Strategies to Reduce CHF Readmissions

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Telemedicine in Heart Failure

- Management of acute and chronic HF poses substantial challenges to health-care systems worldwide
- Advances in modern telecommunication technologies have created new opportunities to provide telemedical care as an adjunct to the medical management of HF patients
- Well structured outpatient care could reduce the need for hospital admission, facilitate early intervention, prevent crisis management, and avoid complications or disease progression in these patients
- Remote telemedical management of heart failure might be an option for future management of patients

Telemedicine in Heart Failure

- Provides the patient with a structured disease management process and can be self empowering
- Mainstay of telemedicine is early detection of disease deterioration and prompt medical intervention
- Can incorporate human interaction that can also detect depression, which is a known risk factor of poor outcome in heart failure
- The most effective approach for patients with heart failure is still unclear


Concept Behind Telemedical Intervention in Heart Failure

Heart Failure Hospitalization

-21 -14 - 7 Days

Symptoms

Proactive

Reactive

Days
Concept Behind Telemedical Intervention in Heart Failure

Telemedicine in Heart Failure: Current Status

• Findings from several meta-analyses have shown that telemedical monitoring in chronic HF can reduce total mortality at a follow-up of 6 to 12 months and can reduce the number and duration of hospital admissions for worsening heart failure.

• However, prospective randomized controlled multicenter clinical trials of non-invasive telemedical approaches have not corroborated these findings.

Unanswered Questions

• What to monitor?
• How to manage?

Key Goal in Treating Heart Failure: Maintain Optimal Fluid/Pressure Status

Too “Wet”
*Increased symptoms, increased risk of hospitalization, increased risk of arrhythmias, increased mortality*

“Just Right”
*Feel good, low risk for hospitalization or death*

Too “Dry”
*Low blood pressure, dizziness, risk for syncope, worsening kidney function*
What do we want to monitor?

- Fluid in the lungs / pressures in the heart
- How do we currently assess these in patients with chronic heart failure? Non-invasively with:
  - Symptoms
  - Daily weights
  - Vital signs
  - Physical examination
- How well do these assessments perform?

Large-Scale Trials of Telemedicine in HF

(A) TEN-HMS trial: total mortality in each randomized group
(B) Tele-HF trial: Kaplan-Meier time-to-event estimates for the primary endpoint of readmission for any reason or death from any cause
(C) TIM-HF trial: Kaplan-Meier cumulative event curves for the primary endpoint of all-cause mortality
(D) CHAMPION: hospital admission due to cumulative heart failure during the entire period of randomized single-blind follow-up

BEAT-HF Design and Patient Disposition

6 academic medical centers in California

Acute decompensated HF patients 50 years or older

Intervention combined health coaching telephone calls and telemonitoring

Daily electronic collection of blood pressure, heart rate, symptoms, and weight

Centralized nurses conducted tele-monitoring reviews, protocolized actions, and telephone calls

BEAT-HF Primary and Secondary Endpoints

Telemonitoring in Heart Failure

- Data must reflect what we really want to know
- Sensors must provide absolute values, rather than relative ones
- Information must be directly actionable
- Treatment algorithms are necessary
- Action must result in improved patient symptoms or outcomes

Abraham WT. 2012

The Pulmonary Artery Pressure Measurement System*

Catheter-based delivery system

MEMS-based pressure sensor

Home electronics

PA Measurement database
CardioMEMS Heart Sensor Allows Monitoring of Pressure to Improve Outcomes in NYHA Class III Heart Failure Patients

- Prospective, multi-center, randomized, controlled, single-blind clinical trial
- All subjects followed in their randomized single-blind study assignment until the last patient reached 6 months of follow-up
- Tested the hypothesis that PA pressure-guided heart failure management could lower the rate of heart failure hospitalization

Primary Endpoint: HF Hospitalizations at 6 Months

Additional Analysis: HF Hospitalizations at All Days (~15 M mean F/U)

Multiple Secondary Endpoints


CHAMPION Clinical Trial: Managing to Target PA Pressures

Treatment Recommendations for Elevated PA Pressures

- Add or increase diuretic
  - increase/add loop diuretic
  - change loop diuretic
  - add thiazide diuretic
  - IV loop diuretic

- Add or increase vasodilator
  - add or increase nitrate

Adamson PB, et al., J Card Fail 2011
Abraham WT, et al., Lancet 2011
### Reduction in Hospitalizations Over Full Duration of Randomized Study

<table>
<thead>
<tr>
<th></th>
<th>Treatment (n=270)</th>
<th>Control (n=280)</th>
<th>Absolute Reduction</th>
<th>Relative Reduction</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Failure</td>
<td>182</td>
<td>279</td>
<td>97</td>
<td>0.67</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hospitalizations</td>
<td></td>
<td></td>
<td></td>
<td>(0.55 – 0.80)</td>
<td></td>
</tr>
<tr>
<td>Death or</td>
<td>232</td>
<td>343</td>
<td>111</td>
<td>0.69</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Heart Failure</td>
<td></td>
<td></td>
<td></td>
<td>(0.59 – 0.82)</td>
<td></td>
</tr>
<tr>
<td>Hospitalizations</td>
<td>554</td>
<td>672</td>
<td>118</td>
<td>0.84</td>
<td>0.0032</td>
</tr>
<tr>
<td>All Cause</td>
<td></td>
<td></td>
<td></td>
<td>(0.75 – 0.95)</td>
<td></td>
</tr>
<tr>
<td>Hospitalizations</td>
<td>604</td>
<td>736</td>
<td>132</td>
<td>0.84</td>
<td>0.0017</td>
</tr>
<tr>
<td>Death or All Cause</td>
<td></td>
<td></td>
<td></td>
<td>(0.76 – 0.94)</td>
<td></td>
</tr>
</tbody>
</table>

Results from Andersen Gill model
Hazard Ratio (HR) and 95% Confidence Interval (CI)

### Ejection Fraction Randomization Group

<table>
<thead>
<tr>
<th>Ejection Fraction</th>
<th>Randomization Group</th>
<th>Number of Heart Failure Hospitalizations</th>
<th>Annualized Rate of Hospitalization for Heart Failure</th>
<th>Hazard Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥40%</td>
<td>Treatment Group (n=62)</td>
<td>29</td>
<td>0.43</td>
<td>0.50 (0.35-0.70) [p&lt;0.0001]</td>
</tr>
<tr>
<td></td>
<td>Control Group (n=57)</td>
<td>59</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>≥50%</td>
<td>Treatment Group (n=35)</td>
<td>13</td>
<td>0.41</td>
<td>0.30 (0.18-0.48) [p&lt;0.0001]</td>
</tr>
<tr>
<td></td>
<td>Control Group (n=31)</td>
<td>31</td>
<td>1.39</td>
<td></td>
</tr>
<tr>
<td>&lt;40%</td>
<td>Treatment Group (n=208)</td>
<td>153</td>
<td>0.67</td>
<td>0.74 (0.63-0.89) [p=0.0010]</td>
</tr>
<tr>
<td></td>
<td>Control Group (n=222)</td>
<td>220</td>
<td>0.90</td>
<td></td>
</tr>
</tbody>
</table>
### PA Pressure-Guided Therapy Benefits Patients with Common HF Comorbidities

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>N size (control)</th>
<th>N size (treatment)</th>
<th>HF Hospitalization rate reduction at 15 months in treatment group</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of myocardial infarction¹</td>
<td>137</td>
<td>134</td>
<td>46% (p &lt; 0.001 vs. control)</td>
</tr>
<tr>
<td>COPD²,³</td>
<td>96</td>
<td>91</td>
<td>41% (p = 0.0009 vs. control)</td>
</tr>
<tr>
<td>Pulmonary hypertension⁴</td>
<td>163</td>
<td>151</td>
<td>36% (p = 0.0002 vs. control)</td>
</tr>
<tr>
<td>AF⁵</td>
<td>135</td>
<td>120</td>
<td>41% (p &lt; 0.0001 vs. control)</td>
</tr>
<tr>
<td>Chronic Kidney Disease⁶</td>
<td>150</td>
<td>147</td>
<td>42% (p = 0.0001 vs. control)</td>
</tr>
</tbody>
</table>

6. Abraham et al., HFSA 2014

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### More to Come
**Absolute Lung Fluid Status Monitoring**

Based on ReDS Technology

- SensiVest™
- Daily Measurements
- SensiCloud™
- Physician Portal

- Sensors are embedded in the wearable vest
- Short measurement session - 90 seconds
- The system includes a cellular communications module that enables automatic data transmission to a secured cloud
- The device is approved for marketing in the USA

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**Heart Failure Management by ReDS**

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Daily Hazard Ratio for Heart Failure Hospitalization
(Andersen-Gill Model)

**Pre-REDS vs. REDS**
Hazard Ratio = 0.07
\( P = 0.01 \)
95% [0.01-0.54]

**Post-REDS vs. REDS**
Hazard Ratio = 0.11
\( P = 0.037 \)
95% [0.14 – 0.88]

Abraham WT, et al. ESC-HF 2015

**Summary**

- Implantable hemodynamic and newer non-invasive monitors provide direct and actionable measurements of intra-cardiac and pulmonary artery pressures and lung fluid content

- Management guided by such monitors reduces the risk of heart failure hospitalizations

- These approaches are revolutionizing the management of heart failure patients