Cardiac Electrophysiology and Pacing

State of the Art - - 2016

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Cardiac Electrophysiology And Pacing

Assessment and Treatment of Cardiac Electrical Disturbances

2016 Advances

New 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 apex with worst hemodynamic effect

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-avablation 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

- LBBB with progression to complete heart block
- Angiography – No CAD
- DDDR pacemaker implanted
- ECHO EF - 55
- Moderate DOE
- ECHO EF - 25
- Perfusion study – No ischemia
- February, 2003
- Pacemaker upgraded to CRT system
- June, 2003
- Improved symptoms
- No heart failure
- ECHO EF - 55
- QRS duration – 170 msec.
- QRS duration – 150 msec.
BLOCK HF study – 691 pts with AV block, no ICD indication

- In patients with AV block and 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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150 msec

Normal conduction

His-bundle pacing
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Right-sided pacing locations:
- Septal
- His bundle
- TV (Tricuspid Valve)
- MV (Mitral Valve)
- His lead
  - Plane of TV not traversed by electrode
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His-bundle pacing study

Mean EF – 0.56

Schematic representation of the study. HBP = His-bundle pacing; RV = right ventricular; RVP = right ventricular pacing.

RV-LV Synchrony (Reflected in QRS) Impacts Hemodynamics

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LBBB conduction 150 msec (0.15 sec)

Standard RV Pacing 180 msec (0.18 sec)

Biventricular Pacing 140 msec (0.14 sec)

RV septal/outflow Pacing 150 msec

His-bundle pacing study


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

No difference in mortality observed

Log-rank test for equality
p = .02

No difference in mortality observed

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- His-bundle pacing
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Impacts 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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RV septal/outflow Pacing 150 msec

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
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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.

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*
RV-LV Synchrony (Reflected in QRS)

Impacts on Hemodynamics

Normal QRS duration: 80 msec (0.08 sec)
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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... pneumothorax, vessel and cardiac perforation. Chronically... Erosion, Perforation, Endocarditis, Venous obstruction. "Twiddler's" syndrome, Lead fracture and dysfunction.

**Leadless Pacemakers and Defibrillators offer alternative solution to electrode issues.**

*Lead fracture and dysfunction*
Leadless Pacemakers

Nanostim

Micra
Nanostim

Axillary approach
Micra

Femoral approach
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.
Subcutaneous ICD (extravascular)

- Generator and electrode implanted in subcutaneous tissue without fluoroscopy
- Potential for reduced infections including endocarditis and lead and vascular complications
CRT pacing beneficial
His-bundle pacing potential
• Heart failure reduction
• BBB reversal possible

Leadless devices with great potential for both pacing and defibrillation