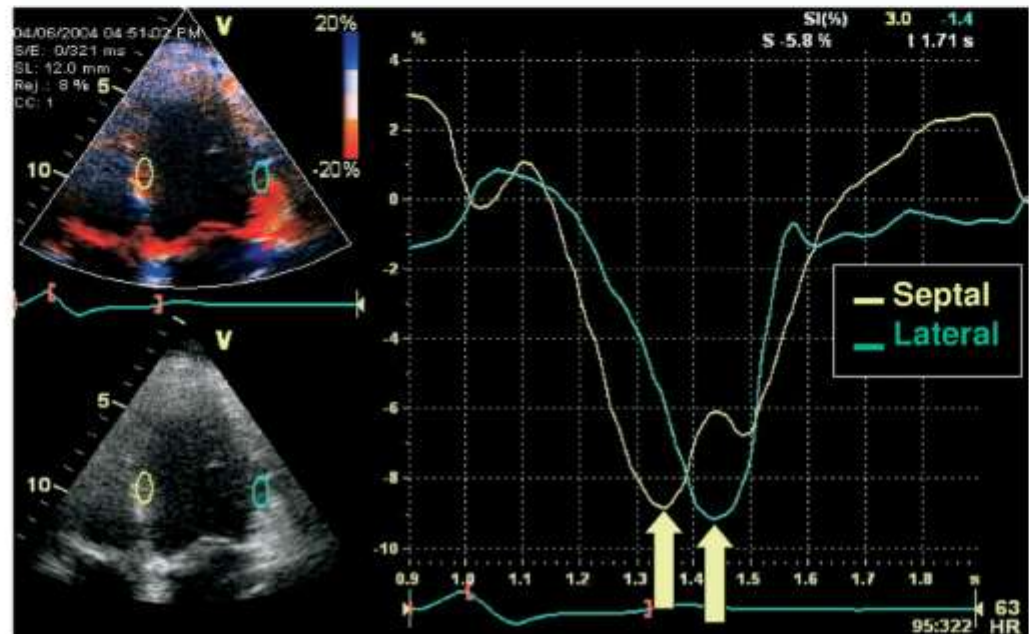


Figure 7 Doppler tissue images demonstrating longitudinal strain in healthy synchronous patient (A) and in patient with left bundle branch block before (B) resynchronization therapy.

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# Radial Strain

- Standard radial strain is geometrically dependent on angle of incidence
- Speckle-tracking is a technique that is not angle-dependent
- Applied in parasternal short axis mid-ventricular view
- Radial septal-to-posterior dyssynchrony of  $>130$  msec in one study
- Radial strain may be a useful addition to longitudinal assessments

# Radial Strain

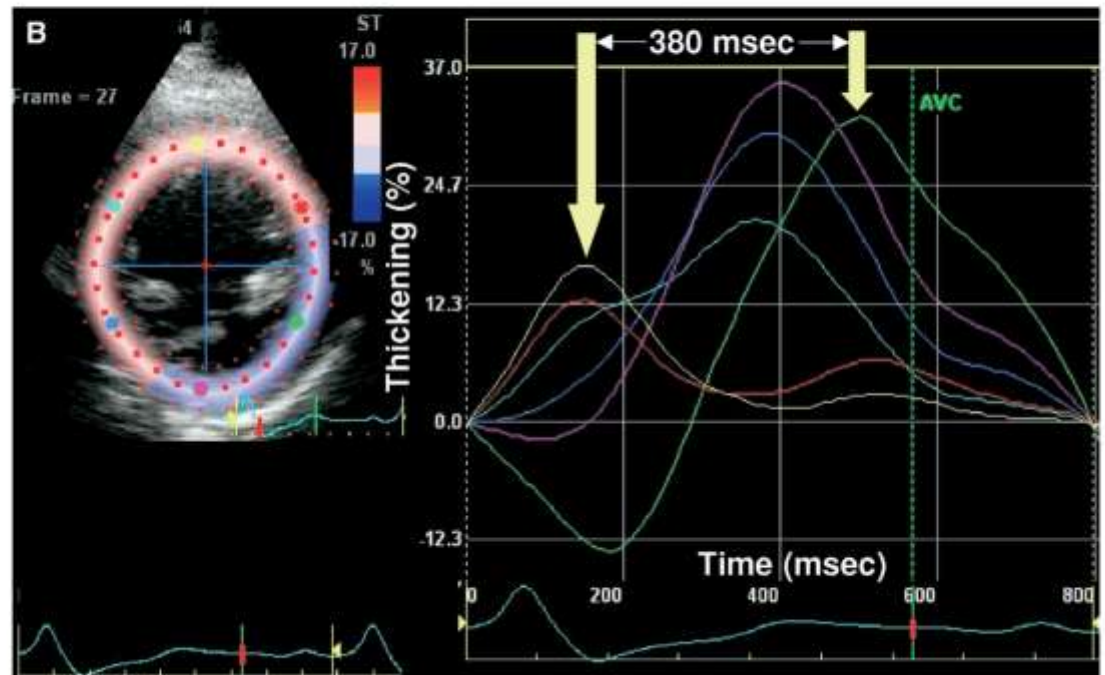
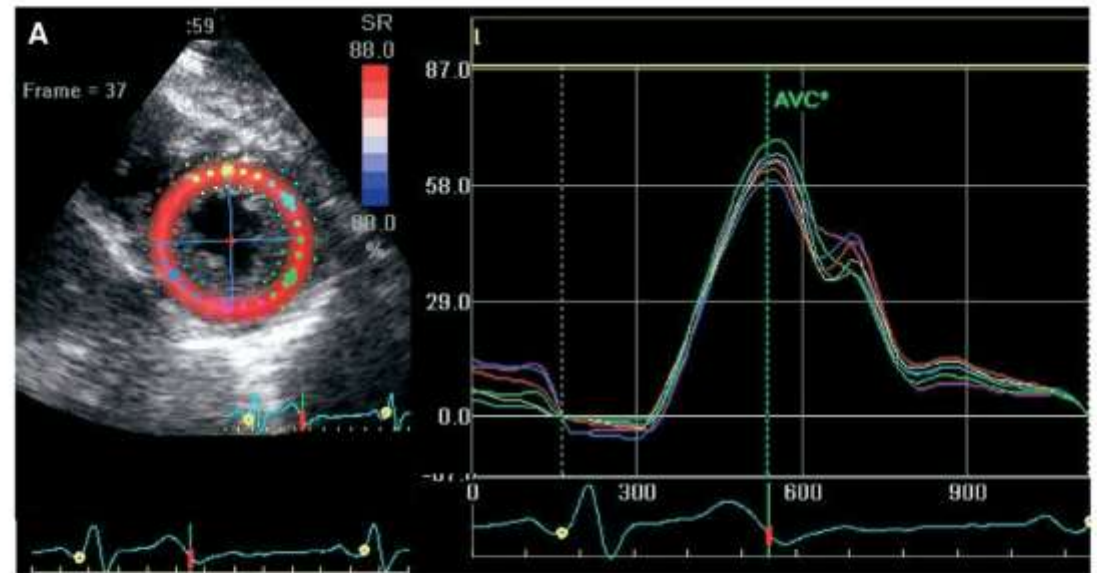


Figure 8 Speckle-tracking images demonstrating synchrony of peak segmental radial strain in healthy individual (A) and severe dyssynchrony in patient with heart failure and left bundle branch block (LBBB) referred for resynchronization therapy (B).

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# Three-Dimensional Echocardiography

- Allows simultaneous assessment of all segments in the same beat
- Semiautomatic contour tracking algorithms could be used to visualize and quantify regional wall motion
- Disadvantages
  - Poorer spatial resolution
  - Poorer temporal resolution (20-30 fps)

# Three-Dimensional Echocardiography

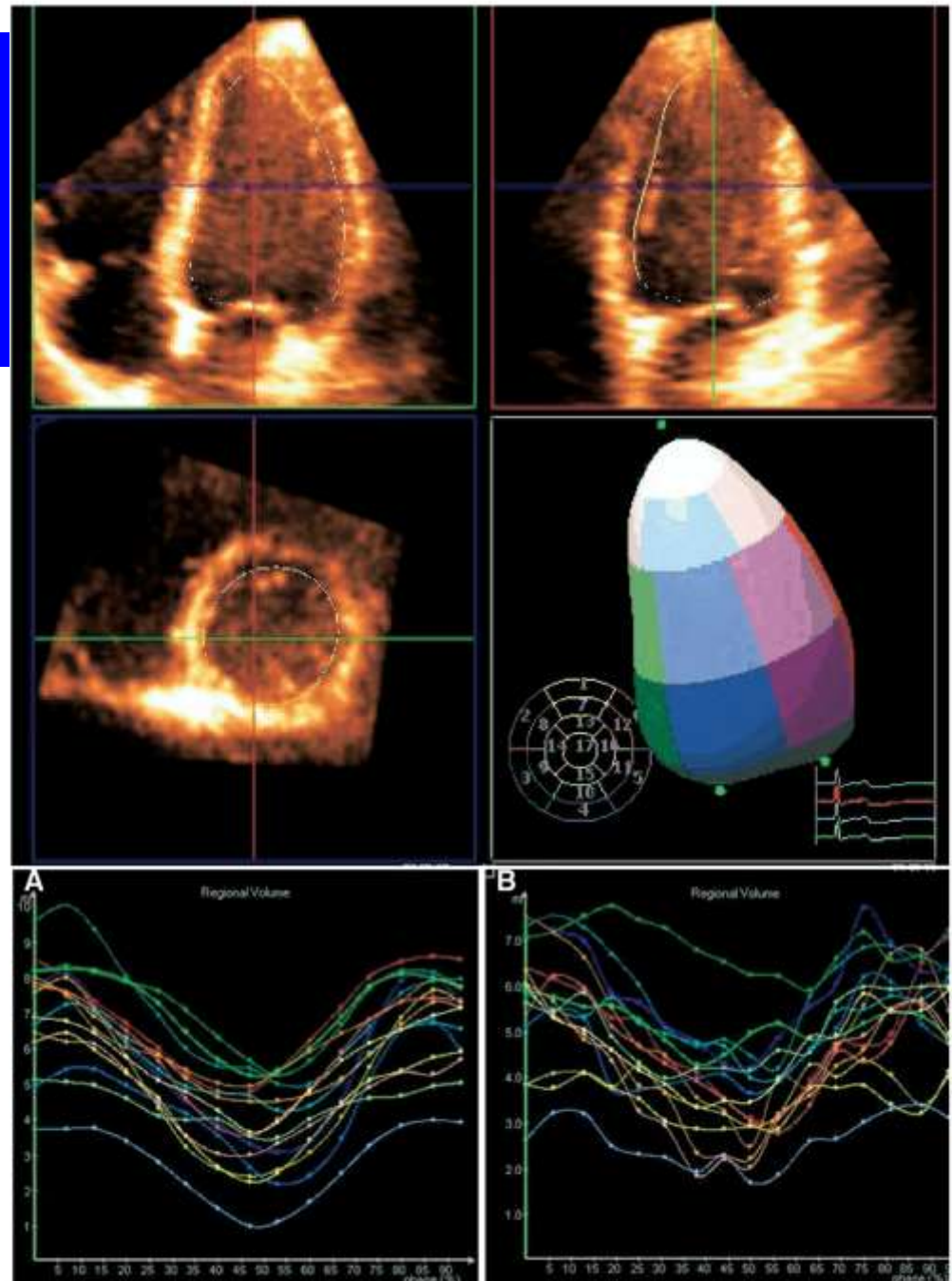


Figure 9 Three-dimensional echocardiographic assessment of segmental volume displacement in patient with normal synchrony (A) and with significant dyssynchrony (B).

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# Inter-ventricular Dyssynchrony

- Interventricular mechanical delay (IVMD) = time difference between RV and LV ejection (use PW LVOT and PW RVOT)
- Abnormal is >40-50 msec
- This measurement does not perform well in distinguishing who will respond to CRT

# Inter-ventricular Dyssynchrony

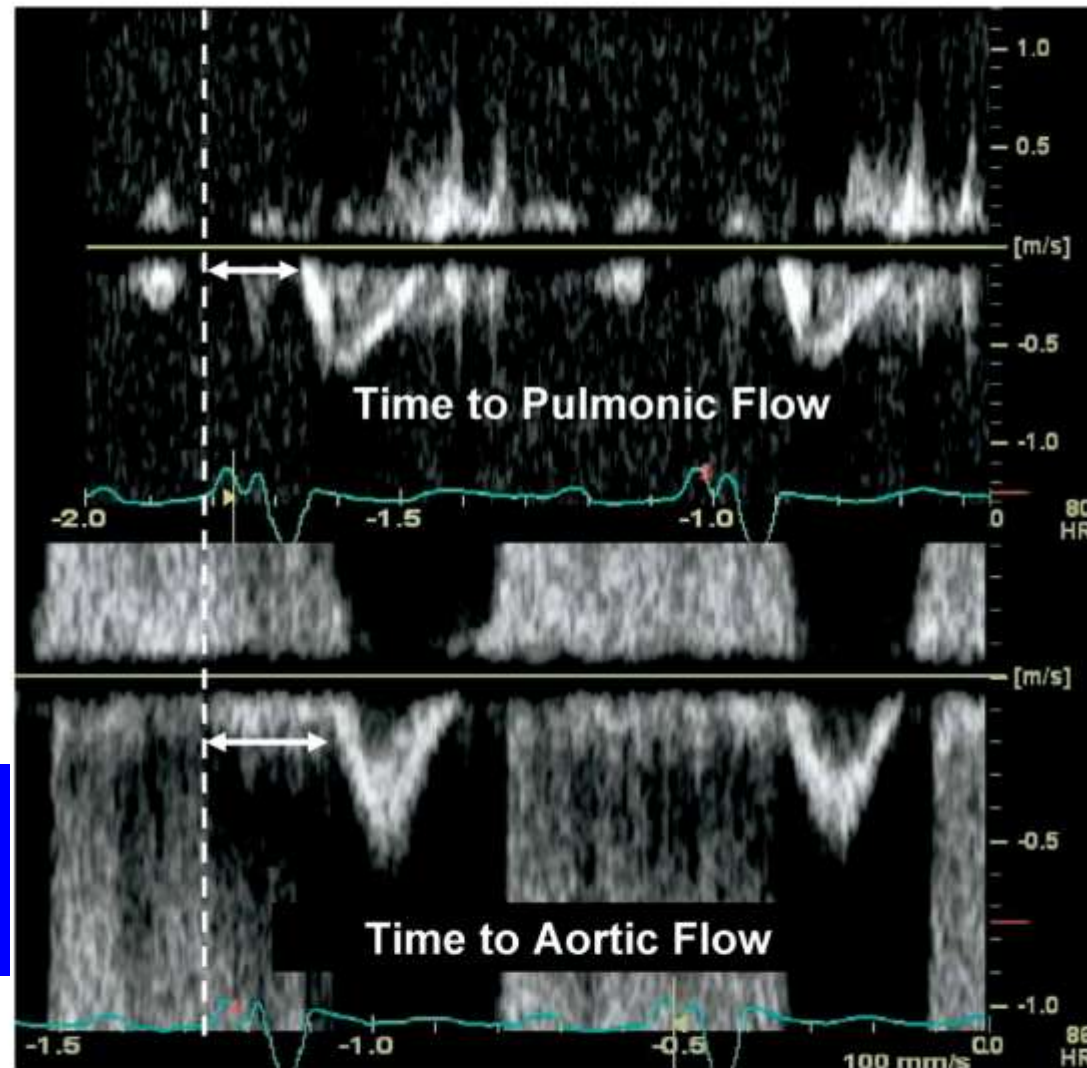


Figure 10 Pulsed Doppler from right ventricular outflow tract and left ventricular (LV) outflow tract demonstrating significant delay in LV ejection (>40 milliseconds).

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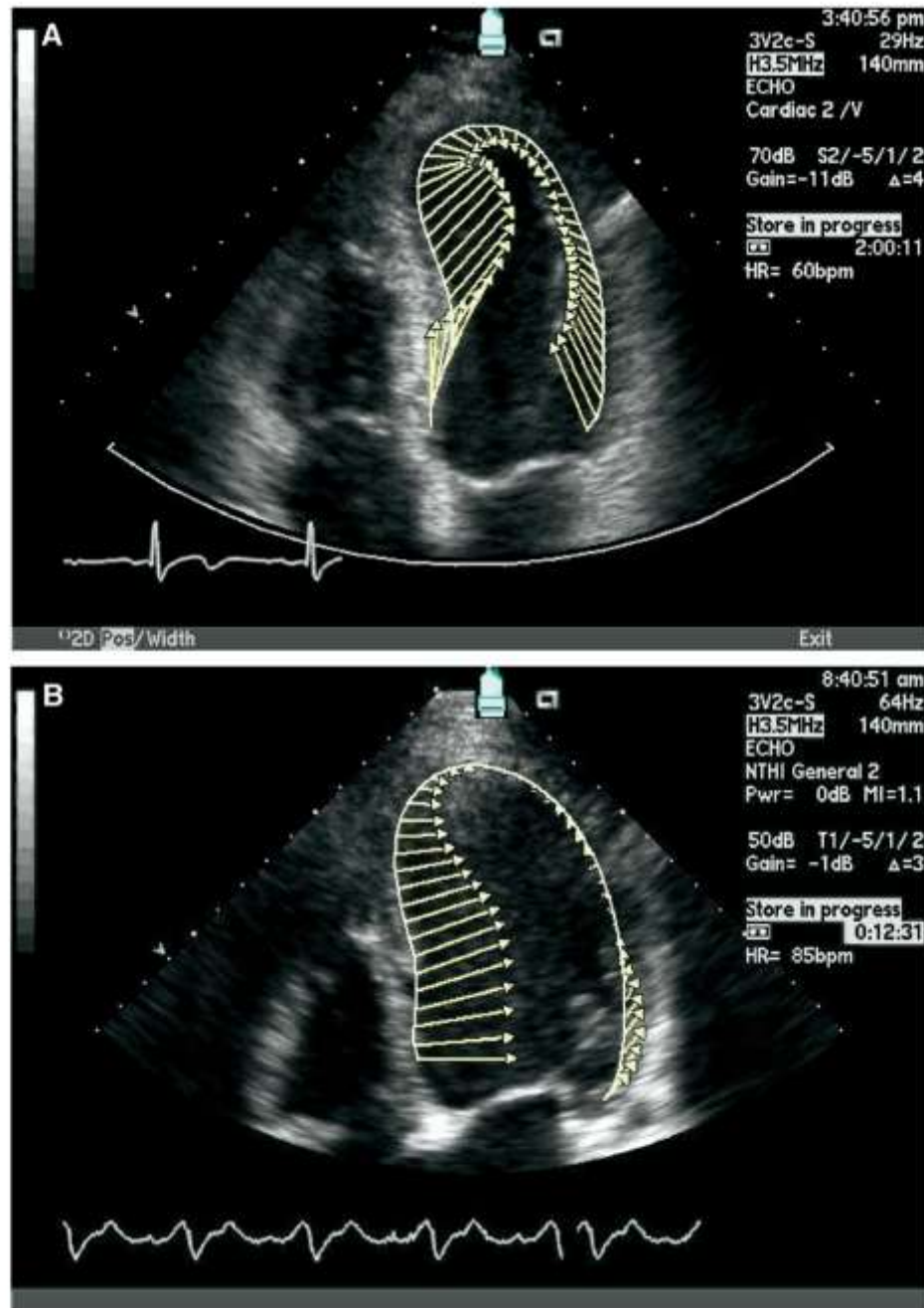
Table 2 Principal dyssynchrony indices associated with response to cardiac resynchronization therapy

Index	Method	Normal	Cutoff	Advantages	Disadvantages
<b>Intraventricular longitudinal dyssynchrony</b>					
Opposing wall delay, two sites <sup>12,15,38</sup>	Color tissue Doppler peak velocity (apical 4-chamber or long-axis views)	<50 ms	≥65 ms	Rapidly applied; offline analysis is possible	Requires color TD equipment; affected by passive motion tethering
Maximum wall delay, 12 sites <sup>43,47</sup>	Color tissue Doppler peak velocity (apical 4-chamber, 2-chamber, and long-axis views)	<90 ms	≥100 ms	More complete detection of longitudinal dyssynchrony; offline analysis is possible	Requires color TD equipment; affected by passive motion tethering
Yu index <sup>14,31,43</sup>	Color tissue Doppler, 12-segment SD (apical 4-chamber, 2-chamber, and long-axis views)	<30 ms	≥33 ms	More complete detection of longitudinal dyssynchrony; offline analysis is possible	Requires color TD equipment; more time-consuming; affected by passive motion tethering
Delay in onset of systolic velocity <sup>51</sup>	Pulsed tissue Doppler (apical 4-chamber, 2-chamber, and long-axis views; LV and RV)	<80 ms	≥100 ms	More widely available	Acquisition technically difficult; offline analysis is not possible; affected by passive motion tethering
Delayed longitudinal contraction <sup>41,42</sup>	Color tissue Doppler-strain-strain rate (apical views)	None	N/A	Less affected by passive motion or tethering; offline analysis is possible	Requires specialized color TD equipment; technically demanding
<b>Intraventricular radial dyssynchrony</b>					
Septal to posterior wall delay <sup>34,35</sup>	M-mode (parasternal mid-LV view)	<50 ms	≥130 ms	Widely available; rapidly applied; no advanced technical requirements	Largely affected by passive motion or tethering; difficulties with segmental akinesis
Septal to posterior wall delay <sup>54,57</sup>	Radial strain (parasternal mid-LV view)	<40 ms	≥130 ms	Less affected by passive motion or tethering; speckle tracking may be applied to routine images	Requires specialized instrumentation for analysis; assesses only radial dynamics
<b>Interventricular dyssynchrony</b>					
Interventricular mechanical delay <sup>62-64</sup>	Routine pulsed Doppler (RVOT and LVOT views)	<20 ms	≥40 ms	Widely available; no advanced technical requirements; highly reproducible	Nonspecific; affected by LV and RV function

LV, Left ventricular; N/A, not applicable; OT, outflow tract; RV, right ventricular; TD, tissue Doppler.



# Other methods of Assessment



**Figure 11** Velocity vector images demonstrating synchrony of velocity convergence toward center of left ventricle in healthy individual (A) and severe septal-lateral wall dyssynchrony in patient with heart failure and left bundle branch block (LBBB) referred for resynchronization therapy (B).

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# Heart Response to CRT

- Reverse remodeling is dynamic, may be progressive, and is reversible
- Reverse remodeling is associated with better patient survival and symptoms
- Reverse remodeling may improve MR
  - Better wall contractile coordination
  - Better papillary muscle contractile coordination

# Heart Response to CRT

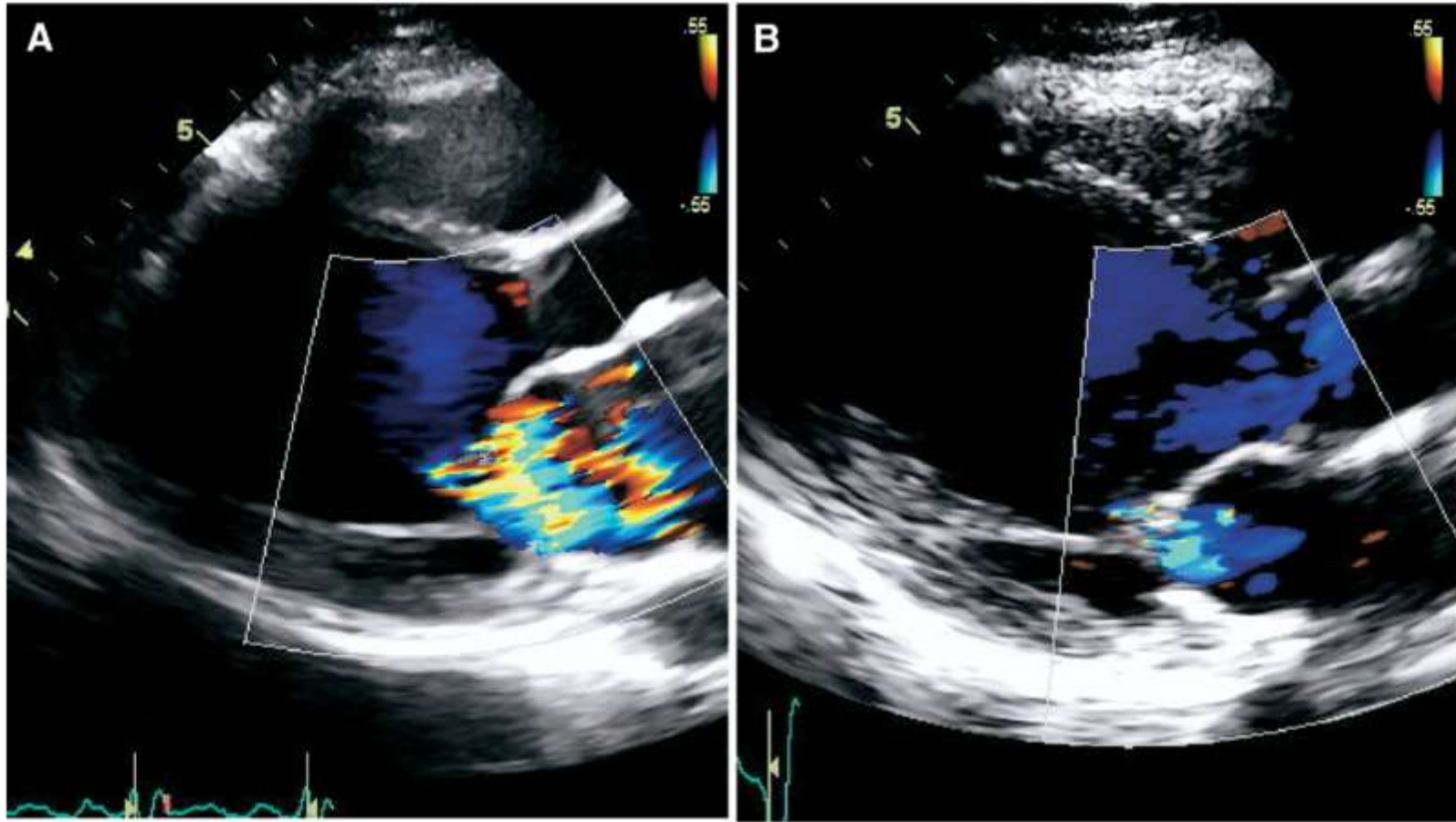


Figure 12 Parasternal long-axis view demonstrating reduction in mitral regurgitation in patient from before (A) to day after (B) resynchronization therapy.

# Echo to Guide LV Lead Placement

- Some studies suggest that placing the LV lead at the point of latest LV activation is most helpful
- More definitive data is necessary to determine definitively the role of echo in guiding LV lead placement

# Optimizing AV Delay

- Allow completion of atrial contribution to transmitral flow
- Delay should be short enough to not allow time for diastolic MR during atrial relaxation
- Need for routine echo optimization of AV delay is controversial
- A short AV delay may be necessary for the LV lead to capture the ventricle

# Optimizing AV Delay – Ritter Method

- Not fully described in recommendations document
- Analyze LVIT and LVOT Doppler PW or CW
- Short AV delay (50 msec)
- Long AV delay (200-250 msec)
- Analyze data and arrive at appropriate delay

# Optimizing AV Delay – Iterative Method

- Simpler than Ritter Method
- Start at 200 msec AV delay of the pacemaker, and record at 20 msec progressive decrements
- Optimum
  - best separation of LVIT E and A waves
  - A wave flow stops about 40-60 msec before QRS onset
- Technique: place sample volume closer to MV annulus from leaflet tips to record good MV closing click; high sweep speeds; low filter settings
- Alternate method – use LVOT Doppler to estimate stroke volume and find optimal settings



# Optimizing AV Delay

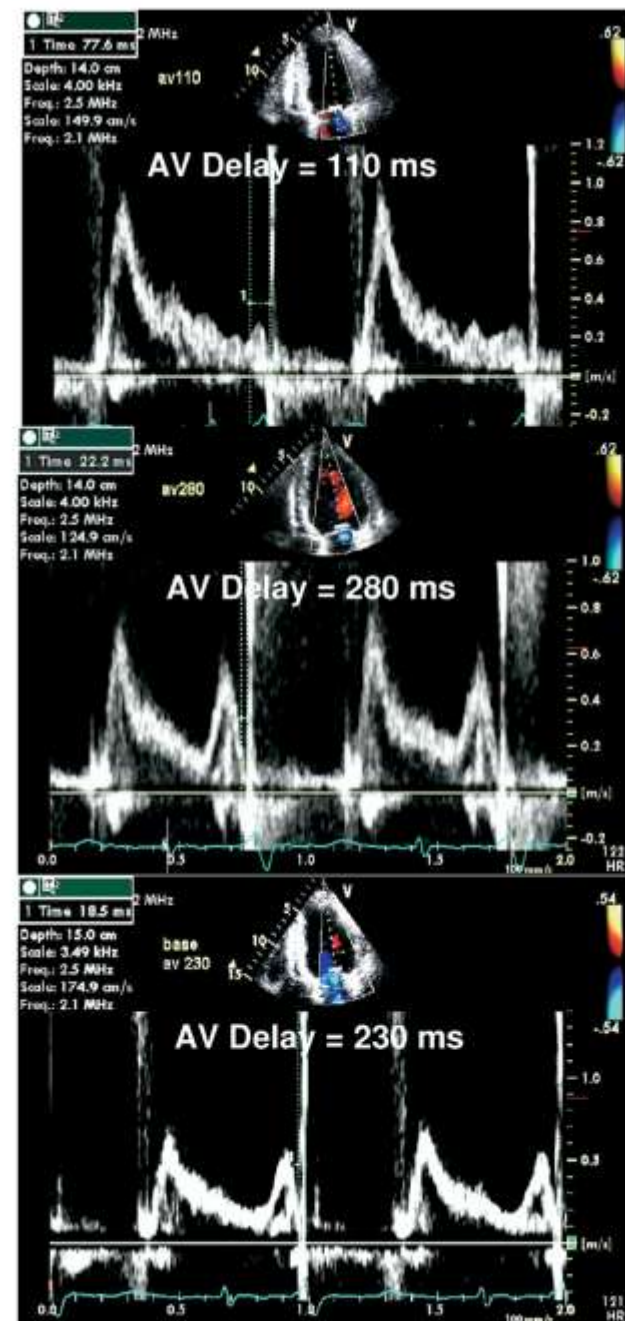


Figure 13 Atrioventricular optimization using mitral inflow velocities in patient with intra-atrial conduction delay. Default setting of 110 milliseconds resulted in loss of mitral inflow A wave (top). Delays of 280 milliseconds (middle) and 230 milliseconds (bottom) improved filling with contribution of atrial component. Alignment of mitral closure click with end of A wave was believed to be optimal with 230-millisecond delay.

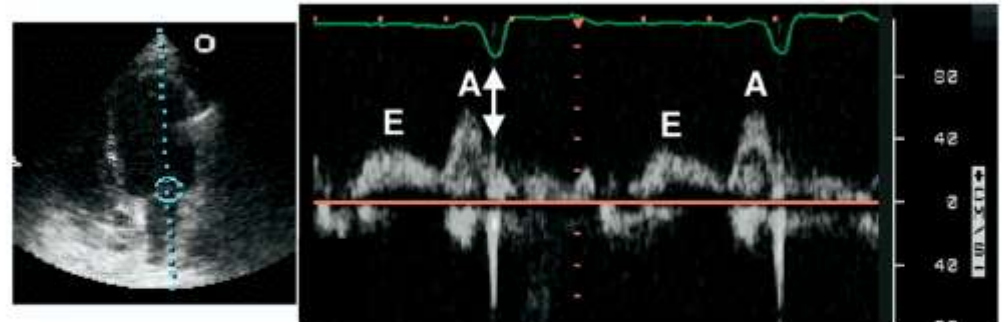


# Optimizing AV Delay – Simple Method

- Optimize ECG signal
- Optimize LVIT signal with high sweep speed, low filters, and sample volume near MV annulus
- Examine LVIT pattern
  - No optimization needed if
    - E and A are clearly separated and
    - A wave terminates at least 40 msec before MV click or onset of QRS
  - Optimization needed if
    - A not identified
    - E and A are merged
    - A is truncated by MV closure

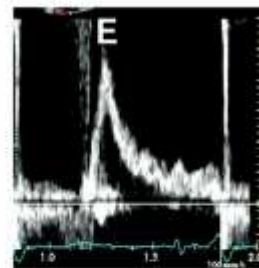
# Optimizing AV Delay

## Simplified AV Delay Screening



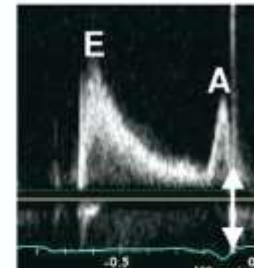
### Satisfactory AV Delay

1. E and A Waves Separated
2. Termination of A after QRS onset or Mitral Closure Click Aligned With End of A and QRS Complex.



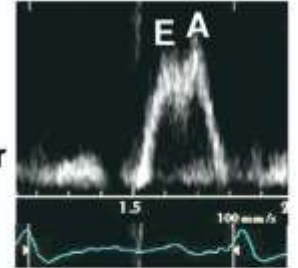
**Absent A Wave**  
*AV Much Too Short*

or



**Truncated A Wave**  
*AV Too Short*

or



**Merged E and A**  
*AV Too Long*

### AV Optimization

Figure 14 Simplified atrioventricular (AV) delay screening using mitral inflow Doppler velocities. Sample volume is placed within mitral valve to see closure click. AV optimization may not be necessary if E and A waves are separated, and termination of A wave is before QRS onset or mitral closure click aligned with end of A and QRS complex (usually type I diastolic dysfunction with E lower than A) (top). AV optimization is indicated if A wave is truncated, E and A waves are merged, or A wave is absent (bottom). Optimization may be considered if stage II (pseudonormal) or stage III (restrictive) diastolic filling patterns are present.

# Optimizing Ventricular Conduction

- Newer CRT pacemakers have ability to vary the timing between the RV lead and the LV lead (V-V timing, or V-V optimization)
- Optimization procedure
  - Vary the V-V interval in 20 msec increments
  - Measure the LVOT VTI at each setting
- Studies show acute benefit
- Long-term benefit not known

# Dyssynchrony with Normal QRS Duration

- Recent trial showed no benefit with CRT in dyssynchronous LV with normal QRS duration (RethinQ)
- Some subsets showed some beneficial effects
- If future trials show clear benefit, echocardiography may become crucial in assessment of these patients, although other imaging modalities could also be used

# Clinical Application of Dyssynchrony Analysis

- If the patient meets clinical and ECG criteria for CRT, dyssynchrony analysis should not be used to withhold CRT

# Clinical Reporting of Dyssynchrony Analysis

- TD opposing wall delay in A4C or ALA views >65 msec or Yu index >33 msec
- IVMD >40 msec
- Radial dynamics, M-mode assessment in non-ischemic disease, speckle tracking radial strain >130 msec

# Clinical Reporting of Dyssynchrony Analysis

- “We advise that the dyssynchrony reporting should not include a recommendation whether a patient should undergo CRT, as this should be a clinical decision on a case-by-case basis for these borderline or challenging cases.”