Advances in Cardiac Pacing #2

State of the Art - - 2017

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Cardiac Implantable Electronic Devices (CIED)

State of the Art 2017

2017 Advances

Evolution of standard pacing approaches

Strategies to reduce CIED complications

Future directions in CIED
**Progress in CIED Technology**

**CENTRAL ILLUSTRATION** 
An Overview of the History of Cardiac Pacing

### Paradigm Shifts in Cardiac Pacemakers

<table>
<thead>
<tr>
<th>Decade</th>
<th>Description</th>
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<tbody>
<tr>
<td>1950s</td>
<td>AC-powered pacemakers tethered to an extension cord (Furman)</td>
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<tr>
<td>1950s</td>
<td>Battery-powered transistorized &quot;wearable&quot; pacemakers (Lillehei/Bakken)</td>
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<tr>
<td>1958</td>
<td>First fully implantable pacemaker (Elmqvist/Senning)</td>
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<tr>
<td>2015</td>
<td>Implantable pacemaker—basic system had not evolved significantly</td>
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<tr>
<td>2016</td>
<td>Leadless pacemaker—the entire device is placed within cardiac chambers</td>
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<td></td>
<td>Future batteryless devices, which harvest cardiac motion to power pacing circuits</td>
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</table>

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

“Pacemaker syndrome” or “Pacing-induced cardiomyopathy”
**MADIT-II**

**Long-term follow-up**
Pacing from the RV septum may help, but data not confirmatory . . .
Pacing Site Study - Hemodynamic response by RV site
(Septum, RV outflow tract, RV apex)

Optimal RV site varied by patient – No ideal site identified
Patterns of Electrical Activation

- RV pacing or left bundle branch conduction
- Biventricular pacing

Normal conduction or His pacing
Ventricular Dyssynchrony

- **LBBB and RV pacing**
  - Activate right and left ventricles sequentially
  - Prolongs QRS duration
  - Asynchronous activation
  - Cardiac output and blood pressure reduced
  - Mitral regurgitation increased

- **CRT pacing**
  - Activates right and left ventricles simultaneously
  - Narrows QRS duration
  - Synchronous activation
  - Cardiac output and blood pressure increased
  - Mitral regurgitation decreased
- Interventional techniques useful
- Favorable results in all classes of heart failure
- Patients with true LBBB with best outcomes
- Superresponders may normalize LV function
11 of 83 patients with normal EF post-CRT
Patterns of Response to CRT

Evolution of LV lead technology

“Multipoint pacing” may enhance CRT response
Potential Benefits of Multipoint pacing
Triventricular Pacing

Multisite with 3 ventricular electrodes in different locations
**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)
RV-LV Synchrony (Reflected in QRS)

Impacts

Hemodynamics

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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 (.15 sec)

Heart failure hospitalizations reduced with HB pacing when % paced >40%
No difference in mortality observed

RAO view

LAO view

His bundle electrode does not traverse the tricuspid valve!
His-bundle pacing replicates the normal QRS complex.
RV-LV Synchrony (Reflected in QRS)

Impacts on Hemodynamics

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**His-bundle pacing**

Favorable outcomes compared with BiV pacing in 29 patients with CRT indication

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

and Chronically . . .

Lead fracture, dysfunction
Until recently, all Pacemakers and ICDs required placement of transvenous electrodes to directly monitor and stimulate the cardiac electrical system.

- **Infection prevention methods**

- **Leadless** Pacemakers and Defibrillators offer alternative solution to electrode issues
Implantable Device Infections

- Nasal prophylaxis
- Chlorhexidine - Alcohol preparation
  - Reduced procedure time
  - Local antibiotic irrigation
- Peri-procedure antibiotic administration
- Secure wound closure
Tyrx antibiotic-eluding envelope

- Bioabsorbable mesh polymer with full resorption achieved by 9 weeks.
- Elution of minocycline and rifampin over minimum of 7 days
- Use of Tyrx envelope results in marked reduction in device infections
CITADEL/CENTURION studies – Interim results - Marked benefit vs Historical controls

- CITADEL, CENTURION studies reported
- 1000 patients
- ICD replacement procedures (Highest risk of infection)
Leadless Pacemakers

Nanostim

Micra
RV - LV Synchrony (Reflected in QRS)

Impacts on Hemodynamics

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Micra
RV - LV Synchrony (Reflected in QRS)

Impacts on Hemodynamics

- Normal QRS duration
  - 80 msec (0.08 sec)
- LBBB conduction
  - 150 msec (0.15 sec)
- Standard RV Pacing
  - 180 msec (0.18 sec)
- RV septal/outflow Pacing
  - 150 msec

RAO

LAO
Deployment
RV - LV Synchrony (Reflected in QRS)

Impacts

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Anchoring: check 10-year predicted longevity in most patients

Loop snare retrieval
Micra performance versus historical controls

In this Micra TPS (Medtronic, Minneapolis, Minnesota) study post hoc analysis, the 725 study patients were compared with 2,667 patients who received transvenous pacemakers in previous studies as a historical control cohort. Leadless study patients were older and had more comorbidities than control subjects. At 6-month follow-up, patients with leadless pacemakers had significantly fewer major complications than control patients (HR: 0.49; p < 0.001), with study patients experiencing fewer hospitalizations, system revisions, and dislodgments. Reprinted with permission from Reynolds et al. (63). Abbreviations as in Figure 4.
Subcutaneous ICD (extravascular) Generator and Electrode implanted in Subcutaneous tissue w/o fluoroscopy.

❖ Potential for reduced infections including endocarditis and lead and vascular complications.
Subxiphoid approach

Leadless ICD alternative
Subxiphoid approach

Leadless CRT alternative
Transseptal LV electrode

- **Anticoagulation mandatory**
  - Valvular issues
    - CVA risk
**WiSE-CRT system**

Wireless acoustic (ultrasonic) LV pacing with external transmitter implanted in the left chest
WiSE-CRT system

Wireless acoustic (ultrasonic) LV pacing with external transmitter implanted in the left chest
Select-LV study

- 35 patients with prior CRT failure
- 97% WiSE-CRT system implantation success
- Favorable CRT response

2017 Advances

LBBB/RV pacing harmful
CRT/His-bundle pacing beneficial

Preventive measures and leadless technology may reduce complications

Subxiphoid and ultrasonic approaches in developmental phase