ΕΚΤΙΜΗΣΗ ΔΥΣΥΓΧΡΟΝΙΣΜΟΥ ΤΟ 2016

Ευαγγελία Χριστοφοράτου
Καρδιολόγος

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* Επιστημονικά Υπεύθυνη Βηματοδοτικού - Απινιδωτικού Τμ. Βιοκλινικής Αθηνών

1ο ΣΥΝΕΔΡΙΟ
ΚΑΡΔΙΑΓΓΕΙΑΚΗΣ ΑΠΕΙΚΟΝΙΣΗΣ
ΣΤΗΝ ΚΛΙΝΙΚΗ ΠΡΑΞΗ
12-14 | 5 | 2016
HILTON, ΑΘΗΝΑ
Definitions of Dyssynchrony
Electrical Vs Mechanical Dyssynchrony

Electrical Dyssynchrony refers to a prolonged conduction time in the ventricles resulting in a prolonged QRS duration.

Mechanical Dyssynchrony is the mechanical discoordination, usually associated with simultaneous contraction and stretch in different regions of the LV as well as delays in the time to peak contraction from one segment to another.
AV dyssynchrony

There is a delay between atrial and ventricular contraction,
shortened ventricular filling time &
superimposition of atrial contraction on early passive filling,
→ both of which reduce LV filling.

atrio-ventricular dyssynchrony : The ratio between diastolic filling time and duration of a complete cardiac cycle (A LV filling time of < 40% cardiac cycle is indicative of A-V dys.)

It can also be associated with late diastolic (presystolic) mitral regurgitation (MR).
Demonstration of AV dyssynchrony
Demonstration of AV dyssynchrony
**Interventricular dyssynchrony**

- Delay between RV and LV activation.

- Occurs mainly with left bundle branch block, in which RV contraction will precede LV contraction, leading to abnormal (partially paradoxical) septal motion, discoordinated LV contraction, and a decreased LV ejection fraction.
- With LBBB induced Dyssynchrony,
  - The LV septum shortens up to 10% prior to ejection, has minimal subsequent systolic shortening and undergoes late systolic stretch
Interventricular Dyssynchrony

- **Inter-ventricular mechanical delay (IVMD) is measured**
- PW aortic \{LVOT - (apical 5-chamber view)\} and pulmonary (RV outflow tract-parasternal short-axis view) flow velocities are used.
- Then calculate the difference in time between ECG-derived Q wave onset and the onset of LV outflow and the time between the onset of Q and the onset of RV outflow
Aortic time to onset

Pulmonary time to onset

IVMD = 211 ms – 122 = 89 ms
• These values represent LV and RV pre-ejection period (PEP)

• IVMD values of > 40 ms and values of LV PEP of > 140 ms are considered pathological
Limitations

- Presence of pulmonary arterial hypertension and/or RV systolic dysfunction, which can prolong RV PEP
- Concomitantly impaired increase of LV pressure in very severe CHF
The time from QRS onset to the peak myocardial systolic velocities ($Sm$) of the RV free wall (tricuspid annulus) versus the same time of LV lateral mitral annulus (apical 4-chamber view)
Intraventricular dyssynchrony

- Here the normal ventricular activation sequence is disrupted, resulting in discoordinated contraction of the LV segments.

- The result is that those LV wall segments, which contract early, do not contribute to the ejection of blood from the left ventricle, and segments that contract late do so at a higher wall stress, causing the early contracting segments to stretch.

- Additionally, MR worsens in part because of LV remodeling, and presystolic regurgitation that may occur with ventricular dyssynchrony and delayed contraction of papillary muscle root attachments.
Intra-ventricular mechanical dyssynchrony

Intra-ventricular dyssynchrony is characterized by either premature or late contraction of LV wall segments due to delayed electrical Conduction

Methods:

- M-mode,
- pulsed Tissue Doppler,
- Colour Tissue Velocity Imaging
- 3-D echocardiography
M Mode

**Septal-to-posterior wall motion delay**

- It is the difference in timing of septal and posterior wall contraction

Place the M-mode cursor perpendicular to the septum and posterior wall at the base of the left ventricle, in parasternal short-axis (or long-axis) view:

SPWMD is the difference between the time from the onset of ECG-derived Q wave to the initial peak posterior displacement of the septum, and the time from the onset of QRS to the peak systolic displacement of posterior wall

Sweep speed - 100mm/s
SPWMD = 30 ms  SPWMD = 400 ms
Pitzalis et al., in an early study, SPWMD > 130 ms was considered pathological and also SPWMD predicted inverse LV remodeling and long-term clinical improvement after CRT, with 100% sensitivity, 63% specificity, and 85% accuracy.
Limitations

Impossibile to measure SPWMD in patients with a poor acoustic window, previous septal or posterior wall myocardial infarction, or abnormal septal motion secondary to RV pressure or volume overload.
Hence in later studies….

- Marcus et al underlined the low feasibility of SPWMD (measured in parasternal long axis view), had a poor sensitivity (24%) and specificity (66%) in predicting the response to CRT of 79 heart failure patients.
Lateral wall post-systolic displacement

- QRS onset to maximal systolic displacement of the basal LV lateral wall (assessed by M-mode in the apical 4-chamber view)

(Minus)

- QRS onset to the beginning of transmitral E velocity (assessed by pulsed Doppler of mitral inflow)
A positive LWPSD, i.e. a longer interval to maximal inward displacement of LV lateral wall than the interval to opening of the mitral valve, identifies a severe post-systolic contraction.

It has been demonstrated to be an independent predictor of CRT response in 48 patients with end-stage heart failure and left bundle branch block.
Pulsed Tissue Doppler

- Using PW TD, following are derived.
  - time interval between the onset of ECG derived QRS and the Sm peak (\(=\) time to Sm peak)
  - time interval between the onset of QRS and the onset of Sm (\(=\) time to Sm onset), which correspond to LV PEP

Intra-ventricular mechanical delay has been defined for differences of > 65 ms of time to Sm Peak between LV segments
Colour Tissue Doppler

1. Off-line colour Tissue Doppler derived Tissue Velocity Imaging (TVI),
2. SRI
TVI measures the time to Sm peak (Ts) or the time to Sm onset in LV basal and middle segments of the three standard apical views.

One or more difference of > 60 ms suggests significant intraventricular dysynchrony.
DI = Standard deviation of Ts of the 12 LV segments
Using a LV 12-segment model,

A dyssynchrony index (DI) can be derived as the Standard deviation of the average values of Ts (Ts-SD)

As per Yu et al, Ts-SD of > 32.6 ms predicts inverse LV remodeling after CRT with 100% sensitivity, 100% specificity and 100% accuracy in 30 candidates to CRT
Speckle tracking

- This is a 2-D strain technique and has been used to assess radial dyssynchrony before/after CRT.
- Speckle tracking has been applied to routine mid-ventricular short-axis images to calculate radial strain from multiple circumferential points averaged to six standard segments.
• Dyssynchrony from timing of peak radial strain has been demonstrated to be correlated with Tissue Doppler measures

• A **time difference ≥ 130 ms between the radial strain peak of LV posterior wall and anterior septum has shown to be highly predictive** of an improved EF during follow-up, with 89% sensitivity and 83% specificity
The TARGET Study: A Randomized, Controlled Trial. Echo guided LV lead placement offers additional benefits

- 220 pts randomized 1:1 to Echo guided vs standard LV lead CRT implantation
- Segments with radial strain amplitude 10% were regarded as nonviable (scar)
- The LV pacing lead was placed in the most delayed segment in 63% of pts in TARGET Group vs 47% in control group.
- Compared with standard CRT treatment, the use of speckle-tracking echocardiography to the target LV lead placement yields significantly improved response and clinical status and lower rates of combined death and heart failure–related hospitalization

The greatest benefit is demonstrated in pts with a concordant LV lead at sites free of scar

Three-dimensional (3-D) echocardiography allows intraventricular dyssynchrony to be evaluated by analyzing LV wall motion in multiple apical planes during the same cardiac cycle.

It also offers better spatial resolution than a single plane.
The global LV volumetric dataset has been used to determine a dyssynchrony index that corresponds to the standard deviation of the average of the time intervals needed by multiple LV segments to reach minimal end-systolic volume.

This index is expressed as the percent value of the overall cardiac cycle, in order to be able to compare patients with different heart rates.

CRT responders show a significant reduction of this 3-D dyssynchrony index, which parallels the reduction of LV enddiastolic volume and the increase in EF.
MRI for Dyssynchrony
VENC-MRI and cine-MRI were performed in 20 patients with heart failure NYHA class III and reduced ejection fraction before CRT device implantation.

The interventricular mechanical delay (IVMD) was assessed by VENC-MRI as the temporal difference between the onset of aortic and pulmonary flow.

Intraventricular dyssynchrony was quantified by cine-MRI, using the standard deviation of time to maximal wall thickening in sixteen left ventricular segments (SDt-16).

RESULTS
14 patients (70 %) clinically responded to CRT. A similar accuracy was found to predict the response to CRT by measurements of the IVMD and SDt-16.

ALSO data analysis of the IVMD is significantly less time-consuming compared to data analysis of the SDt-16.
Main ultrasound techniques, parameters and reference values for detection of intra-ventricular dyssynchrony and prediction of LV reverse remodeling

<table>
<thead>
<tr>
<th>Technique</th>
<th>Parameter</th>
<th>Authors</th>
<th>Cut-off point</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-mode</td>
<td>SPWMD</td>
<td>Pitzalis et al, J Am Coll Cardiol 2002</td>
<td>&gt; 130 ms</td>
</tr>
<tr>
<td>M-mode and PW Doppler</td>
<td>LWPSD</td>
<td>Sassone et al, Am J Cardiol 2007</td>
<td>&gt; 1</td>
</tr>
<tr>
<td>PW Tissue Doppler</td>
<td>Diff. of $T_s$ between LV segments $T_s$-SD</td>
<td>Bax JJ et al, J Am Coll Cardiol 2004</td>
<td>&gt; 65 ms</td>
</tr>
<tr>
<td>TVI</td>
<td>$T_s$-SD</td>
<td>Yu et al, Am J Cardiol 2003</td>
<td>&gt; 32.6 ms</td>
</tr>
<tr>
<td>TSI</td>
<td>$T_s$-SD</td>
<td>Yu et al, J Am Coll Cardiol 2005</td>
<td>&gt; 34.4 ms</td>
</tr>
<tr>
<td>SRI</td>
<td>TPS-SD</td>
<td>Mele et al, Eur Heart J 2006</td>
<td>&gt; 60 ms</td>
</tr>
<tr>
<td>SRI</td>
<td>ExcT</td>
<td>Porciani MC et al, Eur Heart J 2006</td>
<td>&gt; 760 ms</td>
</tr>
<tr>
<td>2D radial strain</td>
<td>Time diff. in peak septal wall-to-posterior</td>
<td>Suffoletto et al, Circulation 2006</td>
<td>≥ 130 ms</td>
</tr>
<tr>
<td></td>
<td>wall strain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D echo</td>
<td>Triplane $T_s$-SD</td>
<td>Van der Veire NR et al, Am J Cardiol 2007</td>
<td>≥ 35.8 *</td>
</tr>
</tbody>
</table>
PROSPECT (Results of the Predictors of Response to CRT Trial)

Polycentric study (53): Europe, US, Hong Kong

- 467 patients, 54% ischemic HF
- NYHA III or IV
- QRS > 130 ms, EF ≤ 35%
- Evaluation of dyssynchrony: 12 parameters
- 5 + 7 TDI
- Response to CRT: 0, 3, 6 months
- Clinical
- Mortality
- NYHA CCS
- Noncardiac hospitalization
- Generalized evaluation of patient
- Echocardiographic
- ↓ LVESV ≥ 15%

Chung et al Circulation 2008;117: 2608-2616
PROSPECT (Results of the Predictors of Response to CRT Trial) Results

CCS end point
5 non-TDI parameters, 1 TDI indicated a statistically significant relationship with the clinical outcome considered as a successful response to CRT.

LVESV end point
4 non-TDI parameters, 1 TDI indicated a statistically significant relationship with the echocardiographic outcome considered as successful CRT.

The sensitivity and specificity of the studied parameters were low.

The study does not demonstrate any of the many echocardiographic factors as reliable as to be used in clinical practice for the evaluation of asynchrony.

It is possible that clinical improvement may come faster in some patients.

Chung et al Circulation 2008;117:2608-2616
**PROSPECT** (Results of the Predictors of Response to CRT Trial)

- Κριτικές **PROSPECT**
  - Υψηλή μεταβλητότητα αποτελεσμάτων μεταξύ των εξεταστών.
  - Βραχύς χρόνος εκπαίδευσης (1day)
  - Κακή ποιότητα εικόνων (1/3 μη αναλυτές)
  - Πολυκεντρικότητα → πρώιμη ένταξη κάποιων ασθενών (US) στη μελέτη.
  - Cut off points για το δυσυγχρονισμό προέρχονται από μικρές μελέτες μονοκεντρικές.
  - Η ετερογένεια των ασθενών που ενταχθήκαν στη μελέτη (ισχαιμικοί που μπορεί να είχαν ουλώδες μυοκάρδιο).
  - Η ύπαρξη παραμέτρων πέραν των υπερηχογραφικών όπως η θέση του ηλεκτροδίου για την αριστερή κοιλία που μπορεί να τροποποιήσει το αποτέλεσμα της βηματοδότησης.
Cardiac-Resynchronization Therapy in Heart Failure with a Narrow QRS Complex

Frank Ruschitzka, M.D., William T. Abraham, M.D., Jagmeet P. Singh, M.D., Ph.D., Jeroen J. Bax, M.D., Ph.D., Jeffrey S. Borer, M.D., Josep Brugada, M.D., Ph.D., Kenneth Dickstein, M.D., Ph.D., Ian Ford, M.D., Ph.D., John Gorcsan III, M.D., Daniel Gras, M.D., Henry Krum, M.B., B.S., Ph.D., Peter Sogaard, M.D., D.M.Sc., and Johannes Holzmeister, M.D., for the EchoCRT Study Group

BACKGROUND
Cardiac-resynchronization therapy (CRT) reduces morbidity and mortality in chronic systolic heart failure with a wide QRS complex. Mechanical dyssynchrony also occurs in patients with a narrow QRS complex, which suggests the potential usefulness of CRT in such patients.

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.

RESULTS
On March 13, 2013, the study was stopped for futility on the recommendation of the data and safety monitoring board. At study closure, the 809 patients who had undergone randomization had been followed for a mean of 19.4 months. The primary outcome occurred in 116 of 404 patients in the CRT group, as compared with 102 of 405 in the control group (28.7% vs. 25.2%; hazard ratio, 1.20; 95% confidence interval [CI], 0.92 to 1.57; P=0.15). There were 45 deaths in the CRT group and 26 in the control group (11.1% vs. 6.4%; hazard ratio, 1.81; 95% CI, 1.11 to 2.93; P=0.02).

CONCLUSIONS
In patients with systolic heart failure and a QRS duration of less than 130 msec, CRT does not reduce the rate of death or hospitalization for heart failure and may increase mortality. (Funded by Biotronik and GE Healthcare; EchoCRT ClinicalTrials.gov number, NCT00683696.)
Cardiac-Resynchronization Therapy in Heart Failure with a Narrow QRS Complex


Table 2. Protocol-Specified Cardiovascular Outcomes.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Control Group (N = 405)</th>
<th>CRT Group (N = 404)</th>
<th>Adjusted Hazard Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary composite outcome</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death from any cause or hospitalization for heart failure</td>
<td>102 (25.2)</td>
<td>116 (28.7)</td>
<td>1.20 (0.92–1.57)</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>Components of primary outcome</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospitalization for heart failure</td>
<td>90 (22.2)</td>
<td>99 (24.5)</td>
<td>1.16 (0.87–1.55)</td>
<td>0.25</td>
</tr>
<tr>
<td>Death from any cause</td>
<td>26 (6.4)</td>
<td>45 (11.1)</td>
<td>1.81 (1.11–2.93)</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Other cardiovascular outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospitalization for cardiovascular event</td>
<td>137 (33.8)</td>
<td>147 (36.4)</td>
<td>1.11 (0.88–1.40)</td>
<td>0.36</td>
</tr>
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<td>Death</td>
<td></td>
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<tr>
<td>Cardiovascular event</td>
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<td>Heart failure</td>
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<tr>
<td>Follow-up data censored</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owing to LVAD implantation</td>
<td>10 (2.5)</td>
<td>7 (1.7)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Owing to heart transplantation</td>
<td>5 (1.2)</td>
<td>3 (0.7)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Death after data were censored owing to LVAD implantation or heart transplantation</td>
<td>4 (1.0)</td>
<td>1 (0.2)</td>
<td>-</td>
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</tr>
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</table>

Figure 2. Kaplan–Meier Estimates for Primary-Outcome Events.
Panel A shows the Kaplan–Meier curves for the primary composite outcome of death from any cause or hospitalization for heart failure. Panel B shows the Kaplan–Meier curves for death from any cause.

CONCLUSIONS
In patients with systolic heart failure and a QRS duration of less than 130 msec, CRT does not reduce the rate of death or hospitalization for heart failure and may increase mortality. (Funded by Biotronik and GE Healthcare; EchoCRT ClinicalTrials.gov number, NCT00683696.)

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

**Frank Ruschitzka, M.D., William T. Abraham, M.D., Jagmohan Sinha, M.D., Feng-Guo Wang, M.D., Ph.D., Hongzhong Li, M.D., Ph.D., Yew-Kong Koh, M.D., Ph.D., Robert D. Califf, M.D., William O. Roberts, M.D., Ph.D., J. Alexander Grayburn, M.D., Daniel J. Goldenberg, M.D., Ph.D., P. J. O’Connor, M.D., Ph.D., John D. Bove, M.D., Cheng-Yu Hsu, M.D., Ph.D., on behalf of the Pivotal Trial Investigators.**

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<td>1 (0.2)</td>
<td>—</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reason of Death</th>
<th>Control Group, number (%) with event N=405</th>
<th>CRT Group, number (%) with event N=404</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any reason</td>
<td>26 (6.4%)</td>
<td>45 (11.1%)*</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death due to heart failure</td>
<td>10 (2.5%)</td>
<td>17 (4.2%)**</td>
</tr>
<tr>
<td>Death due to arrhythmic events</td>
<td>4 (1.0%)</td>
<td>14 (3.5%)*</td>
</tr>
<tr>
<td>Death due to non-ischemic dysrhythmia</td>
<td>0</td>
<td>2 (0.5%)</td>
</tr>
<tr>
<td>Death due to symptomatic heart block/bradycardia/PEA</td>
<td>0</td>
<td>4 (1.0%)</td>
</tr>
<tr>
<td>Sudden cardiac death</td>
<td>4 (1.0%)</td>
<td>8 (2.0%)</td>
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<tr>
<td>Presumed cardiovascular death</td>
<td>1 (0.3%)</td>
<td>5 (1.2%)</td>
</tr>
<tr>
<td>Fatal stroke</td>
<td>1 (0.3%)</td>
<td>1 (0.3%)</td>
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<tr>
<td>Other vascular death</td>
<td>1 (0.3%)</td>
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<tr>
<td>Non-Cardiovascular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>4 (1.0%)</td>
<td>1 (0.3%)</td>
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<tr>
<td>Infection-pneumonia</td>
<td>0</td>
<td>2 (0.5%)</td>
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<tr>
<td>Infection-sepsis</td>
<td>1 (0.3%)</td>
<td>3 (0.7%)</td>
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<tr>
<td>Other non-cardiovascular</td>
<td>1 (0.3%)</td>
<td>0</td>
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<tr>
<td>Respiratory-exacerbation of COPD</td>
<td>2 (0.5%)</td>
<td>0</td>
</tr>
<tr>
<td>Traumatic injury</td>
<td>1 (0.3%)</td>
<td>2 (0.5%)</td>
</tr>
<tr>
<td>Death after crossover</td>
<td>7 (1.7%)</td>
<td>1 (0.3%)</td>
</tr>
</tbody>
</table>

Statistically significant difference of *p<0.05, **p<0.01

**CONCLUSIONS**

In patients with systolic heart failure and a QRS duration of less than 130 msec, CRT does not reduce the rate of death or hospitalization for heart failure and may increase mortality. (Funded by Biotronik and GE Healthcare; EchoCRT ClinicalTrials.gov number, NCT00683696.)

# 2013 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy

## Recommendations

<table>
<thead>
<tr>
<th>Class</th>
<th>Level</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>A</td>
<td>48–64</td>
</tr>
<tr>
<td>I</td>
<td>B</td>
<td>48–64</td>
</tr>
<tr>
<td>IIa</td>
<td>B</td>
<td>48–64</td>
</tr>
<tr>
<td>IIb</td>
<td>B</td>
<td>48–64</td>
</tr>
<tr>
<td>III</td>
<td>B</td>
<td>65, 66</td>
</tr>
</tbody>
</table>

### 1) LBBB with QRS duration >150 ms.
CRT is recommended in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment.

### 2) LBBB with QRS duration 120–150 ms.
CRT is recommended in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment.

### 3) Non-LBBB with QRS duration >150 ms.
CRT should be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment.

### 4) Non-LBBB with QRS duration 120–150 ms.
CRT may be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, III and ambulatory IV despite adequate medical treatment.

### 5) CRT in patients with chronic HF with QRS duration <120 ms is not recommended.
Συμπεράσματα

- Η υπερηχογραφία αποτελεί βασικό εργαλείο στη εκτίμηση των αποτελεσμάτων της θεραπείας επανασυγχρονισμού.

- Προς το παρόν η επιλογή ασθενών για θεραπεία δυσυγχρονισμού βάσει υπερηχογραφήματος δεν είναι τεκμηριωμένη.

- Στοιχεία από μελέτες καθιστούν υπερηχογραφικές παραμέτρους προ και μετά τη CRT ανεξάρτητους προγνωστικούς παράγοντες επιτυχίας της θεραπείας.

- Η πιο σημαντική συνιστώσα είναι ο διακοιλιακός δυσυγχρονισμός-οσο πιο μεγάλος τόσο πιο μεγάλη η πιθανότητα για ανάστροφη αναδιαμόρφωση.

- Νεώτερες τεχνικές όπως το speckle tracking και η 3D υπερηχοκαρδιογραφία υποσχονται πολλα στην επιλογή των ασθενών που θα ανταποκριθούν τα μέγιστα μετά τον επανασυγχρονισμό και στην μείωση των non-Responders(30%).
THANK YOU
When applied to the left ventricle, left ventricular deformation is defined by the three normal strains (longitudinal, circumferential, and radial) and three shear strains (circumferential-longitudinal, circumferential-radial, and longitudinal-radial).

The principal benefit of LV shear strains is amplification of the 15% shortening of myocytes into 40% radial LV wall thickening, which ultimately translates into a >60% change in LV ejection fraction.

Left ventricular shearing increases towards the subendoardium, resulting in a subepicardial to subendocardial thickening strain gradient.
Strain

- Strain is defined as the fractional or percentage change in an object's dimension in comparison to the object's original dimension.

- Similarly, strain rate can be defined as the speed at which deformation occurs.
In Conclusion

- There are several techniques for determining LV dyssynchrony
- The most important clinical application is for assessment of patient planned for CRT (with or without prolonged QRS duration)
- Intraventricular Dyssynchrony seems to be the most important
- Greater the intraventricular dyssynchrony, the higher the possibility of significant inverse LV remodeling
- 3D echo has great potential
The common advantages of these techniques is the possibility of measuring the dyssynchrony of opposite LV walls (horizontal dyssynchrony) and of different segments of the same LV wall (vertical dyssynchrony) in a given view, from the same cardiac cycle.
Mechanical dyssynchrony in left bundle branch block.