TELEMEDICINE IN CHRONIC HEART DISEASE IN HONG KONG-CARE FROM A DISTANCE?

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Uber, the world’s largest taxi company, owns no vehicles. Facebook, the world’s most popular media owner, creates no content. Alibaba, the most valuable retailer, has no inventory. And Airbnb, the world’s largest accommodation provider, owns no real estate. Something interesting is happening.

- Tom Goodwin
WHAT IF PATIENTS DO NOT NEED TO COME/STAY IN HOSPITAL?
NEW HEALTH CARE ACCESS IN NEW AND NON-TRADITIONAL VENUES

• Convenient care at a lower price than traditional healthcare delivery systems
• Robust consumer mobile health applications that can be easily integrated with existing health solutions
• Enable a cultural shift in healthcare delivery in a convenient and efficient service model
DISRUPTION OF TRADITIONAL HEALTH CARE HAS INTRODUCED NEW MECHANISM FOR THE MEDICAL CONSUMER TO ACCESS HEALTHCARE USING DIGITAL TOOLS...
TELEMONITORING IN HK (NGO)

Longevity Home Safety Association

1. 「平安鐘®」
   2. 24小時 x 365日
   3. 召喚救護車
      社區
      資源轉介
      致電999
      信息輔導
      聯繫親人

呼援服務員即時透過手機與使用對話
按使用者情況安排所需的支援服務
TELEMONITORING IN HK (TELECOMMUNICATIONS)

eSmartHealth – For Individuals

- Automatic wireless upload
- Secured data storage
- Professional charts for data analysis
- Personalized health alerts (i.e. exceed threshold)
- Share data with authorized family members and/or medical professionals
INNOVATIVE INSURANCE CONCEPT

- Fitness trackers are linked online through mobile apps
- Allows individuals to monitor activity progress against set goals
- Target reached will result in discounts on their insurance premiums
TELEMEDICINE

- Defined as delivery of healthcare or information at a distance via technology, and includes services such as assessment, monitoring, communications, disease prevention, and education.

**BOTH PROCESS & OUTCOME OF CARE**

- Providing education (improve self management)
- Enabling information transfer (telemonitoring)
- Facilitating contact with health professionals (telephone support and follow-up)
- Improving electronic records

**TWO TYPES:**

- Provision of remote clinical services, via real-time two-way communication between the patient and the healthcare provider, using electronic audio and visual means.
- Store-and-forward transmission of data (asynchronously)
  - Monitoring applications can be entirely automatic or having required the patient to do something.
DEVICES USED IN CARDIAC REMOTE MONITORING

Care Delivery Innovations:

Invasive Implants

Non-invasive Sensors
SCHEMA OF CARDIAC TELEMONITORING

Clinician programs/updates monitor based on patient’s condition.

Patient completes vital signs collection and responds to symptom management questions.

HomMed Monitor securely transfers medical data over network.

Clinician reviews patient assessment data and updates care plan and acts on patient events.

Physician remotely views on smartphone the patient updates and changes in condition.

Physician updates the recommended care plan to patient and clinical oversight team.
Remote Monitoring Using CIEDs

- **CIEDs with Remote Monitoring capability**
- **Remote Monitoring transmitter**
- **Remote Monitoring system website**

Devices send information via wireless radio frequency at scheduled time.

Encrypted information upload through household telephone lines.

Authorized personnel access the information by logging into the system with PIN codes.

Treatment, detection & record

Encrypt the Received information

*CIEDS= Cardiac Implantable Electrical Devices*
Personnel access the information by logging into the system with Authorized PIN codes.

**FastPath® Summary**

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<thead>
<tr>
<th>Note</th>
<th>Aug 26, 2011, 11:14 am (HKT)</th>
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<tbody>
<tr>
<td><strong>1 Alert</strong></td>
<td>Congestion Exceeded Trigger</td>
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<tr>
<td><strong>Battery Information</strong></td>
<td></td>
</tr>
<tr>
<td>Longevity: 6.0-6.3 yrs</td>
<td>Last Max Charge: 9.4 sec (Aug 5, 2011)</td>
</tr>
<tr>
<td>~ERI</td>
<td></td>
</tr>
<tr>
<td>Battery Current Remaining Capacity to ERI</td>
<td>16 uA</td>
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<td></td>
<td>82%</td>
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**Test Results** (Last Session: Aug 3, 2011)

<table>
<thead>
<tr>
<th>Atrium</th>
<th>R. Ventricle</th>
<th>L. Ventricle</th>
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<tbody>
<tr>
<td>Capture</td>
<td>Today: 0.75 V</td>
<td>Today: 0.625 V</td>
</tr>
<tr>
<td></td>
<td>Jul 1, 2011: 0.75 V</td>
<td>Jul 8, 2011: 0.5 V</td>
</tr>
<tr>
<td>Sense</td>
<td>Today: 1.2 mV</td>
<td>Today: 6.3 mV (RV Bi)</td>
</tr>
<tr>
<td></td>
<td>Jul 8, 2011: 3.5 mV</td>
<td>Jul 8, 2011: 8.0 mV (RV Bi)</td>
</tr>
<tr>
<td>Lead Impedance</td>
<td>Today: 350 Ω</td>
<td>Today: 400 Ω</td>
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<tr>
<td>High-Voltage Lead Impedance</td>
<td>Today: 37 Ω</td>
<td>Today: 37 Ω</td>
</tr>
<tr>
<td></td>
<td>Jul 8, 2011: 43 Ω</td>
<td>Jul 8, 2011: 43 Ω</td>
</tr>
</tbody>
</table>

**Current Brady Parameters**

<table>
<thead>
<tr>
<th>Mode</th>
<th>DDD</th>
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<tbody>
<tr>
<td>Base Rate</td>
<td>70 bpm</td>
</tr>
<tr>
<td>Max Track Rate</td>
<td>130 bpm</td>
</tr>
<tr>
<td>Paced/Sensed AV Delay</td>
<td>160/110 ms</td>
</tr>
<tr>
<td>A/RV/LV Pulse Amp</td>
<td>1.75/2.0/2.125 V</td>
</tr>
<tr>
<td>A/RV/LV Pulse Width</td>
<td>0.4/0.4/0.4 ms</td>
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</table>

**Current Tachy Parameters**

<table>
<thead>
<tr>
<th>VT</th>
<th>VF</th>
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<tbody>
<tr>
<td>166 bpm</td>
<td>181 bpm</td>
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<tr>
<td>ATPx3, 15.0J, 30.0J, 40.0Jx2</td>
<td>ATPx1, 32.0J, 40.0J, 40.0Jx4</td>
</tr>
</tbody>
</table>

**VT/VF Episodes**

- **New Episodes:** 0
- **SVT Episodes:** 0

**Diagnostics**

- **AP:** 98 %
- **BP:** >99 %
- **Mode Switch:** 0 %
Remote Monitoring
Transmission of Pre-Set Alerts: VT with Appropriate Shocks

- 68 yrs man with DCM/NSVT-CRT-D implanted as primary prevention
- Stable condition after ICD shock - did not need to attend ER; patient reassured
Initial Transmission Overview

Review the transmission steps. Click to view the monitor animations.
DEVICE DATA IS CRITICAL FOR PATIENT CARE

- Device & lead status
- Arrhythmia episodes (AT/AF)
- Delivered therapies
- AT/AF burden
- Heart rate variability
- % Pacing
- Fluid status
- Activity

Predictive diagnostics for HF hospitalization in the next 30 days

REDUCE HEALTHCARE UTILIZATION

Up to 1 in 4 CRT-D/ICD device patients may visit the Emergency Room

Baseline

Up to 1 in 2 CRT-D/ICD device patients may require a hospitalization

Remote Monitoring

35% potential reduction in ER visits

20% potential reduction in all-cause 3y rehospitalization

18% potential reduction in hospital length of stay

SIMPLIFIES ROUTINE FOLLOW-UP

Routine in-office visits may be replaced by remote visits resulting in 45% fewer\(^1\) in-office visits

58% less time\(^2\) for remote vs. in-office follow-up

Remote monitoring improves patient compliance\(^1\) to follow-up

The Relationship Between Level of Adherence to Automatic Wireless Remote Monitoring and Survival in Pacemaker and Defibrillator Patients

Niraj Varma, MD, PhD,* Jonathan P. Piccini, MD, MHSc,† Jeffery Snell, BA,‡ Avi Fischer, MD, † Nirav Dalal, MS, † Suneet Mittal, MD§

CONCLUSIONS  RM is associated with improved survival, irrespective of device type (including PMs), but demonstrates a graded relationship with the level of adherence. The results support the increased application of RM to improve patient outcomes. (J Am Coll Cardiol 2015;65:2601-10) © 2015 by the American College of Cardiology Foundation.
Patient Adherence to RM

• “Big data” to assess
  – RM is associated with improved survival
  – Type of cardiac device
  – Degree of use

• N=269,471 consecutive pts implanted with automatic RM capable devices between 2008-2011
  – Mean age 71±13.5 yrs; 64.8% male
  – Mean FU 2.9±1 yrs

RM adherence per patient was defined as the proportion of total follow-up weeks having at least 1 status transmission or percentage of time in RM (%TRM)
53% patients never used RM
Dichotomization by a 75% use value divided RM into relatively balanced populations

![Graph showing distribution of remote monitoring utilization among patients with enabled devices]

Low = 59,7865 (22%)
High = 67,920 (25%)
Survival in all Patients (PPM, ICD, CRT)

Survival was greater in patients in all device types.

![Graph showing patient survival according to level of remote monitoring utilization: All Devices. The graph illustrates the proportion of patients surviving over years from implant for three groups: High %TRM, Low %TRM, and RM None. Cox survival analysis results are shown for each comparison, indicating a statistically significant difference in survival between groups.]

- **Cox Survival**
  - High %TRM vs RM None: HR: 2.10 (2.04-2.16) p < 0.001
  - Low %TRM vs RM None: HR: 1.58 (1.54-1.62) p < 0.001
  - High %TRM vs Low %TRM: HR: 1.32 (1.27-1.36) p < 0.001

Mean Follow-Up: 2.87 (1.03) Years
The degree of adherence correlates with the magnitude of survival gain, suggesting a gradient of effect.

Critical impact of adherence: for maximal benefit of RM:

Earlier activation and then maintenance of consistent transmissions were associated with best outcomes.
TELEMONITORING FOR HEART FAILURE DISEASE MANAGEMENT IN HONG KONG
HEART FAILURE – A GROWING GLOBAL CONCERN

Prevalence and Incidence

Overall 2.1% prevalence: 5.1M heart failure patients in 2010

825,000 people ≥ 45 years of age are newly diagnosed each year with HF.

15 M heart failure patients in the European countries

- Overall 2-3% prevalence

Mortality

For AHA/ACC stage C/D patients diagnosed with HF:

- 30% will die in the first year.
- 60% will die within 5 years.

HF prevalence in the US is projected to increase 46% from 2012 to 2030, resulting in > 8M people ≥ 18 years of age with HF.

2. The European Society of Cardiology, ESC HF Guideline, 2008
HEART FAILURE IS ASSOCIATED WITH HIGH HOSPITALIZATION AND READMISSION RATES

In 2010, there were 1 million hospitalizations in the US with HF as the principal diagnosis.¹

- Hospitalization rate did not change significantly from 2000.¹

Average length of hospital stay

- Approximately 5 days (US)²
- 11 days (Europe)³

HF is associated with high readmission rates:

- ~25% all-cause readmission within 30 days⁴ and ~50% within 6 months⁵

1. CDC NCHS National Hospital Discharge Survey, 2000-2010

Data from Organization for Economic Cooperation and Development, 2009.
WORSENING HEART FAILURE LEADING TO HF-RELATED HOSPITALIZATIONS CONTRIBUTES TO DISEASE PROGRESSION

With each subsequent HF-related admission, the patient leaves the hospital with a further decrease in cardiac function.

Graph adapted from: Gheorghiade MD, et al. Am J. Cardiol. 2005
CURRENT HF MANAGEMENT IS INADEQUATE FOR IDENTIFYING AND MANAGING CONGESTION LEADING TO DECOMPENSATION

Identifying congestion early will lead to early treatment, prevent hospitalizations and slow the progression of HF.

90% of HF hospitalizations present with symptoms of pulmonary congestion.¹,²

Post hoc analysis of 463 acute decompensated HF patients from DOSE-HF and CARRESS-HF trials showed:

- 40% of patients are discharged with moderate to severe congestion.³
- Of patients decongested at discharge, 41% had severe or partial re-congestion by 60 days.³

In 2013, there were **3,509 acute admissions** (out of total 23,085 admissions, i.e. **15.2%**), i.e., **10 HF admissions/day**, and the means **LOS: 4.8 days** in QMH, **estimated total cost in QMH = HKD$72,931,056** (3,509 admission x 4.8 days x HKD$4,330)
REMOTE MONITORING VS REMOTE DISEASE MANAGEMENT

Paradigm shift
Access to information in a more timely fashion allowing a more pro-active approach

Can we use devices as disease management tools?

• Can we provide better heart failure care?
  • Can HF hospitalization be prevented by remote monitoring?
CIEDS REMOTE MONITORING IN GH

- From 2010-2015
- 128 patients implanted with RM-capable devices joined RM program in GH
- Total 3495 transmissions (average 27.3 /pt)
- 154 episodes requiring interventions = 5.8% of total transmissions
CONCEPTS OF INTRATHORACIC IMPEDANCE CORRELATING WITH HEMODYNAMIC STATUS

Drier lungs means the transthoracic impedance is higher

Wetter lungs means the transthoracic impedance is lower

Better

Worse
INTRATHORACIC IMPEDANCE: MIDHEFT

Yu CM et al. Circulation 2005;112:841-48

-12.3 +/- 5.3% (p < .001)

Impedance (Ω)

Reference Baseline

The Day Before Hospitalization

18.3 +/- 10.1 Days
INTRA-THORACIC IMPEDANCE & FLUID STATUS MONITORING
DEVICE CONGESTION MONITORING

CorVue™ Congestion Monitoring

Current view: 3 Month

Last Session: Oct 15, 2009
Last Cleared: Nov 21, 2008
42 yrs old lady with CCTGA VSD and subvalvular PS with previous surgeries SSS with sinus arrest/ VT and CHF- CRT-D implanted 12/ 2010

Hospitalized with VT/ HF symptoms received shocks

With treatment

No connection with RM
Limitations of Device-Based Intrathoracic Impedance

False positives

Impedance can change as a result of:

- Prolonged scar tissue at implant site
- Prolonged healing of the device pocket
- Disruption of the electrode-tissue interface secondary to lead dislodgement
- Infection affecting device pocket or electrodes
- Pericardial effusion
- Pneumonia
- Lead/electrode malfunctions
- Other unexplained changes
A GLIMPSE INTO THE FUTURE...
Clinical tools to manage Heart Failure

There are many signs and symptoms of HF decompensation

- Atrial Fibrillation
- Dyspnea
- Orthopnea
- Exercise Intolerance
- Increased Heart Rate
- Pulmonary Edema

Early warning with clinical data can lead to earlier intervention

INCREASES IN PRESSURE START THE CYCLE OF WORSENING HEART FAILURE

Adapted from Jaski BE, “Basics of Heart Failure A Problem Solving Approach”
CARDIOMEMSTM PA SENSOR TECHNOLOGY

The sensor is no larger than the size of a US dime

The sensor is a hermetically sealed capsule containing an inductor coil and pressure-sensitive capacitor.

The inductor coil and pressure-sensitive capacitor create a resonant circuit at a specific frequency. The blood pressure affects the resonant frequency, so that when the blood pressure changes, the resonant frequency changes. The external measurement system wirelessly tracks the resonant frequency and uses this to determine the pressure in the pulmonary artery.

Reliable PA pressure monitoring without leads, batteries or active-fixation mechanisms. Nitinol [nɪˈtɪnəʊl] wire loops extend from each end of the sensor to stabilize the sensor in the implant location.
PULMONARY ARTERY PRESSURE DATABASE

Trend Data

Discrete data

<table>
<thead>
<tr>
<th>Reading</th>
<th>Value</th>
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<tbody>
<tr>
<td>Systolic:</td>
<td>24</td>
</tr>
<tr>
<td>Mean:</td>
<td>19</td>
</tr>
<tr>
<td>Diastolic:</td>
<td>16</td>
</tr>
<tr>
<td>Heart Rate:</td>
<td>81</td>
</tr>
</tbody>
</table>
Patients with moderate NYHA class III HF for at least 3 months, irrespective of LVEF and a HF hospitalization within the past 12 months were included in the study.

Patients managed with PA pressure data had **significantly fewer HF hospitalizations** as compared to the control group.

Compared to the control group, patients managed with PA pressures had significantly more total medication changes, resulting in < 1 incremental medication change/month.

PA PRESSURE-GUIDED THERAPY REDUCES HF HOSPITALIZATIONS

Remote monitoring technologies need to be coupled with an effective delivery system

- FDA approved for class III HF in May 2014
- Success of trial relied on:
  - Effective processing of large data
  - Heart failure RN’s to monitor trends
  - Oversight by HF physicians adept at interpreting hemodynamics
- Is clinical practice equipped?
REMOTE MONITORING FOR HF PATIENTS
A DYNAMIC CONDITION WHERE RETRIEVED DATA DRIVE TREATMENT

Wireless Hemodynamic and Other Data → Analyzed by Implanted or Networked Device → Data Transmitted Clinical Alert Generated

HF Patient at Home → Change in Therapy Implemented

Clinician Data Analyzed, Interpreted, and Treatment Plan Formulated → Treatment Plan Communicated
HEART FAILURE REMOTE MONITORING IN ASIA

OUR EXPECTATIONS

Improve health outcomes

• Improve QoL by offering more autonomy to patients
• Closer monitoring and more rapid dissemination of clinical data allow more informed and timelier treatment decisions

Reduce costs

• Reduction of unnecessary hospitalizations and physicians visits
• Patients become more self responsible and thus reduces home care expenditures
• Telemedicine reduces costs in traditional data collection, recording and communications

Fully accepted by patients

• Supposed to empower patient and generate high motivation for active participation in treatment process
HEART FAILURE REMOTE MONITORING APPLICABILITY IN ASIA PACIFIC?

Devices Implantation rates and FU methods

- PM ranges from 31/million in China to 565/million in Australia 2009
- ICD ranges from 1/million China and 160/million in Australia
- FU methods:
  - Follow international guidelines/recommendations eg Hong Kong, Singapore, Japan
  - Erratic FU pattern eg China/India- patients carry their own records to see their doctors

Multifactorial

- Difference in disease patterns
- Regional guidelines for device implantation
- Patient acceptance
- Cost

Government Policy such as healthcare, reimbursement, telecommunication

Technology

- Landline communication can be sparse in some countries
- Wireless communication is now widely available in Asia-Pacific region
CLINICAL EFFICIENCIES AND WORK-FLOW – CALL FOR DISRUPTIVE INNOVATION?

WORK-FLOW CHANGES AND CHALLENGES

Demands on adjustment to different workflow patterns and mindsets

Dedicated trained allied professional who maintain early reaction ability and reported to responsible physicians

Resources needed to operate such a “virtual clinic” including reimbursement may not be universally available

Data management

• Best with interface with electronic medical records within one database

CLINICAL EFFICIENCIES

Greater reduction of routine non-actionable in-person evaluations

Actionable alert notification quickly acted upon

Patient engagement is emphasized

• Maybe included in the loop for access to results and recommendation

Improved patient care

• Expanded framework for multidisciplinary communication and collaboration eg EP and Heart Failure physicians
MOVING CARE OUTSIDE OUR DOORS: COMMUNITY-BASED HEART DISEASE MANAGEMENT?

Yes but....

Remember goal of health system is to improve population health and to be responsive to the population’s needs and demands

- Acceptance essential through effective communication and education

The standard set has to overcome political, commercial, technical and cultural barriers

- Countries and companies working together
- a unified open standard not just in name but in spirit

3 important rules:

- Mutual interests
- Open standards
- Fair markets
病人醫護一線牽
監察病情更全面

「你好，現在我將會為你的心臟起搏器進行檢查。」
相信植入了心臟儀器，包括起搏器、除顫器、雙室同步起搏器及雙室同步除顫器的病人到診所覆診時，都會對這句話感到陌生。隨著時代進步，病人除了可在診所進行植入式心臟儀器檢查外，遙距監察（Remote Monitoring）也成為一種趨勢。遙距監察利用電話或數據網絡，上載病人儀器檢測的資料至雲端系統，再由心臟科主診醫生及護士以密碼登入查看病人的記錄。上傳的數據包括儀器運作情況和心律不整紀錄，較先進的儀器更能顯示短間期指標以反映心臟衰竭情況，這些資料都用以輔助醫生進行心臟疾病管理。

葛量洪醫院為香港首間發展遙距監察系統的醫院。當初引入系統是因為醫院接收的心臟衰竭病人情況較嚴重，我們希望更緊密關注他們的心臟健康。我們的監察團隊於二零零五年開始籌備，在二零一零年成立，而參加了遙距監察的病人現已逾百個。監察的成員至今有十一人，分別為三名心臟科醫生及八名心臟科護士或技術員，他們事前均需接受不同儀器公司及監察系統的訓練。

我們日常工作主要是訊息檢查，訊息一般分為：儀器自動傳送（圖一）和病人主動傳送（圖二、三）。

遙距監察系統不經不覺在醫院已運行了三年多，開始時監察隊伍和病人實在意需要一段時間協調及適應。然而，當系統發展成熟後，好處亦慢慢顯現。最令我感到欣慰的是，整個團隊與病人關係更加密切，每次對話都有著關懷服務。我們會不厭其煩地電話病人要注意的事項，病人因此逐漸熟悉心臟健康改變的病徵，提高自己對病情的關注。此外，由於儀器監察系統可以立時通知護士人員有病人心臟情況，這大大增加病人接受及時治療的機會，舒緩病情，以免情況惡化。和病人保持進步的醫療服務帶來進步。

注意：遙距監察系統並不能取代緊急醫療服務，有緊急情況請即求診！