Device Interrogation-
Pacemakers, ICD and Loop
Recorders

Dulce Obias-Manno, RN, MHSA, CCDS, CEPS, FHRS
Device Clinic Coordinator, MHVI
Wash DC
Disclosures

Consultant: Medtronic, St. Jude Medical
Do all Cardiac Implantable Electronic Devices deliver therapy?

A. Yes

B. No
Only Pacemakers, ICDs and CRTs provide device based therapies. Implantable Loop Recorders (ILR) are purely diagnostic devices.
Cardiac Implantable Electronic Devices

Pacemaker

- Battery
- Low Voltage
- Asystole
- Heart Failure
- Brady Detections
- Brady Therapies
- AT/AF Detections
- AT/AF Therapies
- VT/VF Detections
- VT/VF Therapies
Cardiac Implantable Electronic Devices

ICD

- Battery
- Capacitor
- Low Voltage
- High Voltage
- Asystole
- Heart Failure

- Brady Detections
- Brady Therapies
- AT/AF Detections
- AT/AF Therapies
- VT/VF Detections
- VT/VF Therapies
Cardiac Implantable Electronic Devices

ILR

<table>
<thead>
<tr>
<th>Feature</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery</td>
<td>✔️</td>
</tr>
<tr>
<td>Capacitor</td>
<td></td>
</tr>
<tr>
<td>Low Voltage</td>
<td></td>
</tr>
<tr>
<td>High Voltage</td>
<td></td>
</tr>
<tr>
<td>Asystole</td>
<td>✔️</td>
</tr>
<tr>
<td>Heart Failure</td>
<td></td>
</tr>
<tr>
<td>Brady Detections</td>
<td>✔️</td>
</tr>
<tr>
<td>Brady Therapies</td>
<td></td>
</tr>
<tr>
<td>AT/AF Detections</td>
<td>✔️</td>
</tr>
<tr>
<td>AT/AF Therapies</td>
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</tr>
<tr>
<td>VT/VF Detections</td>
<td></td>
</tr>
<tr>
<td>VT/VF Therapies</td>
<td></td>
</tr>
</tbody>
</table>
Cardiac Implantable Electronic Devices

Trends

ICDs: Expanding Indications for implantation


Increasing co-morbidity conditions

<table>
<thead>
<tr>
<th>Charleston Co morbidity Index</th>
<th>1993</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCI &gt;2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VVI</td>
<td>14.1%</td>
<td>45%</td>
</tr>
<tr>
<td>DDD</td>
<td>13.5%</td>
<td>42.4%</td>
</tr>
</tbody>
</table>

Greenspon A JACC Vol. 60, No. 16, 2012
Is it necessary to interrogate every CIED you encounter?

A) Yes  
B) No
Device Interrogation

Determine clinical effectiveness

Confirm appropriate function

Evaluate impact on co-morbid conditions
Determine Clinical Effectiveness

Presenting rhythm

Settings (parameters)
Presenting Rhythm

EGM displayed at 25mm per second

- Reference electrode
- Marker channel
- Shock
## Settings (ICD)

<table>
<thead>
<tr>
<th>Parameter Summary</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode</strong></td>
<td>VVI</td>
<td><strong>Lower Rate</strong></td>
<td>60 bpm</td>
</tr>
<tr>
<td><strong>Detection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF</td>
<td>On</td>
<td>Rates</td>
<td>&gt;200 bpm</td>
</tr>
<tr>
<td>FVT</td>
<td>OFF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VT</td>
<td>On</td>
<td>Therapies</td>
<td>ATP During Charging, 35J x 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All Rx Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Burst(3), 20J, 35J x 4</td>
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<tr>
<td>Enhancements On:</td>
<td>VT Monitor, Wavelet, TWave, Noise</td>
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</table>
## Settings (PM)

<table>
<thead>
<tr>
<th>Parameter Summary</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode</strong></td>
<td>AAI&lt;=&gt;</td>
<td>Lower</td>
<td>60</td>
<td>Paced</td>
</tr>
<tr>
<td><strong>Mode Switch</strong></td>
<td>DDD</td>
<td>Rate</td>
<td>bpm</td>
<td>AV</td>
</tr>
<tr>
<td></td>
<td>171</td>
<td>Upper</td>
<td>130</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>bpm</td>
<td>Track</td>
<td>bpm</td>
<td>ms</td>
</tr>
<tr>
<td><strong>Detection</strong></td>
<td>Monitor</td>
<td>Rates</td>
<td></td>
<td>Therapies</td>
</tr>
<tr>
<td><strong>AT/AF</strong></td>
<td></td>
<td></td>
<td></td>
<td>All Rx Off</td>
</tr>
<tr>
<td><strong>VT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;171</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>bpm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Settings (ILR)

### Parameter Summary: 02-Sep-2015 11:13

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Detection</th>
<th>Rate</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachy</td>
<td>On</td>
<td>150 bpm</td>
<td>16 beats</td>
</tr>
<tr>
<td>Brady</td>
<td>On</td>
<td>30 bpm</td>
<td>4 beats</td>
</tr>
<tr>
<td>Pause</td>
<td>On</td>
<td>---</td>
<td>3 seconds</td>
</tr>
<tr>
<td>AT/AF</td>
<td>AF Only</td>
<td>---</td>
<td>All Episodes</td>
</tr>
</tbody>
</table>
Confirm Appropriate Function

Intrinsic Rhythm

Lead integrity

Battery Status
Intrinsic amplitude (mV)

A- EGM: measurement of intrinsic atrial signal

V-EGM: measurement of intrinsic ventricular signal
Atrial sensing

Atrial undersensing with inappropriate ATP

Atrial oversensing with inappropriate mode switch
Ventricular sensing

EGM displayed at 25mm per second

RA sensing channel

RV sensing channel

Reference electrode

Shock

Marker channel

Undersensing of VF

Oversensing of T wave
Lead assessment

Causes of lead noise:

- Lead chatter
- EMI
- RA
- RV
- Shock
<table>
<thead>
<tr>
<th><strong>Battery</strong></th>
<th><strong>Implant Date:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Longevity: 5.3-8.7 yrs</td>
<td>May 12, 2016</td>
</tr>
<tr>
<td>~ERI &gt; 5 yrs</td>
<td></td>
</tr>
</tbody>
</table>

| **Voltage** | 3.01 V |
| **Magnet Rate** | 100.0 ppm |
| **Battery Current** | 12 uA |
| **Remaining Capacity to ERI** | >95% |
Impact on co-morbid conditions

Observations:

- Arrhythmia burden
- Percent paced
- HF Metrics
Observations:

**Arrhythmia burden:** Atrial fibrillation

- Duration
- Average ventricular response
Observations:

Arrhythmia burden: ICD shocks

- Discrimination
- Appropriate intervention
Minimizing ICD Shocks

Conventional programming
VF detection (200 bpm): 1 sec
VT detection (180 bpm): 2.5 secs
ATP therapy: 188-200 bpm
SVT discrimination: 188-200

Therapy reduction programming*
VF detection (230 bpm): 60 sec
VT detection (200 bpm): 6-12 secs
ATP therapy 188-230 bpm
SVT discrimination: 188-230

*in primary prevention

2015 HRS/EHRA/APHRS/SOLAECE expert consensus statement on optimal implantable cardioverter-defibrillator programming and testing
Meta analysis on mortality risk, therapy reduction vs conventional programming

Therapy reduction programming was associated with 30% reduction on all cause mortality  P= <0.001
INCIDENCE Appropriate and Inappropriate Shocks

Appropriate Shock | Inappropriate Shock

1997-2008: Physician discretion or 1 zone shock only

2008-2013: Shock reduction strategies: extended delay, high rate, discriminators, ATP


Moss, A, et al. NEJM 2012; 367:2275-2283
What is the most compelling reason to minimize ICD shocks?

A. To prolong battery life
B. To minimize pain
C. To improve quality of life
D. To improve survival
Answer

A. To prolong battery life
B. To minimize pain
C. To improve quality of life
D. To improve survival

Therapy reduction programming was associated with 30% reduction on all cause mortality  P= <0.001

Impact on co-morbid conditions

Observations:
- Arrhythmia burden
- Percent paced:
  - Minimizing Unnecessary RV Pacing
- HF Metrics
Figure Legend:
For all plots, time zero is the day of randomization. CI indicates confidence interval. A, Survival to death or first hospitalization for congestive heart failure (CHF). Unadjusted P = .02; adjusted for sequential monitoring, P = .03. B, Survival to first hospitalization for CHF. Patients are censored at death. Log-rank P = .07. C, Survival to death from any cause. Log-rank P = .15.
Observations: Percent paced

Meta analysis of atrial based vs ventricular based pacing

Physiologic (atrial based) pacing showed a significant reduction on Afib incidence and a moderate reduction on stroke risk.

Observations:

Percent paced

- Minimizing RV pacing

Loss of conduction

Back-up V-pace

Courtesy of Medtronic Inc
What negative outcomes can result from unnecessary RV pacing?

A. May worsen heart failure in LV systolic dysfunction
B. Increases incidence of Afib
C. Shortens patient survival by 10 years
D. Both A and B
E. Both A and C
Unnecessary RV pacing is associated with higher incidence of Afib and ventricular dyssynchrony.

HEART FAILURE METRICS
Intrathoracic impedance measurement by implantable system

Cheuk-Man Yu et al. Circulation. 2005;112:841-848
Combined Diagnostic Criteria

High risk of HF hospitalization:
Optivol > 100
Criteria ≥ 2

PARTNERS-HF trial: data from 694 CRT-D pts followed for 11.7 2 months

Chart adapted from
Whellan DJ et al PARTNERS HF Trial JACC Volume 55, Issue 17, April 2010
Afib > 6 hours
VR during AF > 90bpm
Loss of CRT due to MS
Night HR > 85bpm x 1 week
Activity level < 1 hr x 1 week
Optivol > 100
Sudden drop in intrathoracic impedance
Evaluation (final):

Appropriate?

Normal function?
And let’s not forget the patient

Pocket appearance

Good

Bad

Ugly
MNEMONIC
P.S. I LOVE the patient

Presenting rhythm
Settings
Intrinsic amplitude
Lead measurements
Observations
Voltage (battery function)
Evaluation

the patient
Take away points

Device interrogation provides a myriad of data

A clinician’s focus
clinical effectiveness
appropriate function
Impact on co-morbid conditions
Thank you!