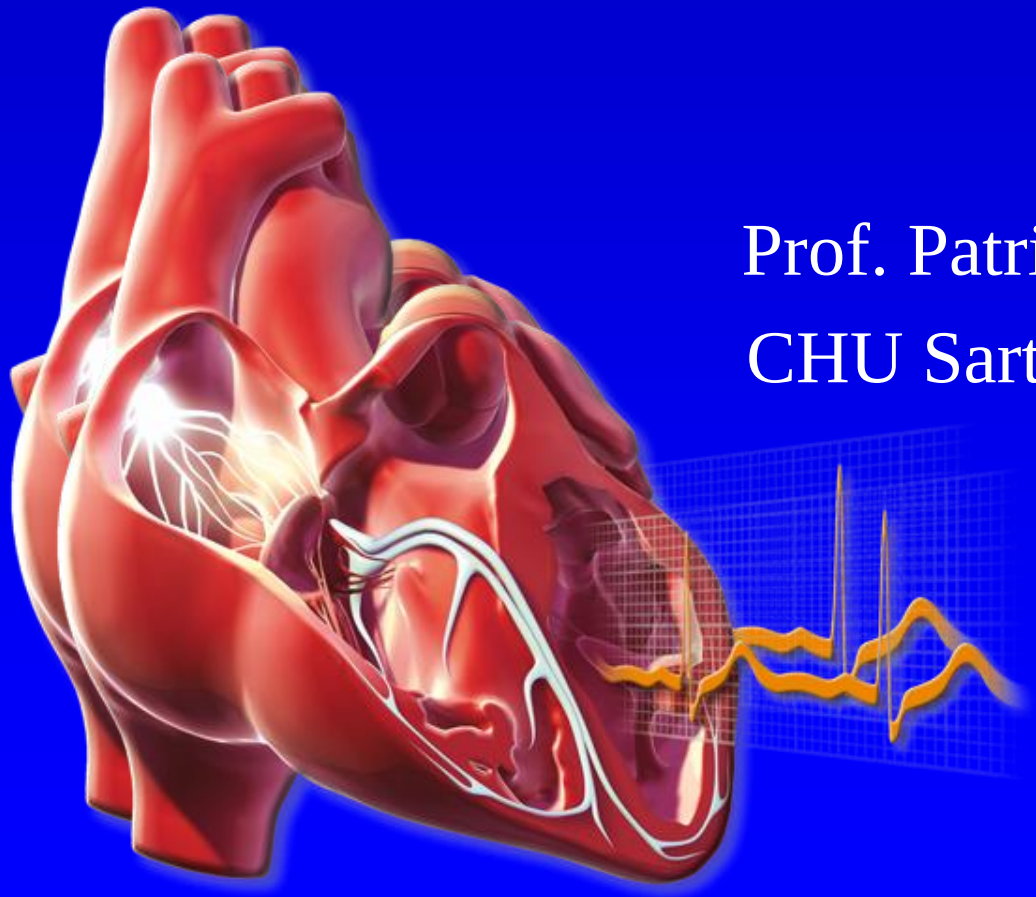
Cardiac Resynchronization Therapy
Selection therapy Echocardiography



Prof. Patrizio LANCELLOTTI
CHU Sart Tilman, Liège

April , 2010

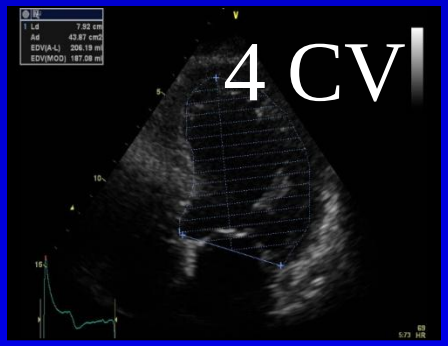
Candidates for CRT : class IA

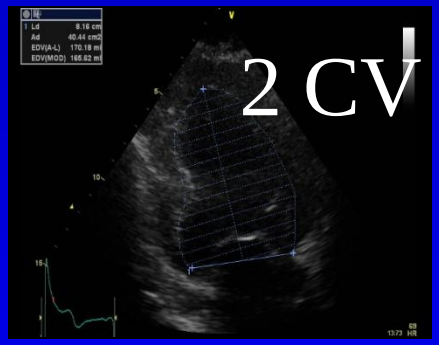
- NYHA Functional Class III or IV (Subjective)
- QRS duration > 120 ms (> 150 ms usually considered)
- LVEF < 35% (overestimated in case of MR)
- Stable HF medical treatment for ≥ 1-month
- All Guidelines are unanimous in defining who should receive CRT

BUT > 30% of patients are “nonresponders”

EVALUATION OF LV FUNCTION AND SIZE

Modified Simpson's Method of discs



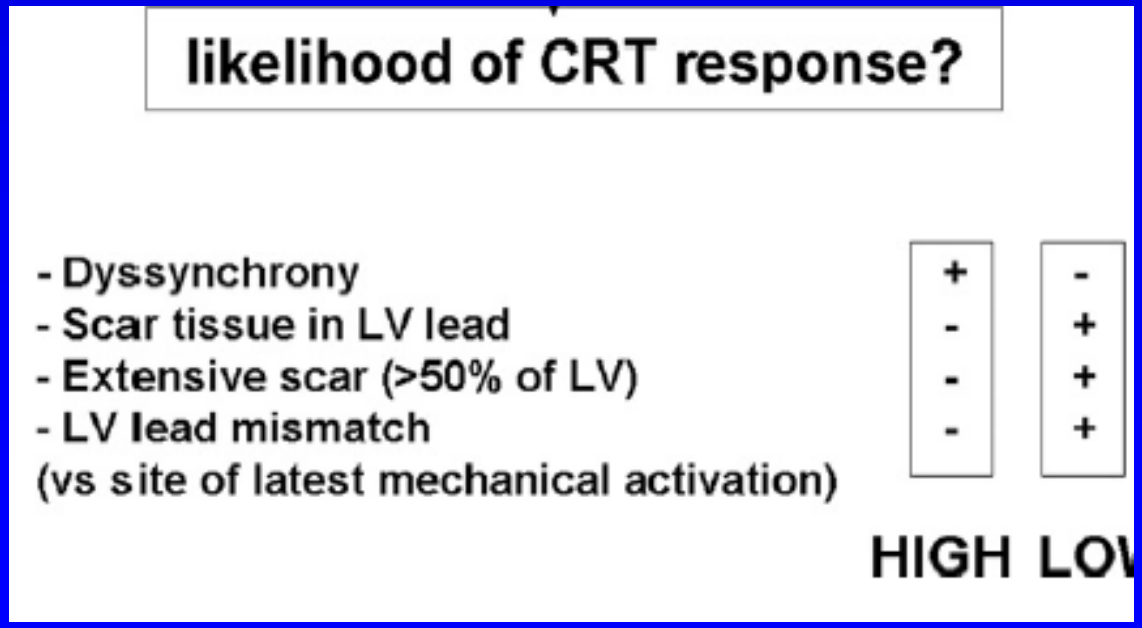


- Endocardial Border ?
- Load dependent
- Geometric assumptions
- Foreshortening in 90%

PROSPECT STUDY
20% had LVEF > 35%

Causes of 30% CRT nonresponse

- Inappropriate patient selection
- Inappropriate lead position
- Lead in front of necrotic tissue in ischemic pts
- Non optimal AV and/or VV delays

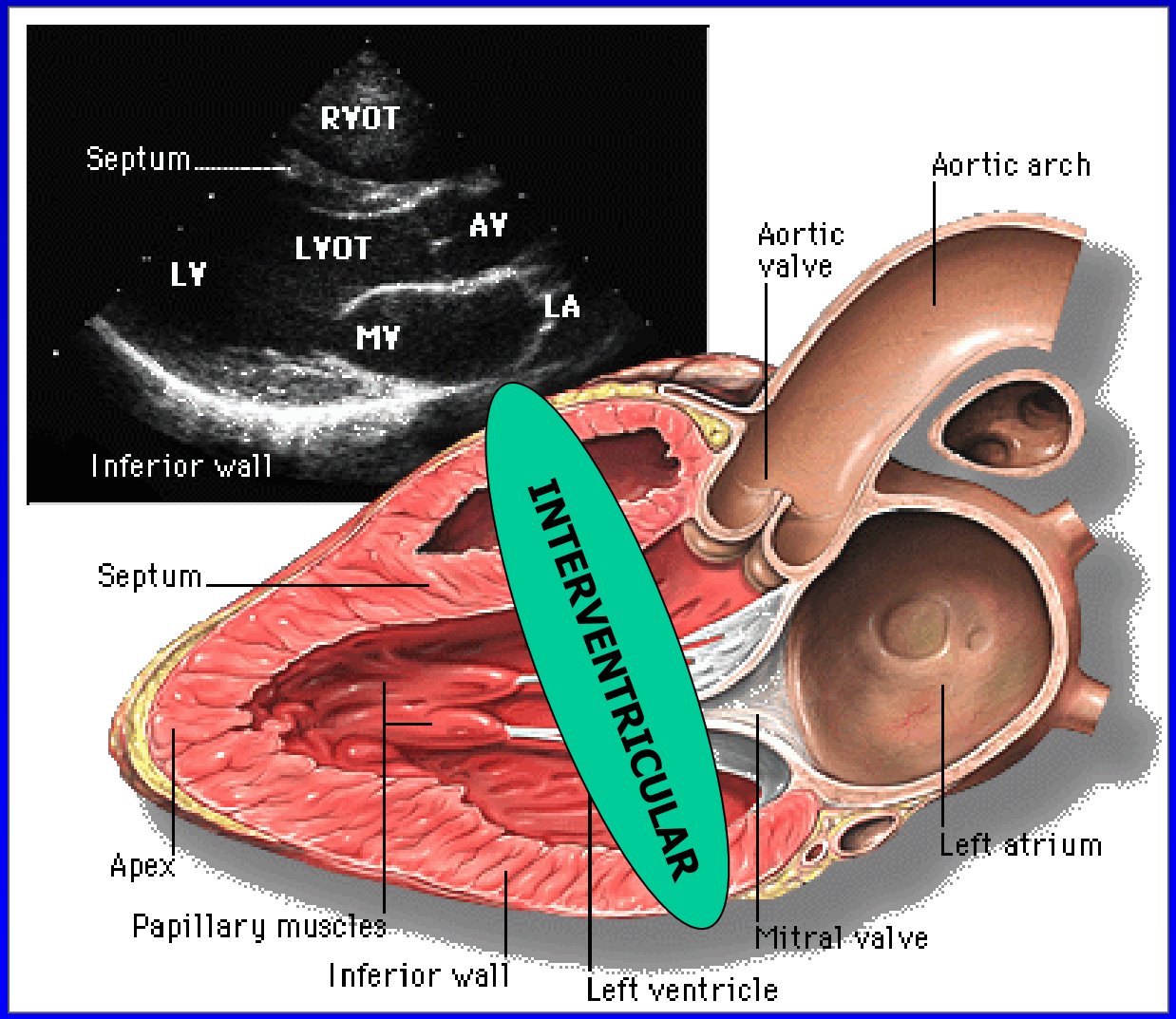


Evaluate cardiac dyssynchrony "globally":

1. Atrio-ventricular dyssynchrony,
2. Inter-ventricular dyssynchrony,
3. Intra-ventricular dyssynchrony.

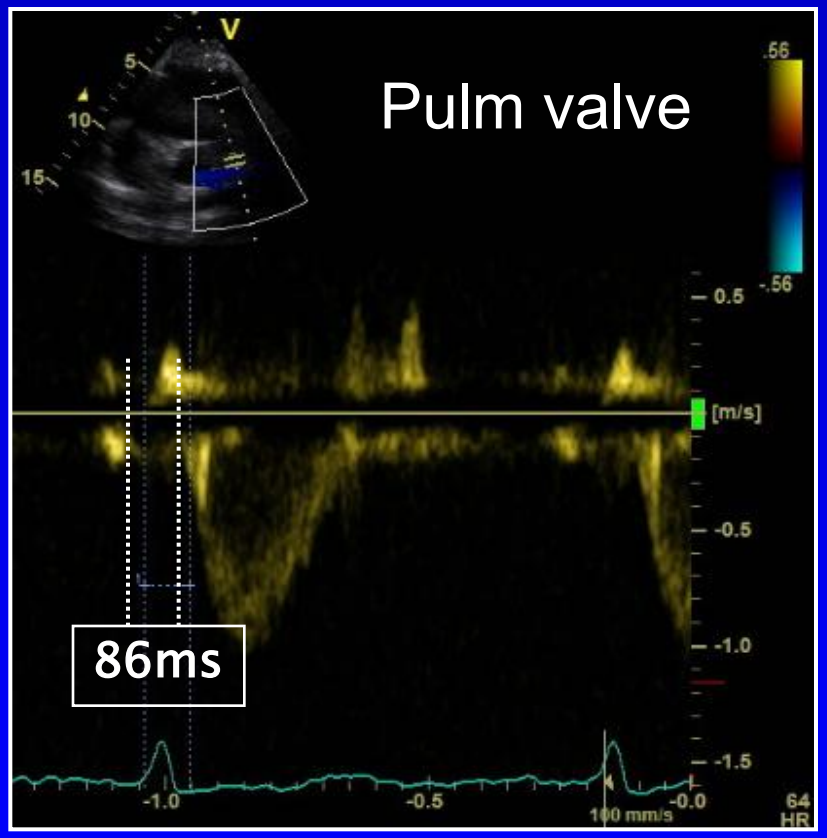
- **Because there is no clear demonstration that only intra-v dyssynchrony is useful.**

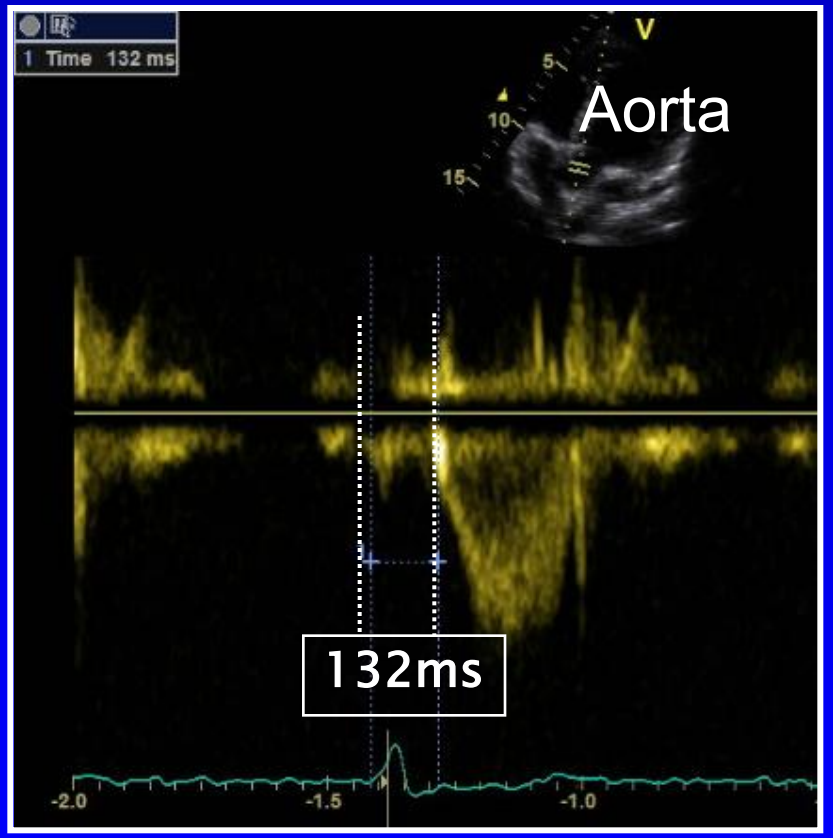
Inter-Ventricular dyssynchrony



Normal physiologic delay

Interventricular Asynchrony
inter-ventricular mechanical delay (IVMD)



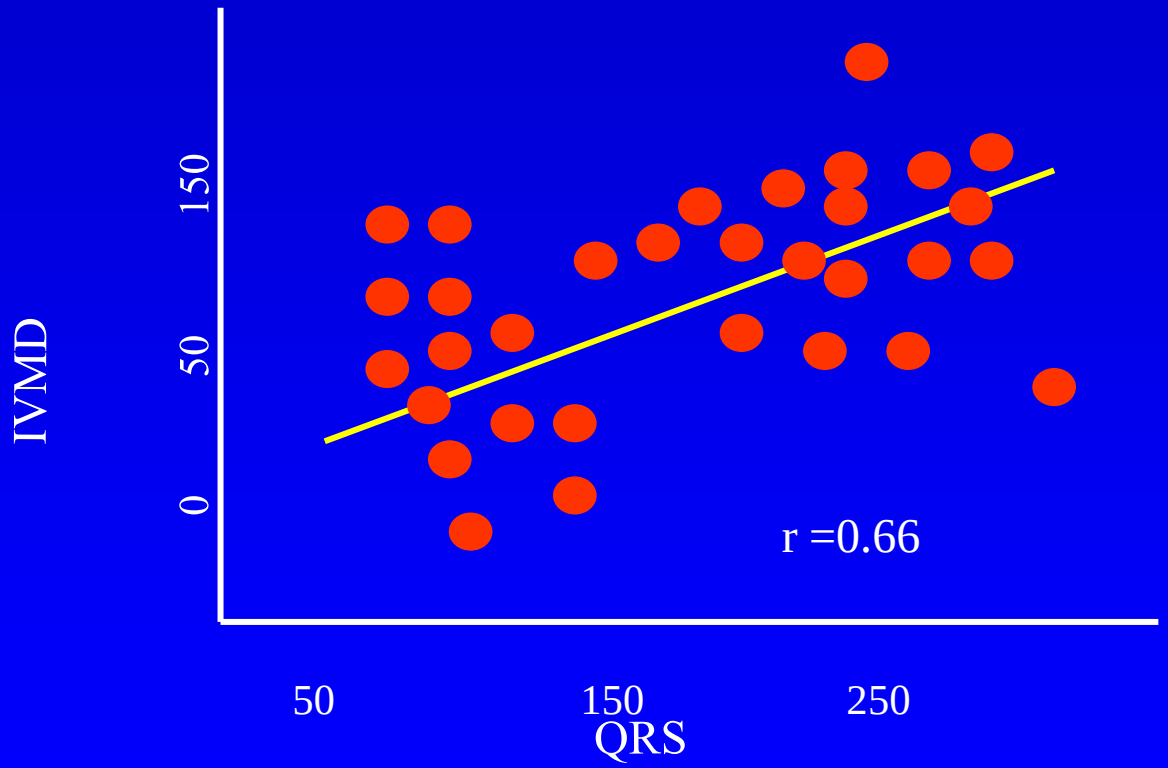


$IVMD = LV_{PEI} - RV_{PEI} = 48ms$

Significant when > 40 ms

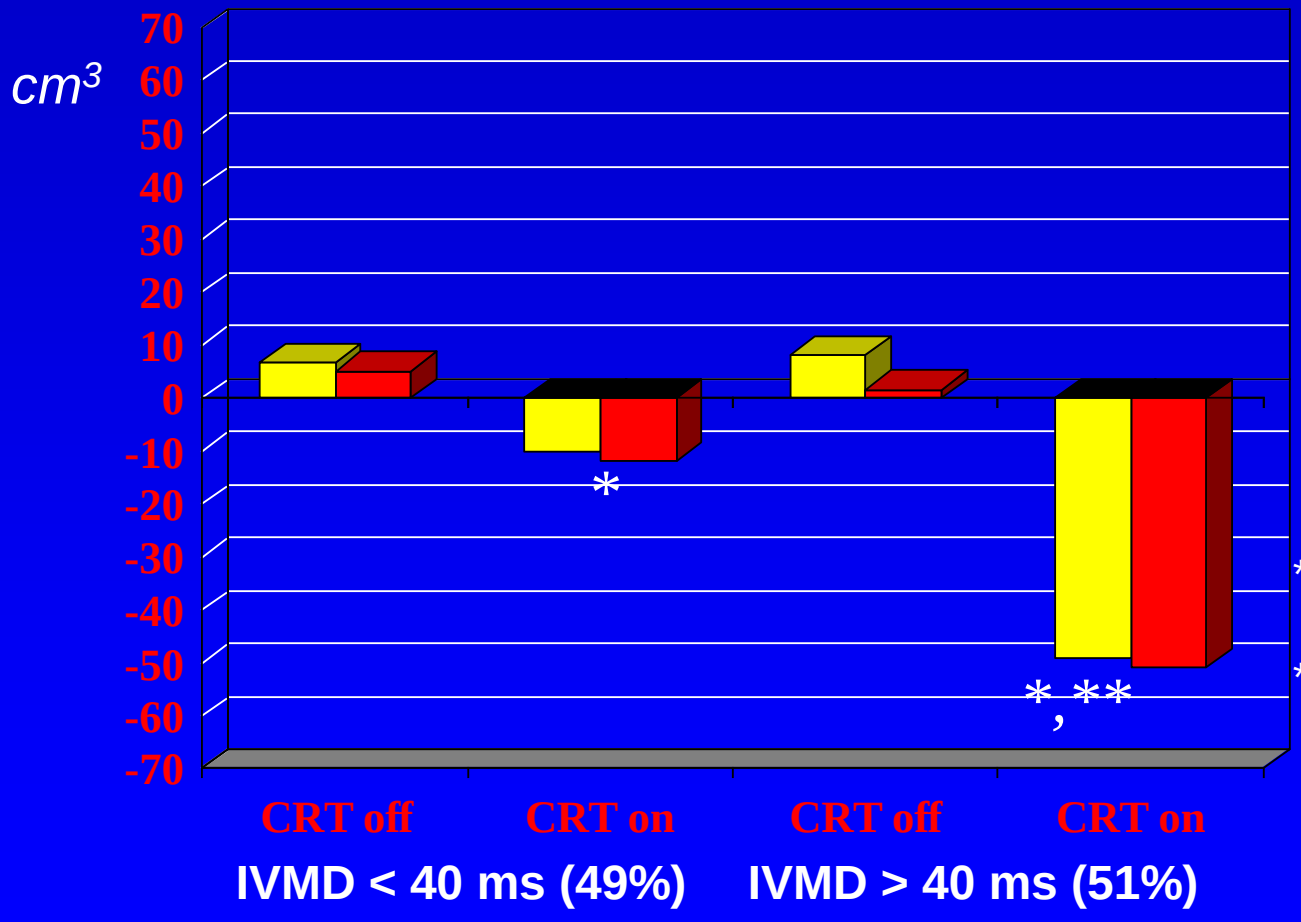
Rouleau et al., PACE 2001

Patient selection : Currently based on electrical, but not mechanical dyssynchrony assessment



Ghio. Eur H J 2004;25:571

Interventricular delay and response to CRT



Miracle study
N = 279 pts
FU = 6 months

delta LVEDV
delta LVESV

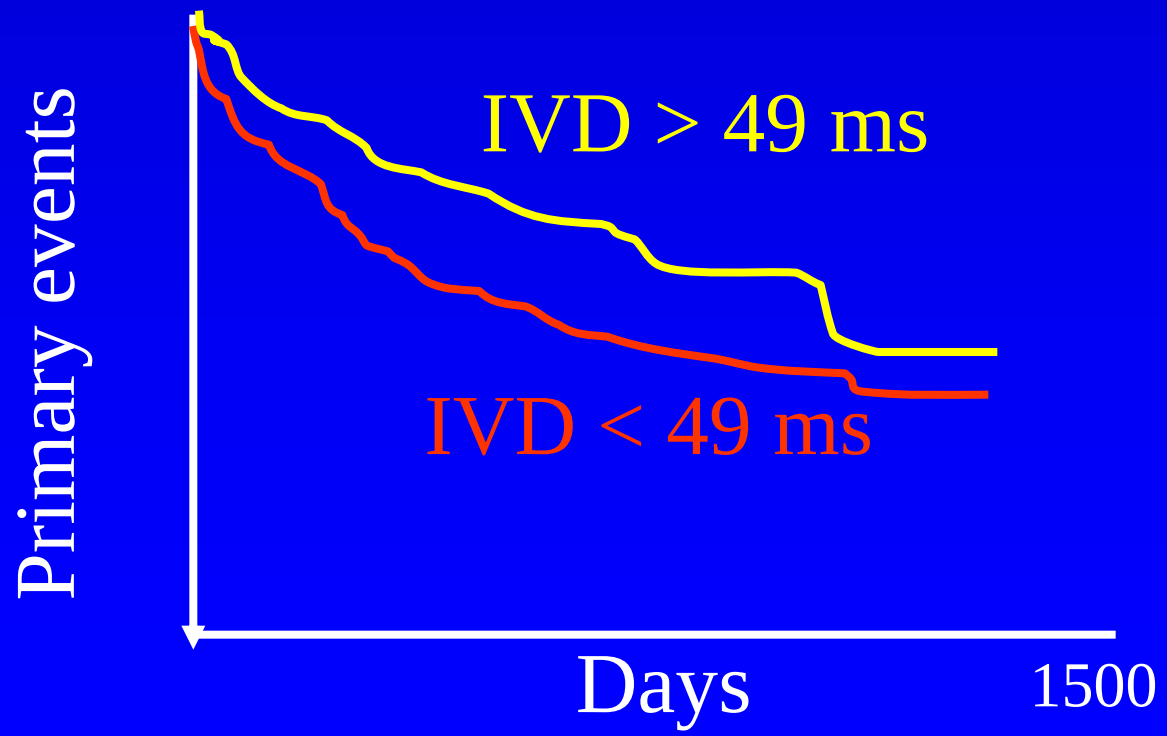
**:p<0.05 CRT off vs on*

***:p<0.05 IVMD<40ms vs IVMD>40ms*

Adamson PB et al, AHA 2002

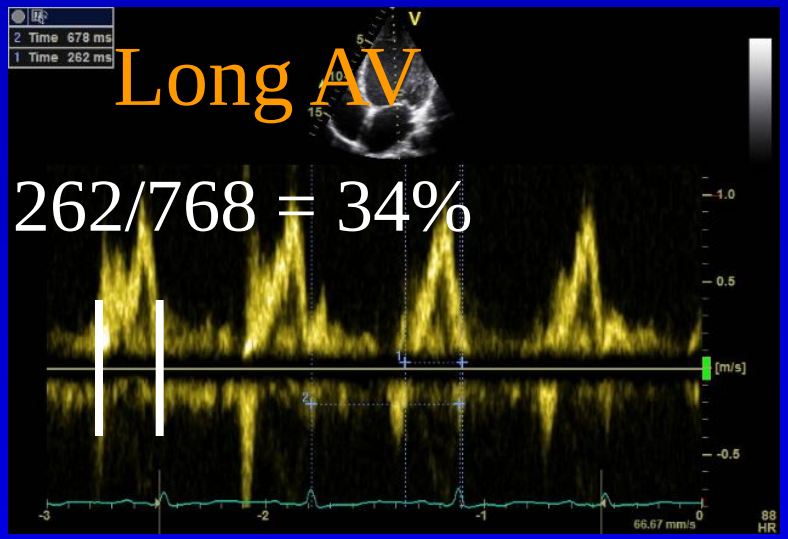
Predictors and treatment response with cardiac resynchronization therapy in patients with heart failure characterized by dyssynchrony: a pre-defined analysis from the CARE-HF trial

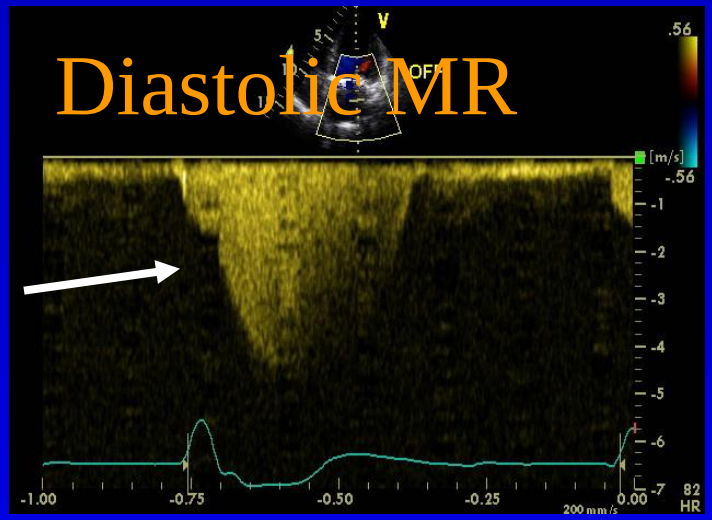
CI 0.98–1.00). The benefits of cardiac resynchronization were modified by systolic blood pressure and interventricular mechanical delay (IVMD). Patients with increasing systolic blood pressure appear to receive reduced benefit from CRT (HR 1.02, 95% CI 1.00–1.03), whereas those patients with more severe IVMD appear to benefit more from treatment (HR 0.99, 95% CI 0.98–1.00).



EHJ 2007

AV Dyssynchrony





AV asynchrony < 40 %

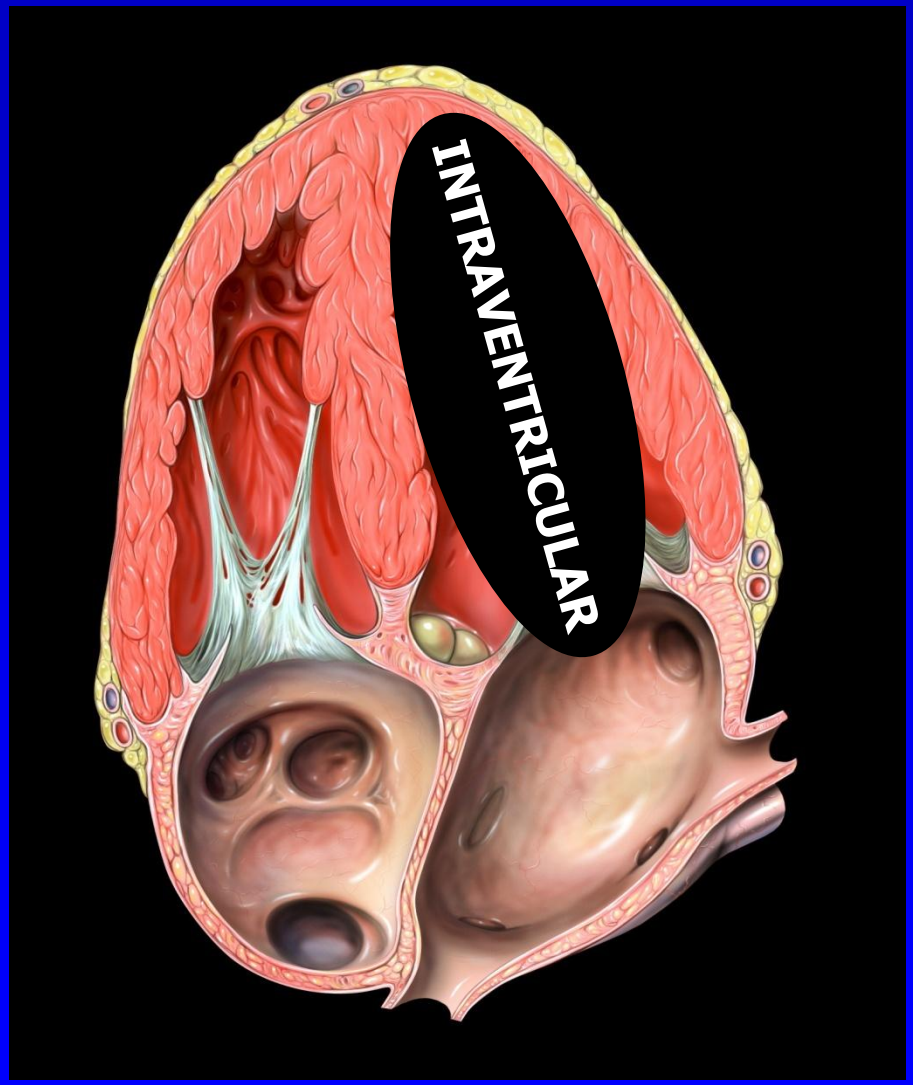
Correction of AV delay

→ LV remodeling

(short > long AV ?)

C. Parsai, ESC 2007

INTRA-VENTRICULAR ASYNCHRONY



Fauchier. JACC 2002; 40:2022

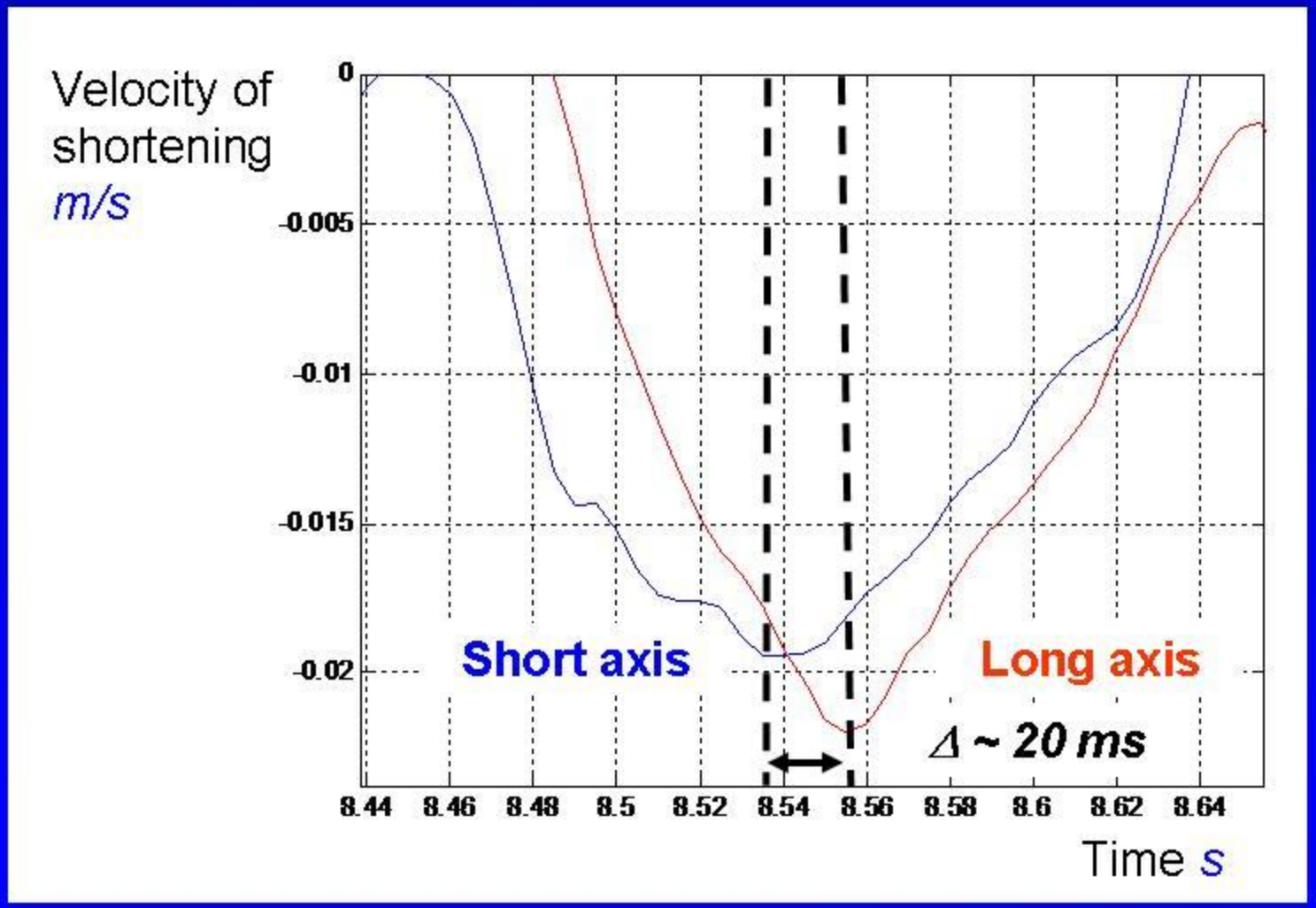
In the *normal heart*, there is spatial and temporal heterogeneity of function

Mechanical dispersion = 40 ms

47 subjects 38-81 yr, ms	Maximal delay
Time to peak systolic velocity	82 ± 47
Time to peak systolic strain rate	183 ± 67
Time to peak systolic strain	202 ± 108
Time to peak systolic displacement	110 ± 96
Time to peak early diastolic velocity	73 ± 36

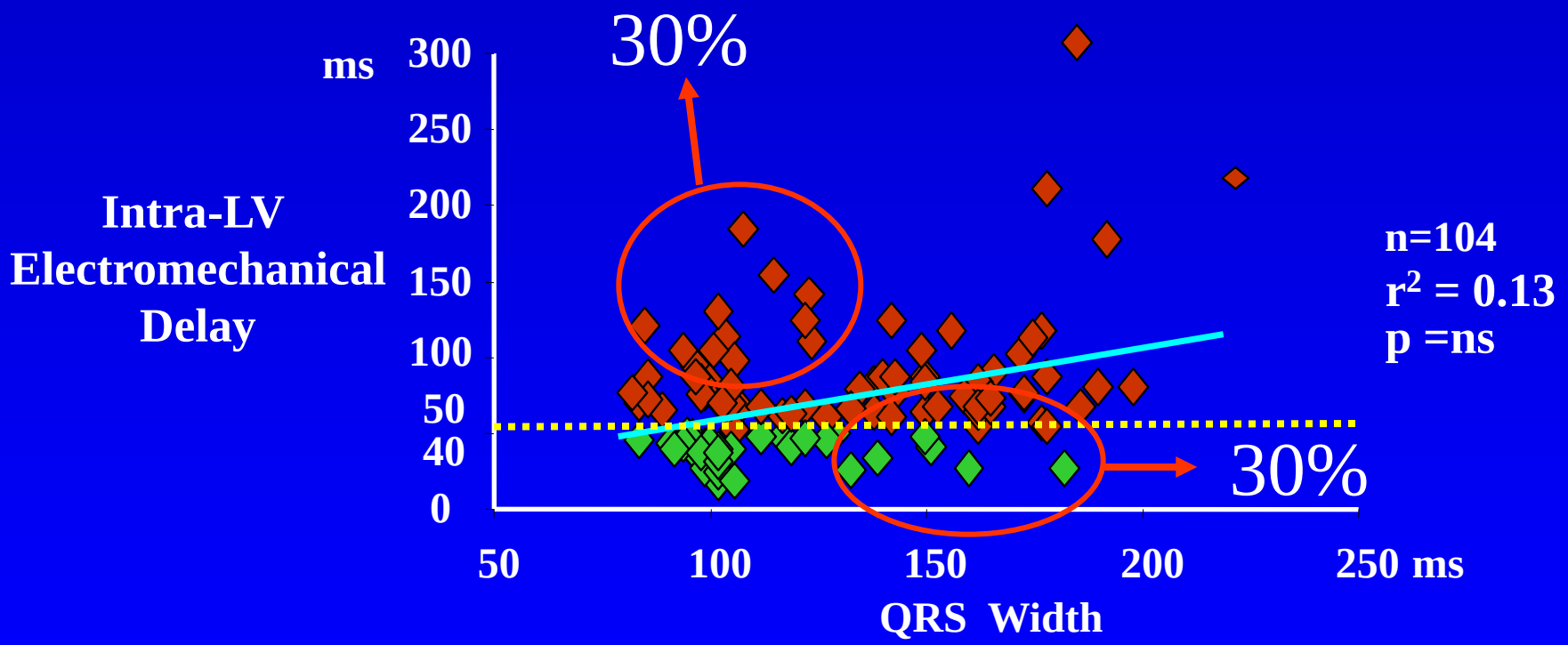
Poerner T et al, Ultrasound Med Biol 2005; 31: 1163

Inhomogeneity of LV systolic function – peak radial shortening precedes peak longitudinal shortening



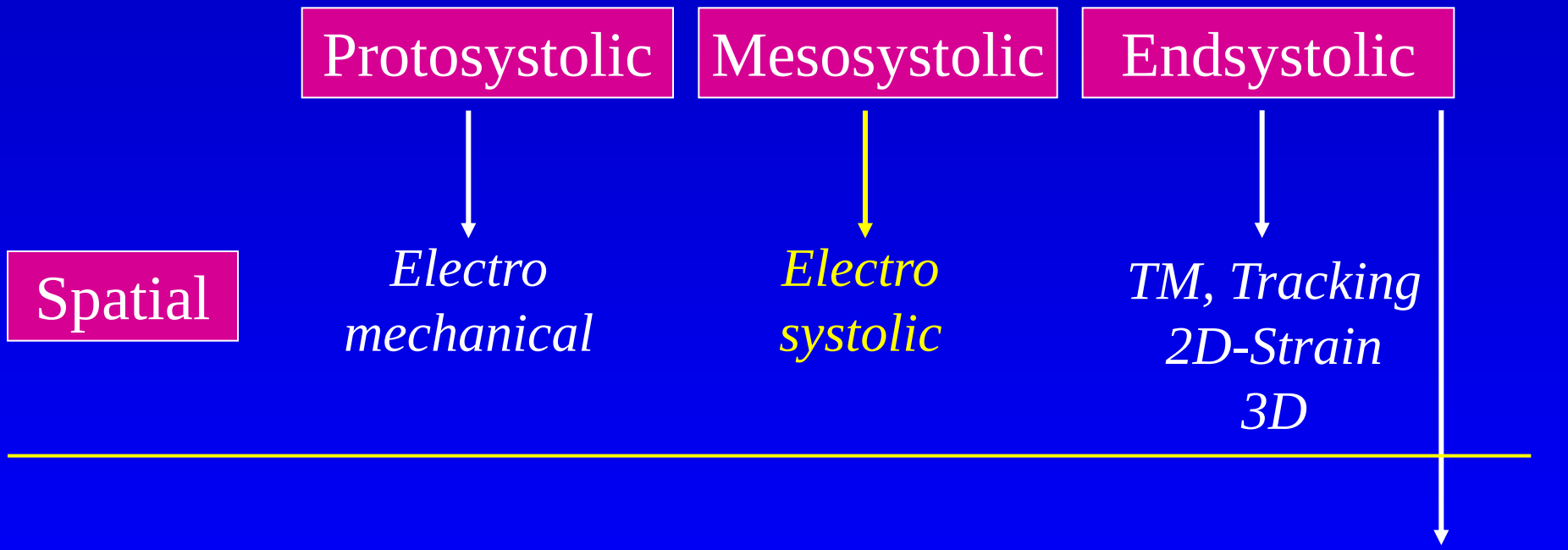
Page C et al, ESC 2007

Patient selection : Currently based on electrical, but not mechanical dyssynchrony assessment

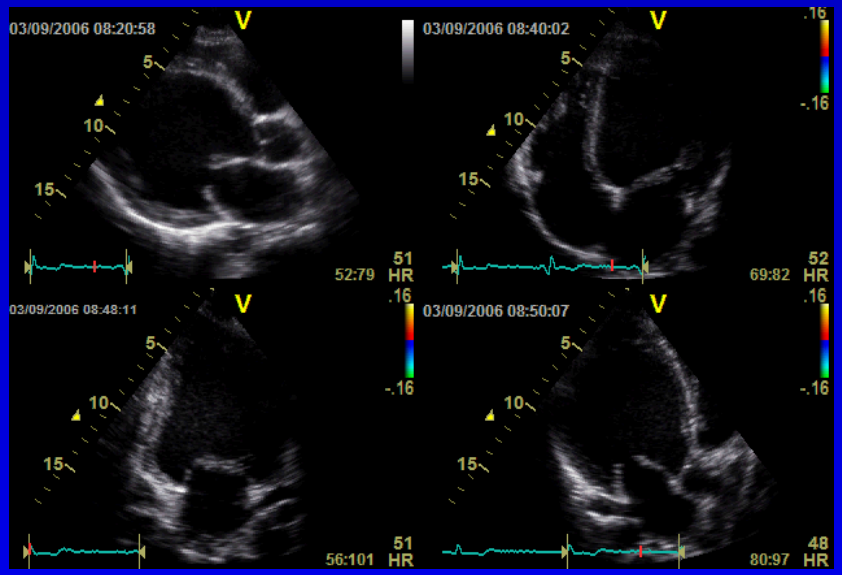


Bader. J Am Coll Cardiol 2004;43:248-56

INTRA-VENTRICULAR ASYNCHRONY



VISUAL INTERPRETATION : Asynchrony ?



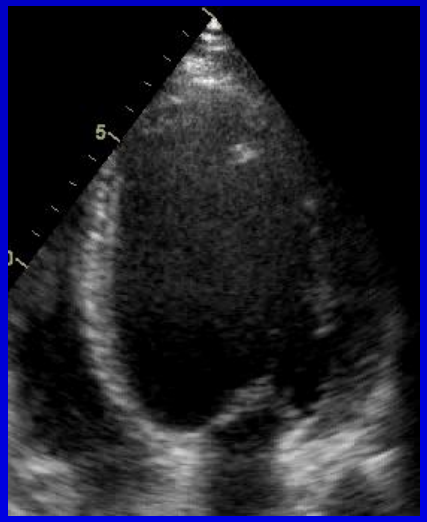
Delays < 70 ms cannot be detected with the human eye

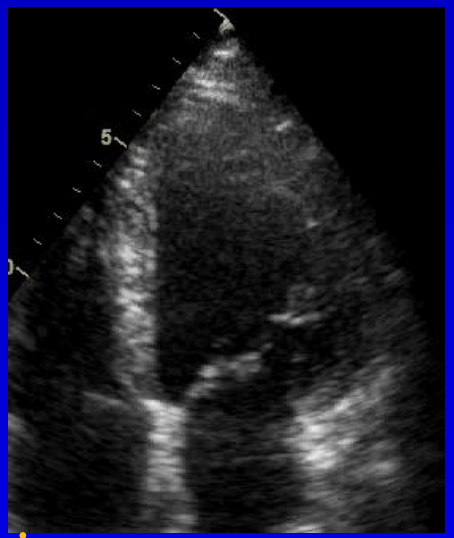
Message: simple visual assessment of LV dyssynchrony is useful (maybe even better than all conventional and TDI measures of dyssynchrony) to predict response to CRT.

Voigt, Szulik et al., 2007

Apical Transverse Motion

Pre-CRT

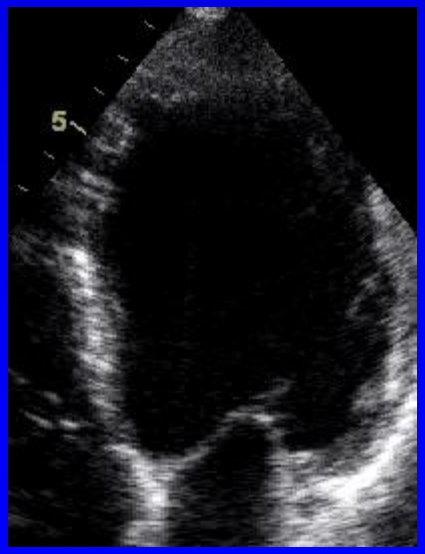


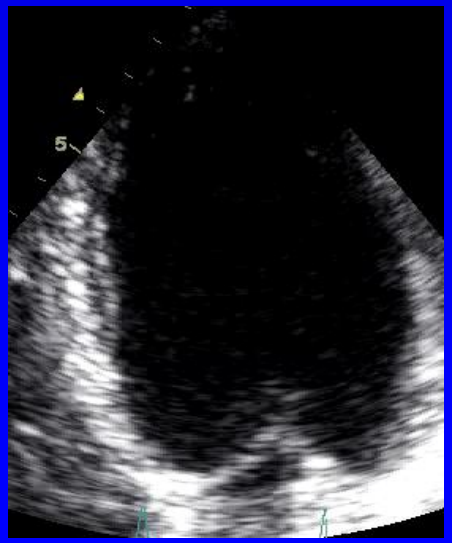


Post-CRT

Rocking

Pre-CRT





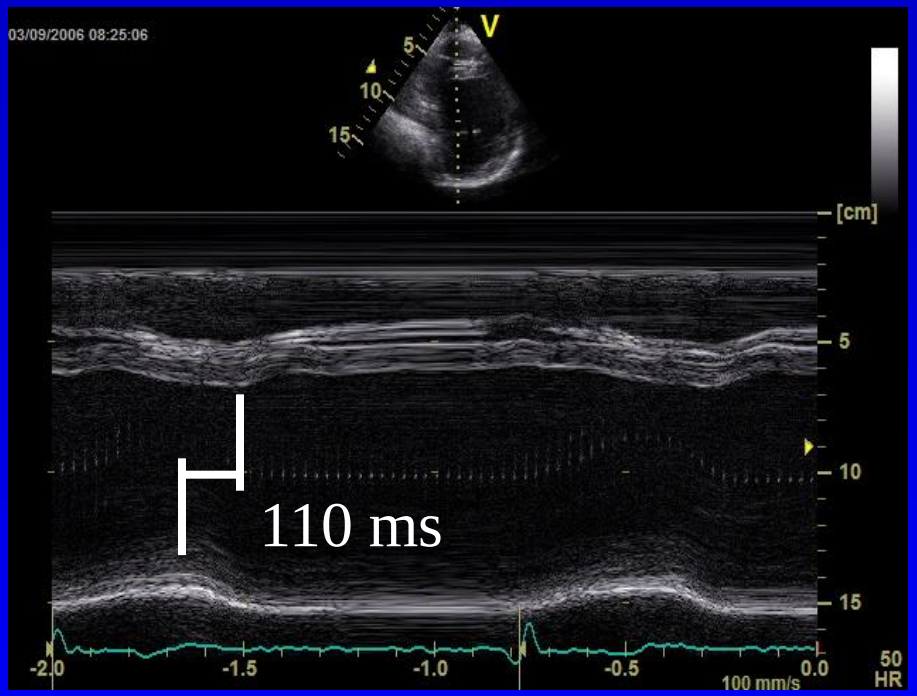
Post-CRT

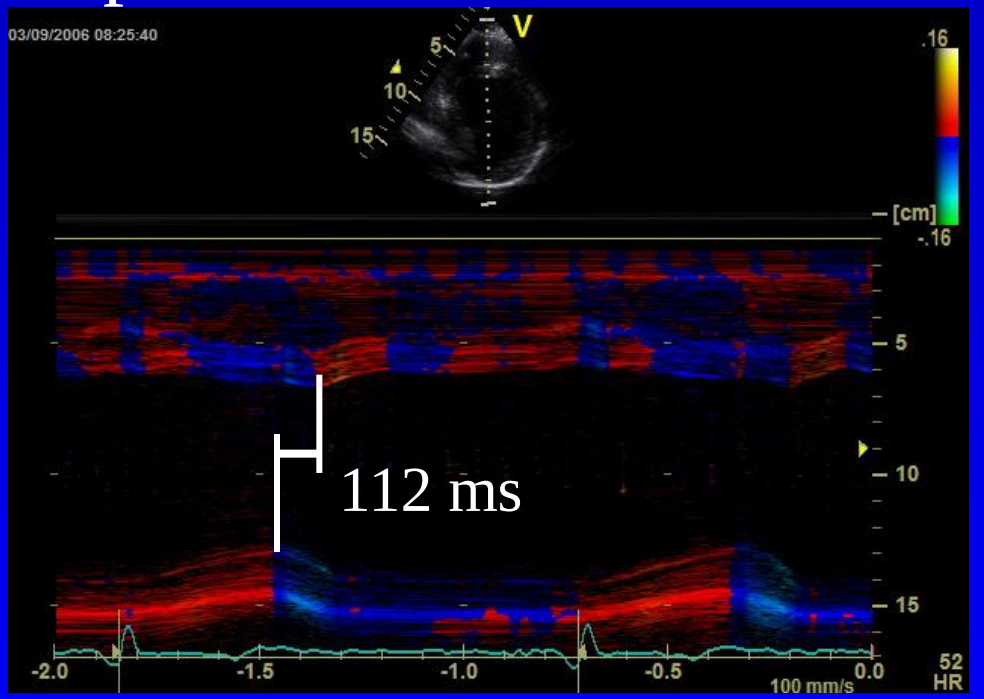
No Rocking

Voigt et al., EHJ 2009

Septal to posterior wall motion delay M-mode or color M-mode

Radial Spatial





Feasible in only 76% of normals and 45% of patients

Predicts reverse remodeling when > 130 ms (specificity ?)

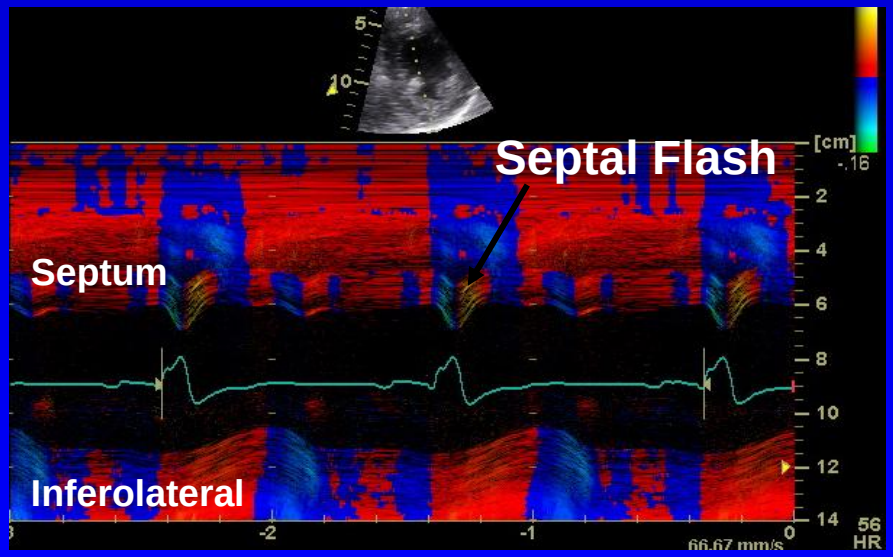
Poor spatial resolution : 1 point in each wall

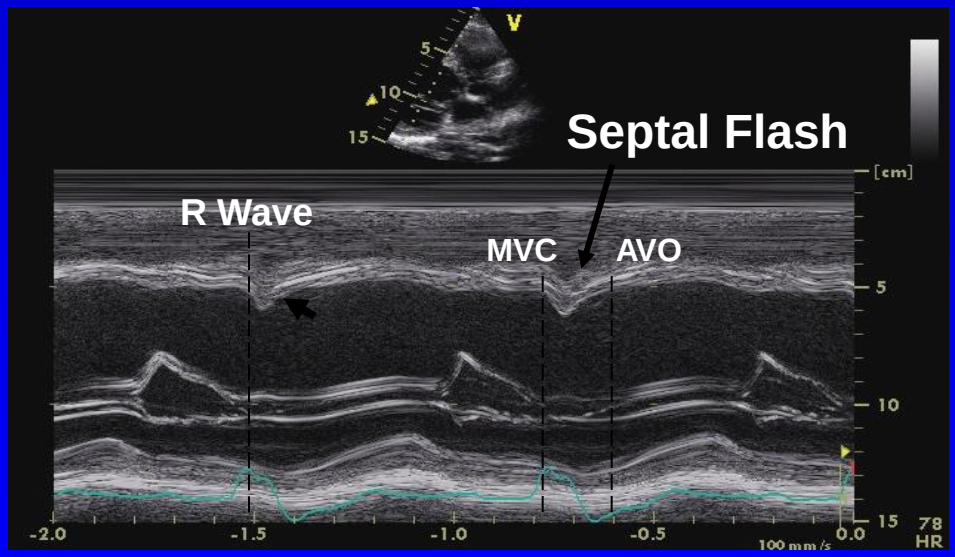
Pitzalis JACC 2005 (n=20), Diaz-Infante AJC 2007 (n=67), Contak CD (n=79)

Septal Flash
M-mode or color M-mode

short, early systolic septal motion

161 patients, multicenter, septal flash rest: Sens 64% , Spec 55%



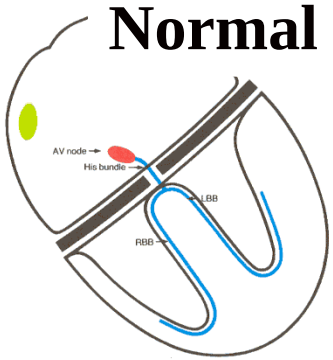


Eliminating the septal flash by CRT predicts LV remodeling (100%)

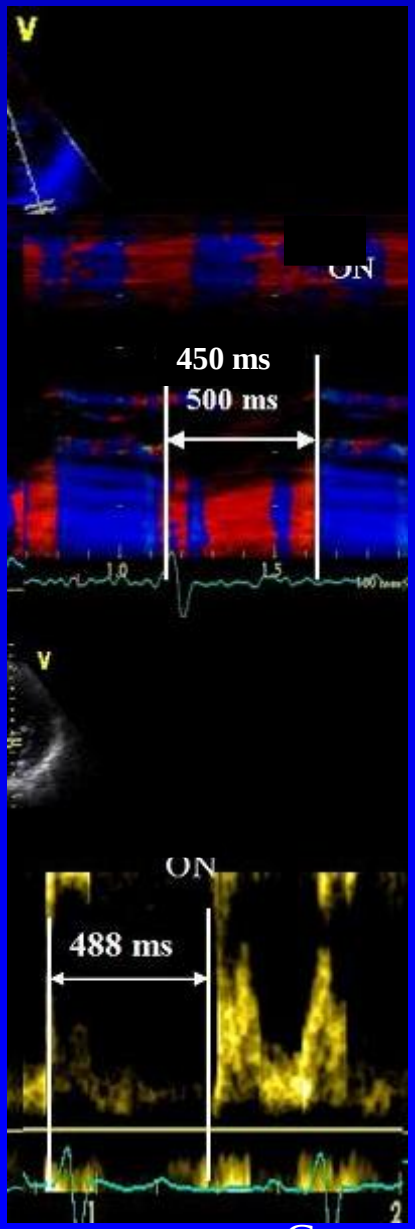
C. Parsai, EHJ 2009

DLC (IDCM) : Longitudinal Temporal
Left lateral wall post-systolic displacement

Normal

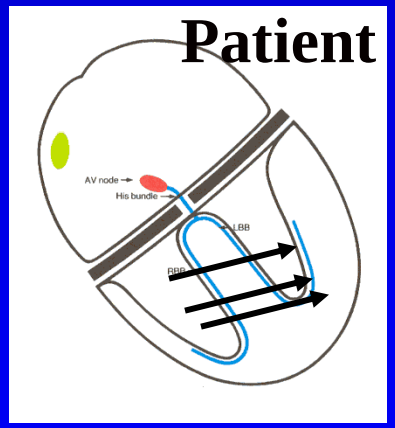


Not assessable in 33%

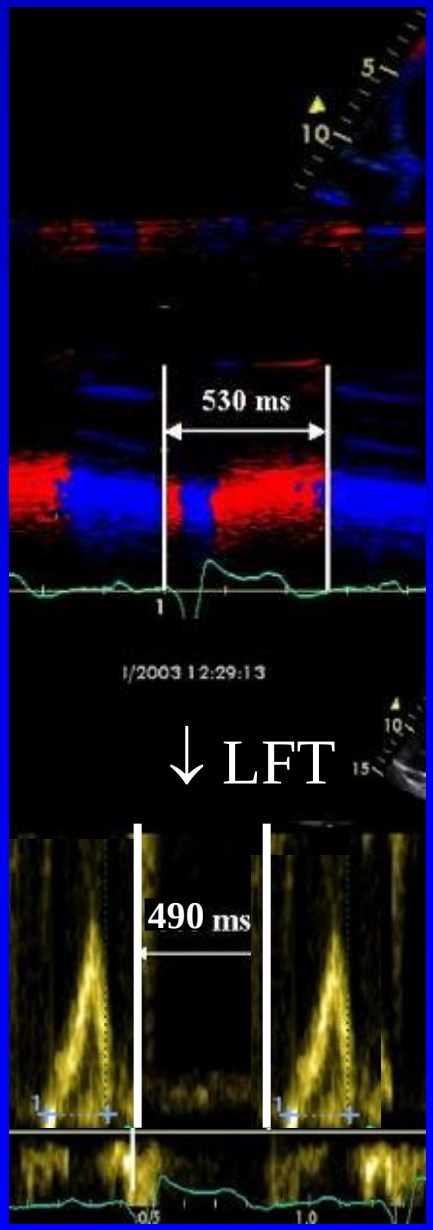


Contraction into early diastole

Patient



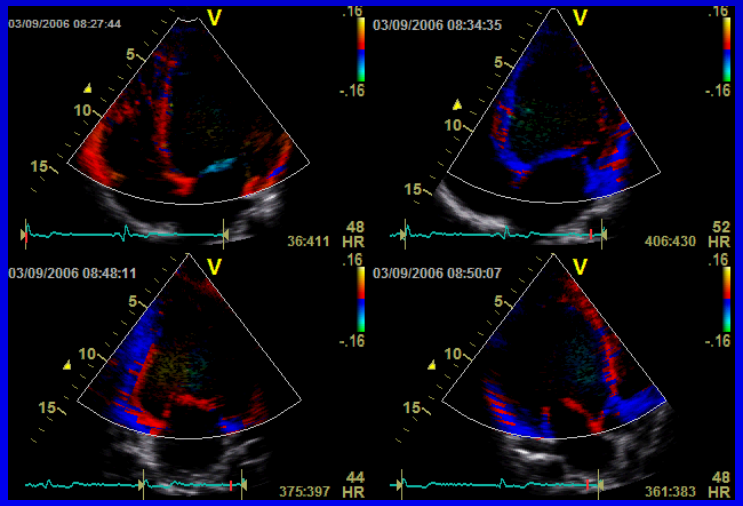
Delay in MV opening

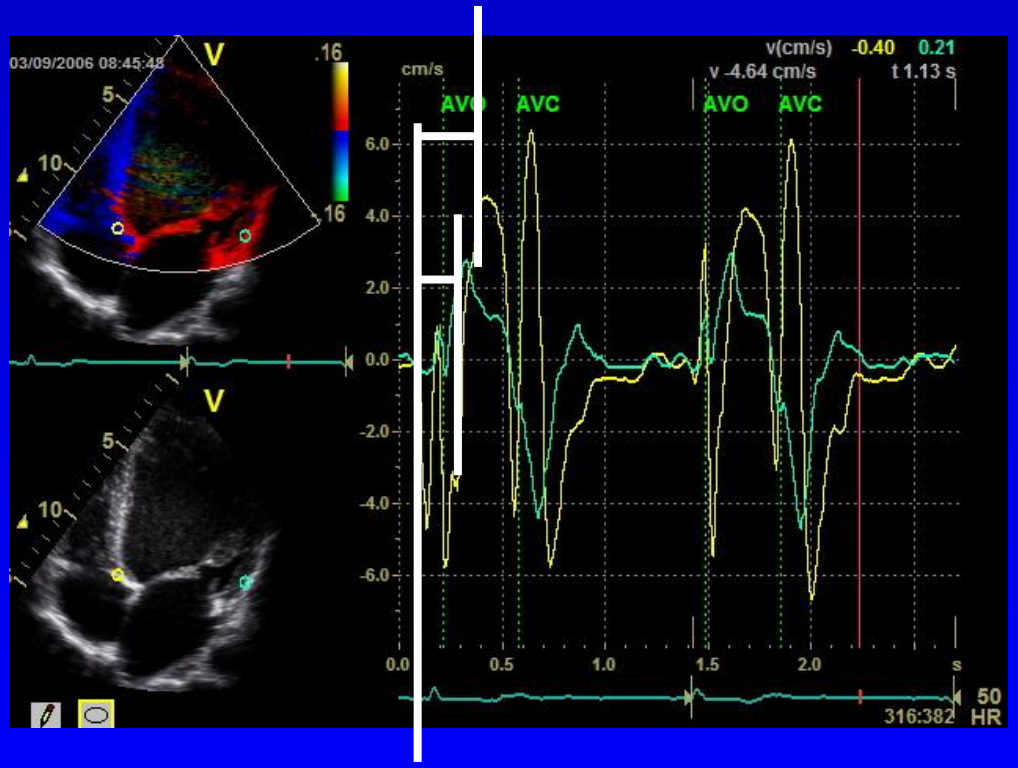


Cazeau Heart 2000, Sassone Am J Cardiol 2007 (n=31)

Color-coded Tissue Doppler Imaging (Longitudinal Spatial)

IDCM : QRS 118 ms

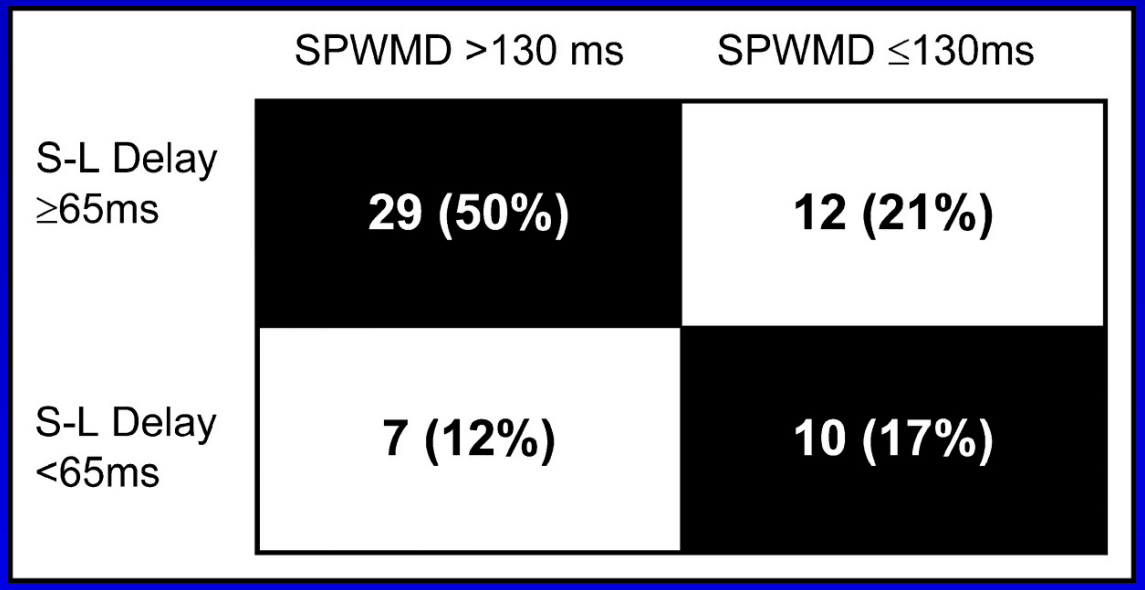




IntraVA = 290 – 180 = 110 ms (> 60 ms Bax AJC 2003)

Septal-lateral delay (n=25) : Sens : 76% Spec : 88% ↑ LV EF

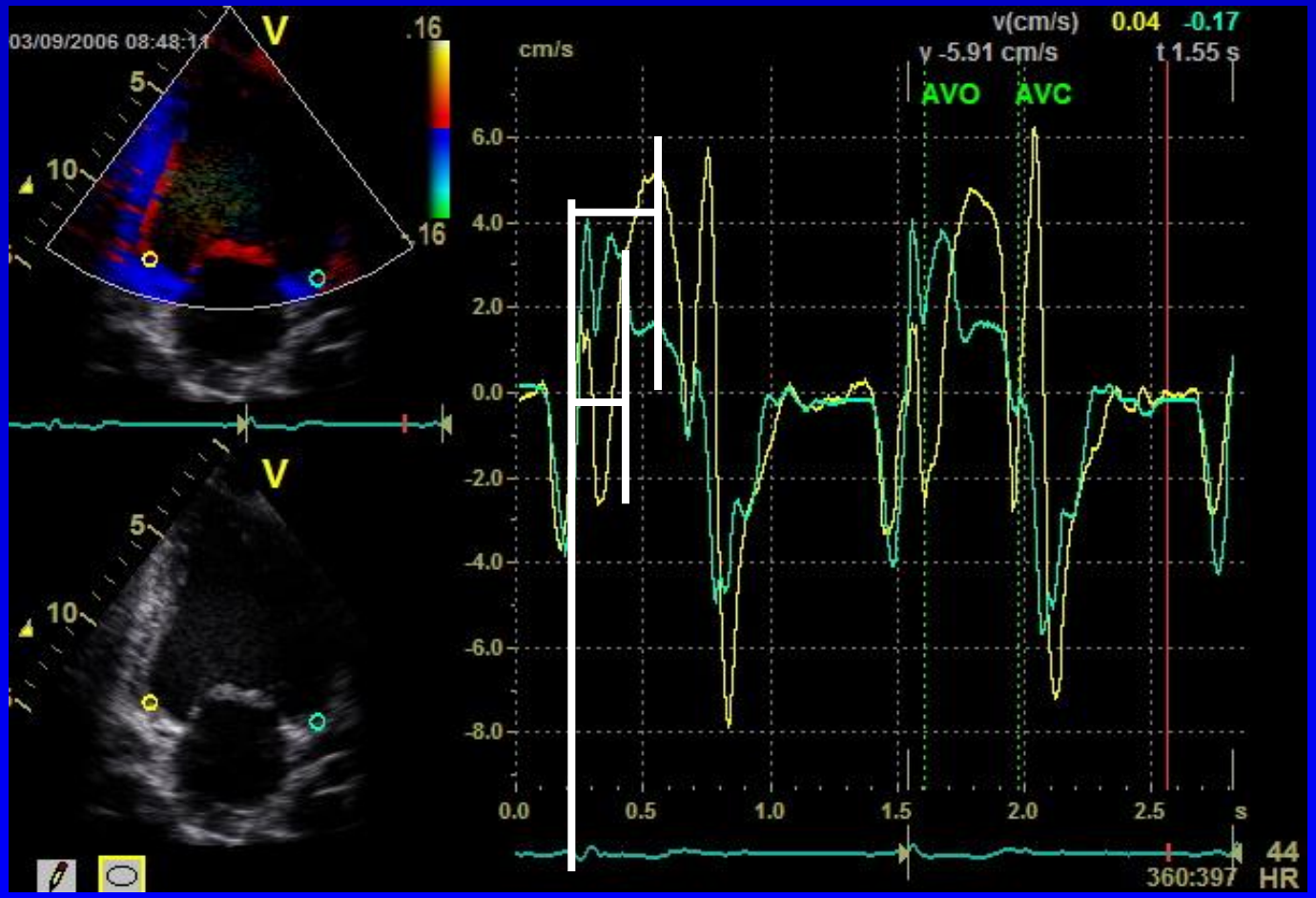
Agreement between SPWMD and SL delay



Response	Septo-to-Lateral delay > 65 ms	SPWD > 130 ms
Sens	90%	66%
Spec	82%	50%

Bleeker Am J Cardiol 2007

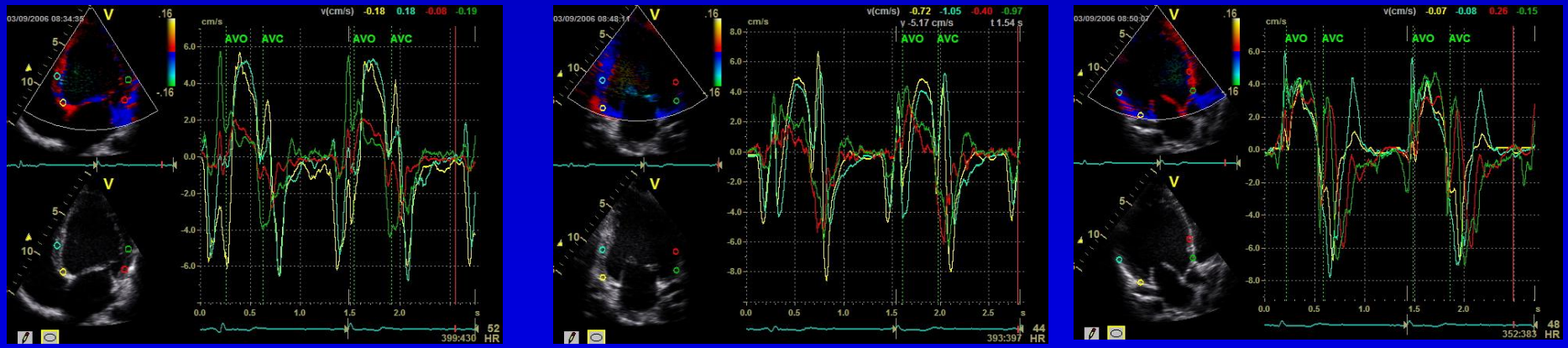
Color TDI: LV dispersion (Longest – Shortest TPS)

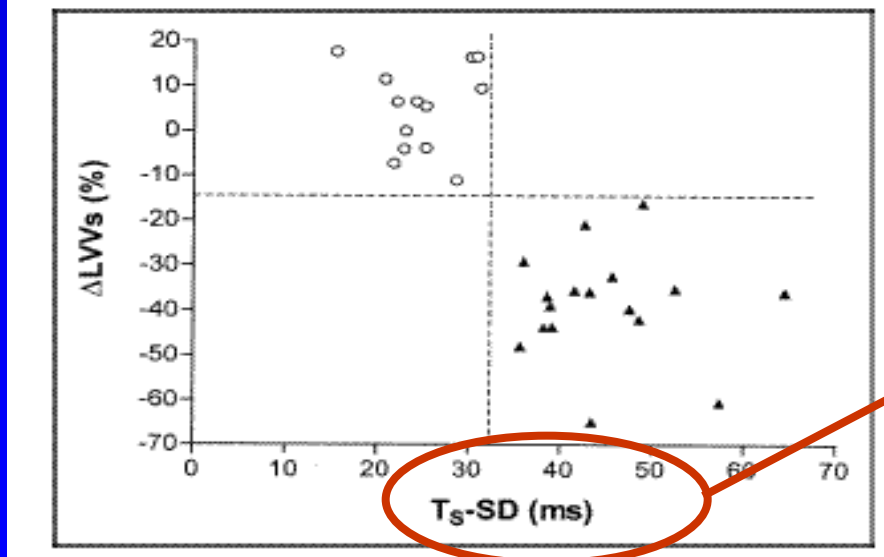


IntraVA = 330 – 160 = 170 ms (> 65 ms Bax JACC 2004)

LV disp (n=85): Sens : 92% Spec : 92% reverse remodeling+outcome

Time to Peak Systolic Velocity: SD of 12 segments





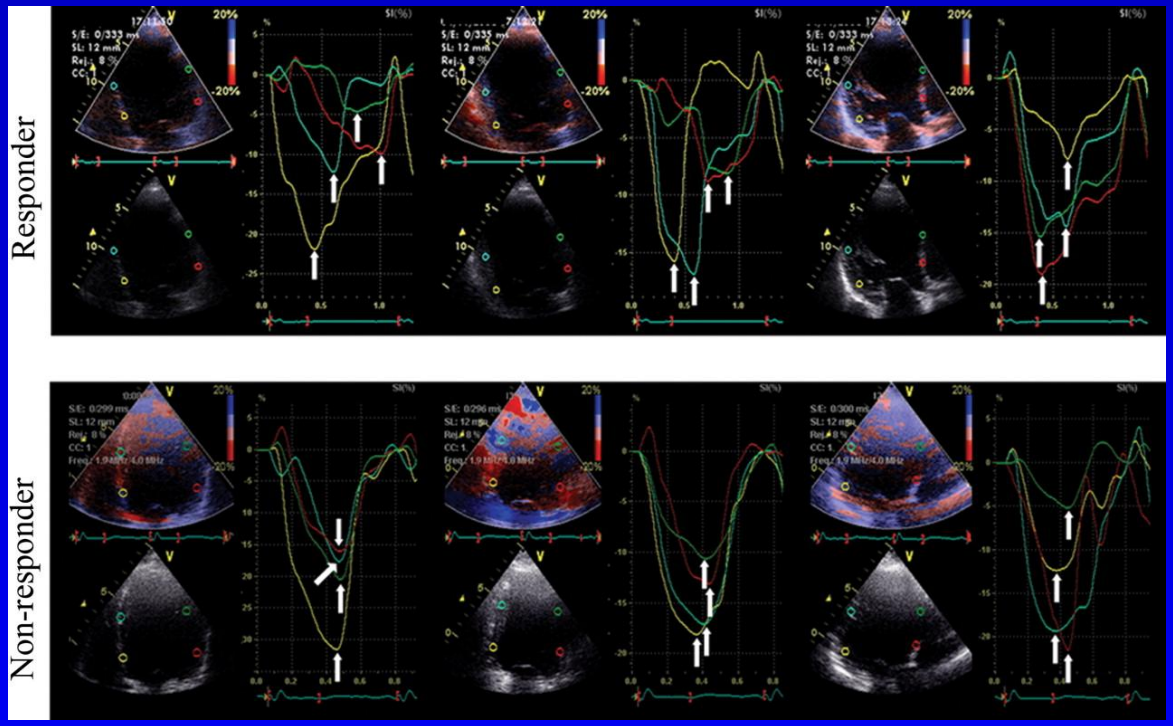
SD-12 = 87 ms

SD>32.6 ms (n=54): predictor of LV reverse remodeling

Sens : 96%, Spec : 78%

Yu et al, Am J Cardiol 2002;91:684-688

Other modalities : Strain



(n=37) SD-$_{12}$ $\geq$ 60 ms

Reverse remodeling

Mele Eur Heart J 2006

(n=59) Exct-$_{12}$ = 760 ms

Sens : 94%, Spec : 83%

For reverse remodeling

Porciani Eur Heart J 2006

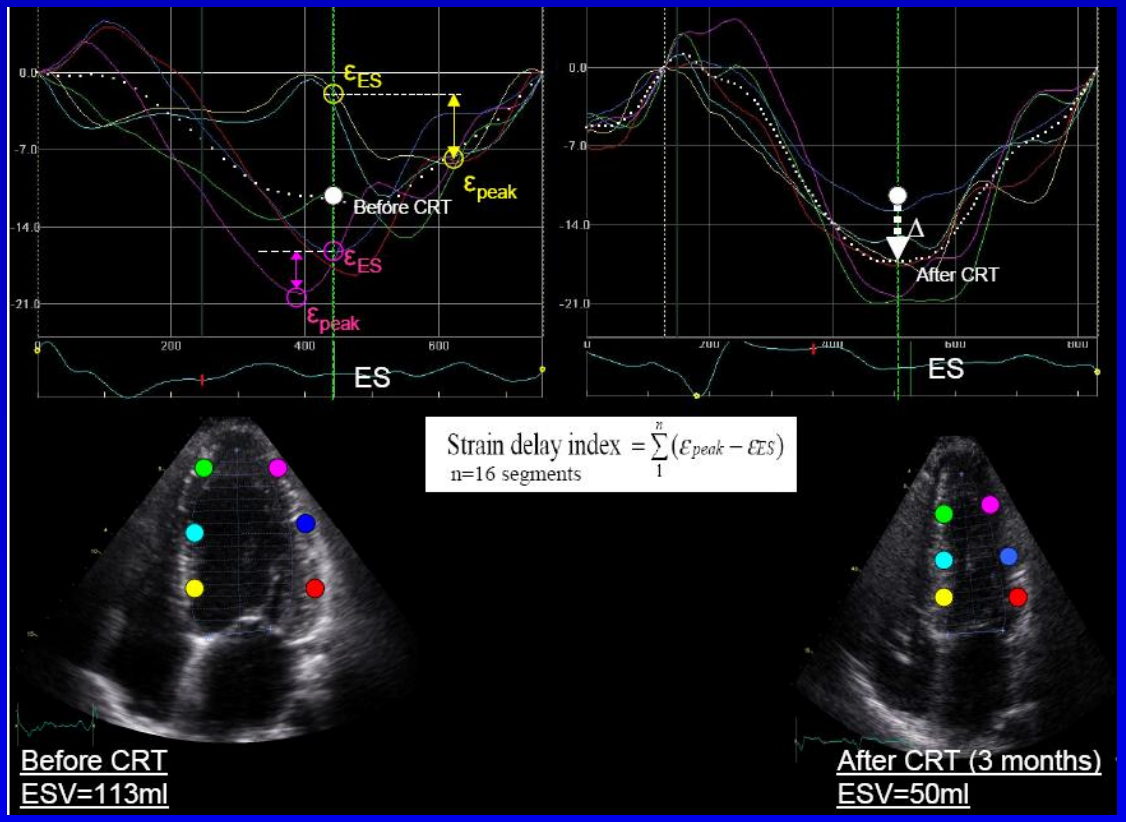
Other modalities : Strain

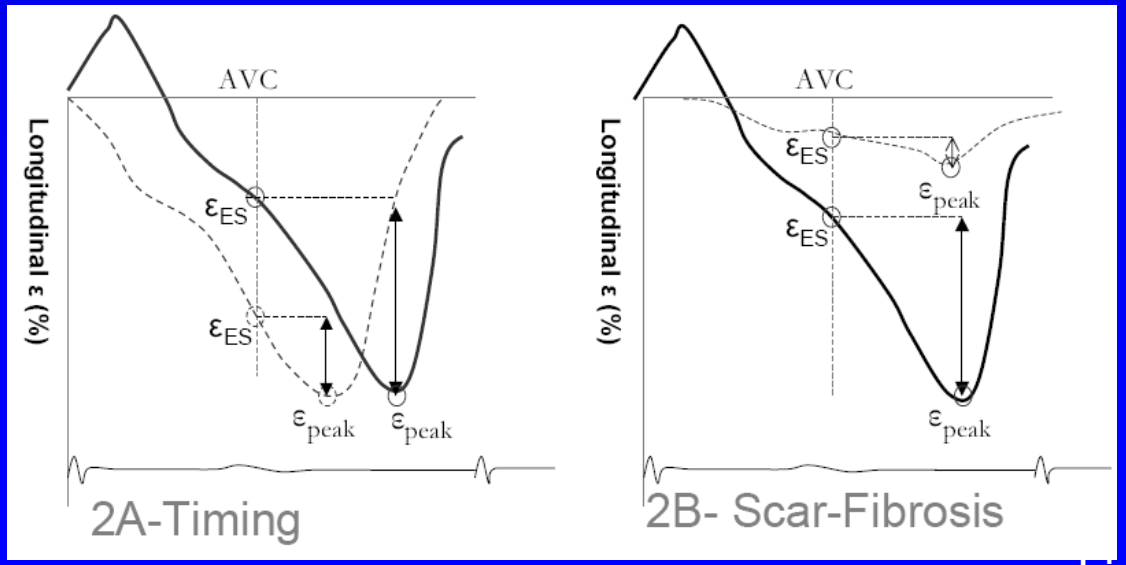
Advantages

- Regional function
- Passive vs acitve motion

Limitations

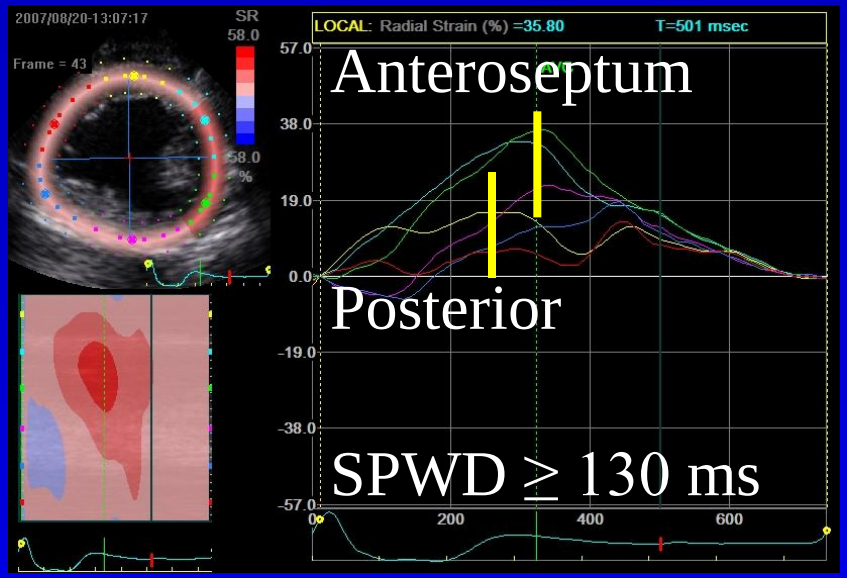
- Angle dependency
- Low signal to noise ratio
- Moderate reproducibility
- High operator variability





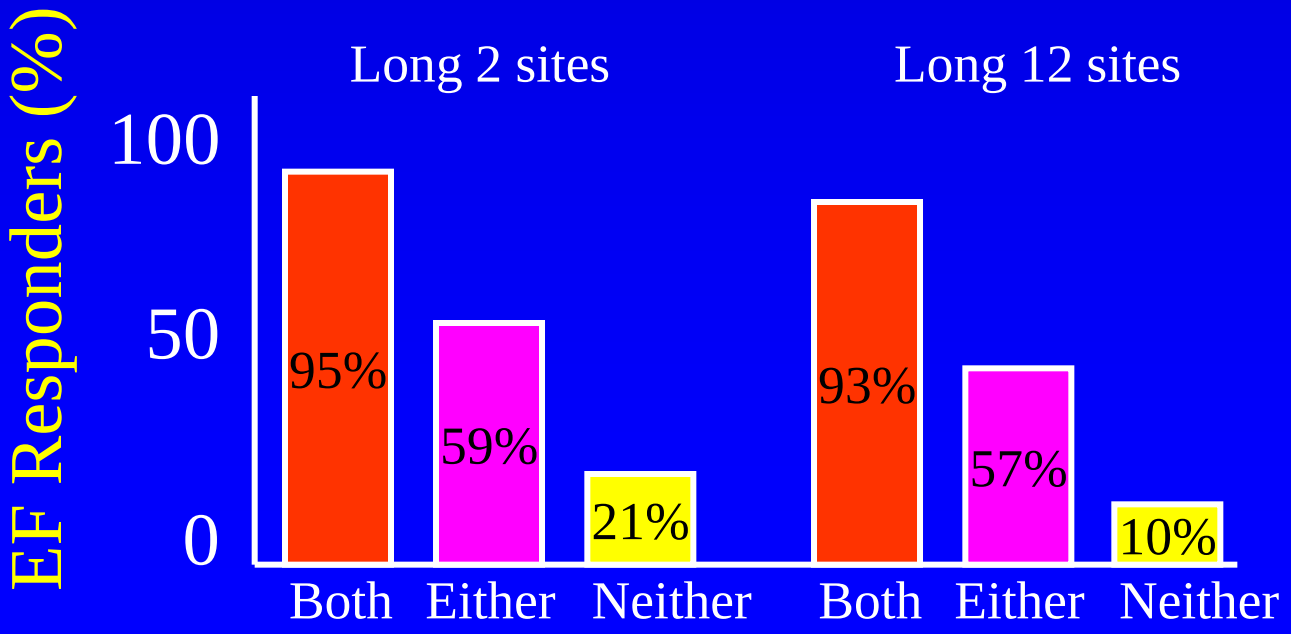
Lim et al Circulation 2009

Longitudinal + Radial



- 190 HF pts with CRT
- TDI SD-12 (n=67) + SL delay (only ejection phase)
- Radial dyssynchrony

Gorscan JACC 2007



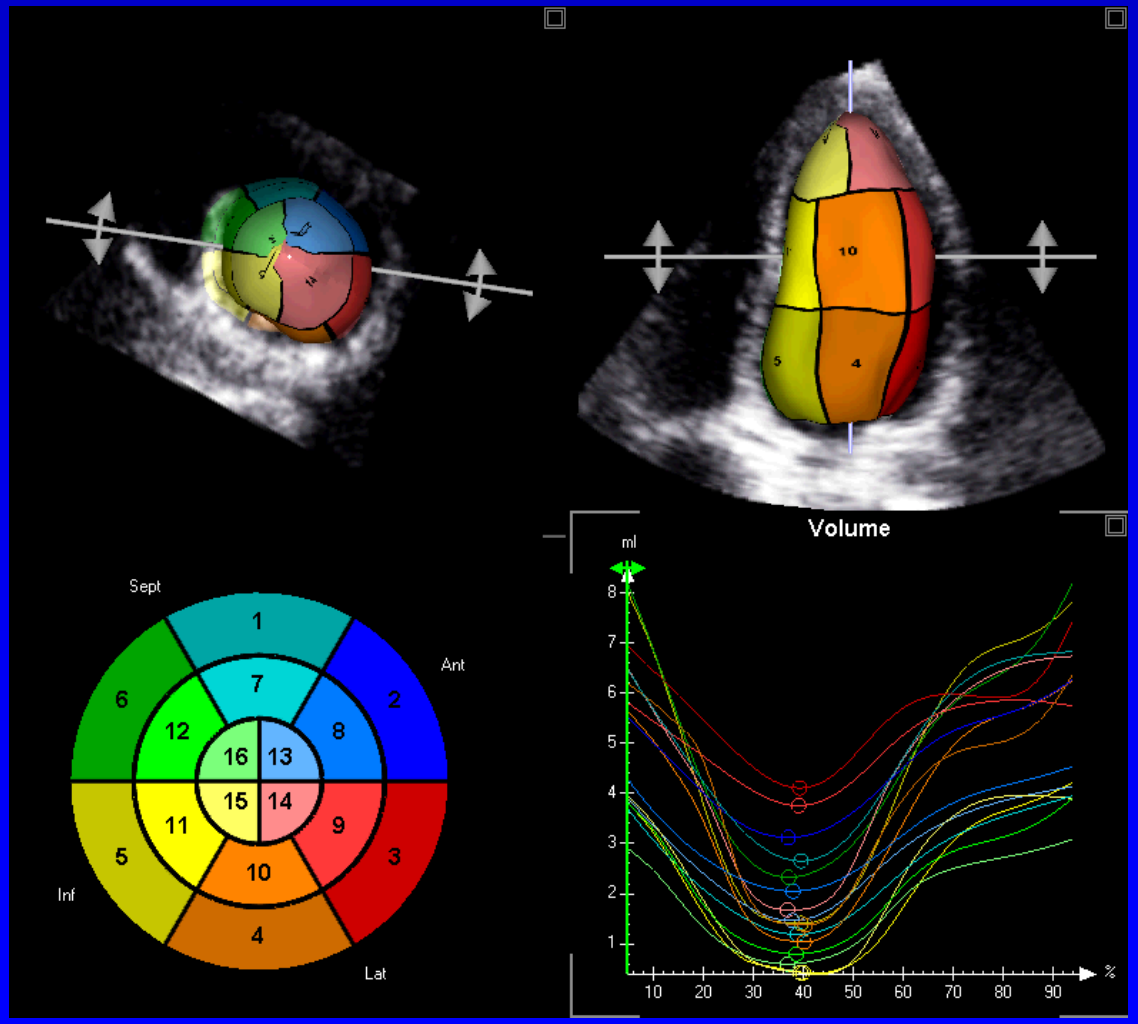
Sens: 88%

Spec : 80%

if both for EF

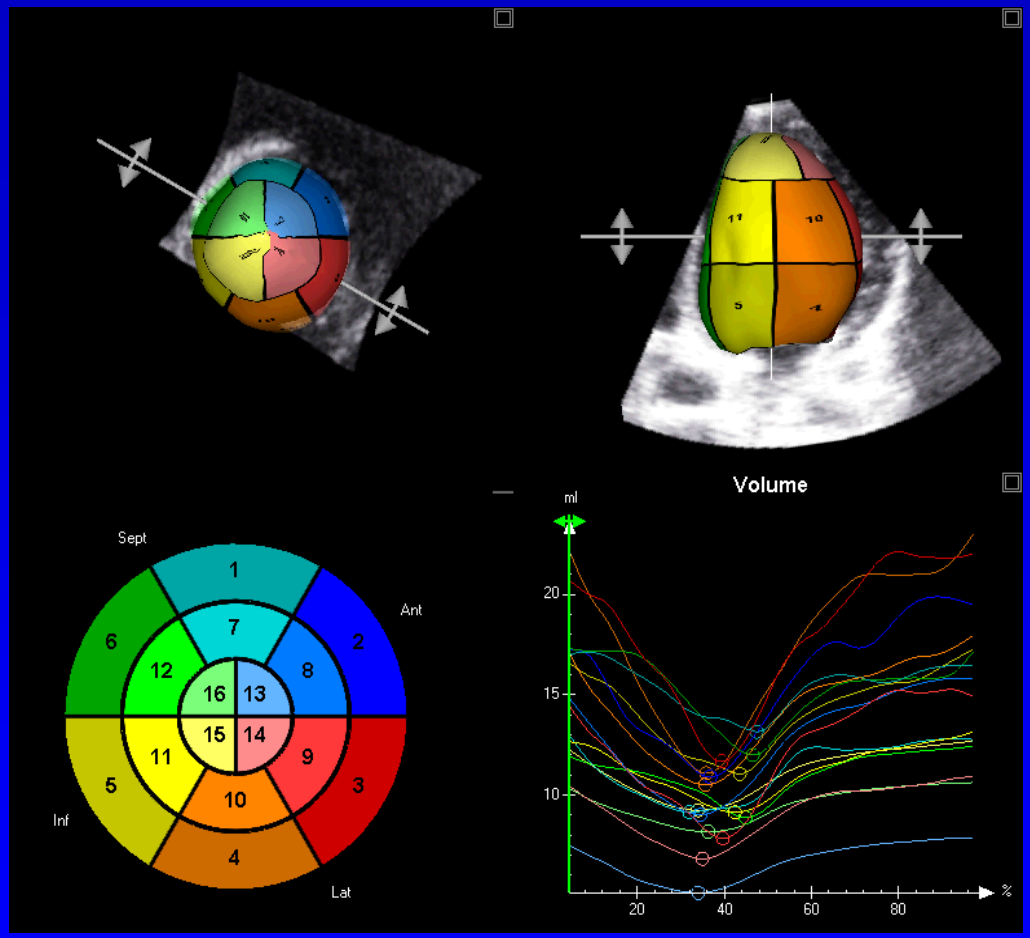
at 6 months

3-D ASSESSMENT OF MECHANICAL LV DYSSYNCHRONY (Normal)
(Radial, Longitudinal, Circumferential)



EDV	89.51 ml
ESV	28.49 ml
SV	61.02 ml
EF	68.17 %
SDI16	1.2 %

3-D ASSESSMENT OF MECHANICAL LV DYSSYNCHRONY (Patient)



SD-16 segments 8.3 %

for reverse remodeling

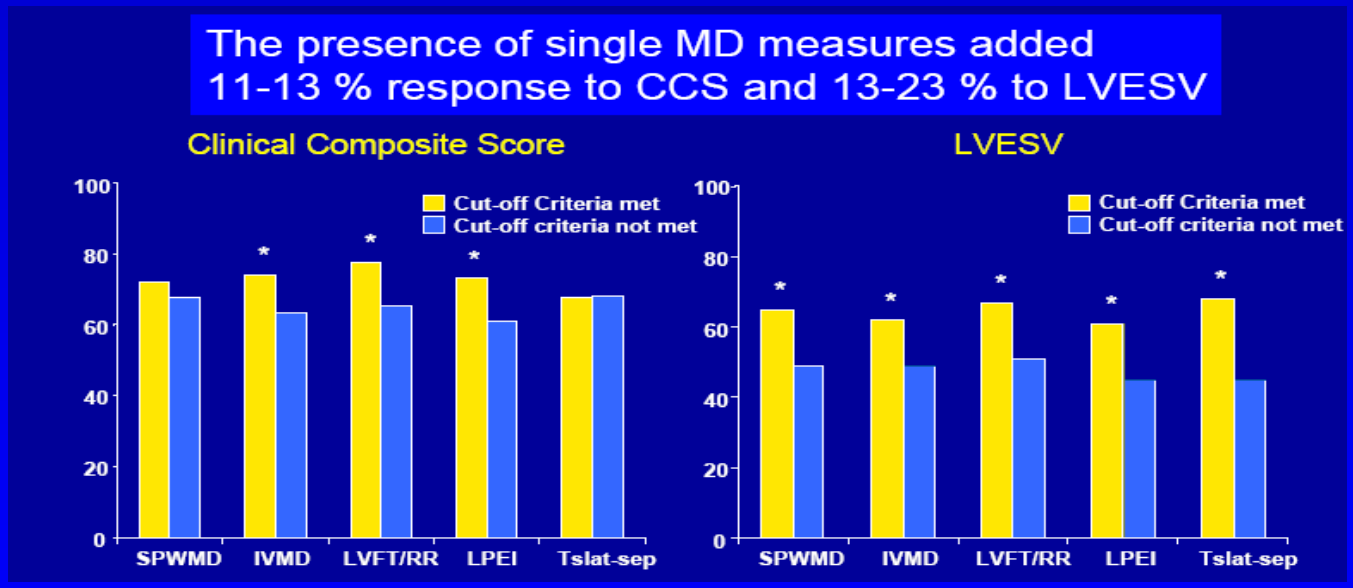
(n=26)

Kapetanakis Circ 2005

Poor agreement with TDI SD-12 : 56.5% for LVMD

Prospect study

- Prospective non randomized
- identify echo measures of asynchrony and predict response
- 53 centers, 426 patients QRS > 130 ms



- 12 echo measures → 8 were associated with response

No single measure of mechanical dyssynchrony may be recommended

ESC 2007 Hotline

Prospect study : Interpretation

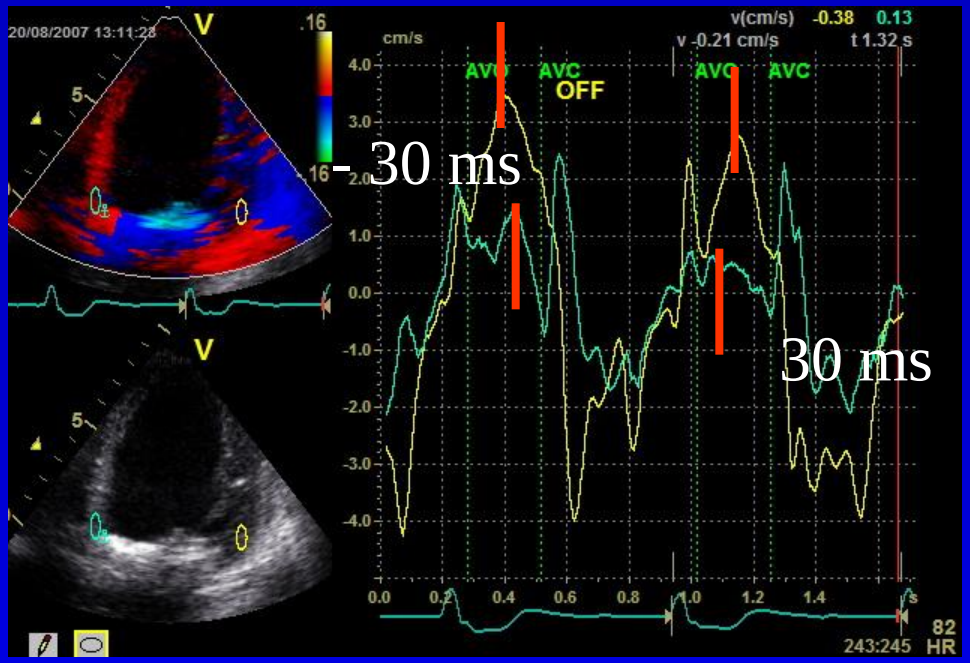
High interecholab variability → Need for standardi n

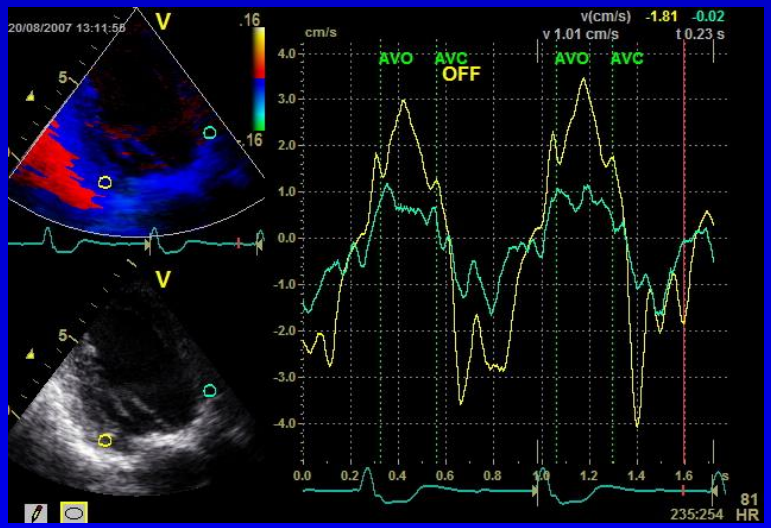
- Coefficient of variation
  - 6.5% LPEI
  - 33.7% TS
  - LPEI 95%
  - TS Lat-Se 67%
  - TS-SD 50%
- M
- ar tissue ?
- timization ?
- Value of combined MD criteria ?
- The role of etiology ?
- The 3D results ?

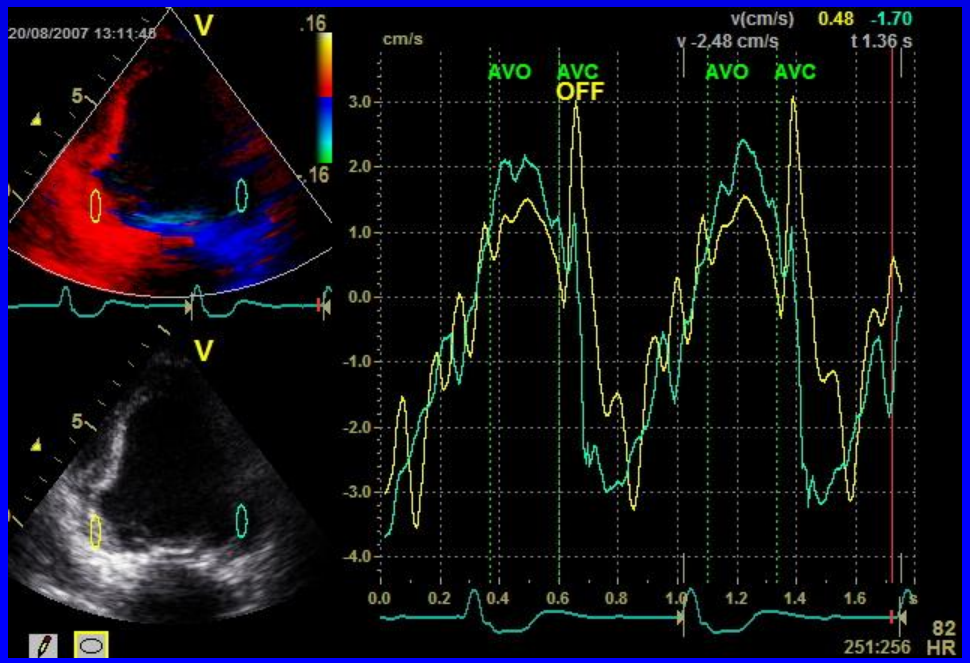
No clear conclusion can be made
Use your own standardized stepwise approach

ESC 2007 Hotline

IDCM : QRS 130 ms
NYHA III





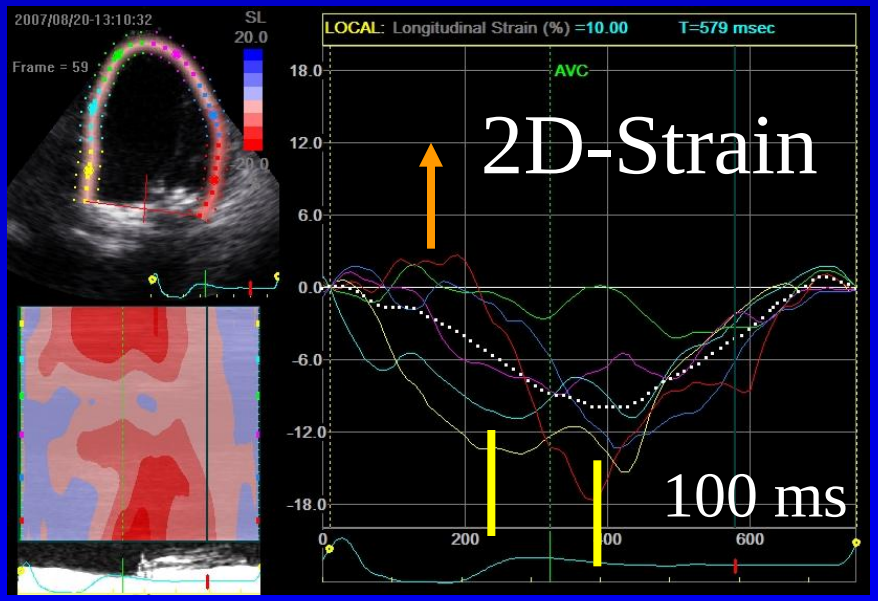


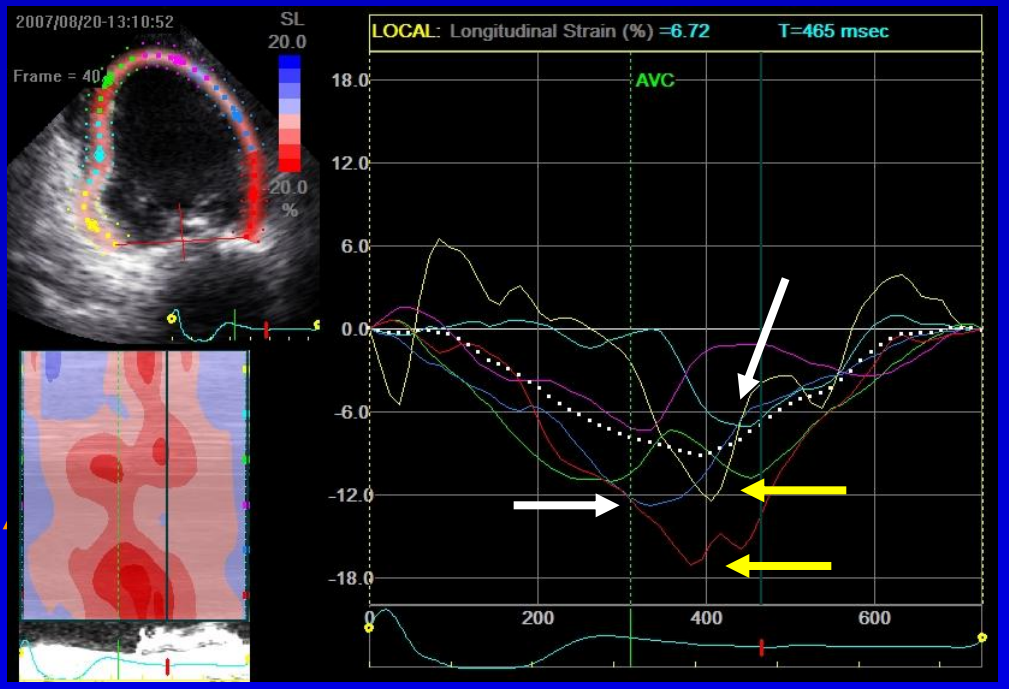
SD-12 = 9 ms

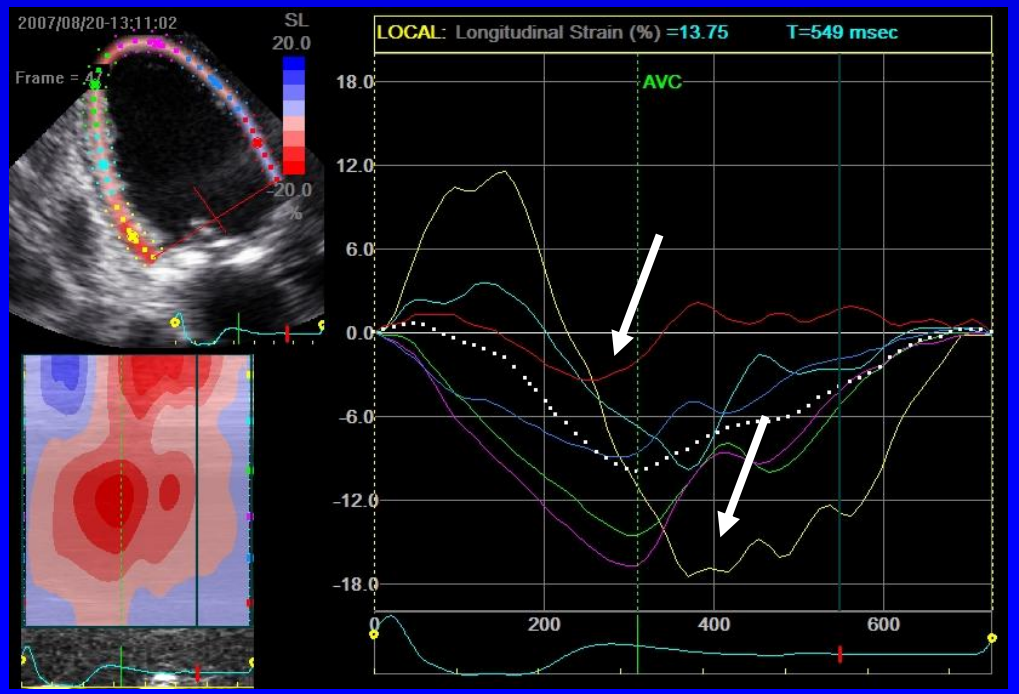
Limitations

- Angle dependency
- Active vs passive motion ?
- Peak ? Low Systolic velocity

IDCM : QRS 130 ms
NYHA III

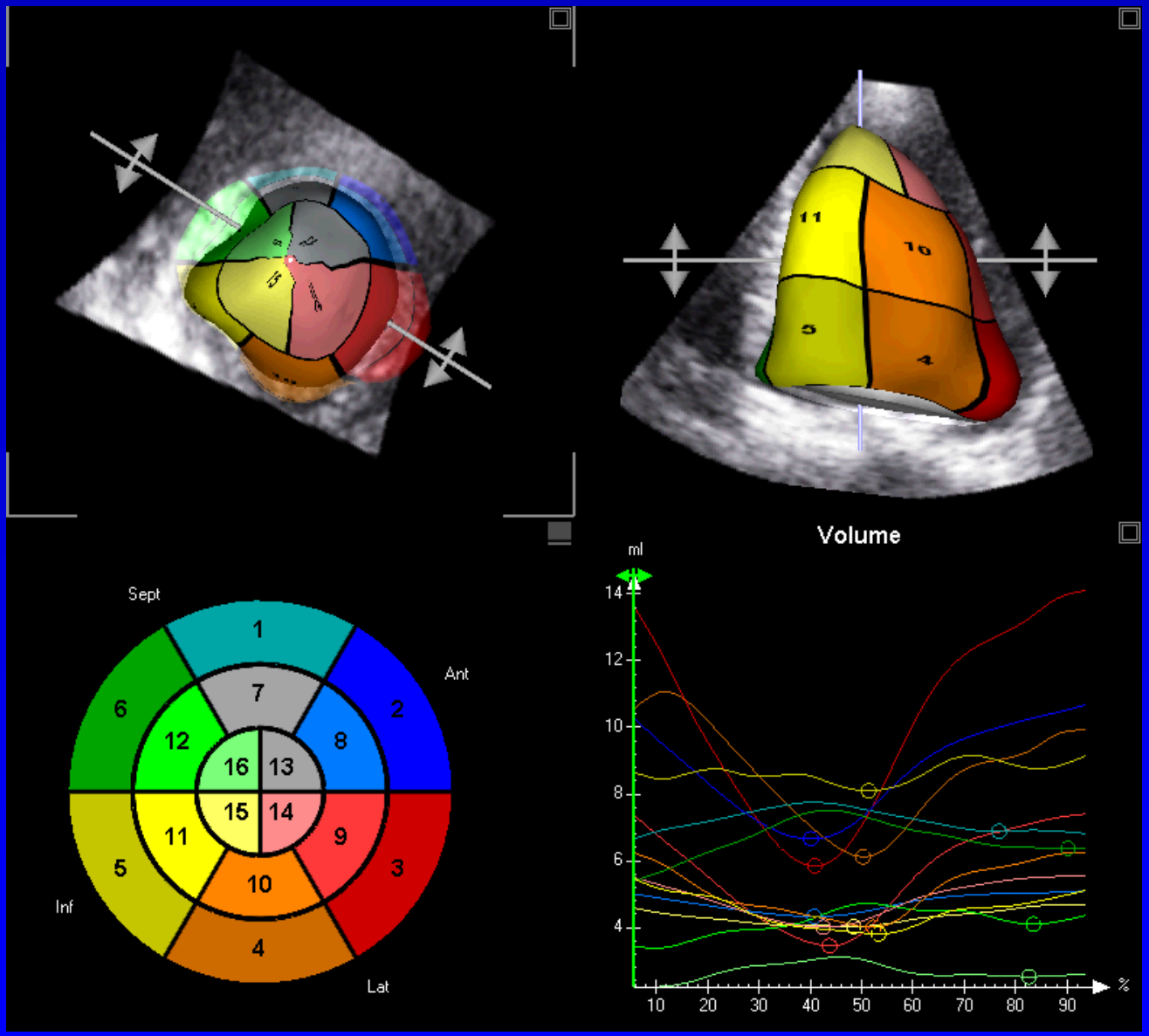






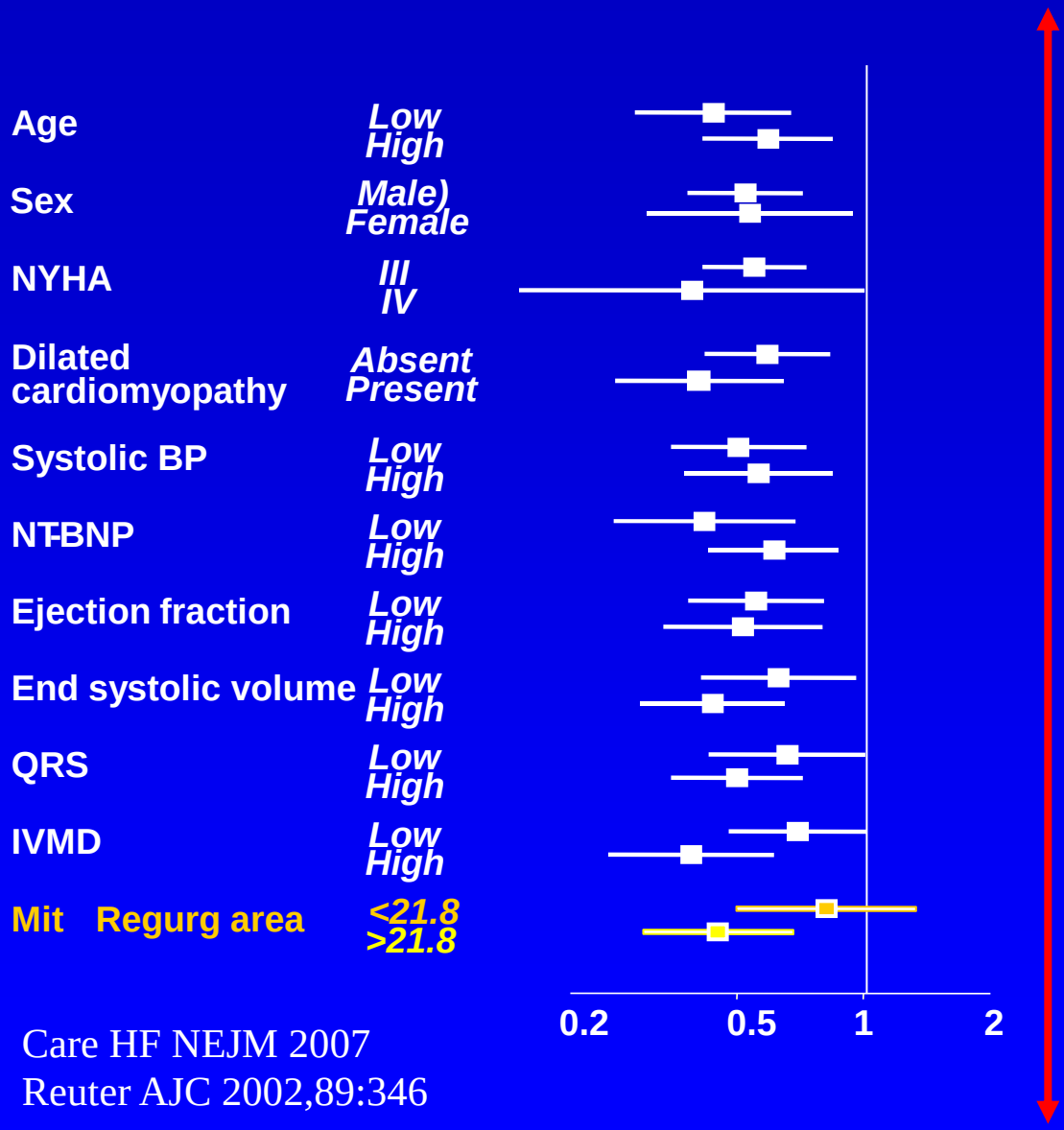
Advantages

- Angle independent
- Passive vs active motion
- Radial/longitudinal/Circonf


Volume
ml
14
12
10
8
6
4
10
20
30
40
50
60
70
80
90
%
Sept
Ant
Inf
Lat
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Pre : SD 18%

FAILURE TO CRT RESPONSE



Care HF NEJM 2007
Reuter AJC 2002,89:346

1. ERO ≥ 20 mm²
2. LV EDD ≥ 75 mm
3. Ischemic disease
4. Narrow QRS
5. Absence of asynchrony

→ Lack of reverse LV remodeling

Cabrero-Bueno Europace 2007
Diaz-Infante AJC 2005,95:1436

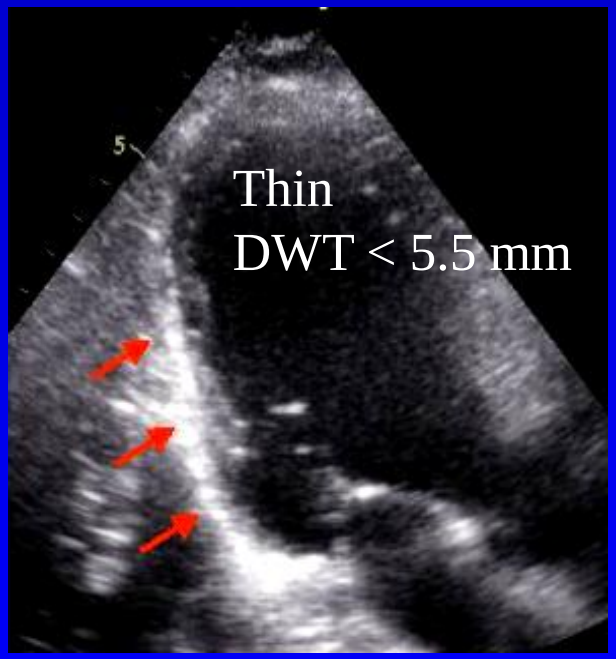
Care HF : only 11 % QRS < 150 ms

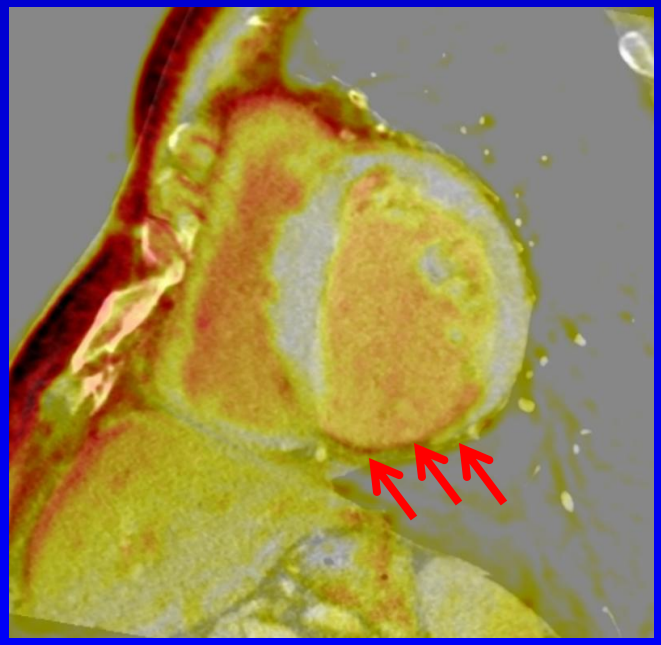
Extent of Myocardial Necrosis

Thin myocardium

Microvascular damage

Delayed enhancement





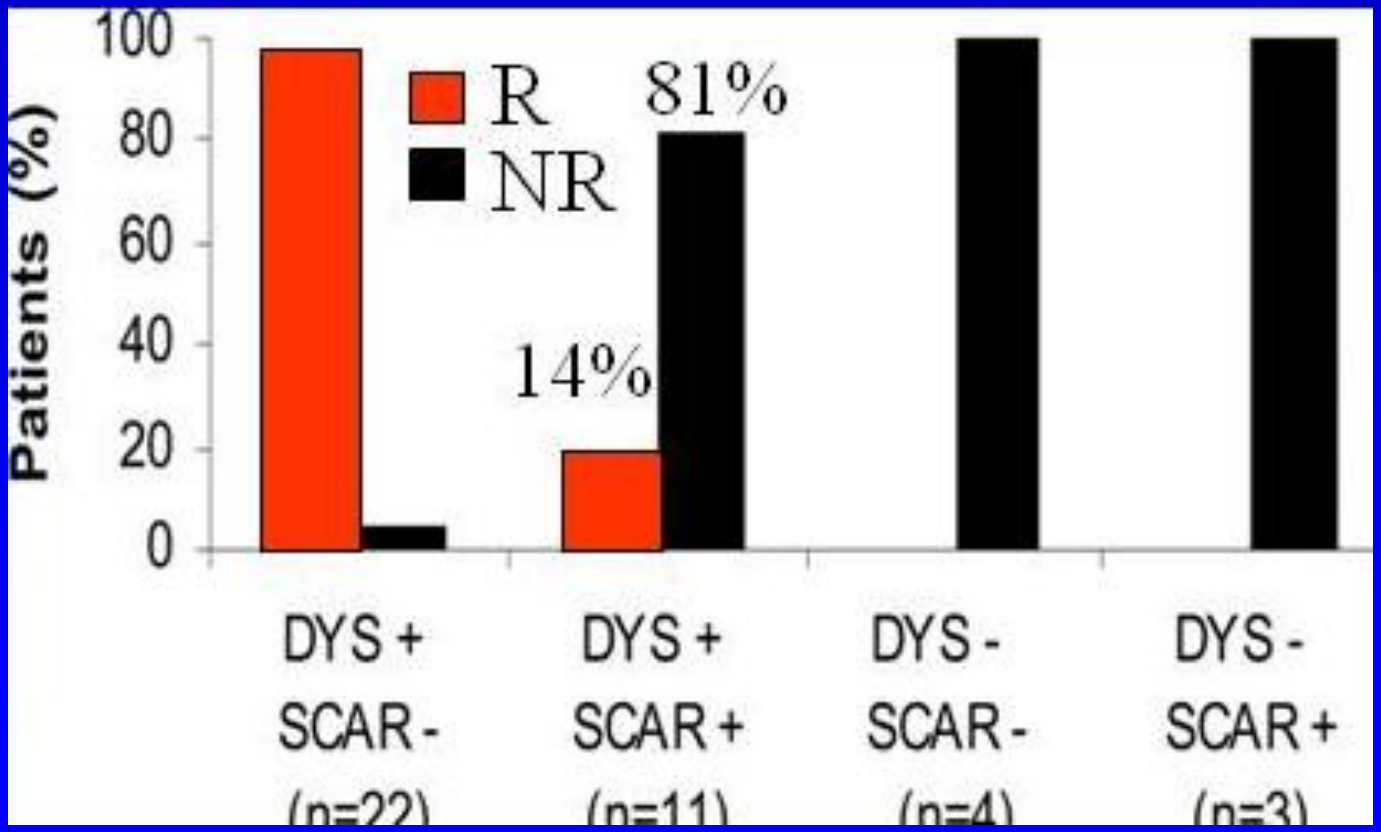
Resting echo

Contrast echo

Cardiac MRI

Extent of Myocardial Necrosis

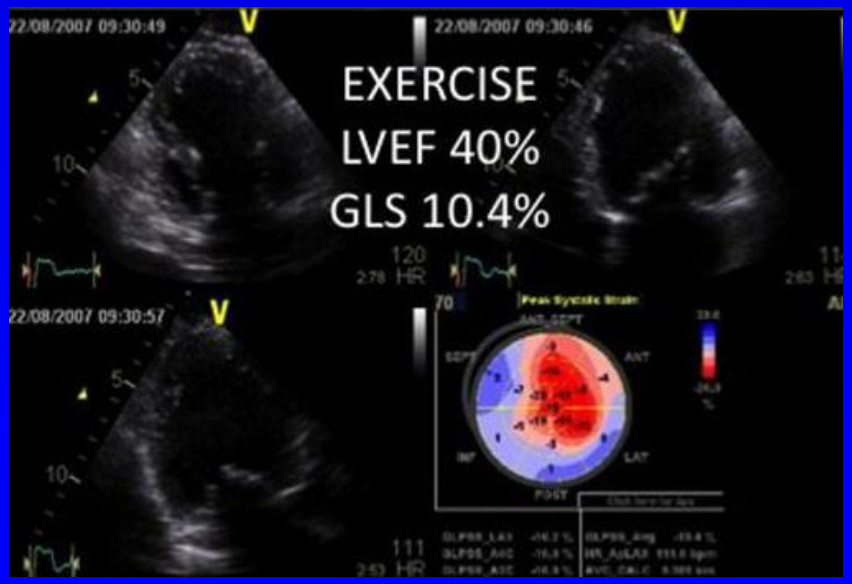
PL Scare



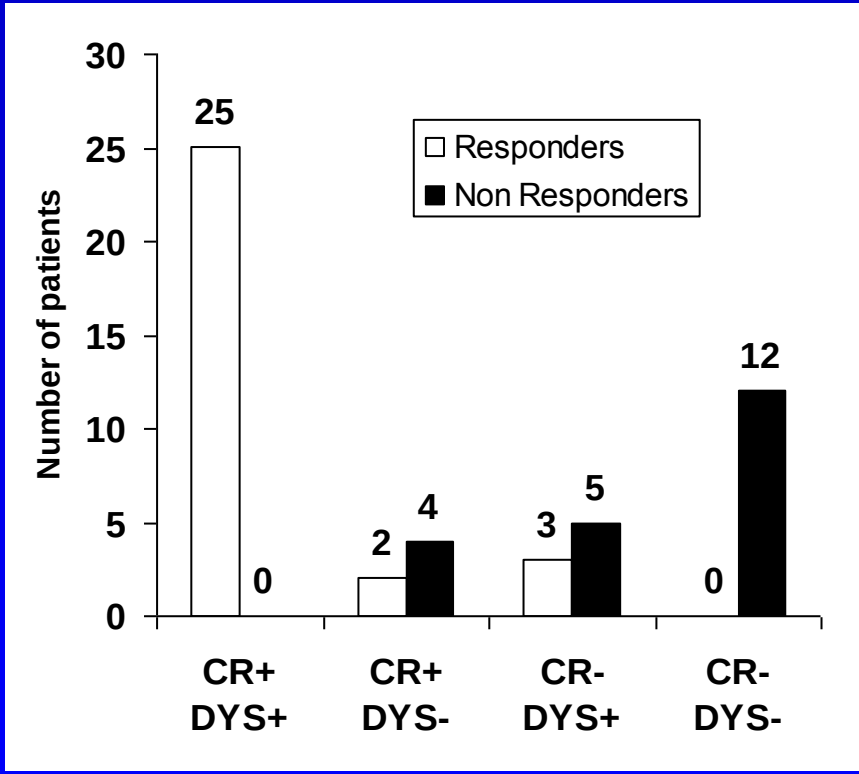
Bleeker GB et al. Circulation 2006

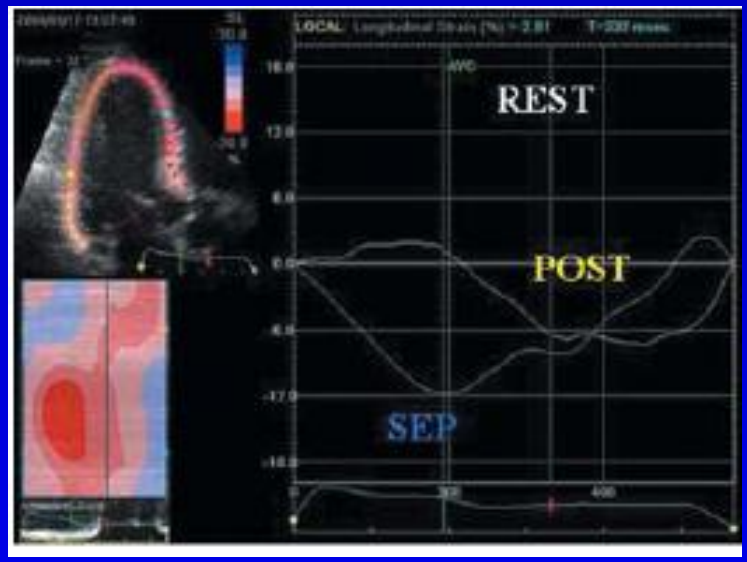
Global Contractile Reserve

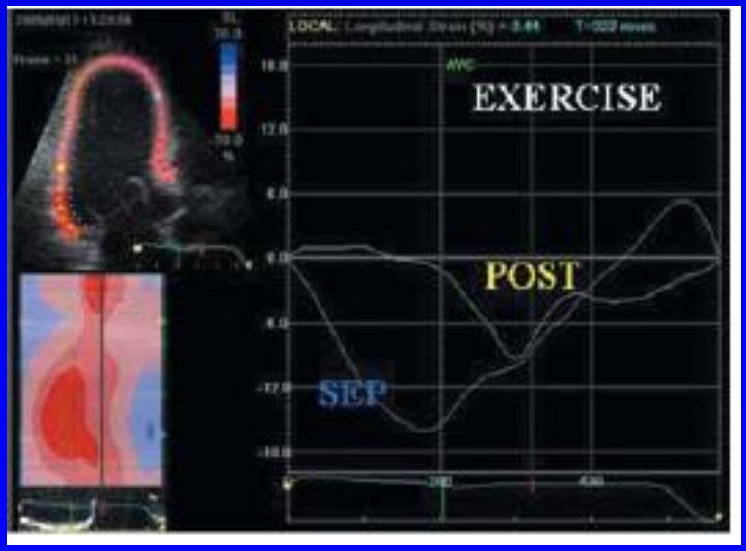
- Independent predictor of event-free survival after CRT (Da Costa et al. Heart Rhythm 2006) (IVD + ↑ 1.25 LV EF at 10 µg/kg/min)
- Predictive value of 7.5 % dobu-induced increase in LVEF (Ypenburg et al. Am Heart J 2007)
- Global CR: increase in LVEF by ≥ 6.7 % (Lancellotti et al Eur J Echo 2009)



Local Contractile Reserve

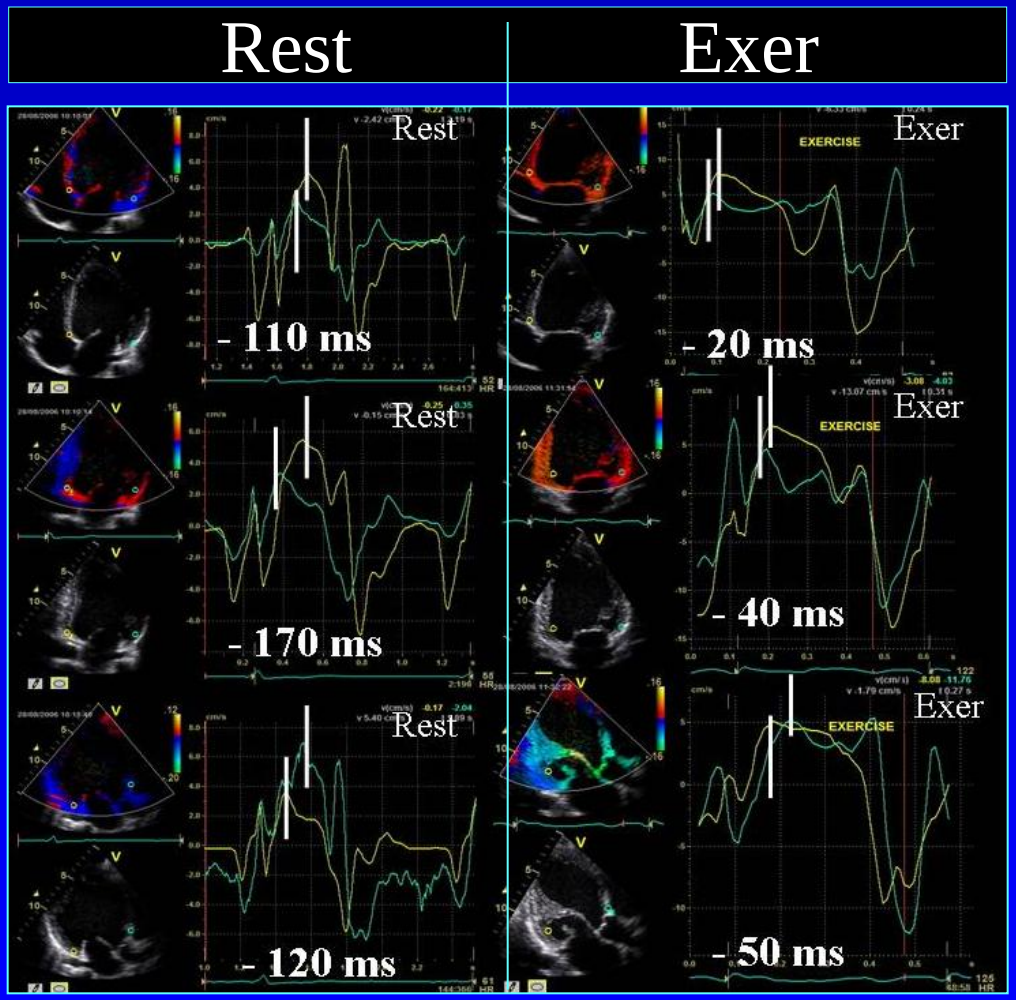






Lancellotti et al Eur J Echo 2009

Role of Stress Echo : dynamic asynchrony



- 30 % normalization

(asynchrony at rest)

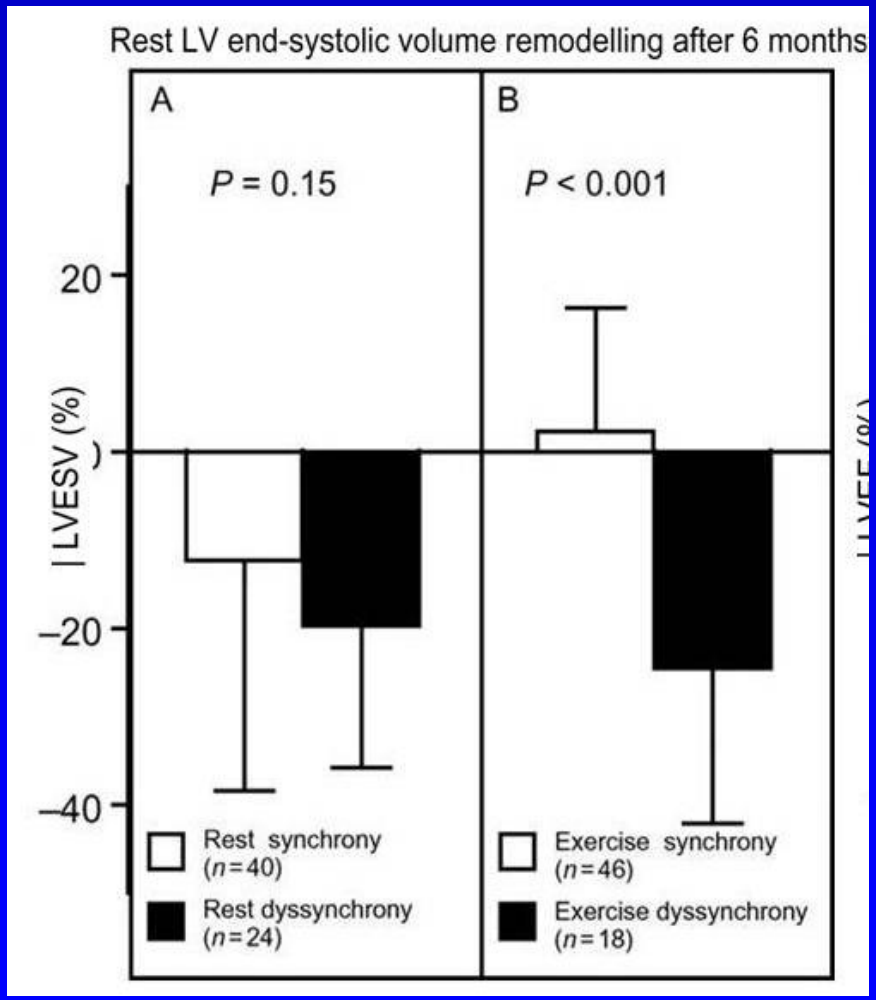
- 30 % induction

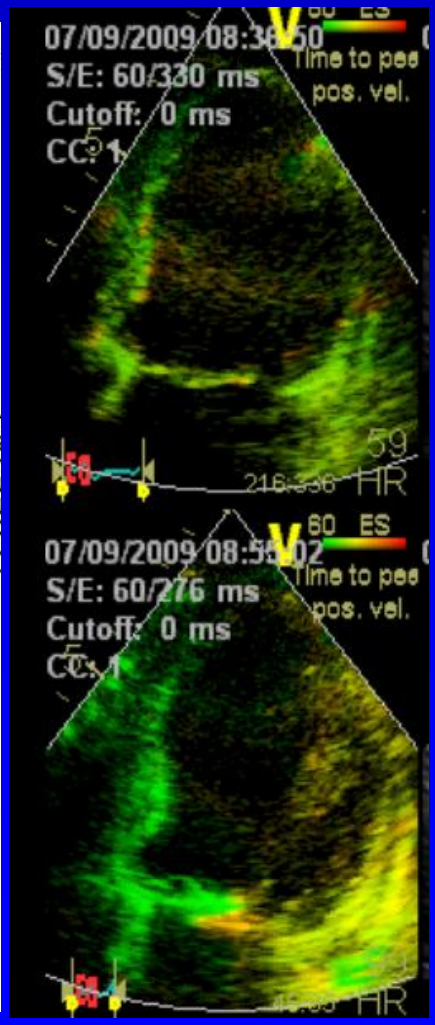
(No asynchrony at rest)

- 30 % No changes

Lancellotti Am J Cardiol 2005, Lafitte JACC 2006, D'Andrea EHJ 2007

Exercise LV asynchrony predicts response to CRT

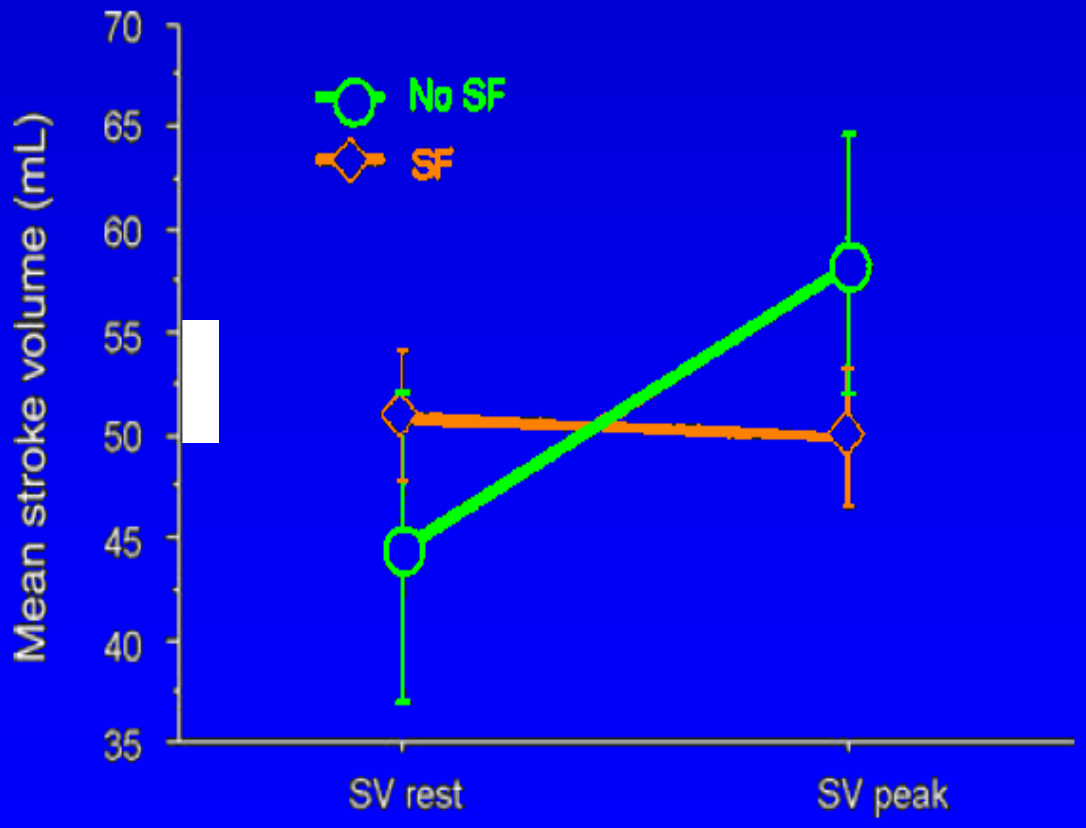




Lancellotti et al AJC 2005, Rocchi et al Eur Heart J 2009

Dynamic Septal Flash Predicts CRT Response

- low dose dobutamine



52 patients

<u>septal flash rest</u>

sensitivity	82%
specificity	88%

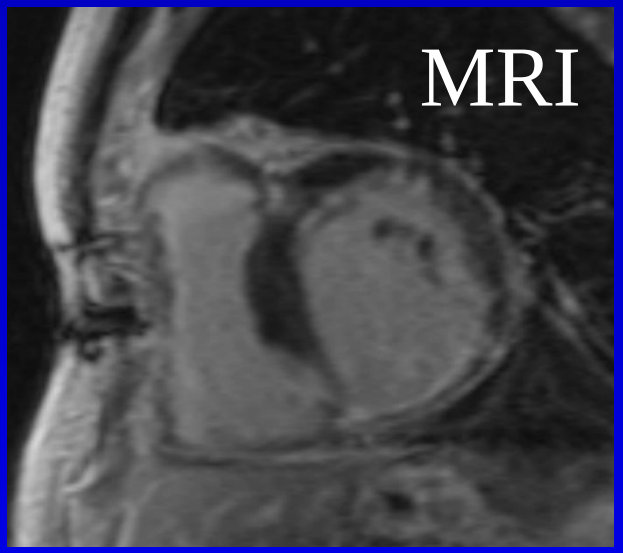
<u>septal flash LDD</u>

sensitivity	97%
specificity	88%

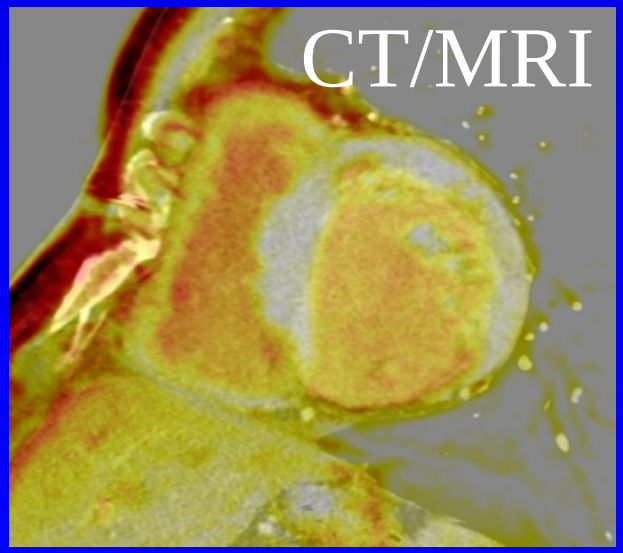
Parsai / Sutherland et al, Eur Heart J 2009

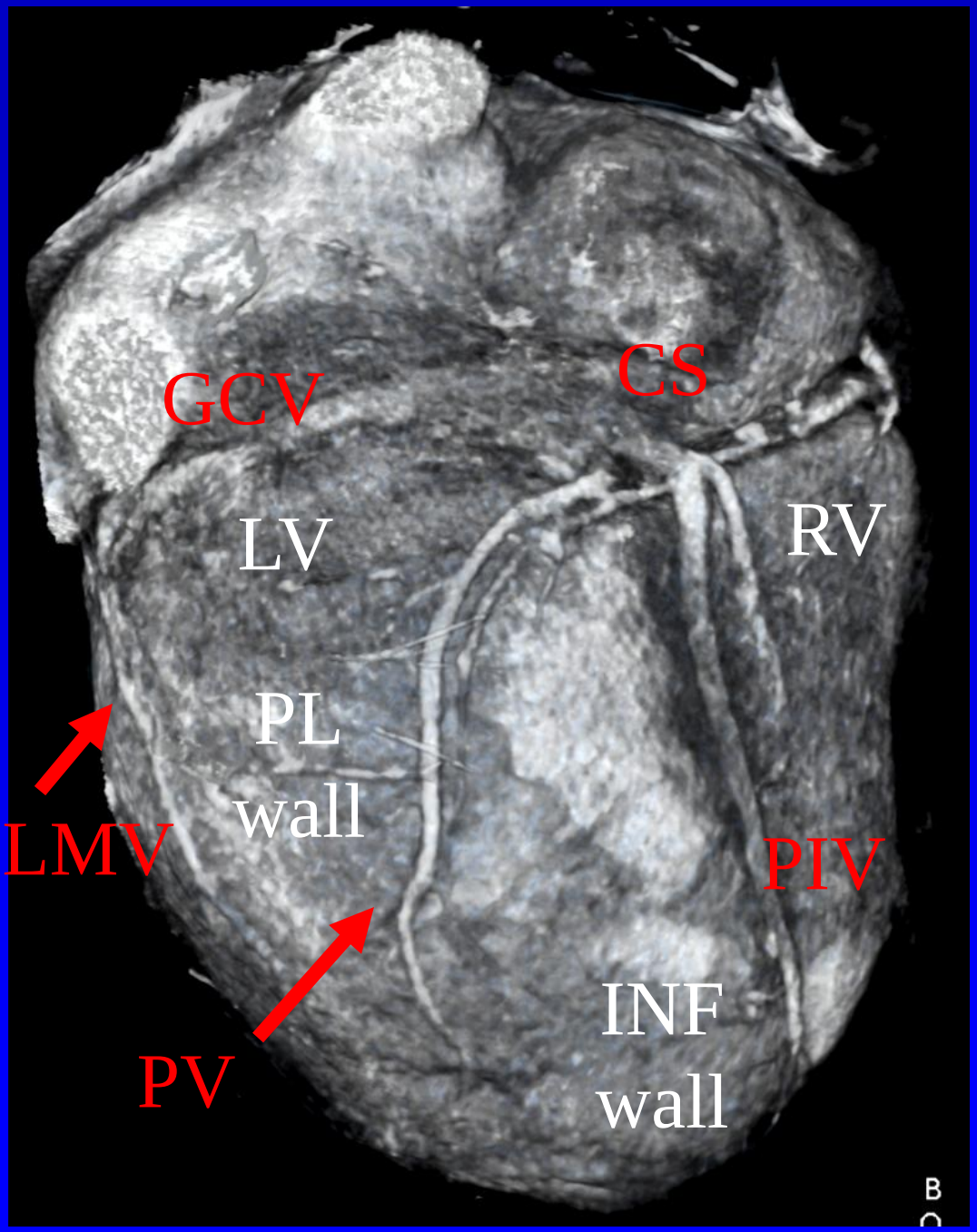
Veinous anatomy and Necrosis

Veins



Necrosis




GCV
CS
LV
RV
PL
wall
LMV
PIV
PV
INF
wall

How do you select a CRT candidate ?

1 Application of official guidelines only

2 Guidelines + evidence of dyssynchrony

3 Guidelines + integrated approach
by different imaging methods

Conclusions

Dyssynchrony is normal and is dynamic

Many tools and many (too many ?) criteria
not included in the guidelines (own echo criteria)

No one single echo parameter represents a magic number. Used several matched parameters ?.

A patient should not be denied CRT on the absence of LV Dyssynchrony alone

If no correctable mechanism is present – the patient will **NOT** respond!

Stepwise approach

QRS > 120 ms, NYHA III, EF < 35%