New Technologies to Improve Patient Selection and Ensure Device Optimization

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Durability of the survival effect of cardiac resynchronization therapy by level of left ventricular functional improvement: Fate of “nonresponders”

1. Pre-CRT - candidate selection
2. Peri-CRT - LV lead delivery
3. Post-CRT - optimization and monitoring

N= 526
Rickard …Varma  Heart Rhythm 2014
“Strict” LBBB

QRS
QRS/ LV Mass

EF Responder (%) vs Pre-implant QRSd/Mass

JACC EP 2017
“Strict” LBBB

Other ECG Features

QRS frequency characteristics help predict response to cardiac resynchronization in left bundle branch block less than 150 milliseconds

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From the ’The Cleveland Clinic, Cleveland, Ohio, and Johns Hopkins University, Baltimore, Maryland.

- Left Bundle Branch Block
- Normal QRS Patient
“Strict” LBBB

Not all LBBB are Created Equal
Electrocardiographic Activation Map of a Clinical Responder to CRT With a 12-Lead Surface ECG Exhibiting a NICD Activation Pattern

Ploux et al JACC 2013
Paced Effects
Programming

Fusion between the left and right excitation waterfronts correlates with highest increase in LV contractility

(van Gelder et al., JACC 2005; Verbeek et al., AJP, 2006)

LV Fusion—Adaptive CRT™

Time to Heart Failure Hospitalization or All-Cause Death
(With Number at Risk)

↑ Benefits with ↑% Synchronized LV Pacing

Birnie…Martin HRJ 2013
LV Lead Position: Hemodynamics

Distribution of Best (A) and Worst (B) Sites

- Stimulation from the best LV site resulted in a 2x ↑dP/dt
- Site was widely distributed

Conclusion - Practice of fixed single site in lateral wall will not capture hemodynamically best site- this requires individualization

*Derval JACC 2010*
Body surface mapping using an ECG belt to characterize electrical heterogeneity for different left ventricular pacing sites during cardiac resynchronization: Relationship with acute hemodynamic improvement

Reduction in electrical heterogeneity guided hemodynamic optimization
Multipoint pacing by a left ventricular quadripolar lead improves the acute hemodynamic response to CRT compared with conventional biventricular pacing at any site.

Compared with BiV pacing at any LV site, MPP yielded:
- A small but consistent contractility increase, which was
- Correlated with greater QRS narrowing
Maintaining Paced Effects
Why Dynamic?

<table>
<thead>
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<th>Recommendations</th>
<th>Class</th>
<th>Level</th>
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<td>1) The goal should be to achieve biventricular pacing as close to 100% as possible since the survival benefit and reduction in hospitalization are strongly associated with an increasing percentage of biventricular pacing.</td>
<td>Ila</td>
<td>B</td>
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For patients with <98% pacing, pacing loss commonly due to AF, PVCs but 
Inappropriately programmed sensed/ paced atrioventricular (AV) intervals accounted for 34.5% of all ventricular sensing episodes
Frequency of Optimization – Adaptive CRT

- Automatically updated every minute
- Prefers LV fusion

![Graph showing Time to Heart Failure Hospitalization or All-Cause Death](image)

**Benefits with %Synchronized LV Pacing**

- **1:** Adaptive LV Pacing < 50%
- **2:** Adaptive LV Pacing ≥ 50%

*Varma, Stadler, Ghosh, Kloppe Europace 2016*
The EffectivCRT™ During AF Algorithm automatically changes the pacing rate to increase effective CRT delivery during AF by up to 15%\(^1\)

Our prospective, randomized, multicenter crossover study demonstrated the ability of the EffectivCRT During AF Algorithm to increase effective pacing (N = 54).

Results showed:

- EffectivCRT During AF increased effective pacing, from 81% to 88% (p < 0.001).
- Heart rate increased by 3 beats per minute, from 77 to 80 BPM (p < 0.001).
- Patients with baseline (< 80%) paced received the greatest benefit.
SyncAV™: Individualized programming

LBBB: 164 ± 17 ms

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<th>QRSd Relative Reduction vs Intrinsic (%)</th>
<th>QRSd</th>
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<tr>
<td>BiV Nominal AV (140/110) VV (Simul)</td>
<td>-13.3%</td>
<td>142 ± 18 ms</td>
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<tr>
<td>NH (-50 ms) BiV</td>
<td>-20.1%</td>
<td>131 ± 12 ms</td>
</tr>
<tr>
<td>NH (Optimal) BiV</td>
<td>-24.4%</td>
<td>123 ± 10 ms</td>
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<tr>
<td>NH (-50 ms) LV only</td>
<td>-14.1%</td>
<td>140 ± 15 ms</td>
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P < 0.01
Wireless pulmonary artery haemodynamic monitoring

Hospitalization rates in CRT Patients

CRT Non-Responders

28% Reduction
HR 0.72, 95% CI 0.54-0.95, p<0.0223
NNT=4

Abraham et al Abstract HRS 2015
CRT Effect: Multiple Factors

Magnitude of Benefit from CRT

- Highest (Responders)
  - Wider QRS, left bundle branch block, females, non-ischaemic cardiomyopathy

- Males, Ischaemic cardiomyopathy

- Narrower QRS, non-left branch block

- Lowest (Non-responders)

- LV Lead
  - Delivery
  - Pacing effects
  - Programming

- Post implant monitoring

*Modified from ESC 2013*