Triage of Acute Decompensated Congestive Heart Failure in the Emergency Department

Initial Results Using a Computer-Based Medical Decision-Support Tool

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Disclosure Statement

Ms. Debora J. Simmons, RN MSN CCRN CCNS recuses herself from the presentation due to conflict of interest

All other co-investigators have no conflict of interest
Nurse, get on the internet, go to SURGERY.COM, scroll down and click on the 'Are you totally lost?' icon.
Computer Applications in Medicine

Computer-aided diagnosis
The "Automated Doctor"

Audio: Courtesy of comedian Ms Kristin Lindner. Performance at the Houston Improv Comedy Club, 2005
Challenges and Limitations of Computer-based Diagnosis

Automated Medical Decision Making Systems

The Shortfalls:

- Inadequate
- Imprecise
- Non-Reproducible
Challenges and Limitations of Computer-based Diagnosis

1. Non-Uniformity of System Elements:

Variations of Human Patient Characteristics
II. Incomplete Understanding of the System's behavioral Patterns:

Such as:

1. How diseases start and progress....
Research about the causes, course, behavior and modification of different diseases is still on-going.

Our understanding of such processes and behavioral patterns remains incomplete.
2. The effects of different therapeutic modalities....

HE'S JUST NOT RESPONDING DOCTOR

HMMM... HAVE YOU TRIED TURNING HIM OFF AND ON AGAIN?

Dream #999
3. The effects of interaction between different System Elements and/or therapeutic modalities

- Population cohort factors
- Individual factors
- Compliance
- Socio-economic factors

- Historical evidence
- Prospective evidence
- Off-Label evidence

- Therapeutic variability
- Therapeutic/Medication interactions
- Side effects
- Complications
- Unexpected effects/Idiosyncracies

- Co-existing conditions
- Unknown/Undiagnosed conditions
For example, rules and behavioral patterns in the Aviation Industry Systems have been well understood for over a century,

Feasible and easy to achieve optimal control over the system’s components
4. Unpredictability of the Consequences or Results of Intended / Planned Actions:

Unpredictability of the Effectiveness of Therapeutic Modality…
5. The Diagnostic Software I.Q.

A Computer Program

will ALWAYS do what you TELL it to do,

But rarely

what you WANT it to do
Can We Teach the Computer?

vs.

I'M SORRY DAVE, I'M AFRAID I CAN'T DO THAT
Basics of Medical Triage

■ Quick Establishment of Diagnosis
■ Assigning a Severity Score
■ Establishing the Predicted Outcome
■ Disposition (according to the predicted outcome)
Basics of Medical Diagnosis

- Information Gathering:
  - Medical history
  - Symptoms
  - Physical Examination
  - Laboratory Data
  - Imaging Data

- Differential Diagnosis List
- Assignment of a Probability Hierarchy
"Guess Who?"  
(Diagnosis)

"Drop that knife!"  
(Predicted Outcome)

"Book 'em, Danno!"  
(Disposition)
Establishing a Diagnosis

A -- Differential Diagnosis

B -- Sorting out the Suspect List
1. The Possibilistic Approach

a.k.a., DRAGNET

THE POSSIBILISTIC APPROACH
2. The Probabilistic Approach

a.k.a., What Are the Odds?!

Bayes Theorem

Bayesian Network
3. The Prognostic Approach

a.k.a. Voted Most Likely to Succeed?
Computer-Based Diagnostic/Predictive Systems: Principles and Correlation

Identify:
- Problem
- Objective

- Identify Data Sub-sets:
  - Determinants
  - Modifiers
  - Associated Data Variables

- Determine Data Flow

- Assign Probability Values

- Develop a Hierarchy

Example

System Interaction

Triage of Acute Decompensated Congestive Heart Failure

**Background:**

**Congestive Heart Failure:**

- About 2-4 million cases in the US
- 15 million cases worldwide.
- 550,000 new cases per year
Triage of Acute Decompensated Congestive Heart Failure

Outcomes:

- Congestive Heart Failure:
  
  • 287,000 deaths per Year
  
  • < 50% expected to live more than 5 years
  
  • Class IV survival:
    At 1 Yr : 43%
    At 3 Yr : 18%


Triage of Acute Decompensated Congestive Heart Failure

Cost:

• In-Patient care: 23.1 Billion $ 

• 300% increase in readmission rates from 1970-1994 (Patients >65 years) 

• Readmission Cost up to 17.4 Billion $ per year (Medicare) 

Sources: 
The American Medical Association 
American Medical Directors Association 
Agency for Health Care Research and Quality
Some others’ work...

D Lombardo, T Bridgmean, N De Michelis, M Nunez. 
An academic medical centre’s programme to develop clinical pathways to manage health care: Focus on acute decompensated heart failure. 
J Integrated Care Pathways. (2008);12:45-55

D Lee, P Austin, J Rouleau, P Liu, D Naimark, J Tu. 
Predicting mortality among patients hospitalized for heart failure. Derivation and validation of a clinical model. 
JAMA.2003;290:2581-2587.

The Seattle Heart Failure Model: Prediction of Survival in Heart Failure. 
Circulation. 2006;113:1424-1433
Study Objective

To develop a custom-built, computer-based clinical decision-support tool to:

a) Help determine the underlying cause of the patient’s clinical presentation

b) Help the emergency department physician predict the likelihood of readmission for ADHF syndrome.
Acute Decompensated Congestive Heart Failure: Emergency Department Parameters

Patient Factors:
- Age
- Gender
- Documented History of Congestive Heart Failure
- Prior Admission for Acute Decompensated CHF

Symptomatology:
- Shortness of Breath
- Orthopnea/Paroxysmal Nocturnal Dyspnea
- Palpitations
- Chills

Physical Examination:
- Heart Rate
- Systolic Blood Pressure
- Fever
- Presence of a Third Heart Sound
- Jugular Venous Distension
- Dependent Edema

Laboratory Data:
- Serum Sodium
- Serum Creatinine
- White Blood Cell Count
- Serum Uric Acid
- Serum BNP

Findings on Chest Radiograph:
- Unilateral Lung Infiltrates
- Bilateral Pleural Effusions
Acute Decompensated Congestive Heart Failure:

Diagnostic and Disposition Tiers
Acute Decompensated Congestive Heart Failure: The Predictive Program “Run Mode”
Initial Results

Phase I:

“Proof-of-Concept”

- 20 cases
- Hypothetical, Randomly Generated Parameters
Initial Results

Phase I:

Successful Prediction:

- Diagnosis: 17/20 (85%)
- Disposition: 16/20 (80%)
Initial Results

Phase II:

Clinical-based, Real-World Retrospective Study

- Retrospective chart review
- Records-based parameters
- 100 Emergency Department case records
- Documented final diagnosis:
  - 55 cases of Acute Decompensated Heart Failure
  - 45 cases of Other Diagnoses
**Phase II:**

**Case number by Diagnosis:**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADHF</td>
<td>55</td>
</tr>
<tr>
<td>Stable HF</td>
<td>14</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>8</td>
</tr>
<tr>
<td>COPD</td>
<td>7</td>
</tr>
<tr>
<td>&quot;Other&quot;</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Initial Results
Initial Results

Phase II:

![Bar Chart]

- ADHF
- Stable
- Pneumonia
- COPD
- Other

Correct Diagnosis

Number of Patients
Initial Results

Phase II:

Phase II Results

- ADHF
- Stable
- Pneumonia Diagnosis
- COPD
- Other

# of Patients

Correct Diagnosis
Correct Disposition
Study Limitations

- Pilot study design
- Retrospective
- Chart Review
- Small Sample Size
Conclusion

A custom-built, computer-based predictive model, using evidence-based, population-wide real-life clinical data and trends, can be a useful adjunct tool in clinical decision making.
Conclusion

...especially in high-paced, high risk clinical environments.
Thank You!