Reprogramming to Prevent Anodal Stimulation

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Outline

• What is anodal stimulation?
• How to detect it
• Risk factors for anodal stimulation
• Reprogramming to prevent anodal stimulation
Components for Response to CRT

- Ventricular Synchrony
- Anodal Stimulation
- Atrioventricular Synchrony
- Lead Position
- Viable Myocardium
- % BiV Pacing
What is Anodal Stimulation?

- **Anodal Stimulation**: the anode electrode is the site of myocardial capture
- **With normal pacing**, the cathode (distal electrode) is the site of myocardial stimulation
Anodal Stimulation
Important when pacing between distant electrodes

LV pacing vector without anodal stim

LV pacing vector in anodal stim

Modified from D Tamborero, et al. PACE 2006;29:940-945
Fused Anodal Stimulation

LV pacing vector with fused anodal stim

Modified from D Tamborero, et al. PACE 2006;29:940-945
Mechanism of Anodal Stimulation

- Hyperpolarization of the myocardium at the anode
  - Depolarization of the “virtual cathode” adjacent to the electrode/myocardial interface (shaded areas)
  - Pacing at higher output creates enough adjacent depolarization around anode

Predisposing Factors for Anodal Stimulation

- Smaller anode electrode creates higher current density at anode
  - CRT-P LV pacing to RV ring electrode
  - CRT-D LV pacing using dedicated bipolar RV ICD lead ring as the anode
- Anodal stim when pacing at high output in
  - 74% of CRT-P pacing to RV ring
  - 0% of CRT-D pacing to RV coil

D Tamborero, et al. PACE 2006;29:940-945
Is Anodal Stimulation Always Bad?

CRT pacing using anodal stimulation in all leads

Possibly due to larger area of direct activation (virtual electrode)

Anodal Stimulation Detected by Far Field Electrograms in CRT

Anodal Stimulation in Cardiac Resynchronization Therapy Devices

- Pacing LV tip to RV ring
  - 37 patients, mainly CRT-P
  - 78% had anodal stim with LV pacing
Anodal Stimulation in Cardiac Resynchronization Therapy Devices

- Pacing LV tip to RV ring
  - 37 patients, mainly CRT-P
  - 78% had anodal stim with LV pacing
  - 41% had different BiV pacing morphology above & below anodal stim threshold

Decreased EF in 20% of patients with Anodal Stim

Anodal Stimulation in Cardiac Resynchronization Therapy Devices

• Thresholds
  - Anodal stim 4.5 +/- 1.7 V
  - LV bipolar 1.1 +/- 0.3 V

(p < 0.0001)

• Pacing at lower outputs is less likely to cause anodal stimulation

Anodal stim with LV pacing at higher output

CRT-P LV pacing from LV tip to RV ring

D Tamborero, et al. PACE 2006;29:940-945
QRS Morphology Clues to Pacing Site

I, aVL

II, III, aVF

RV or Septal

Inferior

Lateral

Anterior
Is there Anodal Stim Pacing LV tip to RV ring?
Is there Anodal Stim Pacing LV tip to RV ring?

Mid lateral LV Lead Position
CRT Pacemaker: Anodal Stim

No anodal stim
LV to RV ring
at 2 V

Anodal stim
LV to RV ring
at 5 V

RV Pacing
**Fused Anodal Stim Patient #1**

LV pacing configuration: LV tip to RV coil

<table>
<thead>
<tr>
<th>ECG Leads</th>
<th>RV Pacing</th>
<th>LV Pacing</th>
<th>BiV Pacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>III</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>aVF</td>
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<tr>
<td>V1</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Lateral LV Lead Position
Case 2

• 81 year old male
• Ischemic cardiomyopathy, EF 16%
• Boston Scientific CRT-D generator, Medtronic dedicated bipolar RV lead
• LV pacing with best threshold
  • LV ring to “RV coil”
### Fused Anodal Stim Patient #2
LV pacing configuration: LV ring to “RV coil”

<table>
<thead>
<tr>
<th>ECG Leads</th>
<th>RV Pacing</th>
<th>LV Pacing</th>
<th>BiV Pacing</th>
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</thead>
<tbody>
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<td>V1</td>
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Anterolateral LV Lead Position
# Case Series of 102 CRT Implants

<table>
<thead>
<tr>
<th></th>
<th>Anodal Stim Patient #1</th>
<th>Anodal Stim Patient #2</th>
<th>Anodal Stim Patient #3</th>
<th>Anodal Stim (n = 3)</th>
<th>No Anodal Stim (n = 99)</th>
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</thead>
<tbody>
<tr>
<td>Patients with change in LVESV &gt;15%</td>
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<td>Patients with ≥10% increase in LVEF</td>
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<td>Patients with ≥10% increase in 6MW</td>
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<td>Improved NYHA by ≥1 class</td>
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<td>No</td>
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</tr>
</tbody>
</table>

KF Dendy, BD Powell, et al. *Indian Pacing Electrophysiol J.* 2011
Case Series of 102 CRT Implants

- Of the 46 patients programmed LV to RV ring or coil
  - 3 had unrecognized anodal stim at implant (6.5%)
Case

- 55 year old female
- Sinus node dysfunction after sinus node modification in 1990’s for inappropriate sinus tachycardia
- Dual chamber pacemaker
- RV pacing induced cardiomyopathy (EF 36%)
- Upgrade to CRT-P (EF improved 56%)
Mid lateral LV lead position
Is there Anodal Stim Pacing LV ring to RV ring at 3 Volts?
Is there Anodal Stim Pacing LV ring to RV ring at 5 Volts?
BiV pacing with LV configured LV ring to Can compared to Anodal Stim

BiV Pacing

Anodal Stim
Reprogramming to Avoid Anodal Stimulation

- Look for anodal stim on ECG
- Pace LV tip to LV ring
  - May get anodal stim of LV ring, but not clinically relevant
- Pace from LV to RV coil instead of smaller electrode RV ring
- Pace at output below anodal stim threshold