Imaging dyssynchrony
Tissue Doppler echocardiography

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Over the past decade, cardiac resynchronization therapy (CRT) has changed the treatment of patients with end-stage, drug-refractory heart failure.¹

Imaging dyssynchrony

Evidence of multiple large trials (≈4,000 patients) and numerous small studies have demonstrated the benefit of CRT on heart failure symptoms, exercise capacity, and systolic left ventricular function.¹


Imaging dyssynchrony

- 20% to 30% of patients do not respond to CRT.¹
- A need for additional selection criteria to identify potential responders.
- The presence of substantial left ventricular (LV) dyssynchrony is a major predictor of response to CRT.

Imaging dyssynchrony

- Mechanical dyssynchrony is not necessarily related to electrical dyssynchrony.¹

- Incidence:

  40% of patients with dilated cardiomyopathy and QRS duration > 120 ms,
  70% of patients with QRS duration > 150 ms.²

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Imaging dyssynchrony

MECHANICAL DYSSYNCHRONY

I- Atrioventricular (AV) dyssynchrony
II- Interventricular dyssynchrony.
III- Intraventricular dyssynchrony.

Atrioventricular (AV) dyssynchrony

LVFT/RR is <40%.
Inter-ventricular dyssynchrony

Interventricular dyssynchrony

Intraventricular dyssynchrony

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<td>Septal to lateral Ts delay</td>
<td>Tissue velocity imaging</td>
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<td>Max delay in Ts in 4 basal LV segments</td>
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<td>Anteroseptal to posterior time to peak strain difference (radial strain)</td>
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<td>SD of time-to peak longitudinal strain in 12 basal and mid LV segments</td>
<td>Colour –Tissue Doppler imaging</td>
<td>&gt; 60 ms</td>
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Intraventricular dyssynchrony

SPWMD

Normally SPWMD is less than 40 ms. The cut-off value is ≥ 130 msec.
Intraventricular dyssynchrony
SPWMD

Normally SPWMD is less than 40 ms. The cut-off value is ≥ 130 msec.

Intraventricular dyssynchrony
Tissue velocity imaging
Intraventricular dyssynchrony
Tissue velocity imaging

• longitudinal velocities of basal (or basal and mid) myocardial segments are measured from standard apical views.
• Measurements of longitudinal velocities from 2, 4, 6 and 12 myocardial segments have been described

Tissue velocity- derived dyssynchrony parameters

- time delays between opposing walls
- standard deviations of time-to-peak systolic velocities
Intraventricular dyssynchrony
TS Lateral to septal

Normal value <50 msec
Cutoff value ≥60-65 msec¹²


Intraventricular dyssynchrony
TS- maximal delay (12 segments)

Normal<90 msec
Cutoff value ≥100 msec¹

Intraventricular dyssynchrony

Dyssynchrony index

Deformation imaging

- Have the potential of distinguishing active contraction from passive motion caused by tethering of adjacent myocardial regions.
- Can be obtained from color Tissue Doppler or two-dimensional speckle tracking images.
Intraventricular dyssynchrony strain

\[
\text{Strain } (\varepsilon) = \frac{L_1 - L_0}{L_0}
\]

-20% → 0% → +20%

\[10 \text{ cm} \]

A: Time to peak tissue velocity
B: Time to peak integrated strain

Intraventricular dyssynchrony strain
Intraventricular dyssynchrony speckle tracking (2-D Strain)

Idea

Intraventricular dyssynchrony anteroseptal-posterior difference in peak radial strain

Cutoff value ≥ 130 msec

Intraventricular dyssynchrony

Apical rocking and septal flash

Both apical rocking and septal flash have been shown to have predictive value for a CRT response which is superior to velocity-based dyssynchrony parameters.¹²


¹ Intraventricular dyssynchrony
² Apical rocking and septal flash
Methods and Results—Fifty-three centers in Europe, Hong Kong, and the United States enrolled 498 patients with standard CRT indications (New York Heart Association class III or IV heart failure, left ventricular ejection fraction ≤35%, QRS ≥130 ms, stable medical regimen). Twelve echocardiographic parameters of dyssynchrony, based on both conventional and tissue Doppler–based methods, were evaluated after site training in acquisition methods and blinded core laboratory analysis. Indicators of positive CRT response were improved clinical composite score and ≥15% reduction in left ventricular end-systolic volume at 6 months. Clinical composite score was improved in 69% of 426 patients, whereas left ventricular end-systolic volume decreased ≥15% in 56% of 286 patients with paired data. The ability of the 12 echocardiographic parameters to predict clinical composite score response varied widely, with sensitivity ranging from 6% to 74% and specificity ranging from 35% to 91%; for predicting left ventricular end-systolic volume response, sensitivity ranged from 9% to 77% and specificity from 31% to 95%. For all the parameters, the area under the receiver-operating characteristics curve for positive clinical or volume response to CRT was ≤0.62. There was large variability in the analysis of the dyssynchrony parameters.

Conclusion—Given the modest sensitivity and specificity in this multicenter setting despite training and central analysis, no single echocardiographic measure of dyssynchrony may be recommended to improve patient selection for CRT beyond current guidelines. Efforts aimed at reducing variability arising from technical and interpretative factors may improve the predictive power of these echocardiographic parameters in a broader clinical setting. (Circulation. 2008;117: 2608-2616.)

Characteristics of heart failure patients associated with good and poor response to cardiac resynchronization therapy: a PROSPECT (Predictors of Response to CRT) sub-analysis

Echocardiography
Left ventricular end-diastolic volume (LVEDV) and LVESV were obtained from the apical two- and four-chamber views, and LVEF was calculated using the biplane Simpson's technique. Three echocardiographic measures of dyssynchrony were evaluated:

(i) LV filling ratio (defined as LV filling time [LVFT]) in relation to cardiac cycle length (CCL) as measured by tissue Doppler echo (LVFT/CCL).12

(ii) Inter-ventricular mechanical delay (defined as the difference between left and right ventricular pre-ejection intervals [LV/RE])12 and finally

(iii) Septal to lateral delay (Te, lateral-septal), defined as the delay between time to peak systolic velocity at basal septal and basal lateral segments.12

Conclusion
Subanalysis of data from PROSPECT showed that gender, etiology of HF, QRS duration, severity of HF, a history of VT, and the presence of baseline mechanical dyssynchrony influence clinical analysis of LV reverse remodeling after CRT. Although integration of information about these characteristics would improve patient selection and counseling for CRT, further randomized controlled trials are necessary prior to changing the current guidelines regarding patient selection for CRT.
Original article

Left ventricular 12 segmental strain imaging predicts response to cardiac resynchronization therapy

Methods Forty-five consecutive patients receiving CRT-D implantation for heart failure (HF) were included in this prospective study. New York Heart Association (NYHA) class, 6-minute walk distance, electrograph character, and multi-echo multi-slice patterns, especially in strain patterns, were measured and compared before and six months after CRT in the responder and non-responder groups. Response to CRT was defined as a decrease in left ventricular end-systolic volume (LVESV) of 15% or more at 6-month follow-up.

Results Twenty-two (49.9%) patients demonstrated a response to CRT at 6-month follow-up. Significant improvement in NYHA class (P < 0.01), left ventricular end-diastolic volume (LVEDV) (P < 0.01), and 6-minute walk distance (P < 0.01) was shown in this group. Although there was an interventricular mechanical delay determined by the difference between left and right ventricular pre-ejection intervals (42.87±9.64 ms vs. 29.43±18.19 ms, P<0.02), the standard deviation of time to peak myocardial strain among 12 basal, mid, and apical segments (Ti-SD) (119.97±33.32 ms vs. 88.62±36.86 ms, P<0.01) and the non-systolic ejection fraction (P<0.03) were significantly higher in responders than non-responders; only the Ti-SD (OR=1.02, 95% CI=1.01–1.04, P<0.02) proved to be a favorable predictor of CRT response after multivariate Logistic regression analysis.

Cardiac-Resynchronization Therapy in Heart Failure with a Narrow QRS Complex

METHODS

We conducted a randomized trial involving 115 centers to evaluate the effect of CRT in patients with New York Heart Association class III or IV heart failure, a left ventricular ejection fraction of 35% or less, a QRS duration of less than 130 msec, and echocardiographic evidence of left ventricular dyssynchrony. All patients underwent device implantation and were randomly assigned to have CRT capability turned on or off. The primary efficacy outcome was the composite of death from any cause or first hospitalization for worsening heart failure.

CONCLUSIONS

In patients with systolic heart failure and a QRS duration of less than 130 ms, CRT does not reduce the rate of death or hospitalization for heart failure and may increase mortality. (Funded by Biosense and GE Healthcare; EchoCRT ClinicalTrials.gov number, NCT00636890.)
Imaging dyssynchrony

Current indications for CRT:
Class Ia
LVEF ≤ 35%,
sinus rhythm,
LBBB with a QRS duration ≥ 150 ms,
NYHA class II, III, or ambulatory IV symptoms on goal-directed medical treatment.¹ ²

1- Device-Based Therapy Guideline Focused Update. Circulation. 2012;126:00-00.
2- 2013 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy.

Imaging dyssynchrony
Conclusions

• Data from several observational studies suggest that baseline LV mechanical dyssynchrony and acute resynchronization effect after CRT are independent determinants of CRT response and long-term outcome.

• Selection of HF patients for CRT based on LV mechanical dyssynchrony assessed with imaging techniques is currently not recommended in recent guidelines.
Imaging dyssynchrony
Conclusions

• Several imaging techniques were evaluated (magnetic resonance imaging, speckle tracking echocardiography, strain imaging, nuclear imaging) and yielded several parameters of LV mechanical dyssynchrony that have demonstrated to be independent determinants of CRT response and long-term outcome in several observational studies.

Imaging dyssynchrony
Conclusions

The real value of these novel technologies remains to be determined in randomized trials.
Thank you