Pacemakers & Implantable Cardiac Defibrillators

A Deep Dive:
Using Device Diagnostics to Assist with Patient Management

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Financial Relationships

Device Check Specialist

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Objectives

- Demonstrate a basic understanding of the diagnostic tools available in implantable devices
- Describe how device diagnostics are used for managing patients.
Benefits of Technology

- Remote Monitoring
  - Improves workflow
  - Decreases patient wait times
  - Provides diagnostic information to clinician in less than half the time of traditional workflow methods.
    - From an average of 80 minutes to 15 minutes.
- Improves quality of care
  - Rapid access to diagnostic data
  - More tools to better manage the patient
    - Arrhythmia status
    - CHF status
What do you Need to Know?

- Know your patient
  - What kind of device do they have?
    - ID card
  - Where is the device located?
    - Pocket site assessment
  - What are their symptoms?
  - What are their medications?
    - Compliance
Identify the Device

- ID Card
Pocket Site

- Right or left subclavian
- Abdominal
Pocket Site Complications

- Hematoma
- Infection
  - Erosion
Pocket Site Complications

- Twiddlers Syndrome
  - Patient manipulation/twisting of the leads
Symptoms

- Syncope / Near Syncope
- Palpitations
- Chest Discomfort
- Dyspnea / Dyspnea with exertion
- Did they receive a shock?

Medications

- What are their medications?
- Are they compliant?
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What does the device report tell you?
1. Device Model / Serial numbers
2. Implant Date
3. Lead data
4. Battery status
5. Programming overview
Lead Trends

- Data tracked over time
- Reflects what is "normal"
- Tracks changes
- Rapid assessment
Lead Trends

- Routine device check
- All testing normal
- Trends shows
  - Rise in V threshold February – April
- Patient reports extended hospitalization
  - CABG
Trends

- Rise in lead impedance
- Potential Lead fracture
- Physiologic issue at the lead tissue interface
Trends

- Rise in lead impedance & Capture thresholds
  - Potential Lead fracture
  - Physiologic issue at the lead tissue interface
Trends

- Rise in lead impedance
- Lead Fracture
Patient Diagnostics

1. Arrhythmia episodes
2. Event counters
3. Rate histograms
4. % pacing
Patient Diagnostics

Clinical Status: 02/11/06 to 08/21/06

Atrial Long Term Histogram
- Sensed
- Paced

% of Beats

Rate (bpm)

Ventricular Long Term Histogram
%

Rate (bpm)

Mode Switches: 251 (Percent of Time: 2.1%)

Atrial High Rate Episodes: 204

Episode Trigger: Mode Switch > 30 sec

Date/Time | Duration | Rate (bpm) | Max A | Max V
--- | --- | --- | --- | ---
07/08/06 10:04 AM | :16:28 First | 400 | 90
08/15/06 2:39 PM | 6:11:38 Longest | >400 | 87
08/18/06 11:48 AM | 3:06:40 Fastest | >400 | 98
08/21/06 1:25 PM | :31:07 Last | 400 | 93

Ventricular High Rate Episodes: 1

08/15/06 5:32 PM | :11 Longest... | 87 | 265

Pacing (% of total):
- AS - VS 72.1%
- AS - VP 2.3%
- AP - VS 24.7%
- AP - VP 0.8%
- MVP On

Event Counters
- PVC singles 2,745
- PVC runs 92
- PAC runs 0
Patient Diagnostics

- Ventricular Rate during atrial arrhythmias
  - Rate control evaluation
  - Episode breakdown by duration
Patient Diagnostics

- Electrograms
  - SEGM = Summed; AEGM = Atrial; VEGM = Ventricular
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The Power of Trending Data
Trends

- Cardiac Compass Report
  - 14 months of trending
- Atrial Arrhythmias
  - AT/AF burden
- Ventricular rates in AT/AF
- Ventricular Arrhythmias
- Heart failure trends
  - % pacing
  - Day / Night heart rates
  - Patient activity
  - HR variability
Case Study – Atrial Arrhythmias

• History of paroxysmal AF
  • On rate control medications

• 3 months prior, presented with persistent AF
  • started on Amiodarone

• Returns for follow-up
  • “I don’t feel any better”
What do the Trends Tell Us?

Note the previous events requiring rate control
Case Study – Ventricular Arrhythmias

- Implanted ICD for recurrent VT
- Hospitalized after Several days of VT/VF episodes & shocks
  - Antiarrhythmics
  - Slow-K⁺
  - Lower rate to 90 bpm
- Predischarge
  - Lower rate to 80 bpm
  - Patient almost 100% A-paced, has good intrinsic conduction, minimal V-pacing
What do the Trends Tell Us?

VT & NSVT episodes

Heart rate reprogramming

Hospitalized

Note activity drop correlates with hospitalization
Diagnostic Electrograms

EGM Source

Marker channels

Onset

Detection
Diagnostic Electrograms

Therapy Delivered
Heart Failure Trends

- % Pacing/day
- Day/Night heart rates
- Patient activity
- Heart rate variability
Heart Failure Diagnostics

- Percent pacing per day
  - Cardiac resynchronization goal = Ventricular pacing as close to 100% as possible
Heart Failure Trends

- Patient Activity
- Built in sensor determines patient activity
- The value is in the trend over time
  - Every patient is different
  - Look for sudden or gradual changes in patient’s baseline
Heart Failure Trends

- Day & Night Heart Rates
  - Increasing severity in Heart Failure results in Day & Night Resting Heart Rates
  - Difference between Day & Night Heart Rates

Heart Failure Diagnostics

- Heart Rate Variability
  - Median atrial interval measured & logged every 5 minutes
  - As Heart Failure progresses
    - Heart rate variability decreases
    - Resting heart rate tends to increase

Case Study: Heart Failure

- 59 y/o female with HTN, probably the cause of her heart failure
- Stable diuretics and ACE inhibitor
- Receives CRTD device
  - 1 month post implant improved status from NYHA class IV to II due to bi-ventricular pacing
- Started on and tolerates beta blockers
Case Study: Heart Failure

- Near 100% paced
  - Room for improvement

- Day/Night rates improving

- Activity improved since implant

- HR variability improved since implant
Case Study: Heart Failure

- 6 months post-implant
  - Hospitalized for upper respiratory infection
  - X-ray shows mild pulmonary congestion

![Graph showing trend reversal and various physiological parameters over time](image)
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Fluid Status Monitoring
Fluid Status Monitoring

- Impedance: Resistance to flow of electrical current measured in ohms.

### Tissue Resistivity

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Resistivity (Ω·cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid</td>
<td>70</td>
</tr>
<tr>
<td>Blood</td>
<td>160</td>
</tr>
<tr>
<td>Myocardium</td>
<td>450</td>
</tr>
<tr>
<td>Lung</td>
<td>2,200</td>
</tr>
<tr>
<td>Bone</td>
<td>4,800</td>
</tr>
<tr>
<td>Fat</td>
<td>2,500</td>
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</table>

Fluid Status Monitoring

- Intrathoracic impedance measurements rise and fall with fluid status changes in the body.

  Impedance is measured from device can to the RV Coil every 20 min from noon until 5 pm.

Fluid Status Monitoring

- Multiple daily measurements
  - Average of multiple days creates an individual reference
- Daily measurements are compared to individual reference baseline.
- Data is trended over time
Fluid Status Monitoring

![Graph showing fluid index and impedance over time.]

Fluid Status Monitoring

• What impacts impedance measurements?

• **FLUID** Change
  - PULMONARY EDEMA
  - Pocket Infection
  - Pericardial Effusion
  - Pleural Effusion

• **BLOOD** Change
  - Blood Volume Change
    - Chamber/Vessel Dilation
    - IV Fluid
    - Transfusion
  - Blood Composition Change
    - Hematocrit
    - Electrolyte
    - Dialysis

Fluid Status Monitoring

- What do we do with this data?
  - OFISSER (JCF in Press)\(^8\)
  - PARTNERS (LBCT HFSA)\(^9\)
  - IMPEDE (HFSA)\(^{10}\)

- Identify patients at higher risk for worsening heart failure
- Symptomatic and asymptomatic events incurred risk

- We can conclude that:
  - Fluid status monitoring is a useful tool in the management of congestive heart failure.

Fluid Status Monitoring : Case Study

- 70 year old female
- Non-ischemic dilated cardiomyopathy
- Sinus node dysfunction
- First-degree AV Block
- EF = 22% prior to receiving CRTD device
- NYHA II after receiving CRTD device
- Medications:
  - Amiodarone, Aspirin, Atacand, Coreg, Coumadin, Imdur, Lanoxin®, Lasix, Spironalactone
Feb 25: HF symptoms: Dyspnea, orthopnea and edema in her ankles. Patient self medicates doubles her Lasix from 80 mg to 160 mg for 2 days.

Feb 27: HF symptoms have resolved but patient’s legs cramp. Patient self medicates doubles her potassium supplement.

Mar 1: All symptoms are resolved. OptiVol fluid index resets.

Apr 1: Regular follow-up visit, no symptoms reported. Fluid Trends investigated & the patient reveals that she had changed her own medication in Feb.
This case illustrates the important role that OptiVol Fluid Trends can play in investigating a patient’s fluid status between office visits.

Without OptiVol Fluid Trends
- fluid accumulation and the patient’s self-medication behavior would have gone unnoticed.

Overall the patient responded very well to her CRTD therapy
- Note the steady rise in patient activity since implant.
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Putting it all Together
How do we use all this information?

- Review the Report
- Risk Stratification
- Phone Call
- Treatment Decision
- Follow-Up
- Reassess
Case Study

- 65 yo male
- Ischemic Cardiomyopathy
  - EF of 27%
- CRTD implant
- Coronary Artery Disease
  - Stents
  - Balloon Angioplasty

Medication List

- Monopril 2.5mg qd
- Digoxin 0.625mg Tue-Fri
- Coreg 3.125mg bid
- Pravachol 10mg qd
- Protonix 40mg qd
- Folic Acid 800mg bid
- Renagel 400mg qid
- Plavix 75mg qd
Phone Call to Clinic

- Friday evening
- Patient is passing out
- Paramedics have been called
- Patient sent a remote transmission for review
Quick Look Report

<table>
<thead>
<tr>
<th>ICD Status</th>
<th></th>
<th>May 11, 2007</th>
<th>May 11, 2007</th>
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<tbody>
<tr>
<td>Battery Voltage (ERI=2.62 V)</td>
<td>3.03 V</td>
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<tr>
<td>Last Full Energy Charge</td>
<td>7.90 sec</td>
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<td></td>
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<tr>
<td>Last Capacitor Formation</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lead Performance</td>
<td></td>
<td></td>
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<tr>
<td>EGM Amplitude</td>
<td>2.8 mV</td>
<td></td>
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<tr>
<td>Pacing Impedance</td>
<td>424 ohms</td>
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<tr>
<td>Defibrillation Impedance</td>
<td>58 ohms</td>
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<td>SVC Impedance</td>
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<tr>
<td>Parameter Summary</td>
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<tr>
<td>Type</td>
<td>Detection</td>
<td>Rx1</td>
<td>Rx2</td>
</tr>
<tr>
<td>VF</td>
<td>On</td>
<td>20 J</td>
<td>35 J</td>
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<tr>
<td>FVT</td>
<td>Off</td>
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<td>Off</td>
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<tr>
<td>VT</td>
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<td>171-200 bpm</td>
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<td>SVT Criteria</td>
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<td>Mode</td>
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<tr>
<td>Mode Switch</td>
<td>On, 175 bpm</td>
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<tr>
<td>V. Pacing</td>
<td>LV-&gt;RV</td>
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<tr>
<td>V-V Pace Delay</td>
<td>0 ms</td>
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<td>Lead Parameters</td>
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<tr>
<td>Amplitude</td>
<td>2 V</td>
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<td>Pulse Width</td>
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<td>Sensitivity</td>
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<tr>
<td>Clinical Status: Since May 09, 2007</td>
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<td>1.6 %</td>
<td>98.4 %</td>
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<tr>
<td>Episodes</td>
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<tr>
<td>VF</td>
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<td>AS-VS</td>
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<td>AS-VP</td>
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<td>AP-VS</td>
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<tr>
<td>SVT</td>
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<td>AP-VP</td>
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<td>NST and others</td>
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<tr>
<td>Mode Switch</td>
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<tr>
<td>Observations (0)</td>
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</tbody>
</table>

- No observations based on currently interrogated data.
Fluid Status

OptiVol fluid index is an accumulation of the difference between the daily and reference impedance.

- P = Program
- I = Interrogate
- _ = Remote

Dec - February
Cardiac Compass Trends

Associated events in December

- Atrial Fibrillation
- High Ventricular rates
- Drop in activity
- Loss of HR Data
- Loss of HR Variab.
- Loss of V pacing
Cardiac Compass Trends

Associated events in December

- Drop in activity
- Day/night HR Elevated
- Loss of HR Variab.
Episode Report

### Table

<table>
<thead>
<tr>
<th>ID#</th>
<th>Date/Time</th>
<th>Type</th>
<th>A. Cycle</th>
<th>V. Cycle</th>
<th>Last Rx</th>
<th>Success</th>
<th>Duration</th>
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<tbody>
<tr>
<td>8</td>
<td>11 May 2007 16:30:25</td>
<td>VF</td>
<td>590 ms</td>
<td>230 ms</td>
<td>VF Rx 1</td>
<td>Yes</td>
<td>9 sec</td>
</tr>
</tbody>
</table>

### Graph

- **VF = 300 ms**
- **VT = 350 ms**
- Symbols: □ V-V, ◯ A-A
- Energy: 20.2 J
- Time (sec): 0 = Detection
- Interval (ms): 2000, 1700, 1400, 1100, 800, 600, 400, 200
EGMs
Patient passed out multiple times with resulting shocks even after the remote transmission
Device report was shared with emergency response team
Patient sent to cardiac catheterization lab for ischemic evaluation
Ultimately received a LVAD
This case study is an example of how remote evaluation facilitates rapid response and continuity of care.
Final Thoughts

- We will see an increased use of device diagnostics in the treatment of heart patients
- We will continue to see increased use of remote transmission to retrieve these diagnostics.
- Successful diagnostic tools rely on the power of trending
  - Trends give us the big picture
  - Changes over time indicate how the patient is responding to treatment.
- Goal?
  - Streamline workflow
  - Improve speed & continuity of care
Questions?
References


