Device Based Management of Congestive Heart Failure: An Electrophysiologist’s Perspective

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Disclosures

• Speakers bureau:
  – Medtronic, Inc, St. Jude Medical, Spectranetics

• Research Support (Institutional)
  – Medtronic, Inc
Objectives

• Describe basis for device therapy in congestive heart failure

• Describe the high risk periods in the management of congestive heart failure

• Outline the benefits of device diagnostics in the management of the heart failure patient…
Sanger Heart and Vascular Institute Device Clinic

- 9,546 active device patients
- 8 EP MDs, 10 Device Clinic Locations
- 16 device nurses (combination of full-time, part-time and as-needed)
- 3 Device Technicians
- 3 dedicated Advanced Care Practitioners
- Multivendor device access (Carelink, Latitude, Merlin.net, Biotronik home monitoring)
Electrophysiologist
Background

Heart failure is the most common:

- Cardiovascular discharge
- Medicare discharge
- Reason for inpatient readmission
  - 20-24% of heart failure patients are readmitted within 6 months
Worsening Chronic Heart Failure: The Major Reason for Heart Failure Hospitalizations

- Worsening chronic heart failure (75%)
- De novo heart failure (23%)
- Advanced/ end-stage heart failure

Fonarow GC. Rev Cardiovasc Med. 2003; 4 (Suppl. 7): 21
Cleland JG et al. Eur Heart J. 2003; 24: 442
Background

- Heart failure affects approximately 1 in 56 individuals
- Prevalence of heart failure increases with age
Background

- Heart failure affects more than 5 million Americans currently, only half of whom will survive the next five years.
- Heart failure prevalence is expected to double over the next 30 years.

Status within 5 years of Diagnosis:

- Survival: 50%
- Mortality: 50%
In people diagnosed with CHF, sudden cardiac death occurs at 6-9 times the rate of the general population.

CHF Patients Survival Results

- **Women (N = 230)**
- **Men (N = 237)**

80% of men and 70% of women who have CHF will die within 8 years.

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Severity of Heart Failure

NYHA II

- CHF: 64%
- Other: 12%
- Sudden Death (N = 103): 24%

NYHA III

- CHF: 59%
- Other: 15%
- Sudden Death (N = 103): 26%

NYHA IV

- CHF: 33%
- Other: 11%
- Sudden Death (N = 27): 56%

SCD in Heart Failure

- Despite improvements in medical therapy, symptomatic HF still confers a 20-25% risk of premature death in the first 2.5 years after diagnosis\(^1\)-\(^4\)

- ≈ 50% of these premature deaths are SCD (VT/VF)\(^1\)-\(^4\)

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\(^3\) Goldman S. Circulation 1993;87:V124-V131.
\(^4\) Sweeney MO. PACE. 2001;24:871-888.
LV Dysfunction and Sudden Cardiac Death Risk
Relationship of SCD and Left Ventricular Dysfunction

- Reduced left ventricular ejection fraction (LVEF) remains the single most important risk factor for overall mortality and sudden cardiac death\(^1\)

- Increased risk is measurable at ejection fractions above 30%, but an ejection fraction ≤ 30% is the single most powerful independent predictor for SCD\(^2\)

\(^1\) Task Force on Sudden Cardiac Death of the European Society of Cardiology. Eur Heart J, 2001;22:1374-1450.

Risk of Sudden Death: Data from GISSI-2 Trial

Patients without LV Dysfunction (LVEF > 35%)

Patients with LV Dysfunction (LVEF < 35%)

Maggioni AP. Circulation. 1993;87:312-322.
## Risk of Sudden Death in HF

<table>
<thead>
<tr>
<th>Study</th>
<th>HF Class</th>
<th>Control (n)</th>
<th>Treatment (n)</th>
<th>Total Mortality Reduction w/ Treatment</th>
<th>SCD % of Total Death in Control Arm</th>
<th>SCD % of Total Death in Treatment Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>MERIT-HF1 (Metoprolol)</td>
<td>II, III, IV 2001</td>
<td>1990</td>
<td>34%</td>
<td></td>
<td>60%</td>
<td>54%</td>
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<tr>
<td>BEST2 (Bucindolol)</td>
<td>III, IV     1354</td>
<td>1354</td>
<td>10%</td>
<td></td>
<td>45%</td>
<td>44%</td>
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<tr>
<td>CIBIS-II3 (Bisoprolol)</td>
<td>III, IV     1320</td>
<td>1327</td>
<td>34%</td>
<td></td>
<td>36%</td>
<td>31%</td>
</tr>
<tr>
<td>CARVEDILOL (US)4</td>
<td>II, III, IV 398</td>
<td>696</td>
<td>65%</td>
<td></td>
<td>48%</td>
<td>54%</td>
</tr>
<tr>
<td>RALES5</td>
<td>III, IV     841</td>
<td>882</td>
<td>30%</td>
<td></td>
<td>28%</td>
<td>29%</td>
</tr>
</tbody>
</table>

Summary of Primary Prevention

![Graph showing different prevention strategies and their effects on EF (%) for various conditions: EF alone, EF+AM +EPS, EF+AM +EPS, and EF+HF.]
Heart Failure and Sudden Death

• Device therapy is prevalent in our current patient population

• Much data is embedded within cardiac devices and may facilitate patient care.

• What is useful and valuable?
Repeated HF hospitalizations

Acute Exacerbations May Contribute to CHF Progression:
Can we identify a high risk patient?
Do patients return to baseline?

Operational Hurdles in HF Care

1. ED Patient Diagnosis
   - 81% Accurate
   - 19% Inaccurate

2. Source of HF Patient Admission
   - 78% ED
   - 22% Other

3. Time to Treatment
   - ED: 1.1 hours
   - Inpatient: 22.2 hours

4. Unit at D/C
   - 47% Cardiac
   - 53% Other

5. HF Patient Provider
   - 57% Cardiologist
   - 43% Other

6. Reason for Admission
   - 48% Noncompliance
   - 52% Other

7. Status at 90 Days
   - 44% Readmitted
   - 56% Not Readmitted

Source: SG2 Data
Non-adherence is the leading cause of HF Readmission

- Diet Nonadherence: 24%
- Drug Nonadherence: 24%
- Inappropriate Drug: 16%
- Other: 17%
- Failure to Seek Care: 19%

• “Even routine and repeated queries by providers will probably not be successful until HF patients know what symptoms are most important and how to monitor for those symptoms. The difficulty patients have in detecting and interpreting their symptoms has led to interest in remote monitoring and devices to monitor fluid accumulation, which may improve outcomes in the future.”

• "Not detailed in these recommendations but essential in terms of promotion of self care is the need for better assessment of patients by providers. The HF pt population in characterized by multiple co morbid conditions. A better way to detect early fluid retention is needed. Implanted devices may provide such information in the near future."
Symptoms: The Tip of the Congestion Iceberg in CHF

Cardiac Insult

Abnormal LV function (Sys and/or Dia)

↑LVDP + Impaired volume regulation

↑LA and LV diastolic pressure

Increase PA pressure

↑RV + RA pressure

Increased PCWP (congestion)

Redistribution in pulmonary vascular bed
+ Interstitial edema

Mitral Regurgitation

Alveolar edema

Dyspnea

Systemic congestion (JVD, edema)
On any given day, the device clinic can be busy…to say the least
“We are drowning in information, but starved for knowledge.”
Similar to PCWP, OptiVol changes precede late-presenting symptoms

- Systemic congestion (JVD, edema)
  - $\uparrow$ RV + RA pressure
  - Increase PA pressure
  - Increased PCWP (congestion)
  - $\uparrow$ LA and LV diastolic pressure
  - $\uparrow$ LVDP + Impaired volume regulation
  - Abnormal LV function (Sys and/or Dia)

- Dyspnea
  - Alveolar edema
  - Redistribution in pulmonary vascular bed
  - Interstitial edema
  - Mitral Regurgitation

Not here
OptiVol Fluid Status Monitoring

Heart Failure Management Report

ICD Model: InSync Sentry 7297
Serial Number: EF, on Implant Apr 13, 2005
Hospital Physician

Date of Birth

Clinical Status (Oct 25, 2005 to Nov 01, 2005)
VT/VF: 0 episodes V. Pacing (V. beats) 87.4 % Lower Rate 50 ppm
AT/AF: 0 episodes Atrial Pacing 20.4 % Upper Rate 140 ppm
Time in AT/AF: 0.0 hr/day (0.0 %)

Observations (2) (Oct 25, 2005 to Nov 01, 2005)
- Possible fluid accumulation, Oct 28, 2005.
- V. Pacing (V. beats) less than 90%.

OptiVol Fluid Trends (Apr 2005 to Nov 2005)

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

P = Program
I = Interrogate

OptiVol fluid index

Thoracic impedance (ohms)

- OptiVol threshold
- Daily
- Reference

Carolinas HealthCare System
OptiVol... How it works

Heart Failure Exacerbation

Increase in Intravascular Volume

Decrease in Intrathoracic Impedance
OptiVol: A Physiologic Correlation


Pearson correlation coefficient = -0.748, p < 0.001
OptiVol Measurements

Days

0 40 80 120 160 200

Fluid Index (Ω days)

OptiVol Measurements

33
OptiVol Fluid Index is an accumulation of the difference between the daily and reference impedance.

Accumulation of the difference between the daily and reference impedance slowly adapts to the daily impedance.

Daily impedance is the average of each day’s measurements.

OptiVol Fluid Trends (June 2003 to June 2004)

P = Program
I = Interrogate
Interpretation of HF Diagnostics: Consistency of documentation!

- OptiVol is trending BELOW reference baseline, indicating that the patient may have an increase in intravascular volume (hypervolemic).
- OptiVol is trending ABOVE reference baseline, indicating that the patient may be hypovolemic.
- OptiVol is trending WITH reference baseline, indicating that the patient is likely to be euvolemic.
So What’s the Data

• We have a goal to reduce heart failure rehospitalization

• What is the value of this information and how does it help our goal?
FAST

• The Fluid Accumulation Status Trial (FAST) study was a 156 patient, multi-center, prospective, double-blinded investigation of the clinical utility of a fluid index derived from intrathoracic impedance measurements (OptiVol).

• OptiVol Fluid Status Monitoring was a more accurate predictor of worsening heart failure than daily weight

• OptiVol sensitivity (76.4%) was significantly greater than weights (22.5%) for detecting worsening heart failure, making OptiVol three times more likely to predict future HF events than weight monitoring alone.

• Unlike daily weight measurements, OptiVol data collection is not limited by patient adherence

OFISSE R

Retrospective, multicenter study involving 326 patients tracked over one year

- Each threshold crossing is associated with as much as a 51% increased risk of HF hospitalization

More frequent crossings, or longer net deviations over threshold are more likely to have a HF event

- OptiVol provides an opportunity to educate patients and improve therapy adherence

Lessons of OFISSER and PARTNERS HF:

This: Is Riskier Than This:

1. ↑ Frequency

2. ↑ Duration

3. ↑ Immediacy
To summarize the reviewed data:

High risk profile

Low risk profile
IMPEDE HF

Small center trial
Symptomatic HF
Getting ICD or BV-ICD

Evaluation of impedance, functional status and cBNP.

- Decrease in impedance 15 days prior to TCE, which confirms data found in previous trials

- Only a small change in weight (approx 2.5lbs), again confirming findings in other large trials.

- Elevation in Fluid Index correlates with increased cBNP
What about the Negative Predictive Value of OptiVol?

✓ 40-60% of CRT-D patients will have NO Fluid Index threshold crossings within 1 year

✓ OptiVol can help rule out symptoms that are related to COPD, not CHF

✓ OptiVol can also be used to titrate diurectics and preserve renal function

Integration of Diagnostic Trends:

“The whole is greater than the sum of its parts”

- Each individual parameter is useful
- Combining parameters may be even more helpful
Combined Diagnostic Algorithm

- Can OptiVol help us understand which comes first… AT or volume overload?
- Rhythm and Rate Control
- Activity: Subjective vs. Objective data and great patient education tool
- Avg. Vent. Day/Night HR: a good predictor of HF decompensation and a great compliance tool
- Has % of Vent. Pacing been altered due to rhythm disturbances?
Combined Heart Failure Device Diagnostics Identify Patients at Higher Risk of Subsequent Heart Failure Hospitalizations

Results From PARTNERS HF (Program to Access and Review Trending Information and Evaluate Correlation to Symptoms in Patients With Heart Failure) Study

David J. Whellan, MD, MHS,* Kevin T. Ousdigian, MSEE, MSIE,† Sana M. Al-Khatib, MD, MHS,‡ Wenji Pu, PhD,† Shantanu Sarkar, PhD,‡ Charles B. Porter, MD,§ Behzad B. Pavri, MD,* Christopher M. O’Connor, MD,‡ for the PARTNERS Study Investigators

Philadelphia, Pennsylvania; Minneapolis, Minnesota; Durham, North Carolina; and Kansas City, Kansas
PARTNERS HF

First large prospective, multi-center study to correlate OptiVol/HFMR diagnostic data to HF events

• 694 patients included in analysis
• 12 month follow-up

• Combined diagnostics increased the ability to risk stratify a HF event beyond the use of impedance alone

• Good negative predictive value

• 5.5x increase risk of HFH for congestion w/in 30 days

Whellan, DJ, et al., Combined Heart Failure Diagnostics Identify Patients at Higher Risk of Subsequent Heart Failure Hospitalizations: Results from PARTNERS HF Study. JAmCollCardiol. April 27, 2010; 55 (17): 1803-1810.
Any 2 Cardiac Compass criteria met = positive combined diagnostic

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Index</td>
<td>≥100 ohms</td>
</tr>
<tr>
<td>Fluid Index</td>
<td>≥60 ohms</td>
</tr>
<tr>
<td>AT/AF Duration</td>
<td>≥6 hours &amp; not persistent AT/AF</td>
</tr>
<tr>
<td>V. rate during AT/AF</td>
<td>AT/AF ≥24 hrs &amp; V. ≥ 90 bpm</td>
</tr>
<tr>
<td>Patient Activity</td>
<td>Avg. &lt;1 hr over 1 week</td>
</tr>
<tr>
<td>Night Heart Rate</td>
<td>≥85 bpm for 7 consecutive days</td>
</tr>
<tr>
<td>HRV</td>
<td>&lt;60 ms for 7 consecutive days</td>
</tr>
<tr>
<td>CRT % Pacing</td>
<td>&lt; 90% for 5 of 7 days</td>
</tr>
<tr>
<td>Shock(s)</td>
<td>1 or more shocks</td>
</tr>
</tbody>
</table>

Whellan, DJ, et all, Combined Heart Failure Diagnostics Identify Patients at Higher Risk of Subsequent Heart Failure Hospitalizations: Results from PARTNERS HF Study. JAmCollCardiol. April 27, 2010; 55 (17): 1803-1810.
Whellan, DJ, et al., Combined Heart Failure Diagnostics Identify Patients at Higher Risk of Subsequent Heart Failure Hospitalizations: Results from PARTNERS HF Study. JAmCollCardiol. April 27, 2010; 55 (17): 1803-1810.

Figure 2 Combined HF Device Diagnostics Triggered

The Venn diagram shows that 72% of evaluations had ≥2 HF device diagnostics triggered with the remaining 28% triggered by OptiVol Fluid Index ≥100. OptiVol Fluid Index, low activity, and low heart rate variability (HRV) were the most common reasons for triggers. AF = atrial fibrillation; ICD = Implantable cardioverter-defibrillator; RVR = rapid ventricular response; other abbreviation as in Figure 1.
Positive Diagnostic = 5.5 x increased risk

P < 0.0001
Hazard Ratio = 5.5 (95% CI: 3.4 - 8.8)

Whellan, DJ, et al., Combined Heart Failure Diagnostics Identify Patients at Higher Risk of Subsequent Heart Failure Hospitalizations: Results from PARTNERS HF Study. JAmCollCardiol. April 27, 2010; 55 (17): 1803-1810.
Conclusions—Patients with chronic ischemic heart disease who are treated with either single-chamber or dual-chamber ICDs have improved survival but an increased risk of HF. The present data suggest that ICD therapy transforms sudden death risk to a subsequent HF risk. These findings should direct more attention to the prevention of HF in patients who receive an ICD. (Circulation. 2006;113:2810-2817.)
• Allocation to the ICD group was associated with a statistically significant 39% increase in the risk of a first HFH and a 58% increase in the intensity of recurrent HFH compared with conventional therapy after adjustment for baseline clinical covariates and post enrollment MI or UA

• Difference in HFH rates between single and dual chamber devices

• The increased risk of HF among patients allocated to the ICD group was related to the life-prolonging effect of appropriate defibrillator shocks. (Shock Reduction Management?)
The development of HF is a major determinant of subsequent mortality in patients with ischemic heart disease and left ventricular dysfunction.

The survival benefit conferred by ICD therapy is associated with an increased risk of first and recurrent HF hospitalizations among patients who receive single-chamber or dual-chamber devices.

The life-prolonging efficacy of ICD therapy is maintained after HF among patients who receive single-chamber devices, whereas there appears to be a significant reduction in ICD benefit after HF among patients who receive dual-chamber devices.
What is the relationship between volume and VT?
The Final Piece to the Puzzle: Educating the Patient

• As we mentioned earlier, the patient is probably the key driver in all of this.
• Promoting Self-Care in HF patients is not only important, but it can also improve outcomes (validated in several trials)
• We have developed “HF Admission Education” packets
  • (We feel this is a good time to educate patients because they are more likely to pay attention and have family members there)
  • May also lessen the likelihood of patients ‘falling through the cracks’
• Cardiac Compass/HFMR
• Temporally Aligned Trends
• Up to 14 months of data
Health Services and Outcomes Research

Associations Between Outpatient Heart Failure Process-of-Care Measures and Mortality

Gregg C. Fonarow, MD; Nancy M. Albert, PhD, RN; Anne B. Curtis, MD; Mihai Gheorghiade, MD; J. Thomas Heywood, MD; Yang Liu, MS; Mandeep R. Mehra, MD; Christopher M. O’Connor, MD; Dwight Reynolds, MD; Mary Norine Walsh, MD; Clyde W. Yancy, MD

Journal of the American Heart Association

Incremental Reduction in Risk of Death Associated With Use of Guideline-Recommended Therapies in Patients With Heart Failure: A Nested Case-Control Analysis of IMPROVE HF

Gregg C. Fonarow, Nancy M. Albert, Anne B. Curtis, Mihai Gheorghiade, Yang Liu, Mandeep R. Mehra, Christopher M. O’Connor, Dwight Reynolds, Mary N. Walsh and Clyde W. Yancy
Information is the key

- Devices provide much information:
  - Arrhythmia burden
  - Heart Failure diagnostics
LAPTOP Study Design

Overview

• LAPTOP-HF is conditionally approved by the FDA as a prospective, multi-center, randomized, pivotal IDE study
• Randomization 1:1 to
  – sensor implanted providing ongoing LAP readings to the hand held along with physician prescribed medication recommendations
  OR
  – no sensor implant but a hand-held device for medication reminders
• Patients will be stratified based on EF and need for CRM
Initial experience with a left atrial pressure system was “well tolerated, feasible, and accurate at a short-term follow-up” 1. The next steps are to evaluate the clinical use of LAP monitoring.
Patient obtains LAP readings with PAM® handheld prior to meds.

LAP data uploaded to Clinician’s PC Software.

Clinician formulates DynamicRX® guided therapy based on LAP data trends.

Patient uses DynamicRX® guided therapy to self-titrate HF meds.

OBJECTIVE = CONTROL of LAP Excursions.
If LAP > 30 then... RX very high... Furosemide 80mg... call MD
If LAP 19-28 then... RX high... Furosemide 40mg
If LAP 11-18 then... RX optimal... Furosemide 20mg
If LAP 5-10 then... RX low... Furosemide 10mg
If LAP < 5 then... RX very low... Furosemide hold, increase fluid intake
Conclusions

• Hands-on clinician based care is still superior
  – Diagnostics point us to high risk patients
  – Increasing frequency of interactions
    (education, compliance) in high risk patients
• Risk stratification using heart failure diagnostics allows:
  – Targeting of resources to high risk patients
    and reduction in use in low risk patients
• HF diagnostics are not a “silver bullet”
• Clinical research to establish more patient guided therapy
  may be helpful.