Advances in Cardiac Pacing

State of the Art - - 2016

Richard Abben, M D
Director, Cardiac Arrhythmia Service
Cardiovascular Institute of the South
Associate Clinical Professor of Medicine
LSU School of Medicine
Disclosures

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Cardiac Devices

State of the Art
2016

2016 Advances

Updated pacing approaches

Leadless devices
However . . . In many cases, particularly patients with baseline LV dysfunction RV apical pacing may worsen ventricular function . . .

“Pacemaker syndrome” or “Pacing-induced cardiomyopathy”
• Asynchronous activation similar to LBBB
• Potential for increased MR, decreased CO

RV Pacing Hazards

DAVID trial (506 ICD pts; VVI vs DDD)
RV pacing hazardous in ICD pts with increased mortality/HF

MADIT II trial (567 ICD pts – 8 yr f/u)
Increased mortality associated with higher % of RV pacing

MADIT II – Long-term survival
RV Apical Pacing - - More Bad News . . .

- Iatrogenically accentuated intraventricular conduction delay
- Left ventricular electrical and mechanical dyssynchrony
- Left ventricular remodeling
- Abnormalities in myocardial histopathology
- Left ventricular dysfunction (both systolic and diastolic)
- Congestive heart failure
- Myocardial perfusion defects and regional wall motion abnormalities
- Functional mitral regurgitation
- Increased risk of atrial fibrillation (in patients with sinus node dysfunction and normal baseline QRS duration)
- Left atrial enlargement
- Promotion of ventricular arrhythmias
- Activation of sympathetic nervous system

Manolis A. PACE 2006;29:298-315.
Pacing from the RV septum may alleviate this issue, but data not confirmatory...
Pacing Study -- Septal location better

- 12 patients with AF and pacemakers post–ablation
  - of AV node
- DDD pacers with electrodes in RV apex and septum
- Respective sites compared over 4 months

Improved LV function (p<0.01)
Biventricular Pacing (CRT) Prevents/Reverses LBBB or RV pacing hazards
NB, 58 year old woman

June, 1996
- LBBB with progression to complete heart block
- Angiography – No CAD
- DDDR pacemaker implanted
  - ECHO EF - - .55

February, 2003
- Moderate DOE
  - ECHO EF - - .25
- Perfusion study - - No ischemia

Pacemaker upgraded to CRT system

June, 2003
- Improved symptoms
- No heart failure
  - ECHO EF - - .55
CRT reversal of Pacemaker Syndrome

- NB, 58 year old woman
  - LBBB with progression to complete heart block
  - Angiography – No CAD
  - DDDR pacemaker implanted
  - ECHO EF – 55%

- June, 1996
- February, 2003
- Pacemaker upgraded to CRT system
  - June, 2003
  - QRS duration – 170 msec.
  - QRS duration – 150 msec.
Cardiac Resynchronization Therapy

- Interventional techniques
- Favorable results in all classes of heart failure
- Patients with true LBBB with best outcomes
- Superresponders may normalize LV function

Balloon angioplasty

Lateral branch stenosis
Cardiac Resynchronization Therapy

- Interventional techniques useful
- Favorable results in all classes of heart failure
- Patients with true LBBB with best outcomes
- Superresponders may normalize LV function

Trans-collateral PTA and access

Difficult anterograde access
Cardiac Resynchronization Therapy

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- Favorable results in all classes of heart failure
- Patients with true LBBB with best outcomes
- Superresponders may normalize LV function
MADIT-CRT – 1820 Class I and II HF patients with EF < 0.30 and BBB

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Events/No. of Patients</th>
<th>Hazard Ratio</th>
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<tbody>
<tr>
<td>Age</td>
<td></td>
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<tr>
<td>&lt;65 yr</td>
<td>342/852</td>
<td></td>
</tr>
<tr>
<td>≥65 yr</td>
<td>230/968</td>
<td></td>
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<tr>
<td>Sex</td>
<td></td>
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<tr>
<td>Male</td>
<td>294/1367</td>
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<tr>
<td>Female</td>
<td>78/453</td>
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<tr>
<td>NYHA class</td>
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<tr>
<td>Ischemic I</td>
<td>53/265</td>
<td></td>
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<tr>
<td>Ischemic II</td>
<td>186/734</td>
<td></td>
</tr>
<tr>
<td>Nonischemic II</td>
<td>133/821</td>
<td></td>
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<tr>
<td>QRS duration</td>
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</tr>
<tr>
<td>&lt;150 msec</td>
<td>347/645</td>
<td></td>
</tr>
<tr>
<td>≥150 msec</td>
<td>225/1175</td>
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<tr>
<td>LV EF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤25%</td>
<td>101/646</td>
<td></td>
</tr>
<tr>
<td>&gt;25%</td>
<td>271/1174</td>
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<tr>
<td>LV EDV</td>
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<td></td>
</tr>
<tr>
<td>≤240 ml</td>
<td>184/828</td>
<td></td>
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<tr>
<td>&gt;240 ml</td>
<td>184/969</td>
<td></td>
</tr>
<tr>
<td>LV ESV</td>
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<td></td>
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<tr>
<td>≤170 ml</td>
<td>190/835</td>
<td></td>
</tr>
<tr>
<td>&gt;170 ml</td>
<td>178/962</td>
<td></td>
</tr>
<tr>
<td>All patients</td>
<td>372/1820</td>
<td></td>
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</table>
In patients with AV block and mild LV systolic dysfunction (LVEF < 50%), BiV pacing compared to RV pacing leads to a significant 26% reduction in the combined endpoint of mortality, heart-failure related urgent care, and increase in LVESVI.

Furthermore, there is a 27% relative risk reduction in the composite endpoint of heart-failure urgent care and all-cause mortality.

RV-LV Synchrony (Reflected in QRS) Impacts Hemodynamics

- Normal QRS duration: 80 msec (.08 sec)
- LBBB conduction: 150 msec (.15 sec)
- Standard RV Pacing: 180 msec (.18 sec)
- RV septal/outflow Pacing: 150 msec (.15 sec)
- Biventricular Pacing: 140 msec (.14 sec)
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Normal conduction

His-bundle pacing
RV-LV Synchrony (Reflected in QRS)

Impacts Hemodynamics

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Right-sided pacing locations

- Septal
- His
- TV
- MV

His lead Plane of TV not traversed by electrode
RV - LV Synchrony (Reflected in QRS) Impacts Hemodynamics

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RV septal/outflow Pacing 150 msec

His-bundle pacing study

Mean EF – 0.56

His-bundle pacing study

Log-rank test for equality
p = .02

No difference in mortality observed

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Impacts Hemodynamics

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150 msec

His-bundle pacing study


Heart failure hospitalizations reduced with HB pacing when % paced >40%

No difference in mortality observed
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Hemodynamics

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His-bundle pacing

Pacing electrode

His catheter – Proximal, distal
RV-LV Synchrony (Reflected in QRS) Impacts Hemodynamics

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Distal His-bundle pacing with BBB resolution

“Longitudinal dissociation” of fibers in the His bundle predestined to become the LBB or the RBB

Bundle branch block may occur at different levels in the conduction system
RV-LV Synchrony (Reflected in QRS) Impacts Hemodynamics

Normal QRS duration
80 msec (.08 sec)

LBBB conduction
150 msec (.15 sec)

Standard RV Pacing
180 msec (.18 sec)

Biventricular Pacing
140 msec (.14 sec)

RV septal/outflow Pacing
150 msec

Distal His-bundle pacing with BBB resolution

Figure 2 Proximal and distal His bundle (HB) recordings (paper speed 50 mm/s) and paced QRS morphology using permanent His bundle lead (3830, Medtronic). A = atrial electrogram; H = His electrogram; V = local ventricular electrogram. Sharma, et al. Heart Rhythm. 13;623-625.
Pre-procedure assessment of pacing needs essential . . .

Options

- **RV septal pacing**
- **Biventricular pacing**
- **His-bundle pacing**

AF with slow response – RV pacing need HIGH
Pre-procedure assessment of pacing needs essential . . .

Complete heart block – RV pacing need HIGH
Pre-procedure assessment of pacing needs essential . . .

*Sick sinus syndrome*– RV pacing need LOW
Until recently . . .

All Pacemakers and ICDs required placement of transvenous electrodes to directly monitor and stimulate the cardiac electrical system.
However, transvenous electrodes may result in adverse events acutely, such as pneumothorax, vessel and cardiac perforation, and chronically, such as erosion, lead migration/ perforation, endocarditis, venous obstruction, "Twiddler's syndrome," lead fracture, and dysfunction. Leadless pacemakers and defibrillators offer an alternative solution to electrode issues.
Leadless Pacemakers

Nanostim

Micra
Micra

Femoral approach
Snare retrieval device
LEADLESS II Study
• 526 patients – 95.8% success
• Primary success at 6 months – 90%
• Complications – 6.7%
  o Device dislodgement with retrieval
  o Elevated threshold
  o Perforations (1.3%)

Micra Pacing Study
• 725 patients – 99.2% success
• Primary success at 6 months – 98.3%
• Complications – 4%
  o Embolism
  o Elevated thresholds
  o Groin site issues
  o Perforations (1.6%)

Figure 2. Kaplan–Meier Estimate of Absence of Major Complications Related to the Micra System or Implantation Procedure through 12 Months after Implantation.
I bars represent pointwise 95% confidence intervals based on the log–log transformation. The P value is for comparison of the 6-month (183-day) rate of freedom from complications against the prespecified performance goal of 83%. The inset shows the same data on an enlarged y axis.
ICD - Preferred Therapy in SCD Prevention in Heart Failure Patients

Implantation Location

- ICD generator
- RV electrode

Subcutaneous ICD (extravascular)

- Generator and electrode implanted in subcutaneous tissue without fluoroscopy
- Potential for reduced infections including endocarditis and lead and vascular complications
PRAETORIAN trial: A Prospective, RAnomizEd comparison of subcuTaneOus and tRansvenous ImplANtable cardioverter-defibrillator therapy

700 patient trial – SQ vs TV ICD
Cardiac Device Therapy

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2016 Advances

CRT pacing beneficial
His-bundle pacing potential
- Heart failure reduction
- BBB reversal possible

Leadless devices will become the preferred option for both pacing and defibrillation
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