Novel Three Dimensional Echocardiographic Guided Optimization of Cardiac Resynchronization Therapy

Dr. Carolin Sonne
Deutsches Herzzentrum
Technische Universität München

ESC Congress 2010
Nothing to disclose
56-year old male patient:

- ischemic cardiomyopathy with severely reduced LV function (EF= 19%)
- left bundle branch block
- NYHA functional class III, despite optimal medical therapy

➤ *how can we achieve the best CRT-response in this patient?*
Background
CRT reduces:

- overall mortality
- hospitalisations for heart failure
- symptoms of heart failure

But: >30% of selected CRT patients show no clinical improvement, so called nonresponders

Linde et al. (MUSTIC). JACC 2002
Young et al. (MIRACLE ICD Trial). JAMA 2003
Bristow et al. (COMPANION). NEJM 2004
Cleland et al. (CARE-HF). NEJM 2005
Abraham et al. (MIRACLE). NEJM 2002
Reuter et al. Am J Cardiol 2002
Bax et al. JACC 2005
Nonresponders

- Possible reasons:
  - ...
  - Suboptimal lead placement
  - Scar tissue (especially postero-lateral, preferred area of the LV-lead) and consequently slowed conduction with mechanical dyssynchrony despite CRT

- Nevertheless often not many alternative locations for LV lead placement

Hummel et al. Heart Rhythm 2005
Bleeker et al. Circulation 2006
Ypenburg et al. Eur Heart J 2007
The aim of this study is to examine a novel combination of doppler echocardiography (DE) and three-dimensional echocardiography (3DE) for individualized optimization of AVD and VVI compared to empiric programming.
Optimization of the AV- und VV-Intervals

Empiric:
- AVD: 120ms
- VVI: LV=RV

Doppler-echocardiography
- Optimal AV-delay: highest aortic velocity time integral (Ao VTI), as an indirect parameter of stroke volume

3D-echocardiography
- Optimal VV-Interval: most synchronous cardiac activity
Optimization of the VV-Interval using 3D-echocardiography
• Volume-time curves for each segment

• The nadir of each segmental volume curve represents the timing of regional end of ejection

• LV-Dyssynchrony Index (LVDI): standard deviation of the timing of regional end of ejection for all segments expressed in percent of the RR interval to take into account differences in heart rate

Kapetanakis et al. Circulation 2005
Sonne et al. JACC Img 2009
Study design

1. Before biventricular pacemaker implantation
2. biventricular pacemaker implantation
3. Empiric AV- and VV-Interval
4. Echocardiographic AV-Interval optimization

Steps:
- 1: echocardiography
- 2: echocardiography
- 3: echocardiography
- 4: echocardiography
Inclusion criteria:
- NYHA III-IV despite optimal medical therapy for heart failure
- Ischemic or non-ischemic cardiomyopathy with LV-EF ≤35%
- QRS>120ms

Exclusion criteria:
- Persistent atrial fibrillation, chronic atrial tachycardias
- Symptomatic bradycardias
- Significant valvular dysfunction
- Instable coronary heart disease
- Significant comorbidities (COPD on chronic oxygen therapy, creatinine>2,5mg/dl, refractory angina pectoris)
Back to the case…
Before implantation of the biventricular pacemaker

EF: 19 %

LVDI: 12.1 %
AV-Delay optimization in our patient

Aortic VTI in the various AV-Delays

AV-Delay (ms)

Ao VTI (cm)
After AV-optimization of the biventricular pacemaker

EF: 20 %

LVDI: 11.5 %
Optimal Intervals: **AVD**: 120ms, **VVI**: stimulation of LV 20ms before RV
After AVD-and VVI-optimization of the biventricular pacemaker

EF: 26 %

LVDI: 4,8 %
3 months follow-up

EF: 30 %

LVDI: 3,5 %

NYHA II
Results
## Baseline characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>25</td>
</tr>
<tr>
<td>Age (years)</td>
<td>67±11</td>
</tr>
<tr>
<td>Gender: n (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14 (56)</td>
</tr>
<tr>
<td>Female</td>
<td>11 (44)</td>
</tr>
<tr>
<td>Etiology: n (%)</td>
<td></td>
</tr>
<tr>
<td>ischemic</td>
<td>14 (56)</td>
</tr>
<tr>
<td>nonischemic</td>
<td>11 (44)</td>
</tr>
<tr>
<td>QRS duration (ms)</td>
<td>165±33</td>
</tr>
<tr>
<td>NYHA functional class: n (%)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>22 (88)</td>
</tr>
<tr>
<td>IV</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Medication: n (%)</td>
<td></td>
</tr>
<tr>
<td>ACE-inhibitors</td>
<td>23 (92)</td>
</tr>
<tr>
<td>β-Blockers</td>
<td>23 (92)</td>
</tr>
<tr>
<td>Diuretics</td>
<td>24 (96)</td>
</tr>
<tr>
<td>Aldosterone antagonists</td>
<td>18 (72)</td>
</tr>
<tr>
<td>LV ejection fraction (%)</td>
<td>23±7</td>
</tr>
</tbody>
</table>
Echo parameters at baseline

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV-EF (%)</td>
<td>23±7</td>
</tr>
<tr>
<td>EDV (ml)</td>
<td>177±62</td>
</tr>
<tr>
<td>ESV (ml)</td>
<td>138±60</td>
</tr>
<tr>
<td>LVDI (%)</td>
<td>14,3±6,0</td>
</tr>
<tr>
<td>Ao VTI (cm)</td>
<td>24,4±7,5</td>
</tr>
</tbody>
</table>
AV-Interval optimization: acute effekt on AoVTI

* $p<0.01$ compared to baseline (before biventricular pacemaker implantation)
¶ $p<0.01$ compared to empiric
AV- und VV-Interval optimization: acute effect on dyssynchrony

Change in LVDI (%)

<table>
<thead>
<tr>
<th></th>
<th>After AVD-Opt (LV=RV)</th>
<th>After AVD- and VVI-Opt</th>
</tr>
</thead>
<tbody>
<tr>
<td>* p&lt;0.01 compared to baseline (before biventricular pacemaker implantation)</td>
<td>-5.3</td>
<td>-8.2</td>
</tr>
<tr>
<td>¶ p&lt;0.01 compared to empiric</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n=25
AV- und VV-Interval optimization: acute effekt on EF

* $p<0.01$ compared to baseline (before biventricular pacemaker implantation)
‡ $p<0.01$ compared to empiric
AV- und VV-Interval optimization: acute effekt on EDV and ESV

After AV-Opt LV=RV
After AV- und VV-Opt

Change in EDV (ml)

-7.8  * p=0.1
-10.6  * p<0.05

\[ \updownarrow p=0.17 \]

Change in ESV (ml)

-17.2  * p<0.01
-23.7  * p<0.01

\[ \updownarrow p<0.01 \]

n=25

* compared to baseline (before biventricular pacemaker implantation)
\[ \parallel \] compared to empiric
18 (72%) of patients show an optimized VV-Interval with LV- or RV-preactivation (≠LV=RV)
Conclusion

Compared to empiric programming of AVD- and VVI, echo-guided optimization of both parameters by doppler echocardiography and this novel 3DE parameter, acutely improved LV systolic function and decreased ESV and can be used to select the optimal AVD and VVI in CRT.
Limitations

- Small study and only acute echocardiographic results directly after CRT-optimization
- Nevertheless, promising results, as LV resynchronization acutely after the implantation of biventricular pacemakers predicts response to CRT in the long-term

Bleeker et al. Circulation 2007
Thank you for your attention!

Acknowledgements:
Dr. L. Bott-Flügel
PD Dr. P. Barthel
Dr. F. Michalk
Dr. K. Hoppe
Cand. med. S. Hauck
PD Dr. J. Hausleiter
PD Dr. C. Kolb