Digital Cardiology

Quantifying the Promise of a Connected Future
Smaller and More Powerful Computers

![Graph showing the decrease in volume of computers from mainframes to smartphones and the increase in processing power over time.](image-url)
Estimated that >90% of world’s population to have a mobile device by 2020.

Woods, The Next Web 11/18/14
Inferior Vena Cava (IVC) Diameter Measured by Vscan As a New Heart Failure Biomarker

Khandwalla, Raj M, Birkeland, Kade, Zimmer, Raymond, Kedan, Ilan, ASE Scientific Sessions 2016, Moderated Poster Presentation
Major Problem: Most Days of Heart Failure Management Are Not Clinic Days
**BACKGROUND**

- Wearable medical devices that can remotely measure volume status have the potential to improve HF management by identifying worsening clinical status at home [1].
- The toSense CoVa™ Monitoring System (Figure 1) is a wearable device that measures vital signs, impedance [2], stroke volume, and cardiac output (Figure 2,3) [3].
- We conducted a pilot study to investigate if a wearable device that non-invasively measures daily outpatient HF exacerbations, and 1 episode of ventricular tachycardia defibrillation. During the 5-day period prior to the cardiac event, 100% of patients with events demonstrated greater than 20% variability in TFI. 60% showed an increase in TFI greater than 20%, and 80% had a decrease in SV greater than 5% (Table 3). Vital signs and weight displayed no correlation to the cardiac events.

**METHODS**

- 20 NYHA Class II-IV HF patients underwent daily home monitoring with the toSense CoVa™ Monitoring System, which uses a novel derivative of bio-impedance to acquire stroke volume (SV, mL), cardiac output (CO, L/min), thoracic fluid index (TFI, %) and vital signs (Figure 4). From these values, TFI variability was calculated, which is defined as the standard deviation of the TFI determined over a 5-day period divided by the average TFI over the same 5-day period. Data were wirelessly transmitted to the Omnifon platform and then

**Table 1: Compliance**

<table>
<thead>
<tr>
<th>Compliance Range</th>
<th>Number of Subjects</th>
</tr>
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<tbody>
<tr>
<td>&lt; 50%</td>
<td>3</td>
</tr>
<tr>
<td>51-79%</td>
<td>6</td>
</tr>
<tr>
<td>&gt; 80%</td>
<td>9</td>
</tr>
<tr>
<td>Drop Outs</td>
<td>2</td>
</tr>
</tbody>
</table>

**REFERENCES**

[2] 510(k) approval pending
[3] 510(k) approval pending
<table>
<thead>
<tr>
<th>Fee for Service</th>
<th>Payment</th>
<th>Bundled, shared savings, capitated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>Focus</td>
<td>Population</td>
</tr>
<tr>
<td>Treat</td>
<td>Incentive</td>
<td>Prevent</td>
</tr>
</tbody>
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Through the trough of disillusionment
Venture Capital Investment in mHealth
Stronger than Ever

[Diagram showing an increasing trend in venture capital investment ($ in Millions) from 2002 to 2013, with a significant increase after 2009.]
...but based on little research-based evidence
Does Ranolazine Improve Step Count in Patients with Microvascular Coronary Disease?

Figure 1. Study Design Flow Diagram
Treatment periods 1 and 2: randomized to sequence of ranolazine first followed by crossover to placebo or vice versa. CMR = cardiac magnetic resonance; SAQ = Seattle Angina Questionnaire; DASI = Duke Activity Status Index; SF-36 = Short-Form 36.
AWAKE-HF

Measurements of waking activity and sleep, as health-related quality of life functions in subjects with Heart Failure and reduced ejection fraction.

- Steering Committee Morning
  - Principal Investigator - Raj Khandwalla
  - Kade Birkeland
  - Steve Steinhubl
  - Robert Owens
  - Thomas Heywood
  - Lynn Warner Stevenson

- Cedars-Sinai – Site PI’s: Michele Hamilton, Raymond Zimmer

- Enrollment expected to begin January 2017