ROLE OF DIFFERENT IMAGING MODALITIES FOR CRT IMPLANTATION IN BORDERLINE QRS PATIENTS

Dr. Rehab M. Hamdy
Lecturer of cardiology
AFMG-CardioEgypt 2018

Agenda

- Current guidelines for CRT implantation
- Borderline QRS patients: Electrical vs. mechanical dyssynchrony
- EBM for implementation of imaging modalities
- Imaging modalities for CRT implantation
- How to deal----conclusions
Current guidelines for CRT implantation

ESC 2016: Recommendations for CRT implantation in patients with HF

I

- Symptomatic patients with HF in SR with QRS ≥150 m and LBBB with LVEF ≤35% despite OMT
- Symptomatic patients with HF SR with QRS 130–149 ms and LBBB with LVEF ≤35% despite OMT
- CRT rather than RVP is recommended for patients with HFpEF regardless of NYHA class who have an indication for VP and high degree AVB (including AF)

Ila

- Symptomatic patients with HF in SR with QRS ≥150 m and non-LBBB with LVEF ≤35% despite OMT
- Patients with LVEF ≤35% in NYHA Class III–IV despite OMT, in AF and QRS ≥130 m with ensuring BV-capture is in place or the patient is expected to return to SR.
ESC 2016: Recommendations for CRT implantation in patients with HF

- Symptomatic patients with HF in SR with QRS 130–149 m and non-LBBB with LVEF ≤35% despite OMT
- HFrEF patients on conventional PM/ICD and develop worsening HF despite OMT with high proportion of RVP may be considered for upgrade to CRT (not for patients with stable HF)

CRT is contra-indicated in patients with QRS < 130 m

2017 ACC/AHA/HFSA Heart Failure Focused Update
Treatment of HFrEF Stage C and D

[Flowchart showing treatment steps and recommendations]
Clinical factors influencing the likelihood to respond to CRT

- Patients with extensive myocardial scar will have less improvement in LV function with CRT, but this is true of any treatment for HFrEF (how to solve????).

- Pacing thresholds are higher in scarred myocardium and if possible, lead placement should avoid such regions (how to find the target site???)

- Although patients with extensive scarring have an intrinsically worse prognosis, there is little evidence that they obtain less prognostic benefit from CRT (worse prognosis or less prognosis???)
2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

Imaging tests for dyssynchrony have not yet been shown to be of value in selecting patients for CRT

So, .....what should we do???
ECG evidence of electrical dyssynchrony due to the presence of IVCD serves as a surrogate for ventricular mechanical dyssynchrony. However, its precision in predicting response may be limited by the complexity of electrical and mechanical dyssynchrony.
Clinical trial results support QRS duration as a critical, but not the sole, indicator of CRT response. Differences in the outcomes between the trials likely reflect varying endpoints and follow up times, differences in the patient populations studied.

Variance affecting LV activation pattern in LBBB

- Heterogeneous LV activation pattern
- Type and extent of CM disease process
- Myocardial scarring and cardiac dimensions
- QRS duration increases, the band of electrical and mechanical dyssynchrony widens

Some have suggested that unless a “true” LBBB is present, patients are unlikely to respond to CRT
Variance affecting LV activation pattern in RBBB

- Electroanatomic mapping has found significant LV conduction delay (the presence of an RBBB ECG pattern may mask a coexistent LBBB).
- Ventricular dyssynchrony patterns, which are not favorable for CRT.
- Concomitant RV dysfunction.
- More extensive conduction disease.

Variance affecting LV activation pattern non-LBBB morphology

In patients with non-LBBB morphology, a more individualized approach may be required when considering patients with a less than “ideal” ECG profile.
EBM for role of imaging prior to CRT

- **The STARTER trial**

Patients with QRS 120 to 149 ms or non-LBBB demonstrated favorable CRT outcome if the LV lead was placed concordant or adjacent to the site of latest mechanical activation using ST radial strain.

- **The TARGET trial**

Targeted LV lead placement using 2D radial train yielded a greater proportion of responders at 6 months.
Percentage assignment of the study population to recommendations classes for CRT implantation according to the European and the American guidelines

A.S. Beela et al. European Heart Journal Cardiovascular Imaging (2018) 0, 1–9

Volumetric response of patients assigned to the different European recommendation classes for CRT implantation

A.S. Beela et al. European Heart Journal Cardiovascular Imaging (2018) 0, 1–9
Volumetric response of patients assigned to the European recommendation classes, separated by the presence (Dyss) or absence (-Dyss) of mechanical dyssynchrony at baseline.

Our data are in-line with other studies, which have demonstrated an added prognostic value of mechanical dyssynchrony assessment in patients with moderately wide QRS complex (120–150 ms).

Our data show that specific signs of mechanical dyssynchrony, reflecting typical LBBB contraction pattern is closely linked to volumetric response regardless of QRS width. QRS width measurements have been shown to be associated with low reproducibility and high inter- and intraobserver variability.

An obvious conclusions by Beela et al., 2018

- Current guideline criteria for CRT candidate selection leave room for improvement of both sensitivity and specificity.
- Incorporating the assessment of specific mechanical dyssynchrony patterns amendable by CRT is a promising tool and should be considered for future evaluation.
Echo

Nuclear imaging

CCT

CMR

Integrated imaging modalities

Echocardiography can add information

2
- Estimation of mechanical dysynchrony

3
- Detection of scar area

4
- Detection of area of latest mechanical activation
Echocardiographic techniques for detection of mechanical dyssynchrony

- Conventional echo (M-mode, Doppler)
- Advanced techniques
  - Longitudinal (PWTD, CCTD & strain).
  - Radial Imaging (Speckle tracking, strain)
- 3D echo

Low feasibility (50%)
It only analyzes 2 segments
Limited to radial motion
Poor correlation with changes in LVEDV index, LVESV index, LVEF and clinical improvement
Prior septal or posterior wall infarction
Abnormal septal motion secondary to RV pressure/volume overload
Echo-Doppler parameters

IVD > 40 ms
LVPET > 140 ms

Limitations:
- RV PEP prolongs and the RV ET shortens in pts with P++ & RV systolic dysfunction.
- LV PEP may not accurately reflect ICT (prolonged because of the increases in PR & QRS intervals and, impaired rate of LV pressure increase (dP/dt)).

Septal flash and apical rocking
CTDI and off-line analysis of time velocity curve

1- Maximum difference between Ts of any 2 of the 12 segments >100 ms

2- Difference between any 2 opposing segments >65 ms

3- The Ts-SD of all 12 segments >32.6 ms (dyssynchrony index).
• Cut-off value of radial dyssynchrony ≥130 ms to predict response to CRT
3D–longitudinal strain computation in a multi-parametric approach

Fournet et al. Cardiovascular Ultrasound (2017) 15:15

Integrated Information on Dyssynchrony, Scar, and Region of Latest Mechanical Activation May Improve Response to CRT

Heart failure patients – eligible for CRT
LVEF <35%, NYHA III –IV, QRS >120

likelihood of CRT response?

- Dyssynchrony
- Scar tissue in LV lead
- Extensive scar (>50% of LV)
- LV lead mismatch
  (vs site of latest mechanical activation)

HIGH
LOW
Mechanical dyssynchrony is indicated by the heterogeneous phase angle distribution of the polar map (panel A) and the wide histogram (panel B).

- Optimal value for prediction of response to CRT was 135° for histogram bandwidth and 43° for phase standard deviation.
- <15% of total myocardium infarcted and the absence of significant posterolateral scar (Van de Veire et al., 2009).
Integrated imaging modalities

Echo
CCT
Nuclear imaging
CMR

CMR prior CRT implantation

1. Reliable and accurate assessment of LV volumes and EF
2. Estimation of the degree of mechanical asynchrony
3. Detection and quantification of scar tissue in myocardium & its spatial relation to the site of LV pacing
4. Evaluation the coronary venous anatomy
Assessment of LV volumes and EF
Estimation of the degree of mechanical asynchrony

Mechanical dyssynchrony - CMR techniques

1. Cine MRI
2. Myocardial tagging
3. Strain-encoded MRI (SENC)
4. Phase-contrast MRI
5. Displacement encoding with stimulated echoes (DENSE)
Cine MRI- SSFP: TSI

Myocardial tagging (SPAMM& 3-D)
Detection and quantification of scar tissue in myocardium & its spatial relation to the site of LV pacing

Can the extent of scar Predict Response to CRT?

- A cutoff value of <15% for scar burden in patients in IDCM and NIDCM was associated with clinical responders to CRT, (sensitivity of 85% and specificity of 90%)
- in patients with IDCM, scar transmurality ≥50% is associated with a suboptimal response to CRT
Can the location of the scar affect response to CRT?
Evaluation the coronary venous anatomy
Integrated imaging modalities

- Echo
- CCT
- Nuclear imaging
- CMR

CCT prior CRT implantation

1. Evaluation of LV EF and volumes
2. Assessment of asynchrony
3. Quantification of scar
4. Evaluation of coronary venous anatomy
5. Assisting in determining the optimal LV lead placement
Assessment of asynchrony

Quantification of scar
Evaluation of coronary venous anatomy
Comparison of Different Imaging Modalities of CRT

<table>
<thead>
<tr>
<th>Clinical utilities</th>
<th>Echocardiography</th>
<th>CCT</th>
<th>CMR</th>
<th>SPECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scar burden</td>
<td>++ (strain)</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>LVEF volumes</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>RV volumes</td>
<td>++ (SD)</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Mitral regurgitation</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Simplicity of interpretation, no. indices</td>
<td>&gt;16</td>
<td>1-3</td>
<td>-5-7</td>
<td>2</td>
</tr>
<tr>
<td>Latest site of activation, regional</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Coronary vein</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Post-CRT follow-up</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Clinical experience</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Poole et al. JACC 2016

![Flowchart](chart.png)

- **QRS Width ≤ 120 ms:**
  - Non-LBBB
  - Reduced evidence of prior infarction
  - Reduced evidence of prior myocardial infarction
  - Target LV lead to region of electrical and mechanical delay

- **QRS Width > 120 ms:**
  - LBBB
  - Reduced evidence of prior infarction
  - Reduced evidence of prior myocardial infarction
  - Target LV lead to region of electrical and mechanical delay

- **QRS Width ≥ 150 ms:**
  - Non-LBBB
  - Reduced evidence of prior infarction
  - Reduced evidence of prior myocardial infarction
  - Target LV lead to region of electrical and mechanical delay

- **QRS Width > 150 ms:**
  - LBBB
  - Reduced evidence of prior infarction
  - Reduced evidence of prior myocardial infarction
  - Target LV lead to region of electrical and mechanical delay

- **IVCD:**
  - Reduced benefit of CRT expected
  - Individualized approach recommended
  - QRS morphology suggesting greater delay in the left bundle branches favors benefit
  - Imaging techniques to identify predictors and location of left activation may help
  - Target LV lead to region of electrical and mechanical delay

- **RESERVE:**
  - Reduced benefit of CRT expected
  - Individualized approach recommended
  - QRS morphology suggesting greater delay in the left bundle branches favors benefit
  - Imaging techniques to identify predictors and location of left activation may help
  - Target LV lead to region of electrical and mechanical delay

- **Predicted high-CRT response:**
  - Maximizing CRT response
  - Avoiding LV lead to region of electrical and mechanical delay

- **Predicted high-CRT response:**
  - Maximizing CRT response
  - Avoiding LV lead to region of electrical and mechanical delay
3/21/2018

QRS 120-149 ms

Non-LBBB

- Poor response to CRT (RBBB)
- Individualized approach:
  - QRS morphology suggesting greater delay in LB favors benefit
  - Imaging techniques to identify presence and location of late activation
  - Target LV lead to region of electrical and mechanical delay

LBBB

- Moderate to high CRT response (wider QRS and female)
- Maximize CRT response:
  - Avoid apical LV, target lateral LV
  - Target LV lead to region of electrical and mechanical delay

Poole et al. JACC 2016

QRS >150 ms

Non-LBBB

- Reduced response to CRT
- Individualized approach:
  - QRS morphology suggesting greater delay in LB favors benefit
  - Imaging techniques to identify presence and location of late activation
  - Target LV lead to region of electrical and mechanical delay

IVCD

RBBB+LAHB/LPHB

LBBB

- High CRT response
- Maximize CRT response:
  - Avoid apical LV, target lateral LV
  - Target LV lead to region of electrical and mechanical delay

Poole et al. JACC 2016
To conclude......

Critical factors that must be taken into account for CRT to be effective:

1) Mechanical dyssynchrony is actually present
2) Conduction is sufficiently delayed
3) Comorbid conditions are considered
4) Myocardial scarring, possibly altering conduction pattern, is recognized
5) Placement of the pacing lead ideally targets the area of late activation